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Influence of soil physical characteristics and drainage on land suitability for crop production in the beach sands area of Akwa Ibom state

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Abstract

The current shortage of food and the increasing food demand of the rapidly expanding population necessitates that, marginal lands such as the beach sands hitherto left under-utilized, be brought under intensive agricultural land use. However, available information on the soils of the beach ridge sand parent material is insufficient for efficient scientific planning for the future use of the soils for agriculture. FAO Land Suitability Evaluation (LSE) system was used to evaluate six pedons identified through field survey within the beach sands area of Akwa Ibom State of Nigeria for their suitability for coconut and sugarcane cultivation. By individual ratings, the results showed that certain land qualities- climate, topography and salinity were optimal (100% suitable) for coconut and sugarcane cultivation. However, suitability classification by the parametric method revealed that the area of study was not suitable (N1) for the cultivation of coconut and sugarcane. Also, by the non-parametric evaluation, all the pedons were only marginally suitable (S3) for the cultivation of selected crops despite the optimal (100 %) climatic condition. The result of the fertility capability classification (FCC) of the six pedons showed that all the pedons belonged to the same FCC unit S gkeh, irrespective of site. The major limitations were soil physical characteristics (texture) and wetness (drainage). This indicates the importance of soil and climate as the major environmental factors that determine crop performance.

Keywords: Soil characteristics, land suitability, drainage, crop production, beach sands, Akwa Ibom State.

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1.0 Introduction

Land evaluation techniques are required to develop models for predicting the land's suitability for different types of agriculture if self-sufficiency in agricultural production is to be achieved in developing countries (Ahukaemere *et al*., 2016). Land suitability evaluation is the examination of the land potential for a specified utilization (Food and Agriculture Organization [FAO], 2007). The suitability of a given piece of land is its natural ability to support a specific purpose. The physical properties of soil– texture, structure, density, porosity, water content, , temperature, andu are dominant factors affecting the use of soil. These properties determine the availability of oxygen of soil, the mobility of water into or through soils, and the ease of root penetration. Soil texture is an important consideration in the growth of certain crops, in the application of some mechanized treatments, and decisions on soil conservation (Ogban and Ibitt, 2018). Shukla (2014), stated that the quality of land is dependent on its physical properties. Knowledge of the physical and drainage properties of soils is essential to an understanding of the practical agricultural problems related to soil productivity.

Cucumber *(Cucumis sativus L.)* is an ancient vegetable and one of the most important members of the *Cucurbitaceae* which is comprised of 118 genera and 825 species. Members of this family are spread mainly in tropical and subtropical regions of the world (Adinde *et al.,* 2016). Recently, cucumber entered the farming system of Akwa Ibom State and farmers cultivate cucumber mainly as sole crop in the flood plains and lowland soils (Ibia and Udo, 2009). Cucumbers are long, cylindrical green fruits that contain about 95 % water and are for this reason often recommended as natural diuretics and helpful for bodybuilding (Wilcox *et al.,* 2015). Coconuts are the seed (or nut or fruit) of the coconut palm or *Cocos nucifera.* They play important role in the livelihood of people as a direct source of income, nutrition and materials. Everything about the tree is useful, that is, it has economical, medicinal and nutritional values (Udoh, 2015).

The beach ridge sands are fluvio-marine deposits of unconsolidated sands deposited by tidal waters along the fringes of the Atlantic Ocean and in estuaries of the various rivers. They are therefore found in those states (Rivers, Akwa Ibom and Cross River) which border the coast (FMANR, 1990). In the southern coastal areas along the bight of Bonny, fine sandy coastal beach ridges occupy about 560 square kilometres within the Qua Iboe River Basin (Udoh *et al.,* 2013). Due to the very poor agricultural productivity of the beach ridge sands, they are not intensively cultivated by farmers who seem to regard these areas as marginal lands because of lack of knowledge and appropriate technology for managing them for optimum productivity.

According to Nsor *et al*. (2014), a visionary technology hinged on efficient land use based on suitability recommendation and management will resuscitate the great hope and potentials of our soils. The current shortage of food and the increasing food requirements of the rapidly expanding population necessitate that marginal lands such as the beach ridges hitherto left under-utilized, be brought under intensive agricultural land use, and commercially oriented permanent farming as opposed to shifting cultivation. The main aim of this study was to evaluate the influence of soil physical characteristics and drainage on land suitability for coconut (*Cocos nucifera* and cucumber *(Cucumis sativus*) cultivation in the beach sands area of Akwa Ibom state.

2. Materials and Methods

Description of the Study Area:

The study was conducted within the coconut plantation in the coastal part of Akwa Ibom State. It is in the Niger Delta fringe, the South-South geopolitical zone of Nigeria. It lies between latitudes 4° 28' and 4° 53 ' North and longitudes 7° 50' and 7° 55' East.

Akwa Ibom State has a warm humid tropical climate characterized by distinct wet and dry seasons which is determined by the direction of the Southwest and Northeast trade winds. The rainfall pattern is bimodal, with rainfall beginning early March and ending around mid-November. The annual rainfall range from 3172.8 mm to 4718.3 mm in the study area. The wet season has features including high proportion of total annual rainfall, with peak in July and September, and a moisture stress period of 2-3 weeks in August, often called "August Break". The temperature in Uyo between 2011 and 2016 varies from 25^{o}C to 28^{o}C (Uniuyo Met. Station, 2016). The relative humidity between 2009 and 2019 ranges from 70% in January to 90% in August (Eket Synoptic Station, 2020). The state is underlain by one geological formation, the coastal plain sands comprising largely poorly consolidated sands (Udoh *et al.,* 2013). The area generally comprises of low-lying delta plain underlain mainly by beach ridge sands and Holocene fluvio-marine deposits. The natural rainforest vegetation has lost its original nature due to anthropogenic activities arising from population increase. Trees like coconut and oil palm are predominant. In the narrow valleys where the soils are hydromorphic, the terrain is covered by natural vegetation of shrubs and bush. Land use practices predominating in the area is coconut plantation, tree crop plantation, and intensive upland cultivation with a great variety of crops.

2.1 Field Study

Field reconnaissance was conducted to ascertain the physical attributes and terrain of the plantation which is divided into many plots. Three plots within the plantation were selected for the study. Within each plot, an area measuring 500 m by 500 m was demarcated for the study and a rigid grid method of soil survey was employed. The baseline was predetermined and traverses were cut at 200m intervals. Coordinates of each point were obtained using Global Positioning System. Based on similarities in morphological properties and other features, the augered examination points were used to delineate the soil into mapping units. A total of six profile pits were dug in the three study sites, two pits per plot. The profile pits were described according to FAO Guidelines for soil description (FAO, 2006) and sampled by genetic horizons for laboratory analysis. Soil colour was determined with the Munsell colour chart (Munsell, 1994). Undisturbed core samples were collected at each genetic horizon for the determination of hydraulic conductivity, moisture content and bulk density.

2.2 Laboratory Analysis

The core samples were placed in water for 24 hours to reach saturation by capillarity to determine saturated hydraulic conductivity. On the other hand, samples collected were air-dried, ground and sieved with 2mm mesh. Particle size distribution was determined using the Bouyoucos hydrometer method according to the procedure of Gee and Or (2002). Saturated hydraulic conductivity was measured with the core samples, using the constant head permeameter method as described by Klute (1986). Moisture content was determined from the difference of the weight of wet core samples and the weight of oven-dried core samples, dried to a constant weight at a temperature of 105^{0}C. The difference was divided by the weight of the oven-dried sample and multiplied hundred. Moisture content was expressed in percentage (Udo *et al*., 2009). Soil bulk density was determined as described by Grossman and Reinsch (2002). Total porosity was calculated from the bulk density data using the formula in the equation.

$$\text{Porosity} = 1 - e_b / e_s \quad (1)$$

Where e_b is bulk density (g/cm^3), e_s is particle density (2.65 g/cm^3) and 2.65 g/cm^3 is an assumed particle size value in most mineral soils.

2.3 Statistical Analysis

The statistical analysis that was carried out was descriptive statistics to determine the mean, minimum and maximum values. Data collected were subjected to analysis of variance (ANOVA) to compare soil properties for the three sites (Genstat Discovery Edition, 2013). Significant means were separated using Least Significant Difference (LSD) at a 5% probability level.

2.4 Land Suitability Evaluation (LSE)

i.Non-parametric method: in this method, soils were first placed in suitability classes by matching their land characteristics with the land use requirements of selected crops (Tables 1 and 2).

ii. Parametric method: For the parametric method, each limiting characteristic was rated and the index of productivity for each pedon was calculated for each of the four selected crops using the equation.

IP = A x √ (B/100 xC/100 xD/100xE/100) …….. .. (2)

Here, IP is the index of productivity, A is the overall lowest characteristics rating. B, C, D…E are the lowest characteristics ratings for each land quality group.

In this study, there were six land quality groups. They are climate (c), soil physical characteristics (s), topography (t), wetness (w), fertility characteristics (f) and salinity (s). Only one member in each group was used because there is usually a strong correlation among members of the same group ‘s’ or ECEC and base saturation in group ‘f’ (Ogunkunle, 1993).

Rating of land characteristics is a two-staged process. Firstly, each characteristic was scored from 100 (95) indicating the best and 40 indicating the lowest based on the extent to which land characteristics meet the requirements of the crop. The second stage involves the combination of the scores of the relevant characteristics into an overall index by multiplication.

Suitability classes S1, S2, S3, N1 and N2 are equivalent to IP values of 100-75, 74-50, 49-25, 24-15 and 14-0 respectively.

Table 1: Factor ratings of land use requirements for coconut (Cocos nucifera)

Land Qualities / CharacteristicsUnit	**S1 S2 S3 N1 N2**
100 – 85 84 – 60	**59- 40 9 –**
25 24 – 0	
Climate (c)	
Annual Rainfall	mm
	1700 -2000
1450 1700	1250 -1450 -
	-
Length of Dry Season	month
	<2
	<3 <4
	-
	Any
Mean Annual Temperature	^{0}C
	>24 >22
	>20
	- Any
Relative Humidity (Mean Annual)	% >60
	>50
	Any -
	-
Topography (t)	
Slope	
	%
	<8 <16
	<30
	<50 Any
Wetness (w)	
Drainage	
	2-3
	1-2
	1-2 4
	4
Soil Physical Characteristics (s)	
Texture	
	C, CL, SC
SCL, SL, L	LCS, FS S,
Coarse	-
Soil depth	
	(cm) >100
	>50
	>25 -
<25	
Fertility Status (f)	
Apparent CEC	Meg/100g
clay	any
-	
Base Saturation	%
	>35
	<20
Organic matter (0-15cm)	0.8
	Any
Salinity (n)	
EC	
	Mmhos/cm
	<12 <16
	<20
	<25 Any

Source: Sys *et al.* (1985)

Key: C – Clay, S – Sand, SL – Sandy Loam, LS- Loamy Sand, EC- Electrical conductivity

Drainage: 1 = imperfectly drained; 2= moderately or poorly drained; 3= good or well drained; 4=very poorly drained

Table 2: Factor ratings of land use requirements for sugarcane (Saccharum officinarum L.)

Land Qualities / Characteristics	**Unit**	**S1**	**S2**	**S3**	**N1**	**N2**
		95 – 85	**84 – 60**	**59- 40**	**39 – 25**	**24 – 0**
Climate (c)						
Annual Rainfall	mm	1600 -2500	1200 - 1600	900- 1200	<900	
Mean Annual Temperature	^{0}C	>24	>22	>20	-	-
Relative Humidity (Mean Annual)	%	>60	>50	Any	-	-
Topography (t)						
Slope	%	0 -8	8 -16	16 -30	30 -50	-
Wetness (w)						
Drainage		2-3	1-2	1-2	4	-
Soil Physical Characteristics (s)						
Texture		C, CL, SL,	LSSL, LS	S, Coarse	-	-
Soil depth	(cm)	>100	50 - 100	25-50	>25	Any
Fertility Status (f)						
pH		6.1 -7.3	7.4 – 8.5	8.4	>8.4	
Nitrogen	%	>25	6 – 25	<6	-	
Available Phosphorus	mg/kg	>0.153	0.076 – 0.153	0.076		
Exchangeable Potassium	Cmol/kg	>0.8	0.4 – 0.8	0.1-0.4	<0.1	
Salinity (n)						
EC	Mmhos/cm	<12	<16	<20	<25	Any

Source: Sys *et al. (*1985)
Key: C – Clay, S – Sand, SL – Sandy Loam, LS- Loamy Sand, EC- Electrical conductivity
Drainage: 1 = imperfectly drained; 2= moderately or poorly drained; 3= good or well drained; 4=very poorly drained

3.0 Results and Discussion

The physical properties of the study area are presented in Table 3. The particle size distribution of the soils of the study area is shown in Table 4.2. The particle sizes that were determined include sand, silt and clay contents of the soils of the three sites. The textural class was generally sand and this could be associated with the parent material known as the beach ridge sands from which the soil was formed. This aligns with the works of Osujieke *et al*. (2017) and Obasi *et al*. (2016) that parent material influences soil texture and this could explain the low silt and clay fractions in the soil. The pattern of clay distribution down the profile pits indicates that the soils in the study area are young and relatively less developed (Soil Survey Staff, 1999). The similarity in soil texture throughout the study area, therefore reflects the uniformity in the underlying lithology as well as the influence of other predominating soil formation factors, mainly climate and processes.

Bulk density ranged from 1.338 – 1.499 g/cm^3 (mean 1.443 g/cm^3) and 1.356 – 1.659 g/cm^3 (mean 1.556 g/cm^3) for pedon 1 and 2 in the study Site 1. In site 2, it ranged from 1.115 to 1.517 g/cm^3 (mean 1.389 g/cm^3) and 0.426 to 1.436 g/cm^3 (mean 0.929 g/cm^3) for pedon 1 and 2. In site 3, the range of bulk density was 0.584 to 1.525 g/cm^3 (mean 1.240 g/cm^3) for pedon 1 and 0.271 to 1.481 g/cm^3 (mean 1.091 g/cm^3) for pedon 2. The bulk density increased down the profile in all pedons while there was a decrease in porosity down the profile and this in consonance with the findings of Onweremadu *et al*. (2007). The inverse relationship between total porosity and bulk density was also reported by Brady and Weil (2002) that for soils with the same particle density, the lower the bulk density, the higher the per cent pore spaces and vice versa. Bulk density is an index of soil strength, the resistance that soil offers to the penetration and growth of roots. Also, bulk density is a soil parameter that significantly influences soil processes and acts as an indicator of soil quality (Ogban and Ibitt, 2018). A high rate of total porosity in soils encourages greater availability of soil air and soil water, as well as the activities of soil aerobes.

In the study area, Ksat ranged from 0.012 cm/min to 7.0 cm/min. Ksat is highly sensitive to soil texture and structure and tends to increase significantly with coarser texture and enhanced structure because of an increase in the number and sizes of water-conducting pores, and is responsible for the high hydraulic conductivity of these soils at high matric potential (Ogban and Ibitt, 2018)

Table 3 Physical properties of soils derived from the beach ridge sands parent material

Location	Horizon designation	Depth (cm)	Texture (%)			TC	Bd (g/cm^3)	Ks (cm/min)	Tp (%)	Mc (%)
			Sand	Silt	Clay					
Site 1	Ap1	0-12	93.86	4.30	3.84	Sand	1.338	0.823	49.50	25.0
pedon 1	Ap2	12-39	93.86	4.30	3.84	Sand	1.463	0.555	44.80	21.5
	AB1	39-70	91.86	2.30	3.84	Sand	1.472	0.589	44.50	21.1
	AB2	70-100	91.86	2.30	3.84	Sand	1.499	0.157	43.40	21.1
		Mean	92.86	3.30	3.84		1.443	0.531	45.55	22.18
	Ap1	0-11	95.86	0.30	3.84	Sand	1.356	0.212	48.80	24.4
Site 1	Ap2	11-21	93.86	2.24	3.90	Sand	1.552	0.151	41.40	20.2
Pedon 2	AB1	21-50	93.86	2.24	3.90	Sand	1.659	0.091	37.40	19.9
	AB2	50-90	89.86	6.24	3.90	Sand	1.659	0.012	37.40	18.1
		Mean	93.36	2.75	3.88		1.556	0.117	41.25	20.55
		S. 1 mean	93.11	3.03	3.86		1.500	0.650	43.40	21.37
	Ap1	0-19	95.86	0.24	3.90	Sand	1.115	3.887	57.90	29.4
Site 2	Ap2	19-37	93.86	2.24	3.90	Sand	1.436	0.454	45.80	23.0
Pedon 1	AB	37-58	94.10	2.00	3.90	Sand	1.490	0.252	43.80	21.6
	BA	58-90	88.30	7.74	3.96	Sand	1.517	0.145	42.80	22.0
		Mean	93.03	3.06	3.91		1.390	1.184	47.56	27.00
	Ap1	0-13	95.86	0.18	3.96	Sand	0.428	0.925	83.80	24.4
Site 2	Ap2	13-32	95.36	0.18	3.96	Sand	0.452	0.724	82.90	22.8
Pedon 2	AB1	32-60	94.10	1.94	3.96	Sand	1.374	0.707	48.20	28.0
	AB2	60-90	94.10	1.94	3.96	Sand	1.436	0.959	45.80	22.6
		Mean	94.98	1.06	3.96		0.930	0.829	65.18	24.45
		S. 2 mean	93.94	2.06	3.94		1.156	1.010	56.37	25.73
	Ap1	0-12	95.92	0.12	3.90	Sand	0.584	7.000	78.00	36.6
Site 3	Ap2	12-30	95.92	0.18	3.90	Sand	1.409	0.454	46.80	24.4
Pedon 1	AB1	30-50	89.86	6.24	3.90	Sand	1.409	0.182	42.50	22.3
	AB2	50-98	87.60	8.24	3.90	Sand	1.525	0.109	53.20	22.0
		Mean	92.32	3.69	3.90		1.240	1.936	55.13	26.33
	Ap1	0-16	95.86	0.24	3.90	Sand	0.271	0.131	89.80	22.2
Site 3	Ap2	16-39	95.86	0.24	3.90	Sand	1.240	2.389	53.20	27.6
Pedon 2	AB1	39-58	91.86	4.24	3.90	Sand	1.374	2.567	48.20	23.4
	AB2	58-80	87.60	8.24	3.90	Sand	1.481	0.024	44.10	23.1
		Mean	92.79	3.24	3.90		1.092	6.778	58.83	24.08
	LSD (0.05)	S. 3 mean	92.56	3.47	3.91		1.162	4.357	57.00	25.21

Source: Field data (2019)

TC= Textural class, Bd= Bulk density, Ks= Saturated hydraulic conductivity, Tp= Total porosity, Mc= Moisture content

Land Suitability Evaluation

The land qualities/ characteristics presented in Table 4 were matched with the land use requirements of each of the two crops (Tables 1 and 2) for coconut and cucumber respectively. The approaches adopted were parametric and non-parametric (Sys *et al*., 1985; Ogunkunle, 1993).

1. Coconut (*Cocos nucifera*):

The suitability class scores of all the pedons for coconut cultivation are presented in Table 5. The results show the extent to which each land quality/characteristic meets the requirements for coconut cultivation. In terms of climate (annual rainfall, temperature and relative humidity), all the pedons were rated highly (100 %) suitable or optimum for coconut cultivation. The soil physical properties (soil depth and texture, as land quality/ characteristics were rated sub-optimal (85 – 60 %) for coconut cultivation (in terms of soil depth) and marginal (40 %), in terms of texture – in all the pedons in the study area. Furthermore, the results also show that in terms of the land quality/ characteristics- wetness (drainage), all the pedons were rated 25 % (N1), that is, not suitable for coconut cultivation. This aligns with the previous study by Udoh (2015) which noted that beach ridge soils were highly suitable for coconut cultivation in terms of climate but marginally suitable due to serious constraints of texture and drainage.

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Table 4: Land Qualities/ Characteristics of pedons of beach ridge sands (BRS)

Land Qualities/ Characteristics unit	Site 1 Pedon 1	Site 1 Pedon 2	Site 2 Pedon 1	Site 2 Pedon 2		Pedon 1	Site 3 Pedon 2
Climate (C)							
Annual Rainfall mm	3991	3991	3991	3991	3991	3991	
Mean Temperature ^{o}C	28	28	28	28	28	28	
Relative Humidity %	90	90	90	90	90	90	
Solar Radiation NJm^{2}/day	12	12	12	12	12	12	
Soil Physical Characteristics (S)							
Soil depth cm	100	90	90	90	80	98	
Sand %	92.86	93.36	93.03	94.98	92.79	92.32	
Silt %					2.75 3.69	3.30 1.06	3.06 3.24
Clay					3.84 3.96	% 3.91 3.90	3.88 3.91
Texture					- sand sand	sand sand	sand sand
Topography (t)							
Slope					0 – 2 0 – 2	% 1 0 -2	0 -2 0 - 2
Wetness (w)							
Drainage					- 5 5	5 5	5 5
Ground water table					90 98	100 90	cm 90 80
Fertility Characteristics(f)							
pH					4.95 5.08	4.72 4.56	4.92 4.52
Total Nitrogen					% 0.035 0.013	0.034 0.041	0.085 0.034
Organic Carbon					0.80 0.95	0.49 0.79	% 0.81 0.29
Organic matter					1.38 1.64	0.49 1.36	% 1.39 0.39
Available Phosphorus (P)					12.10 7.81	mg/kg 13.11 5.55	13.11 9.90
Exchangeable potassium (K)					0.085	cmol/kg	0.074

		0.092	0.086	0.091	0.069		
Exchangeable Calcium (Ca)	cmol/kg	1.03	0.73	1.07	0.91	0.94	1.02
Exchangeable Magnesium (Mg)	cmol/kg	0.92	0.84	0.92	0.64	0.90	0.87
Exchangeable Sodium (Na)	cmol/kg	0.051	0.067	0.057	0.067	0.061	0.056
ECEC (soil)	cmol/kg	3.48	3.47	3.13	3.00	3.71	4.22
Base saturation	%	60.50	58.41	67.29	61.29	54.12	46.40
Salinity (n) Electrical Conductivity	ms/cm	0.05	0.04	0.04	0.05	0.06	0.24

Source: Computed by the researcher using results obtained from the laboratory analysis of field data of the study area (2019).
CEC = Cation Exchange Capacity. Drainage: 1 = imperfectly drained; 2 = moderately or poorly drained; 3 = good or well drained; 4= very poorly drained

Table 5: Suitability class scores of pedons for coconut cultivation in the study area

Land qualities/ characteristics	Pedon 1	Pedon 2	Pedon 3	Pedon 4	Pedon 5	Pedon 6
Climate (c)						
Annual Rainfall (mm)	S1 (100)	S1 (100)	S1 (100)	S1 (100)	S1 (100)	S1 (100)
Mean temperature ^{0}C	S1 (100)	S1 (100)	S1 (100)	S1 (100)	S1 (100)	S1 (100)
Mean Relative Humidity (%)	S1 (100)	S1 (100)	S1 (100)	S1 (100)	S1 (100)	S1 (100)
Topography (t)						
Slope (%)	S1 (100)	S1 (100)	S1 (100)	S1 (100)	S1 (100)	S1 (100)
Soil Physical Properties (s)						
Soil depth	S1 (85)	S2 (60)	S2 (60)	S2 (60)	S2 (60)	S2 (60)
Texture	S3 (40)	S3 (40)	S3 (40)	S3 (40)	S3 (40)	S3 (40)
Wetness (w)						
Drainage	N1 (25)	N1 (25)	N1 (25)	N1 (25)	N1 (25)	N1 (25)
Fertility Status (f)						
Organic matter	S1 (100)	S1 (100)	S1 (100)	S1 (100)	S1 (100)	S1 (100)
Base Saturation	S1 (100)	S1 (100)	S1 (100)	S1 (100)	S1 (100)	S1 (100)
Salinity (n)						
Electrical conductivity	S1 (100)	S1 (100)	S1 (100)	S1 (100)	S1 (100)	S1 (100)
Aggregate Stability	N1(15.81)	N1 (15.81)	N1 (15.81)	N1 (15.81)	N1 (15.81)	N1(15.81)

Aggregate Suitability Scores: 100 - 75 is S1, 74 – 50 is S2, 49 – 25 is S3, 24 – 15 is N1 and 14 – 0 is N2.
(Ogunkunle, 1993)

Cucumber (*Cucumis sativus*):

The suitability class scores of all the pedons for cucumber cultivation are shown in Table 6. The results show the extent to which each land quality/characteristic meets the requirements for cucumber cultivation. In terms of climate (annual rainfall, temperature and relative humidity), all the pedons were rated highly (100 %) suitable or optimum for cucumber cultivation. Similarly, the following land qualities/ characteristics: topography (slope), fertility status (base saturation), soil physical properties (soil depth) and salinity (electrical conductivity) were all rated highly (100 %) suitable or optimum for cucumber cultivation. This agrees with the report by Adinde (2016) which stated that cucumber requires a stable warm temperature for good yield.
On the other hand, the results in Table 6 also shows that soil physical properties (soil texture), as a land quality/ characteristics were rated marginally (40 %) suitable for cucumber cultivation – in all the pedons in the study area. Also, the results show that in terms of the land quality/characteristics-wetness (drainage), all the pedons were rated 25 % (N1), that is, currently not suitable for cucumber cultivation.

Suitability aggregate scores and suitability classification of pedons for selected crops indicating limiting characteristics

The suitability aggregate scores of pedons in the study area for the selected crops are shown in Table 7. Aggregate (final) suitability classification by the parametric method revealed that the area of study was currently not suitable (N1) for the cultivation of coconut and permanently not suitable (N2) for cucumber cultivation. Also, by the non-parametric evaluation, all the pedons were only marginally suitable (S3) for the cultivation of selected crops despite the optimal (100 %) climatic condition. The major limitations were soil physical characteristics (texture) and wetness (drainage). This indicates the importance of soil and climate as the major environmental factors that determine crop performance. Similarly, Udoh *et al*. (2013) opined that even with an adequate climate, optimum crop yield cannot be obtained without favourable soil conditions. Though the study area was optimal (100 %) in some land qualities/ characteristics - climate, topography and salinity, soil physical properties and drainage (limiting factors) render the study area marginally suitable (S3) for the cultivation of selected crops. The reason is that the most limiting factor determines the final (aggregate) suitability class of the pedon (Ogunkule, 1993).

Table 6: Suitability class scores of pedons for cucumber cultivation in the study area

Land qualities/ characteristics	Pedon 1	Pedon 2	Pedon 3	Pedon 4	Pedon 5	Pedon 6
Climate (c)						
Annual Rainfall (mm)	S1 (100)	S1 (100)	S1 (100)	S1 (100)	S1 (100)	S1 (100)
Mean temperature (^{0}C)	S1 (100)	S1 (100)	S1 (100)	S1 (100)	S1 (100)	S1 (100)
Mean Relative Humidity (%)	S1 (100)	S1 (100)	S1 (100)	S1 (100)	S1 (100)	S1 (100)
Topography (t)						
Slope (%)	S1 (100)	S1 (100)	S1 (100)	S1 (100)	S1 (100)	S1 (100)
Soil Physical Properties (s)						
Soil depth	S1 (100)	S1 (100)	S1 (100)	S1 (100)	S1 (100)	S1 (100)
Texture	S3 (40)	S3 (40)	S3 (40)	S3 (40)	S3 (40)	S3 (40)
Wetness (w)						
Drainage	N1 (25)	N1 (25)	N1 (25)	N1 (25)	N1 (25)	N1 (25)
Fertility Status (f)						
pH	N1 (25)	N1 (25)	N1 (25)	S3 (40)	N1 (25)	N1 (25)
Organic Carbon	S2 (59)	S2 (59)	S2 (59)	S2 (59)	S2 (59)	S2 (59)
Available Phosphorus	S2 (59)	S2 (59)	S2 (59)	S2 (59)	S2 (59)	S2 (59)
Base Saturation	S1 (100)	S1 (100)	S1 (100)	S1 (100)	S1 (100)	S1 (100)
Salinity (n)						
Electrical conductivity	S1 (100)	S1 (100)	S1 (100)	S1 (100)	S1 (100)	S1 (100
Aggregate Stability	N2 (7.91)	N2 (7.91)	N2 (7.91)	N2 (7.91)	N2 (7.91)	N2 (7.91)

Aggregate Suitability Scores: 100 - 75 is S1, 74 – 50 is S2, 49 – 25 is S3, 24 – 15 is N1 and 14 – 0 is N2.
(Ogunkunle, 1993)

Table 7: Suitability aggregate scores and suitability classification of pedons for coconut and cucumber indicating limiting characteristics

Study		coconut		cucumber	
Site	**Pedon**	**parametric**	**non-Parametric**	**parametric**	**Non-Parametric**
Site 1	1	N1 (15.81)	S3wsf	N2 (7.91)	S3wsf
	2	N1 (15.81)	S3wsf	N2 (7.91)	S3wsf
Site 2	1	N1 (15.81)	S3wsf	N2 (7.91)	S3wsf
	2	N1 (15.81)	S3wsf	N2 (7.91)	S3wsf
Site 3	1	N1 (15.81)	S3wsf	N2 (7.91)	S3wsf
	2	N1 (15.81)	S3wsf	N2 (7.91)	S3wsf

Key: Non- par = non-parametric, N1= currently not suitable, N2= permanently not suitable, S3= marginally suitable, w= wetness limitation, s = soil physical characteristics, f = soil fertility,

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