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Suitability evaluation for *Elaeis guineensis, Cocos nucifera* and *Theobroma cacao* cultivation on some soils of Isua community in Edo State, Nigeria.

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ABSTRACT

This study was conducted on a 128-hectare land in Isua community of Edo state to assess its suitability for Oil palm, Coconut and Cocoa cultivation. Rigid grid Soil survey methodology at detailed scale was done which produced four mapping units. The soils were classified according to USDA soil taxonomy and local series; three soil orders were classified in the study area (Entisols-Ahiara, Inceptisols-Kulfo and Ultisols-Orlu). Major limitations to assessment were climate (mean annual temperatures) and soil physical characteristics (texture/structure). Aggregate suitability rating (both actual and potential) showed that Orlu series (pedons 3 and 4 amounting to 56.73 ha) was suitable for all the crops; Kulfo series (pedon 2, covering 54.25 ha) was suitable for Coconut and Cocoa; Ahiara series (Pedon 1covering 17.13 ha) was not suitable for any of the crops. Thus, area occupied by pedon 1 should not be used for cultivation of any of the crops due to major limitation in texture. Moreover, both assessment approaches captured the major limitations; therefore, the use of any of the approaches employed in this study and for these crops becomes a matter of choice as both of them show no major differences in the application of their procedures.

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1.0 Introduction

Considering the rapid growth of the world population, increasing demand and utilization of arable lands around the world, the dire need for effective and efficient utilization of the cropland has been felt more than ever. Land evaluation is the process of estimating the potentials of land for one use or several alternative uses (FAO 1976). It is the assessment of the capability of the land for producing a specific crop or combination of crops under specific management practices (FAO 1976; Egwu, 2015). Suitability assessment of land resources for cultivation for certain crops is the key for sustainable crop production, including landuse planning and policy making for agricultural crop production (Peter and Umweni, 2020)

Potentials of soils can readily be tapped when information on its physical, chemical and biological properties are available. The need for proper land suitability evaluation before starting any Agricultural project cannot be over emphasized, as a neglect of this in the past has resulted to haphazard allocation of crops to portions of the landscape where they are not ecologically suited and this has led to the failure of massive agricultural projects.

Due to the tremedous advantages of cash crops such as Oil palm (*Elais guineensis*), Coconut (*Cocos nucifera*) and Cocoa (*Theobroma cacao*) in boosting the Nigerian industrial and economic development, attempts have been made to increase their production. To achieve this goal, it is necessary to have comprehensive information on the biophysical resource and identify the major limitations to the cultivation of specific crops in order to maximize landuse and increase production (Oko-Oboh *et al*., 2018). Hence the

objective of this study was to assess the suitability of some soils of Isua community of Edo state for Oil palm (*Elais guineensis*) Coconut (*Cocos nucifera*) and Cocoa (*Theobroma cacao*) using Parametric and non-parametric approaches. Different scholars have used several guidelines for a study of this nature; however, the guidelines provided by Sys (1985) for Oil palm; Djaenudin *et al* (2003) as modified by Oko-Oboh *et al*., (2018) for Coconut and Fasina *et al*., (2007) for Cocoa were used in this study.

2.0. Materials and Methods

2.1. Study Area

The study was conducted on a 128 hectare land in Isua community (Uhunmwode Local Government) of Edo state. The site lies within latitude 6° 18'24.08"N and 6° 18'30.56"N and Longitude 5° 57'12.23"E and 5° 57'58.3"E . The annual rainfall is within the range of 1500 mm to 2500 mm with an average of 1900 mm per annum. The average annual temperature ranges from 23-37°C, mean annual relative humidity ranging from 89% in the morning (10.00 am) to 75% in the evening (4 pm), (NIFOR,2013). Some of the crops grown include cassava, leafy vegetables, Oil palm.

The area is situated in the rainforest zone, with two distinct climatic seasons, namely; the rainy and dry seasons. The rainy season is between April and October with a 2-week break in August. The dry season lasts from November to April, with a cloudy, humid and dusty harmattan period between December and January.

The soils here are generally the red ferrasols, derived from coastal plain sands (unconsolidated sands and Sandy clay) and alluvial deposits (Umweni, 2007). Furthermore, the soils of the area were generally derived from the coastal plain sand which is Benin formations of sedimentary rock. The topography is a terrace (0.3-9%) throughout the study area.

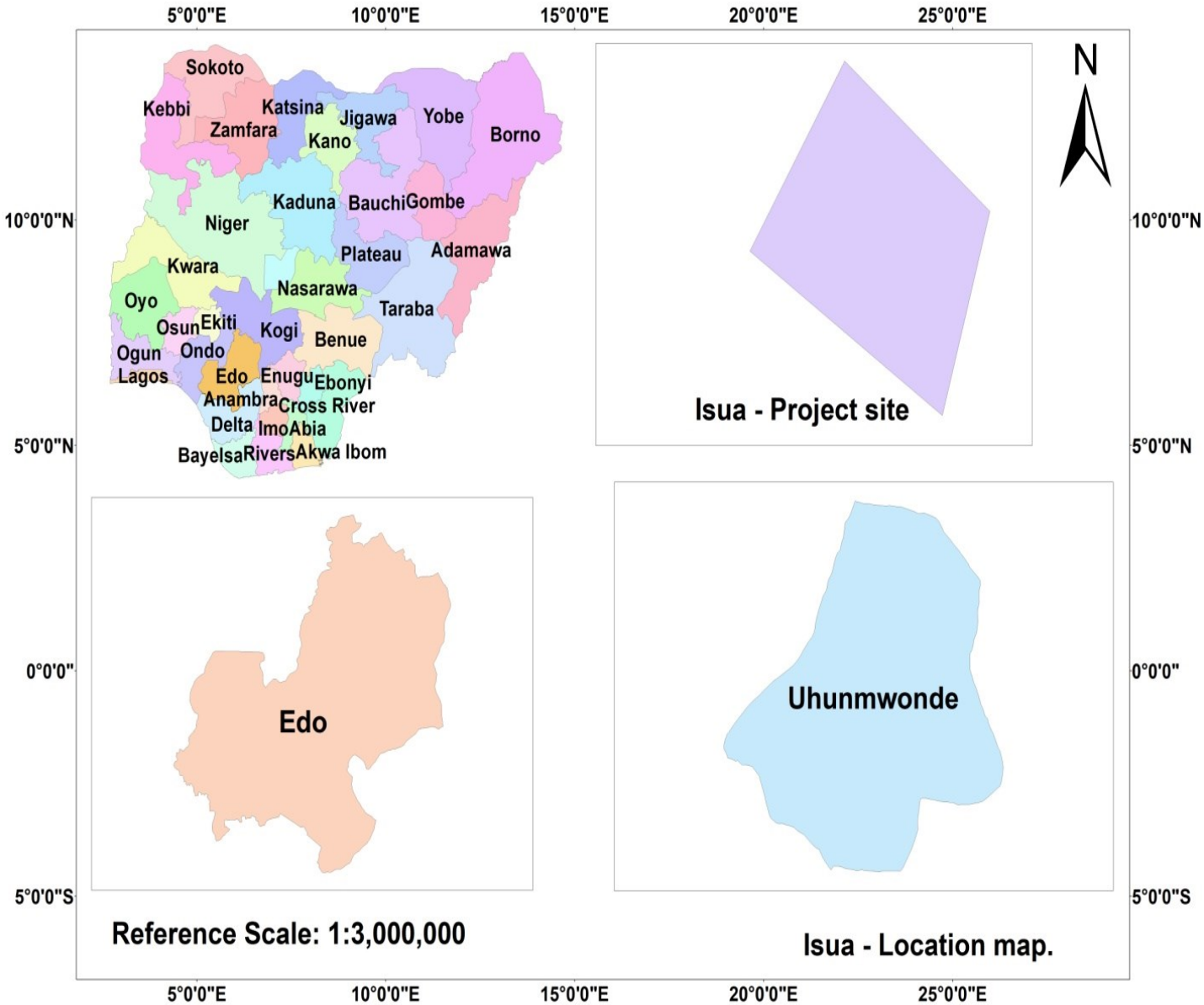

Fig: Map showing location of the study area

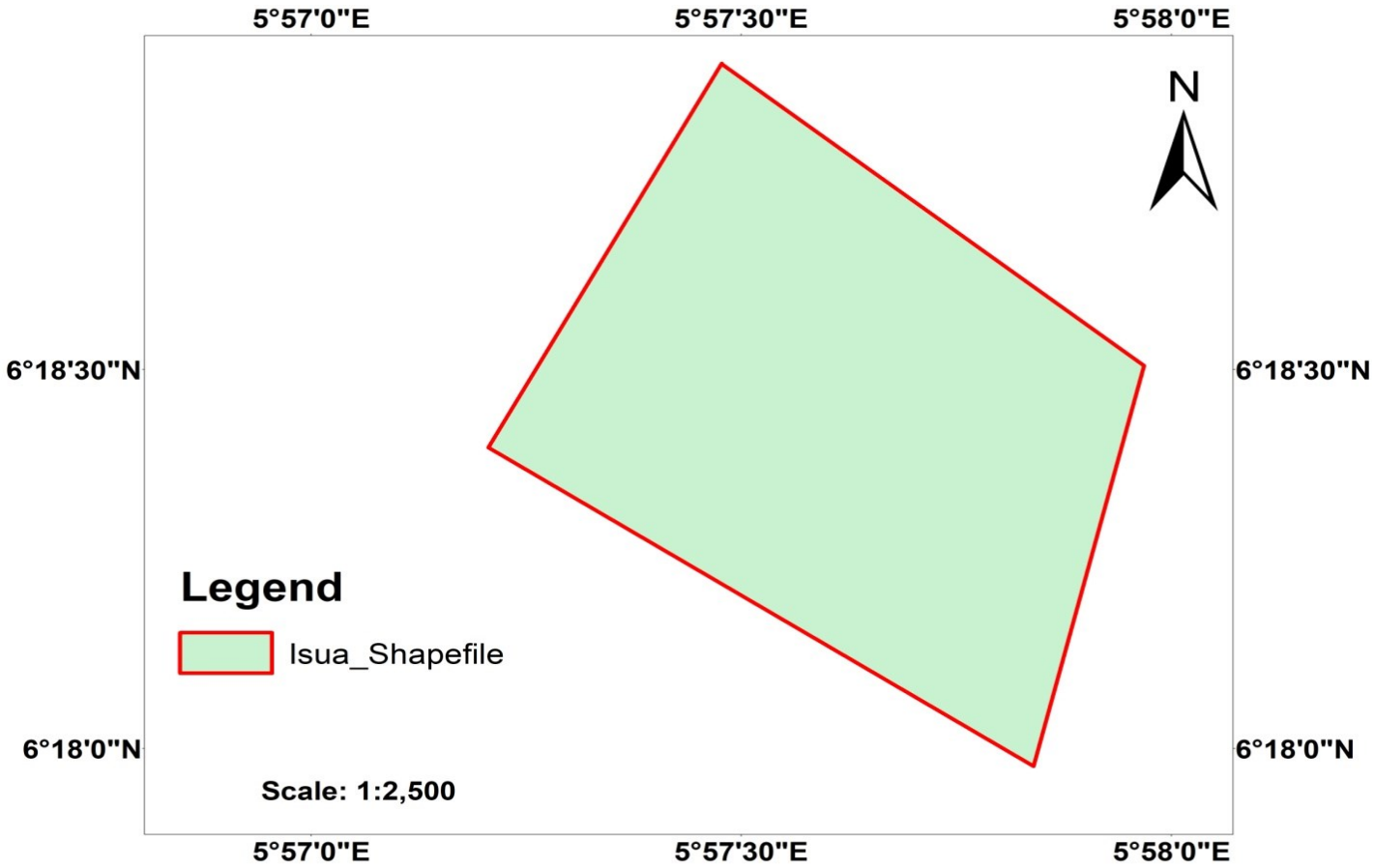

Fig: Map showing location of the study area

Field Studies

Soil survey process was by the rigid grid method at a detailed scale. Traverses were cut at intervals of 100 m from pre-determined baseline with the transverses running in both vertical and horizontal directions, making a total of 10 traverses. Auger borings were done at 100 meters apart along the traverses; auger samples were observed at depth intervals of 0-30 cm, 30-60 cm, 60-90 cm and 90-120 cm respectively and were appropriately described morphologically on the field (soil colour, texture by feel, presence or absence of mottles, presence or absence of concretions, and so on). Areas with similar properties were put together to form the various mapping units; four (4) mapping units were delineated. Each mapping unit was represented by a pedon that was described according to FAO (2006); identified horizons / layers were sampled from bottom to top. The samples were properly bagged, labelled and taken to the laboratory for analysis. The samples were analyzed using standard procedures.

Soil Classification

Soil classification was done using the USDA soil taxonomy (Soil Survey Staff, 2014) and locally according to Ogunkunle (1983).

Laboratory Analysis

Soil samples collected from each horizon were air-dried and passed through a 2mm sieve.

The sieved samples were analysed for some physical and chemical properties. Particle size distribution was determined by the hydrometer method (Gee and Or, 2002) after the removal of organic matter content with hydrogen peroxide and dispersion with sodium hexametaphosphate (International Institute for Tropical Agriculture - IITA, 1979). Available P was determined by Bray-1 method (Olsen and Sommers, 1982). The pH was determined with glass electrode pH meter in soil: soil and water at ratio 1:1 (Maclean, 1982). Exchangeable Bases (Na, K, Ca and Mg) were extracted with neutral normal ammonium acetate (NH_4OAC at pH 7.0); Na and K were determined by flame photometer while Ca and Mg were determined by atomic absorption spectro photometer (Thomas, 1982). Total N was determined by Macro Kjedhal method (Bremner, 1996). Exchangeable Acidity was determined by titration method (Anderson and Ingram, 1993). Organic Carbon was determined by Walkley Black method (Page, 1982). Effective Cation Exchange Capacity (ECEC) was obtained by the summation of Exchangeable Bases and Exchangeable Acidity (Tan, 1996). Base Saturation was calculated by dividing the sum of Exchangeable Bases (Na, K, Ca and Mg) by the ECEC and multiplying the quotient by 100.

Land Suitability Evaluation

Land suitability evaluation was by both parametric and limitation methods. Limitaion method was based on FAO (1976) frame work for rain fed agriculture and guidelines provided by Sys (1985) for Oil palm; Djaenudin *et al* (2003) as modified by Oko-Oboh *et al*., (2018) for Coconut and Fasina *et al*., (2007) for Cocoa. Pedons were placed in suitability classes by comparing their land qualities and characteristics with the guideline. The suitability class of a pedon (aggregate suitability) is that indicated by the most limiting (poorest) characteristics of that pedon. This was done in accordance with the principle of the law of minimum, which states that performance is always determined by the least favourable factor or plant nutrient in

the lowest supply (FAO, 1984).

For Parametric method, scores were given to the quality of each pedon and suitability was calculated as index of productivity using the square root model of Storie(1976)

IPc= A √(B/100 * C/100 * D/100 * E/100)-------(Equ. 1) (Sys 1985)
(c) (t) (w) (s) (f)

Where A is the overall least characteristic rating, c = climate, t = topography, w = wetness, s = slope,

f = fertility.

Using this method, each characteristic was first rated as follows: No limitation: 100-85, (S1); Moderate limitation: 84-60 (S2); Severe limitation: 59-40 (S3); Very severe limitation 39-0 (N). The index of productivity for each pedon was expressed from the rating of each characteristics of the land qualities of each group, using the lowest rating. Index of productivity was rated into classes as follows:

Highly suitable (S1) 100-75, moderately suitable (S2) 74-50, marginally suitable (S3) 49-25 and Non suitable (N) 24-0. (Ogunkunle, 1993)

3.0. Results and Discussions

3.1. Soil Classification

Pedon 1 was classified as Typic Udipsamment (Ahiara); pedon 2 was classified as Typic Dystrudept (Kulfo); pedon 3 was classified as Typic Rhodudults (Orlu); pedon 4 was classified as Rhodic Kandiudult [Orlu (Clayey)] by USDA soil taxonomy (Soil Survey Staff, 2014) and Locally by Ogunkunle (1983).

3.2. Limitation Approach

CLIMATE: According to the guidelines provided by Djaenudin *et al* (2003) as modified by Oko-oboh *et al*., (2018) for Coconut; Sys (1985) for oil palm and Fasina *et al*., (2007) for Cocoa, the mean annual rainfall of the study area is 1900mm (NIFOR, 2017). This according to the guideline falls in the class S_1 (highly suitable) for Coconut and Cocoa; and S_2 (Moderately suitable) for Oil Palm cultivation. The mean annual temperature of the study site ranges from 23^{o}C to 37^{o}C with a mean of 30^{o}C, this placed the study area in class S_1 (highly suitable) for Oil palm and Cocoa; class S_3 (Marginally suitable) for Coconut. Length of Dry months was rated moderately suitable (S_2) Oil palm and Coconut and marginally suitable for Cocoa. Relative humidity (75-89%) was rated highly suitable for Coconut cultivation and marginally suitable for Cocoa according to the guidelines.

TOPOGRAPHY: Topography of the study area was highly suitable (S_1) for coconut and Cocoa in mapping units 1 (0.3-1.9%), 2 (3-5.2%) and 4 (3.5-5%) but moderately suitable (S_2) in mapping unit 3 (7.1-9%) (Sys 1985). However, mapping unit 1 was highly suitable for oil palm while mapping units 2, 3 and 4 were moderately suitable for (S_2) for oil palm. Djaenudin *et al.* (2003) as modified by Oko-oboh *et al*., (2018), Fasina *et al*. (2007).

WETNESS:

The results showed that the study area has no flooding problem, it was well drained and results obtained from table showed that it falls under $S1_1$ (Highly suitable) for all the crops according to the guidelines.

3.3. Soil Physical Characteristics:

The soil depth was greater than 100 cm in all the Pedons; which according to the guidelines (tables 2 and 3) is highly suitable for cultivation of Oil palm, Coconut and Cocoa. However, pedons 2, 3 and 4 were moderately suitable for Cocoa cultivation. Texture of pedon 1 was not suitable for all the crops (S-LS). Pedon 2 (S-SL) was not suitable for Oil palm, moderately suitable for Coconut and marginally suitable for Cocoa. Pedons 3 and 4 (LS-SCL) were highly suitable (S_1) for Coconut but marginally suitable (S_3) for Oil palm and Cocoa. Soil structure for pedon 1 was permanently not suitable (N_2) for Oil palm (single grain crumbs); and marginally suitable in pedons 2, 3 and 4 (ranged from single grain crumbs to sub-angular blocky) (Sys, 1985). Guidelines for Coconut and Cocoa did not include soil structure in their evaluation Djaenudin *et al* (2003) AS modified by (Oko-oboh *et al*., 2018), (Fasina *et al*., 2007).

Fertility Characteristics: This refers to the chemical fertility of the soil with reference to the properties that are easily altered (actual) as well as the requirements for potential fertility as it affects the production of Oil palm, Coconut and Cocoa.

The guidelines provided by Djaenudin, *et al.* (2003) as modified by Oko-oboh *et al*., (2018) for Coconut and Sys (1985) for Oil palm, Fasina, *et al*. (2007) for Cocoa showed that Base saturation, which ranged from 28.32-73.68%, in all the pedons, placed Oil palm and Coconut in suitability class S1 (highly suitable); however, pedons 1 and 2 were highly suitable while pedons 3 and 4 were moderately suitable for Cocoa cultivation. pH (4.6-6.4) ranged from strongly acid to slightly acid; a situation that is expected of acid sands (soils developed from coastal plain sand), rating pedon 1 highly suitable (S_1) while pedons 2, 3 and 4 were moderately suitable for Oil palm and Coconut according to the guidelines. In Pedon 1, Organic carbon/organic matter (0-30cm) ranging from 1.18- 3.46 % / 20.30-59.50gkg^{-1}, rated all the pedons S_1 (highly suitable) for all the crops. ECEC range of 1.27 – 4.34 cmolkg^{-1} for all the pedons rated the study area S_2 (moderately suitable) for all the crops according to the guidelines Sys (1985), Djaenudin *et al* (2003) as modified by Oko-oboh *et al*., (2018), Fasina *et al*., (2007).

Suitability Class: Individual and Aggregate rating (both current and potential) of land characteristics was done for the four pedons encountered in the study area.

On actual suitability ratings, pedons 3 and 4 (56.73 ha) representing 44.28% of the study area was marginally suitable [S_3 (s)] for Oil palm because of limitation in soil physical characteristics (texture); marginally suitable for Coconut and Cocoa [S_3 (c)] because of limitation in climate (mean annual temperature / length of dry season). Pedon 2 (54.25 ha) representing 42.35% of study area was currently not suitable [N_1 (s)] for Oil palm cultivation because of limitations in soil physical characteristics (texture/ structure), marginally suitable [S_3 (c)] for coconut cultivation due to limitation in climate; marginally suitable [S3 (c,s) for Cocoa due to limitation in climate and soil physical characteristics (texture). Pedon 1 (17.13 ha) representing 13.37% of the study area was permanently not suitable [N_2 (s)] for all the crops due to limitation in soil physical characteristics (texture/structure).

However, on potential suitability rating, aggregate suitability classes did not change because the major limitations were soil physical characteristics (texture) and climate (temperature) which cannot be altered.

Table 1. Some physical and chemical properties of the study area

Horizon Designation	Depth (cm)	pH	EC	Org. C	Org. M	T. N	Av. P	Na	K	Ca	Mg	ECEC	Al^{3+}	H^{+}	CEC	BS (Soi) %	BS (CEC) %	CLAY	SILT	SAND	TEXTURAL CLASS
			µS/cm	% gkg^{-1}	gkg^{-1}		$Mgkg^{-1}$	←			Cmolkg^{-1}				→						
Ap	0-12	5.3	91.6	2.03	3.49	0.185	2.02	0.061	0.225	0.411	0.137	1.93	0.8	0.3	8.98	43.12	9.24	4	2	94	Sand
A	12-26	5.3	83.1	1.64	2.82	0.15	2.16	0.111	0.426	0.794	0.198	2.33	0.6	0.2	8.39	65.62	18.24	5.5	2.1	92.4	Sand
AB	26-62	5.8	61.2	1.28	2.2	0.116	2.96	0.084	0.317	0.57	0.101	1.87	0.5	0.3	7.65	57.33	13.99	6.5	2.6	90.9	Sand
BA	62-89	6.4	59.4	1.16	1.99	0.105	2.9	0.063	0.212	0.404	0.092	1.27	0.3	0.2	7.73	60.71	9.96	7.5	3.1	89.4	Sand
Bh	89-156	6.4	83.5	1.44	2.48	0.131	3.74	0.104	0.41	0.702	0.184	1.9	0.3	0.2	7.53	73.68	18.59	10.5	3.6	85.9	Loamy Sand
A	0-12	4.4	91.1	2.12	3.65	0.193	4.56	0.14	0.592	0.91	0.291	3.53	1	0.6	8.99	54.75	21.47	9.5	1	89.5	Sand
Bw1	12-31	4.3	88.2	1.71	2.94	0.155	3.22	0.127	0.521	0.872	0.274	3.3	1.1	0.4	11.38	54.36	15.82	11	3.6	85.4	Loamy Sand
Bw2	31-54	4.7	81.5	1.64	2.82	0.149	3.18	0.122	0.511	0.768	0.26	3.06	0.9	0.5	15.14	54.28	10.96	19	4.6	76.4	Sandy Loam
Bw3	54-86	4.5	74.1	1.54	2.65	0.14	2.28	0.095	0.51	0.711	0.255	3.07	1	0.5	15.30	51.17	10.26	20	3.6	76.4	Sandy Loam
Bw4	86-128	5.1	68.5	1.36	2.34	0.124	1.92	0.081	0.487	0.653	0.191	2.61	0.8	0.4	14.68	54.10	9.60	20	1.6	78.4	Sandy Loam
Ap	0-12	5.5	121.6	2.52	4.33	0.229	5.86	0.221	0.486	0.641	0.262	2.61	0.7	0.3	13.66	61.69	11.79	10	3.1	86.9	Loamy Sand
A	12-36	5.4	105.3	1.18	2.03	0.107	3.4	0.241	0.73	1.084	0.522	3.58	0.7	0.3	9.56	71.98	26.96	11	5.1	83.9	Loamy Sand
Bt	36-70	4.6	93.3	1.01	1.74	0.092	2.22	0.072	0.304	0.466	0.185	3.627	1.6	1	14.48	28.32	7.09	22	3.1	74.9	Sandy Clay Loam
Bth	70-123	4.6	94.4	1.16	1.99	0.105	1.84	0.161	0.69	0.977	0.384	4.01	1.1	0.7	14.98	55.16	14.77	22	3.6	74.4	Sandy Clay Loam
A	0-14	6.3	131.4	3.46	5.95	0.315	7.18	0.135	0.555	0.705	0.341	4.34	0.8	1.8	17.4	40.04	9.977	11	3.6	85.4	Loamy Sand
Bt1	14-68	4.7	94.3	2.04	3.51	0.185	2.84	0.095	0.312	0.474	0.236	4.017	0.9	2	16.58	37.81	6.737	25	3.1	71.9	Sandy Clay Loam
Bt2	68-122	4.6	85.4	1.8	3.09	0.164	2.68	0.152	0.594	0.823	0.28	3.25	1	0.4	15.35	56.89	12.046	23.5	2.6	73.9	Sandy Clay Loam

Table 2. Summary of Suitability Evaluation by Limitation Approach

Land Characteristics Pedon	**1 (AHIARA)**			**2 (KULFO)**			**3 (ORLU)**			**4 (ORLU)**		
CROPS	OILPALM	COCONUT	COCOA	OILPALM	COCONUT	COCOA	OILPALM	COCONUT	COCOA	OILPALM	COCONUT	COCOA
CLIMATE (c)												
Mean annual Rainfall (mm)	$S1_1$	S1	S1	$S1_1$	S1	S1	$S1_1$	S1	S1	$S1_1$	S1	S1
Length of dry season (months)	S2	S2	S3	S2	S2	S3	S2	S2	S3	S2	S2	S3
mean annual Temperature (°C)	$S1_1$	S3	S3	$S1_1$	S3	S3	$S1_1$	S3	S3	$S1_1$	S3	S3
Relative Humidity (%)		S1	S3		S1	S3		S1	S3		S1	S3
TOPOGRAPHY(t)												
Slope (%)	S2	S2	S2	S2	S1	S2	$S1_2$	S1	S2	$S1_1$	S1	S2
WETNESS (w)												
Flooding	$S1_1$		S1	$S1_1$		S1	$S1_1$		S1	$S1_1$		S1
Drainage	$S1_1$	S1	S1	$S1_1$	S1	S1	$S1_1$	S1	S1	$S1_1$	S1	S1
SOIL PHYSICAL CHARACTERISTICS (s)												
Texture	N2	N	N1	N1	S2	S3	S3	S1	S2	S3	S1	S2
Structure	N2			N2			S2			S2		
Coarse fragment	-	-		-	-		-	-		-	-	
Soil depth	$S1_1$	S1	S1	$S1_1$	S1	S2	$S1_1$	S1	S2	$S1_1$	S1	S2
SOIL FERTILITY (f)												
CEC ($cmolkg^{-1}$)	S2			S2			S2			S2		
Base Saturation (%)	$S1_1$	S1	S1	$S1_1$	S2	S1	$S1_1$	S2	S1	$S1_1$	S2	S1
Soil pH	$S1_1$	S1		$S1_1$	S2		$S1_1$	S2		$S1_1$	S2	
Organic matter	$S1_1$	S1	S1	$S1_1$	S1	S1	$S1_1$	S1	S1	$S1_1$	S1	S1
Salinity	-	-	S1	-	-	S1	-	-	S1	-	-	S1
EC	$S1_1$	-	-	$S1_1$	-	-	$S1_1$	-	-	$S1_1$	-	-
AGGREGATE SUITABILITY CLASS												
Actual suitability	N2(s)	N(s)	N1(s)	N1(s)	S3 (c)	S3(c,s)	S3(s)	S3(c)	S3(c)	S3(s)	S3 (c)	S3 (c)
Potential suitability	N2(s)	N(s)	N1 (S)	N1(s)	S3 (c)	S3(c,s)	S3 (s)	S3(c)	S3 (c)	S3 (s)	S3(c)	S3 (c)
SIZE (ha)	17.13			54.25			25.27			31.46		
% Coverage	13.37			42.35			17.73			24.56		

Table 3. Summary of Suitability Evaluation by Parametric Approach

Land Characteristics	**1**	**(AHIARA)**		**2 (KULFO)**			**3 (ORLU)**			**4(ORLU)**		
Pedon												
CROPS	OIL-PALM	COCO-NUT	COCOA	OILPALM	COCONUT	COCOA	OILPALM	COCONUT	COCOA	OILPALM	COCONUT	COCOA
CLIMATE (c)												
Mean annual Rainfall (mm)	85($S1_2$)	100(S1)	100(S1)	100($S1_1$)	100(S1)	100(S1)	100($S1_1$)	100(S1)	100(S1)	100($S1_1$)	100(S1)	100(S1)
Length of dry season (months)	75(S2)	75(S2)	59(S3)	75(S2)	75(S2)	59(S3)	75(S2)	75(S2)	59(S3)	75(S2)	75(S2)	59(S3)
mean annual Temperature (° C)	100 ($S1_1$)	59(S3)	59(S3)	100($S1_1$)	59(S3)	59(S3)	100($S1_1$)	59(S3)	59(S3)	100($S1_1$)	59(S3)	59(S3)
Relative Humidity (%)		100(S1)	59(S3)		100(S1)	59(S3)		100(S1)	59(S3)		100(S1)	59(S3)
TOPOGRAPHY(t)												
Slope (%)	75(S2)	75(S2)	75(S2)	75(S2)	100(S1)	75(S2)	85($S1_2$)	100(S1)	75(S2)	100($S1_1$)	100(S1)	75(S2)
WETNESS (w)												
Flooding	100 ($S1_1$)		100(S1)	100($S1_1$)		100(S1)	100($S1_1$)		100(S1)	100($S1_1$)		100(S1)
Drainage	100 ($S1_1$)	100(S1)	100(S1)	100($S1_1$)	100(S1)	100(S1)	100($S1_1$)	100(S1)	100(S1)	100($S1_1$)	100(S1)	100(S1)
SOIL PHYSICAL CHAR-ACTERISTICS (s)												
Texture	24(N2)	24(N)	35(N1)	24(N)	75(S2)	59(S3)	59(S3)	100(S1)	75(S2)	59(S3)	100(S1)	75(S2)
Structure	24(N2)			24(N)			75(S2)			75(S2)		
Coarse fragment	-	-		-	-		-	-		-	-	
Soil depth	100 ($S1_1$)	100(S1)	100(S1)	100($S1_1$)	100(S1)	75(S2)	100($S1_1$)	100(S1)	75(S2)	100($S1_1$)	100(S1)	75(S2)
SOIL FERTILITY (f)												
CEC ($cmolkg^{-1}$)	75(S2)			75(S2)			75(S2)			75(S2)		
Base Saturation (%)	100 ($S1_1$)	100(S1)	100(S1)	100($S1_1$)	75(S2)	100(S1)	100($S1_1$)	75(S2)	100(S1)	100($S1_1$)	75(S2)	100(S1)
Soil pH	100 ($S1_1$)	100(S1)		100($S1_1$)	75(S2)		100($S1_1$)	75(S2)		100($S1_1$)	75(S2)	
Organic matter	100 ($S1_1$)	100(S1)	100(S1)	100($S1_1$)	100(S1)	100(S1)	100($S1_1$)	100(S1)	100(S1)	100($S1_1$)	100(S1)	100(S1)
Salinity	-	-	100(S1)	-	-	100(S1)	-	-	100(S1)	-	-	100(S1)
EC	100 ($S1_1$)	-	-	100($S1_1$)	-	-	100($S1_1$)	-	-	100($S1_1$)	-	-
AGGREGATE SUITABIL-ITY CLASS												
Actual suitability	15.59(N)	15.96(N)	22.81(N)	15.59(N)	45.61(S3)	51.09(S2)	47.11(S3)	51.09(S2)	51.09(S2)	44.25(S3)	51.96(S2)	51.09(S2)
Potential suitability	15.59(N)	15.96(N)	22.81(N)	15.59(N)	45.61(S3)	51.09(S2)	47.11(S3)	51.09(S2)	51.09(S2)	44.25(S3)	51.96(S2)	51.09(S2)
SIZE (ha)	17.13			54.25			25.27			31.46		
% Coverage	13.37			42.35			17.73			24.56		

Table 4

Pedon	USDA Classification	Areal extent (Ha)	Limitation (actual)			Limitation (potential)		
			Oil palm	Coconut	Cocoa	Oil palm	Coconut	Cocoa
1	Typic Udipsamment (Ahiara)	17.13	N2(s)	N(s)	N1(s)	N2(s)	N(s)	N1(s)
2	Typic Dystrudept (Kulfo);	54.25	N1(s)	S3 (c)	S3 (c,s)	N1(s)	S3 (c)	S3 (c,s)
3	Typic Rhodudults (Orlu)	25.27	S3(s)	S3 (c)	S3 (c)	S3(s)	S3 (c)	S3 (c)
4	Rhodic Kandiudult [Orlu (Clayey)]	31.46	S3(s)	S3 (c)	S3 (c)	S3(s)	S3 (c)	S3 (c)

Pedon	USDA Classification	Areal extent (Ha)	Parametric (actual)			Parametric (actual)		
			Oil palm	Coconut	Cocoa	Oil palm	Coconut	Cocoa
1	Typic Udipsamment (Ahiara)	17.13	15.59(N)	13.42(N)	13.42(N)	15.59(N)	13.42(N)	13.42(N)
2	Typic Dystrudept (Kulfo);	54.25	15.59(N)	45.00(S3)	51.96(S2)	15.59(N)	45.00(S3)	51.96(S2)
3	Typic Rhodudults (Orlu)	25.27	28.73(S3)	51.96(S2)	51.96(S2)	28.73(S3)	51.96(S2)	51.96(S2)
4	Rhodic Kandiudult [Orlu (Clayey)]	31.46	44.25(S3)	51.96(S2)	51.96(S2)	44.25(S3)	51.96(S2)	51.96(S2)

Aggregate suitability class scores: 100-75=S1, 74-50=S2, 49-25=S3, 24-0=N

S1=Highly suitable; S2=Moderately suitable; S3= Marginally suitable, N1= Currently not suitable, N2 = Permanently not suitable, N = Not suitable

Table 5. Land and climatic characteristics for suitability classes for Oil palm (Elaeis guineensis)cultivation

Land & climatic requirements	$S1_1$	$S1_2$	S_2	S_3	N_1	N_2
Score %	95-100	85-95	85	60	40	25
Climate (c)						
Mean ann. Rainfall(mm)	>2000	1,700-2000	>1450-1700	>1250-1450	-	<1250
Length of dry season(months)	≥1	1-2	2-3	3-4	-	>4
Mean ann. Temperature (^{0}C)	>29	27-29	24-27	22-24	-	<22
Topography(t)						
Slope (S) (%)	0-4	4-8	8-16	16-30	-	>30
Wetness (w) Flooding	F0	Fo	F1	F2	-	F3
Drainage	Perfect	Mod-Well	-	Poor, aeric	Poor drainable	Very poor, not drainable
Soil physical characteristic(s)						
Texture	Cl, SCL,L	CL,SCL,L	SCL-L	SCL-LFS	ANY	S,CS
Structure	Blocky	Blocky	-	-	-	Massive single grain
Coarse fragmentation (vol.) within 100 cm (z)	>3-10	10-15	15-35	35-55	-	>55
Depth (cm)	>100	10-100	50-90	25-50	-	<25
Fertility characteristics(f)						
ECEC (meq/100g)	>16	15-16	<15	-	-	-
Base saturation (BS %)	>35	20-35	<20	-	-	-
pH	5.5-6.0	5.5-6.0	6.0-6.5	6.5-7.0	<4,>7.0	<4,>7.0
Organic matter (g/kg OC, 0-15)	>15	1.2-0.8	<8	-	-	-
Salinity % Alkalinity (N) EC mmhos	<1	<1-2	>2-3	>3-4	>4-8	>38

Table 6. Suitability evaluation for Elaeis giuneensis, Cocos nucifera and Theobroma cacao cultivation on some soils in Isua community of Edo State, Nigeria

Land, Soil and Climatic Characteristics	S1	S2	S3	N1	N2
Climatic (c)					
Annual rainfall (mm)	1,600-2,500	1,400-1,600	1,200-1,400	-	< 1,200
Length of dry season (months)	< 2	< 3	< 4	-	-
Mean annual temperature (°c)					
Relative Humidity (%)	23 - 32	22 - 35	22 - 38	-	< 21
	40 – 65	35 - 75	30 – 85	Any	-
Topography (t)					
Slope (%)	< 8	< 16	< 30	-	Any
Wetness (w)					
Flooding	No	No	F1	F1	Any
Drainage	Well	Moderate	Imperfect	Poor	Very poor
Physical Soil Characteristics (s)					
Texture/structure	C-60s to SC	C+60s to SCL	C+60s to LFS	C+60s to LFS	Cm to Cs
Coarse fragments (vol. %)	< 15	< 35	< %	< 55	
Soil depth (cm)	> 150	> 100	> 50	> 50	Any
					Any
Fertility Characteristics (f)					
Apparent CEC (meq 100g soil)	> 16	< 16	Any	-	-
Base Saturation (%)	> 35	> 20	Any	-	-
Organic matter (% C, 0-15cm)	> 1.5	> 0.8	Any	-	-

Legend: Fo=No flooding, F1= 1-2 flooding months in ≥ ten years, F2=not more than 2-3 flooding months in 5years out of 10, F3= 2-4 months every year, F4 ≥ 4 months in almost every year.
Source: Oko-oboh *et al.* (2018).

Table 7. Land and climatic requirements for Cocoa (Theobroma cacao)

Land, Soil and Climatic Characteristics	S1	S2	S3	N1	N2
Climatic (c)					
Annual rainfall (mm)	1,600-2,500	1,400-1,600	1,200-1,400	-	< 1,200
Length of dry season (months)	< 2	< 3	< 4	-	-
Mean annual temperature (°c)					
Relative Humidity (%)	23 - 32	22 - 35	22 - 38	-	< 21
	40 – 65	35 - 75	30 – 85	Any	-
Topography (t)					
Slope (%)	< 8	< 16	< 30	-	Any
Wetness (w)					
Flooding	No	No	F1	F1	Any
Drainage	Well	Moderate	Imperfect	Poor	Very poor
Physical Soil Characteristics (s)					
Texture/structure	C-60s to SC	C+60s to SCL	C+60s to LFS	C+60s to LFS	Cm to Cs
Coarse fragments (vol. %)	< 15	< 35	< %	< 55	
Soil depth (cm)	> 150	> 100	> 50	> 50	Any
					Any
Fertility Characteristics (f)					
Apparent CEC (meq 100g soil)	> 16	< 16	Any	-	-
Base Saturation (%)	> 35	> 20	Any	-	-
Organic matter (% C, 0-15cm)	> 1.5	> 0.8	Any	-	-

F1 = Slight, C+60s to SCL = Very fine clay blocky structure to sandy clay loam, C-60V to L = Clay vertisol structure to loam, C+60s to fs = Very fine clay blocky structure to fine sand, C+60v to fs = Very fine clay vertisol to fine sand, C+60s to s = Very fine clay, vertisol structure to sandy soil, CM to SC = Massive clay to sandy clay.
Source: A.S Fasina *et al*., (2007).

Table 8. Land and Climatic Characteristics for Coconut (Cocos nucifera)

Land & climatic requirements	S1	S_2	S_3	N
Annual mean temp (^{0}C)	25-28	28-32 23-25	32-35 20-23	>35 <20
Water availability (wa)				
Mean annual rainfall (mm)	2000 – 3000	1300 - 2000 3000 - 4000	1000 – 1300 4000 – 5000	<1000 >5000
Dry months (months)	0 – 2	2 – 4	4 – 6	>6
Humidity (%)	>60	50 – 60	<50	-
Oxygen availability (oa)				
Drainage	Good Moderate	Mod. Poor	Poor. Mod. Rapid	Very poor. Rapid
Rooting condition (rc)				
Soil texture	Fine, slightly fine, medium	Slightly fine	Very	Coarse
Volume of coarse material (%)	<60	15-35	35-55	>55
Soil depth (cm)	<140	75 – 100	50 – 75	<50
Peat				
Thickness (cm)	>60	60 – 140	140 – 200	>200
Nutrient retention (nr)				
CEC clay (cmolkg^{-1})	-	-	-	-
Base saturation (%)	>20	≤ 20	-	-
pH H_20	5.2-7.5	4.8 – 5.2 7.5-8.0	>8.0	-
Organic Carbon (%)	>0.8	≤ 0.8		
Toxicity (xc)				
Salinity (dsm^{-1})	<12	12-16	16-20	>20
Erosion hazard (eh)				
Slope (%)	<8	8 – 16	16 – 30	>30
Erosion hazard	Very low	Low moderate	Severe	Very severe
Flooding hazard (h)				
Flooding	Fo	-	F1	>F1
Land preparation (lp)				
Surface stoniness (%)	<5	5 – 15	15 – 40	>40
Rock out crops (%)	<5	5 – 15	15 - 25	>25

Legend: Fo=No flooding, F1= 1-2 flooding months in ≥ ten years, F2=not more than 2-3 flooding months in 5years out of 10, F3= 2-4 months every year, F4 ≥ 4 months in almost every year.

Source: Oko-oboh et al., (2018).

Parametric Approach

Actual (current) suitability rating showed that pedon 1 (17.13 ha) representing 13.37% of the study area was not suitable (N) for all the crops. Pedon 2 (54.25 ha) representing 42.35% of study area was not suitable (N) for Oil palm cultivation, marginally suitable (S_3) for coconut cultivation and moderately suitable (S_2) for Cocoa cultivation. Pedons 3 and 4 (56.73 ha) representing 44.28% of the study area were marginally suitable (S_3) for oil palm and moderately suitable for coconut and Cocoa cultivation.

Potential rating, showed that there was no difference in aggregate suitability classes which buttresses the fact that major limitations encountered in the study area cannot be altered.

The disparity in aggregate suitability ratings by both approaches (Parametric and limitation) indicates differences in the approaches; while just a characteristic that is not suitable places a pedon in the not suitable class (N) under limitation approach, parametric approach takes all the characteristics into consideration. Thus, the parametric approach is truly an aggregate of the whole, in arriving at the final suitability class.

4.0 Conclusion

Parametric approach revealed that pedons 3 and 4 (Orlu) covering 56.73 ha, representing 44.28% of the study area were moderately suitable (S_2) for coconut cultivation (both potentially and currently); but marginally suitable for Oil palm cultivation. Pedon 2 (Kulfo) 54.25 ha, representing 42.35% of study area was marginally suitable for Coconut cultivation but not suitable for Oil palm cultivation; pedons 2,3 and 4 (Orlu and Kulfo) amounting to 110.98 ha, representing 86.63% were moderately suitable (S_2) for Cocoa cultivation; while pedon 1 (Ahiara) which covers 17.13 ha and represents 13.37% of the study area was not suitable for any of the crops. By limitation approach (both potential and current), pedons 2, 3 and 4 (Orlu and Kulfo), amounting to 110.98 ha and representing 86.63% of the study area were

marginally suitable (S_3) for Coconut and Cocoa cultivation; pedons 3 and 4 (Orlu), covering 56.73ha and representing 44.28% of the study area were marginally suitable for Oil palm; pedon 2 was not suitable for Oil palm cultivation while pedon 1 (Ahiara) covering 17.13 ha and representing 13.37% of the study area was not suitable for all the crops. Major limitations encountered were climate and soil physical characteristics. Area represented by pedon 1 (Entisols - 17.13 ha) should not be used for cultivation of any of the crops. Moreover, both assessment approaches (parametric and limitation) captured the major limitations (climate and soil physical characteristics) therefore, the use of any of the approaches employed in this study and for these crops becomes a matter of choice as both of them showed no major differences in the application of their procedures.

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