Eurasian J Soil Sci 2019, 8 (1) 73 - 82

Eurasian Journal of Soil Science

Journal homepage : http://ejss.fesss.org

Suitability evaluation of some peri-urban soils for rainfed arable crop production in Lagos State, Southwestern Nigeria

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Article Info

Received : 17.05.2018
Accepted : 31.12.2018

Abstract

A study was carried out to evaluate the suitability of some Peri-urban soils in Lagos state for arable crop production. Six pedons classified as *Alagba* (Rhodic Hapludult), *Dodokindo* (Plinthic Kandiudult), *Idesan* (Typic Endoaquept), *Owode* (Typic Kandiudult), *Atan* (Fluvaquentic Endoaquept) and *Pakoto* (Plinthic Kandiudult) Series identified at two study sites located at Igbokuta and Ibomwon communities in Ikorodu and Epe Local Government Areas of Lagos state were evaluated. The land use potentials for maize, cassava and leafy vegetables (Amaranth family) were assessed following the conventional non-parametric and the parametric (square root) methods of land suitability evaluation according to the revised FAO framework. All the pedons were rated as marginally suitable (S3) for maize except *Idesan* and *Owode* Series that made up 2.53% and 34.74% of the total area respectively, which were rated moderately suitable (S2). With respect to cassava and leafy vegetables, all the pedons were rated marginally suitable (S3) except *Atan* Series occupying 19.71 % of the total area, that was rated non-suitable (N1). The major limitations to sustainable crop production in all pedons were low nutrient supply (N, K, P and cations) coupled with high soil acidity (pH of between 3.9 and 5.8). In addition to this, *Idesan* and *Atan* series also have waterlogging problem hence may not be used for cultivating the afore-mentioned crops, but could be used for swamp rice. With appropriate liming, soil fertility management and proper drainage, most of the pedons may be rated as being moderately suitable (S2) for the cultivation of these crops. As a peri-urban area with high demand for agricultural products, year-round cropping with irrigation facilities is quite promising in most of the pedons studied.

Keywords: Land Evaluation, soil characteristics, peri-urban agriculture, land use.

Introduction

Recently, human populations in urban areas around major cities have increased very rapidly, especially in developing countries resulting in drastic increase in food demand (Liu and Chen, 2006). Considering the rapid growth in population in urban centres such as Lagos and other major cities and the attendant increase in demand for food and fiber, the need for effective, efficient and sustainable utilisation of peri-urban croplands is now more imperative than ever (Teklu, 2005, Behzad et al., 2009). Sustainability in agricultural production is a measure of how well the qualities of a land unit match the requirement of a particular form of land use (FAO, 2007). It is important that the land that will be used for agricultural production should be used according to its capacity for optimization and sustainability of soil productivity (Adeboye, 1994).

In order to resolve the problem of land use, there is need for the introduction of land evaluation and appropriate use of natural resources. The need for land evaluation arose from the fact that soil classification, soil map and the accompanying legends do not meet the needs of farmers and other land users (Ogunkunle, 2016). At present, the importance of land evaluation should be seen in the context of land becoming a scarce

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e-ISSN: 2147-4249
DOI: 10.18393/ejss.509405

and non-renewable natural resource which is highly desired and for which there is a growing competition that holds a proper exchange value (Verheye, 2009). Land evaluation enables management guidelines in order to promote a more sustainable use of the soil and environmental resources (Maniyunda et al., 2007). Maize is an important tropical cereal crop both as staple and animal feed while cassava is the most important root crop in Sub Saharan African with food and industrial applications.

However, agricultural productions in many developing countries including Nigeria are carried out without proper study of the soil and optimal requirements for maximum production, which has led to low agricultural productivity. It was observed that the productivity of Nigerian soil is decreasing and the lands have been utilized intensively for all purpose regardless of its suitability and capability functions thereby resulting in land degradation and alteration of the natural ecological conservatory balances in the landscape (Senjobi, 2007); therefore, it is important that the land to be used for agricultural production should be used according to its capacity for optimisation and sustainability of soil productivity. This study was carried out to characterize some representative soils at two selected sites which are being proposed for commercial agriculture in Lagos State and evaluate the suitability of the different soil types for sustainable arable crop production.

Material and Methods

Site description

The study was carried out in two areas of Lagos State (Figure 1). One of the sites was at Igbokuta village, Imota Area development Council, Ikorodu Local Government Area, Lagos State, which lies within the latitudes 6°37'51.10"N-6°38'1.18"N and longitudes 3°38'38.40"E-3°38'53.50"E. The site covered a total area of 87.3 hectares located on a gently undulating terrain with an average elevation of 15m above sea level (asl). The other site was at Ibomwon Town, Epe Local Government Area of Lagos State within the Latitudes 6°40'12.50"N-6°40'34.58"N and Longitudes 3°56'38.14"E-3°56'55.29"E. The area was on an approximately 106.8 hectares with elevations ranging from 11m to 18 m asl generally sloping south-westward in a somewhat gently rolling fashion. The two study areas have a climate of humid tropical with annual rainfall of 1554 mm. The mean maximum and minimum temperatures are 32°C and 18 °C respectively (NIMET, 2012). The natural vegetation comprises of Swamp Forest of the coastal belt and dry lowland rain forest. The geology is derived from the quaternary sedimentary rocks of the coastal plain sands.

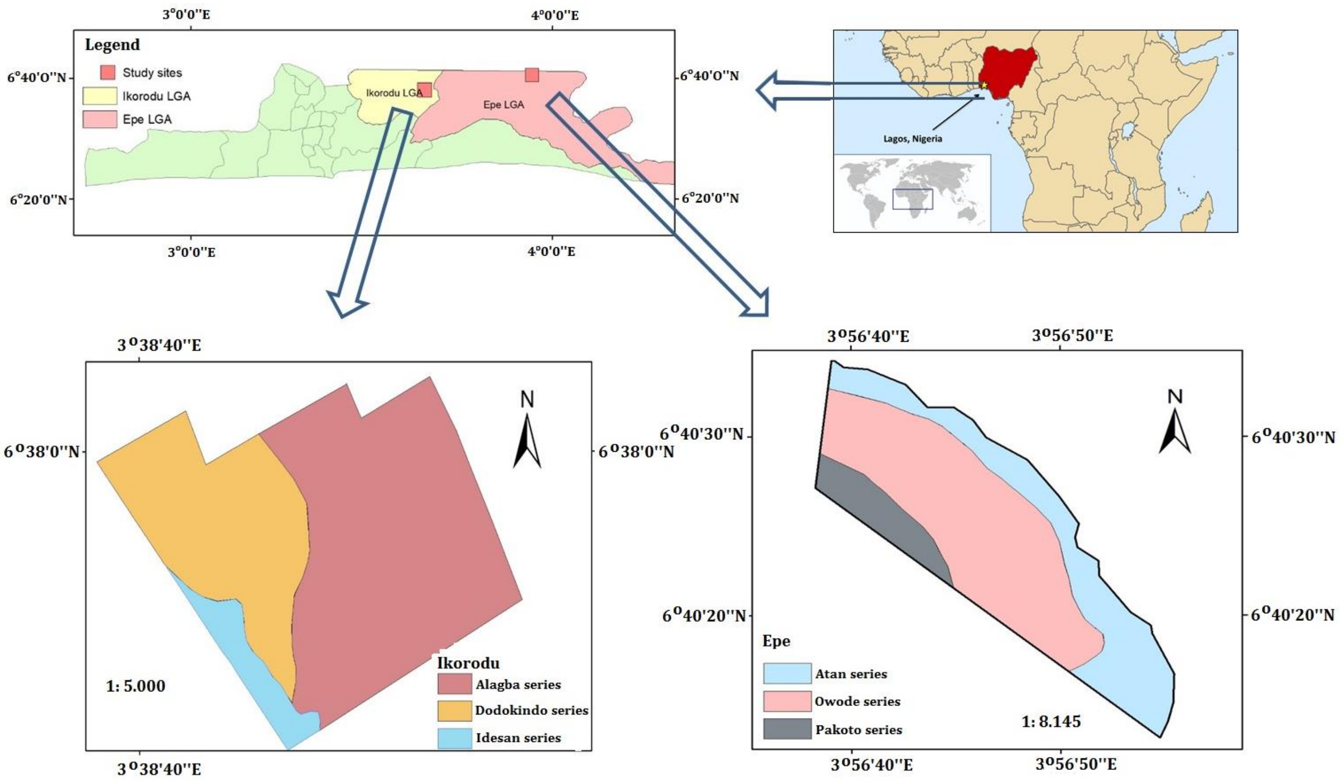

Figure 1. Location and soil maps of the study sites in Ikorodu and Epe Local Government Areas of Lagos State, Nigeria

Field survey

A detailed soil survey was conducted on the study sites. Soil morphological properties such as texture (by field method), colour (using Munsell soil colour chart), consistency, mottles, cementations etc. were examined - at each pedogenic horizons of modal soil profiles pits measuring 2x1.5x2m depth representing each of the identified soil mapping units. The pits were described according to the FAO (2006) guidelines, soil samples were collected from each horizon in each soil profile pit for laboratory analysis.

Laboratory analysis and soil classification

Soil samples collected from the field were shipped to the laboratory, and subsequently air dried, crushed and passed through 2mm sieves for physical and chemical analysis. The soils were analyzed for particle size using the modified hydrometer method, pH and electrical conductivity were determined in 1:1 soil/water ratio (ie 10g of soil in 10ml of deionised water) with glass electrode digital pH and conductivity meter. Total nitrogen was determined using Technicon Autoanalyzer while organic carbon was determined using the dichromate wet oxidation method. Available phosphorus was extracted with Mehlich III solution and concentrations were estimated colourimetrically with a UV spectrometer. Exchangeable bases (K, Ca, Mg and Na) were leached with neutral normal Ammonium Acetate solution and concentrations of Ca and Mg were determined using Atomic Absorption Spectrophotometer (AAS) while that of Na and K were measured using Flame Photometer. Exchangeable acidity was determined titrometrically using standard laboratory procedures. All parameters were determined in the Soil and Analytical Laboratory of the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. The soils were classified according to USDA Soil Taxonomy (Soil Survey Staff, 2014) and World Reference Base (WRB) for soil resources (FAO, 2014). The classifications were correlated with the local series classification of soils (Moss, 1957).

Land Evaluation

The suitability of the soils for maize, cassava and leafy vegetable cultivation were evaluated by both non-parametric and parametric suitability evaluation methods based on the revised FAO land evaluation framework (FAO, 2007). For the non-parametric evaluation, mapping units were first placed in suitability classes by matching their characteristics with the established land use requirements for maize, cassava and leafy vegetable as presented in Tables 1, 2 and 3 respectively. The land requirement compared with the land qualities and characteristics place the soil in classes designated as S1, S2, S3, N1 and N2, which interprets to highly suitable, moderately suitable, marginally suitable, currently not suitable and permanently not suitable respectively. Land quality and factor rating for maize, cassava and leafy vegetable follows Liebig's law of minimum, the suitability class of a pedon is indicated by its most limiting characteristics for the conventional Non-Parametric approach (actual and potential) (Ogunkunle, 1993; FAO, 2007).

Table 1. Factor rating of land use requirement for maize

Land qualities	Land Characteristics	Unit	S1	S2	S3	N1
			100-85	84-60	60-40	39-20
Climate (c)						
Water availability	Mean Annual Rainfall	mm	750-1600	600-1800	>500	<500
Temperature regime	Mean annual Temp	^{0}C	32-18	18-16	16-14	<14
Wetness (w)						
Oxygen availability	Soil drainage		Well drained	Imperfectly drained	Poorly drained	Very poorly drained
Fertility(f)						
Nutrient availability	Org C (0-15cm)	%	2-1.2	1.2-0.8	0.8-0.4	<0.4
	Available P	mg/kg	>25	6-25	<6	any
	pH		5.5-7.5	5.0-5.5 or 7.5-8.0	4.0-50 or 8.0-8.5	<4.0 or >8.5
Nutrient retention	Base saturation	%	50-35	35-20	20-15	<15
Soil physical characteristics(s)						
Water retention capacity	Texture/structure		SCL	SL,LS	C	S
Rooting condition	Soil depth	cm	>75	>50	>20	<20
Salinity (n)	Ec	ms/cm	0-4	4-6	6-8	>8
Topography (t)	Slope	%	0-4	4-8	8-16	>16

Modified from Sys et al. (1991)

C, clay; LS, loamy sand; S, sand; SC, sandy clay; SCL, sandy clay loam; SL, sandy loam; EC, electrical conductivity

Table 2. Factor rating of land use requirement for cassava

Land qualities	Land Characteristics	Unit	S1 100-85	S2 84-60	S3 60-40	N1 39-20
Climate (c)						
Water availability	Mean Annual Rainfall	Mm	1000-2400	>600	>500	
Temperature regime	Mean annual Temp	^{0}C	18-30	>16	>12	Any
Wetness (w)						
Oxygen availability	Soil drainage		Well drained	Moderate or imperfectly drained	Poorly drained	Very poorly drained
Fertility (f)						
Nutrient availability	Total N	%	>0.2	0.1-0.2	<0.1	Any
	Available P	mg/kg	>25	6-25	<6	Any
	Exchangeable K	cmol/kg	>6	3-6	<3	Any
	pH		6.1-7.3	7.4-7.8 or 5.1-6.0	>8.4 or <4.0	
Nutrient retention	Base saturation	%	>35	20-35	<20	Any
	CEC	cmol/kg	>16	3-16	<3	Any
Soil physical characteristics (s)						
Water retention capacity	Texture		L,SCL, SL,CL	LS,S,CL	S, SiC	C
Rooting condition	Soil depth	cm	>105	>75	>50	<50
Salinity (n)	EC	ms/cm	0-4	4-6	6-8	>8
Topography (t)	Slope	%	0-5	5-12	12-20	>20

Modified from Sys et al. (1991).

C, clay; LS, loamy sand; S, sand; SC, sandy clay; SCL, sandy clay loam; SL, sandy loam; EC, electrical conductivity

Table 3. Factor rating of land use requirement for tropical leaf and fruit vegetables

Land qualities/characteristics	S1	S2	S3	Ns
Rainfall (mm)	1700-2000$^+$	1250-1700	850-1250	<850
No of dry months	<3	3-4	4-5	>5
Absolute temperature(^{0}C)	25-30	22-25	15-22	<15
Relative humidity during dev stage (%)	75-85	70-75	60-70	<60
Topography (t)				
Slope (%)	0-4	4-8	8-16	>16
Wetness (w)	Well drained	Moderately	Poorly drained	Poor drained
Drainage	Drained	Drained not imperfect	Drainable	Aerie
Flooding potentials	F0	F1	F2	F3
Soil physical characteristics				
Texture	CL,SL,CL,SIL	SL,LFS,LS	LCS,FS,S,C,CS,C	SIC,SC,L,SCL
Depth (cm)	>75	50-75	20-50	<20
Soil fertility (f)				
Base saturation (%)	>35	20-35	<20	
Organic matter(organic carbon in 0-15cm) %	>1.2	0.8-1.2	0.4-0.8	<0.4
pH	5.5-6.5	6.5-7.0	4.5-5.5	<4.0 >7.5

S1, Highly suitable (85-100%); S2, moderately suitable (60-85%); S3- marginally suitable (40-60%); NS Not suitable; F1, 1-2 months flooding in >10 years; F2, not more than 2-3 months flooding in 5 out of 10 years; F3 Flooding 2 months almost every year; C, clay; CL, clay loam; CS, coarse sand; Fs, fairly sand; L, loam; LCS, loamy, coarse sand; LFs loamy fine sand; LS, loamy sand; S, sand; SC, sandy clay; SCL, sandy clay loam; SIC, silty clay loam; SIL, silty loam; SL, sandy loam.

For parametric evaluation, each limiting characteristic was rated by scoring using the criteria presented in Table 1, 2 and 3. The index of suitability (actual and potential) was calculated using the equation (Eq. 1):

$$IS= A\times\sqrt{B/100\times C/100\times D/100\times E/100\times F/100} \quad \text{Eq. 1}$$

Where IS= Index of Suitability, A= overall fertility limitation and B, C….F is the lowest characteristics rating of each land quality group (Ogunkunle, 1993; Udoh et al., 2006).

Five land quality groups climate (c), topography (t), soil physical properties (s), wetness (w) and fertility (f) were used in this evaluation. Only one member in each group was used for calculation purpose because there is usually a strong correlation among members of the same group (e.g. texture and structure) (Ogunkunle, 1993). For actual suitability index, all the lowest characteristics rating for each land quality group were substituted into the index of suitability equation, for potential suitability index, the corrective limitation observed will no longer have such constraints. The final suitability indices were allocated to land suitability classes (Table 4) according to the ratings suggested by Sys et al. (1991).

Table 4. Rating of limiting factors and suitability index of land quality for parametric suitability evaluation

Suitability class	Suitability index (SI)	Designation
Highly Suitable	>75	S1
Moderately Suitable	50-75	S2
Marginally Suitable	25-50	S3
Marginally Not Suitable	10-25	N1
Permanently Not Suitable	<10	N2

Source: Sys et. al. (1991)

Results and Discussion

Soil classification and land characteristics

The six pedons were identified and based on the morphological properties, were classified as *Alagba*, *Dodokindo*, *Idesan*, *Owode*, *Atan* and *Pakoto* series respectively using the criteria and classification of Moss, (1957). This classification method was designed for soils of sedimentary origin and most of the distinguishing characteristics were based on observable morphological features of the profiles defining each pedon. The correlating classification in higher categories of USDA Soil Taxonomy (Soil Survey Staff, 2014) and World Reference Base (WRB) system (FAO, 2014) together with the summary of land characteristics of the six mapping units/pedons are shown in Table 5. The soils are generally deep with effective soil depths above 100cm with the exception of *Idesan* and *Atan* Series with effective depths of < 80 cm and 85 cm respectively. The lower effective depths of these pedons were due to seasonally high water table which is responsible for the poor drainage in both pedons because they are located at the valley bottom positions on the landscape. All the pedons are free of hard pans, gravels and stones as the gravel concentrations were below the 25% critical value of gravel concentration for arable crops as proposed by Babalola and Lal (1977) except *Pakoto* Series which had a gravel content of 50% within 50cm depth from the surface. This is in agreement with the observation of earlier workers that described soils of the sedimentary origin especially the sandstones and coastal plain sand parent materials as 'stoneless latosols' (Vine, 1970; FDALR, 1995; Ojanuga, 2006). The gravel concentration of soils of *Pakoto* Series was due to secondary concretions and pan rubbles obtained at the upper and middle slope positions of concretionary and ferrugenized land forms of the Maku Fasc to which the soil belongs (Ojanuga et al., 1981). The range of soil texture in the surface soils is from Loamy Sand (LS) to Sandy Loam (SL) while at the subsurface, texture ranges widely from Sandy Loam in *Dodokindo* Series to heavy clay in *Pakoto* Series. The variation in soil texture with depth in most of the pedons could be attributed to clay illuviation in the process of profile development as pointed out in similar soils of Benin area (Orimoloye and Akinbola, 2013). Though in arable cropping, more emphasis is placed on the surface texture as it influences workability, nutrient and water retention, the subsurface texture is of much importance with respect to nutrient adsorption, water infiltration and susceptibility to leaching. Soil texture therefore influences the soil's inherent fertility and directly or indirectly, erodibility and moisture characteristics which could have great impacts on soil management, rooting ability and crop yields (Jalota et al., 2010; Nciizah and Wakindiki, 2015).

The chemical properties revealed that a available P is generally deficient as none of the pedons contains the required critical level of 15 mg/kg (Fernandes and Soratto, 2012) for sustainable arable cropping. The soils are also low in potassium, with values of K ranging from 0.13 cmol/kg at the surface in *Dodokindo* Series to 0.31 cmol/kg at both *Atan* and *Pakoto* Series' which are just within the lower limits of the critical level of 0.2 – 2.6 cmol/kg (Quezada-Crespo et al. 2017). Effective Cation Exchange Capacity is above the critical value of 5.0 cmol/kg observed by Quezada-Crespo et al. (2017) in *Dodokindo* and *Owode* Series but are lower in the other soil types. This could be as a result of leaching due to high intensity of rainfall and the parent materials that are inherently poor in weatherable cation-yielding minerals in addition to the preponderance of low activity clays of the soils. Calcium levels are generally below the minimum requirement of 3.8 cmol/kg in almost all the soils (Quezada-Crespo et al., 2017). The micro-nutrients (Fe and Zn) are at sufficiency level only at the top soil. Their critical values are 5 – 9 mg/kg and 3.0 – 3.45 mg/kg respectively. Zn is generally below 20 – 25 mg/kg critical value. So also is cupper (Cu) content of the soils which are very low, below the critical value of 1.2 – 2.0 mg/kg. Those nutrient elements that are below the critical levels need be supplied through deliberate fertilizer application to build up their levels in the soil.

Table 5. Summary of classification, land characteristics and quality of soils of Ikorodu and Epe study sites

Characteristics/Qualities	Pedons/Mapping units					
	Alagba	*Dodokindo*	*Idesan*	*Owode*	*Atan*	*Pakoto*
USDA Soil Taxonomy	Rhodic Hapludult	Plinthic Kandiudult	Typic Endoaquept	Typic Kandiudult	Fluvaquentic Endoaquept	Plinthic Kandiudult
WRB system	Haplic Acrisol (Rhodic)	Petroplinthic Acrisol (Vetic)	Gleyic Fluvisol (Oxyaquic)	Haplic Acrisol (Nitic)	Gleyic Fluvisol (Oxyaquic)	Pisoplinthic Acrisol (Vetic)
Proportion of Area covered (%)	23.91	12.78	2.53	34.74	19.79	6.25
Physiographic Location	Upper slope	Middle slope	Valley bottom	Upper slope	Valley bottom	Upper middle slope
Slope Gradient (%)	8-13	4-10	0-3	5-7	2-5	5-7
Drainage	Well drained	Well drained	Poorly drained	Well drained	Poorly drained	Well drained
Effective soil depth (cm)	180	150	<80	105	85	150
Stoniness/gravel (%) (top 50cm)	20	20	<10	20	20	50
Soil Texture	SL – SC	LS – SL	LS – SCL	SL- SC	SL- SCL	SL- C
Chemical/Fertility						
ECEC (cmol/kg)	2.21 – 3.56	7.54 – 8.92	2.98 – 9.61	6.99- 8.92	2.51- 9.16	2.69- 7.94
pH (H_2O)	4.7 – 5.3	5.0 – 5.2	5.1 – 5.4	5.3- 6.4	3.9- 5.1	4.7- 5.8
Available P (mg/kg)	0.8- 2.20	2.1-.9.1	1.00-4.81	3.81- 7.35	3.93-7.15	1.2-3.31
Organic C (g/kg)	3.2 – 14.2	3.2 – 27.8	7.4 – 20.1	9.50- 70.80	7.00- 66.40	6.70- 31.90
N (g/kg)	0.07 – 2.20	0.8 – 3. 10	1.0 – 4.90	0.01- 1.11	2.33- 7.12	0.01- 4.31
Exchangeable Acidity (cmol/kg)	0.6 – 1.4	3.6 – 4.8	0.6 – 1.0	0.6- 7.2	1.0- 7.0	1.8- 6.4
Ca (cmol/kg)	0.15 – 1.67	0.04 – 1.48	0.05 – 1.76	0.61- 4.73	0.62- 1.62	0.32- 0.89
Mg (cmol/kg)	0.31 – 0.95	0.07 – 0.66	0.06 – 1.69	0.09- 3.17	0.03- 0.21	0.02- 0.05
K (cmol/kg)	0.07 – 0.18	0.06 – 0.13	0.60 – 1.00	0.14- 0.24	0.14- 0.31	0.14- 0.31
Na (cmol/kg)	0.17 – 0.21	0.16 – 0.20	0.16 – 0.18	0.14- 0.16	0.16- 0.26	0.16- 0.22
Fe (mg/kg)	17.5 – 27.40	15.6 – 80.10	43.3 – 95.60	9.4- 73.6	22.3- 104.4	16.8- 58.4
Cu (mg/kg)	0.4 – 0.8	0.3 – 0.5	0.6 – 1.20	0.1- 0.5	0.2- 0.7	0.1- 0.6
Mn (mg/kg)	1.0 – 20.1	0.1 – 4.3	0.1 – 24.6	1.0- 12.4	1.0- 17.4	1.1- 7.4
Zn (mg/kg)	2.5 – 8.0	2.2 – 4.5	2.7 – 10.7	3.5- 6.3	3.8- 8.1	3.7- 8.1

Suitability classification

The non-parametric and parametric suitability rating of the study areas for the maize are shown in Tables 6 and 7. By non- Parametric (actual) evaluation for maize, is moderately suitable (S2) with fertility (f) and topography (t) as the limitations. If some of these constraints (fertility limitations) are ameliorated, the potential suitability evaluation remains moderately suitable with topography (t) being the only limitation that cannot be easily ameliorated. Alagba, Dodokindo, Idesan, Atan and Pakoto Series' were marginally suitable (S3) with fertility (f) as the only limitation. This limitation is also common to all therefore, the potential suitability evaluation of Alagba, Dodokindo, Atan and Pakoto, becomes moderately suitable if the fertility problem is corrected with chemical or organic soil ammendments. Topography (t) was a limitation applicable to Dodokindo and Pakoto Series while but Dodokindo Series further has soil physical characteristics (s) as additional contraints.

Table 6. Non Parametric suitability classification for maize in the peri-urban soils of Ikorodu and Epe study sites

Land qualities	Land Characteristics	Unit	Pedons					
			Alagba	*Dodokindo*	*Idesan*	*Owode*	*Atan*	*Pakoto*
Climate(c)								
Water availability	Mean Annual Rainfall	mm	1554(S1)	1554(S1)	1554(S1)	1554(S1)	1554(S1)	1554(S1)
Temperature regime	Mean annual temp	⁰C	25(S1)	25(S1)	25(S1)	25(S1)	25(S1)	25(S1)
Wetness (w)								
Oxygen availability	Soil drainage		Well drained (S1)	Well drained (S1)	Poorly drained (S3)	Well drained (S1)	Poorly drained (S3)	Well Drained (S1)
Fertility(f)								
Nutrient availability	Org C (0-15cm)	%	0.83(S2)	2.35(S1)	1.60(S1)			
	Available P	mg/kg	0.15(S3)	0.16(S3)	0.15(S3)	7.32(S2)	7.02(S2)	2.36(S3)
	pH		5.3(S2)	5.15 (S2)	5.3(S2)	5.9(S1)	5.1 (S2)	5.8(S1)
Nutrient retention	Base saturation	%	67.69(S1)	22.78(S2)	53.17(S1)	58.85(S1)	41.80(S1)	19.79(S3)
Soil physical characteristics(s)								
Water retention capacity	Texture/structure		SCL(S1)	SL,LS(S2)	SL(S2)	SCL(S1)	SL,LS(S2)	SCL(S1)
Rooting condition	Soil depth	cm	180(S1)	150(S1)	107(S1)	155(S1)	85(S1)	150(S1)
Salinity (n)	EC	ms/cm						
Topography (t)	Slope	%	4-6(S2)	5-7(S2)	0-2(S1)	5-7(S2)	2-5(S1)	5-7(S2)
Actual			S3f	S3f	S3fw	S2ft	S3w	S3f
Potential			S2t	S2ts	S3w	S2t	S3w	S2t

S1, highly suitable; S2, moderately suitable; S3, marginally suitable; Ns, not suitable; f, low fertility status; w, wetness; s, soil physical characteristics; t, topography, c, climate.

Table 7. Parametric suitability classification for maize in the peri-urban soils of Ikorodu and Epe study sites

Land qualities	Land Characteristics	Unit	Pedons					
			Alagba	*Dodokindo*	*Idesan*	*Owode*	*Atan*	*Pakoto*
Climate(c)								
Water availability	Mean Annual Rainfall	mm	100(S1)	100(S1)	100(S1)	100(S1)	100(S1)	100(S1)
Temperature regime	Mean annual temp	⁰C	100(S1)	100(S1)	100(S1)	100(S1)	100(S1)	100(S1)
Wetness (w)								
Oxygen availability	Soil drainage		100 (S1)	100(S1)	40(S3)	100 (S1)	40(S3)	100(S1)
Fertility(f)								
Nutrient availability	Org C (0-15cm)	%	85(S2)	100(S1)	100(S1)			
	Available P	mg/kg	40(S3)	40(S3)	40(S3)	85(S2)	85(S2)	40(S3)
	pH		85(S2)	85 (S2)	85(S2)	100(S1)	85 (S2)	100(S1)
Nutrient retention	Base saturation	%	100(S1)	85(S2)	100(S1)	100(S1)	100(S1)	40(S3)
Soil physical characteristics(s)								
Water retention capacity	Texture/structure		100(S1)	85(S2)	85(S2)	100(S1)	85(S2)	100(S1)
Rooting condition	Soil depth	Cm	100(S1)	100(S1)	100(S1)	100(S1)	100(S1)	100(S1)
Salinity (n)	EC	ms/cm						
Topography (t)	Slope	%	85(S2)	85(S2)	100(S1)	85(S2)	100(S1)	85(S2)
Actual			40(S3)	34(S3)	23.32(N1)	78.36(S1)	34(S3)	36.88(S3)
Potential			85 (S1)	78.4 (S1)	36.9 (S3)	85 (S1)	36.9 (S3)	85 (S1)

S1, highly suitable; S2, moderately suitable; S3, marginally suitable; Ns, not suitable; f, low fertility status; w, wetness; s, soil physical characteristics; t, topography, c, climate.

Idesan and Atan have wetness as limitations and the potential suitability evaluation remains marginally suitable with wetness as constraint which will cost a lot to drain.

For parametric actual suitability evaluation, Alagba, Dokindo, Atan and Pakoto are marginally suitable (S3), Idesan is not suitable (N1) and Owode is highly suitable (S1). With proper management practices such as mulching, addition of organic manure etc. (the potential suitability evaluation) of Alagba and Atan remain marginally suitable (S3), Dodokindo, Owode and Pakoto become highly suitable (S1), while Idesan becomes marginally suitable (S3) and Atan remains marginaly suitable (S3).

By non- Parametric (actual) evaluation for cassava (Table 8), the entire mapping unit are marginally suitable (S3) with fertility (f) as the major limitations and wetness as additional limitation in Idesan and Atan soil series. With proper soil fertility amelioration, the potential suitability evaluation is moderately suitable (S2) for Alagba, Dodokindo, Owode and Pakoto soil series with topography (t) as the only limitation that cannot be easily ameliorated for Alagba, Owode and Pakoto soil series while Dodokindo has topography and soil physical characteristics (s) as its limitations. Idesan and Atan remains marginally suitable with wetness as constraint that cannot be easily corrected except by drainage which might not be economically significant with respect to cassava production.

For parametric actual suitability evaluation for cassava (Table 9), Alagba, Dodokindo, Idesan Owode and Pakoto are marginally suitable (S3) and Atan is not suitable (N1) with proper management practices such as mulching, addition of organic manure e.t.c (the potential suitability evaluation), Alagba, Dodokindo, Owode and Pakoto may become highly suitable (S1), Atan becomes marginally suitable (S3) while Idesan remains marginally suitable (S3).

Table 8. Non parametric suitability classification for cassava in the soils of Ikorodu and Epe study sites

Land qualities	Land Characteristics	Unit	Pedons					
			Alagba	*Dodokindo*	*Idesan*	*Owode*	*Atan*	*Pakoto*
Climate(c)								
Water availability	Mean Annual Rainfall	mm	1554(S1)	1554(S1)	1554(S1)	1554(S1)	1554(S1)	1554(S1)
Temperature regime	Mean annual temp	⁰C	25(S1)	25(S1)	25(S1)	25(S1)	25(S1)	25(S1)
Wetness (w)								
Oxygen availability	Soil drainage		Well drained(S1)	Well drained(S1)	Poorly drained(S3)	Well drained(S1)	Poorly drained(S3)	Well drained(S1)
Fertility(f)								
Nutrient availability	Org C (0-15cm)	%	0.19(S2)	0.31(S1)	0.26(S1)	0.21(S1)	0.47(S1)	0.29(S1)
	Available P	mg/kg	0.15(S3)	0.16(S3)	0.15(S3)	7.32(S2)	7.02(S2)	2.36(S3)
	pH		0.13(S3)	0.11(S3)	0.05(S3)	0.2(S3)	0.17(S3)	0.15(S3)
Nutrient retention	Base saturation	%	5.3(S2)	5.15(S2)	5.3(S2)	5.9(S2)	5.1(S2)	5.8(S2)
Soil physical characteristics (s)								
Water retention capacity	Texture/structure		3.25(S2)	6.22(S2)	2.20(S3)	8.85(S2)	5.84(S2)	7.65(S2)
Rooting condition	Soil depth	cm						
Salinity (n)	EC	ms/cm	SL, SCL(S1)	SL,LS(S2)	SL(S1)	SC, SCL(S1)	SC(S1)	SC,CL(S1)
Topography (t)	Slope	%	180(S1)	150(S1)	107(S1)	155(S1)	85(S2)	150(S1)
Actual								
Potential			4-6(S2)	5-7(S2)	0-2(S1)	5-7(S2)	2-5(S1)	5-7(S2)

S1, highly suitable; S2, moderately suitable; S3, marginally suitable; Ns, not suitable; f, low fertility status; w, wetness; s, soil physical characteristics; t, topography, c, climate.

Table 9. Parametric suitability classification for cassava in the soils of Ikorodu and Epe study sites

Land qualities	Land Characteristics	Unit	Pedons					
			Alagba	*Dodokindo*	*Idesan*	*Owode*	*Atan*	*Pakoto*
Climate(c)								
Water availability	Mean Annual Rainfall	mm	100(S1)	100(S1)	100(S1)	100(S1)	100(S1)	100(S1)
Temperature regime	Mean annual temp	⁰C	100(S1)	100(S1)	100(S1)	100(S1)	100(S1)	100(S1)
Wetness (w)								
Oxygen availability	Soil drainage		100(S1)	100(S1)	40(S3)	100(S1)	40(S3)	100(S1)
Fertility(f)								
Nutrient availability	Org C (0-15cm)	%	85(S2)	100(S1)	100(S1)	100(S1)	100(S1)	100(S1)
	Available P	mg/kg	40(S3)	40(S3)	40(S3)	85(S2)	85(S2)	40(S3)
	pH		40(S3)	40(S3)	40(S3)	40(S3)	40(S3)	40(S3)
Nutrient retention	Base saturation	%	85(S2)	85(S2)	85(S2)	85(S2)	85(S2)	85(S2)
Soil physical characteristics(s)								
Water retention capacity	Texture/structure		85(S2)	85(S2)	40(S3)	85(S2)	85(S2)	85(S2)
Rooting condition	Soil depth	Cm						
Salinity (n)	EC	ms/cm	100(S1)	85(S2)	100(S1)	100(S1)	100(S1)	100(S1)
Topography (t)	Slope	%	100(S1)	100(S1)	100(S1)	100(S1)	85(S2)	100(S1)
Actual			36.88(S3)	34(S3)	25.30(S3)	36.88(S3)	23.32(N1)	36.88(S3)
Potential			85(S1)	78.37(S1)	40(S3)	85(S1)	36.88(S3)	85(S1)

S1, highly suitable; S2, moderately suitable; S3, marginally suitable; Ns, not suitable; f, low fertility status; w, wetness; s, soil physical characteristics; t, topography, c, climate.

By non-Parametric (actual) evaluation for Leafy vegetables (Table 10), the entire mapping unit are marginally suitable (S3) with fertility (f) and wetness as their limitations. However with proper amelioration such as fertilizer application, liming and proper organic matter management; the potential suitability could be moderately suitable (S2) for Dodokindo, Owode and Pakoto with climate as a limitation common to all, Dodokindo has topography and soil characteristics (s) as its other limitations, Pakoto has topography as another limitation. Idesan and Atan remain marginally suitable with wetness (w) as the major limitation for Idesan and Atan while Alagba has topography (t) as a constraint. Off-season cultivation with irrigation may favour leafy vegetable production in Idesan and Atan soil series but these could not be factored in here under rainfed system

For parametric actual suitability evaluation for vegetables (Table 11), Owode is moderately suitable (S2), Alagba, Dodokindo and Pakoto are marginally suitable (S3) while Idesan and Atan are not suitable (N1), with proper amelioration (the potential suitability evaluation), Owode and Pakoto become highly suitable (S1), Alagba and Dodokindo become moderately suitable (S2) while Idesan and Atan becomes marginally suitable (S3).

Table 10. Non parametric suitability classification for tropical leaf and fruit vegetables the soils of Ikorodu and Epe study sites

Land qualities/characteristics	Pedons					
	Alagba	*Dodokindo*	*Idesan*	*Owode*	*Atan*	*Pakoto*
Rainfall(mm)	1554(S2)	1554(S2)	1554(S2)	1554(S2)	1554(S2)	1554(S2)
No of dry months	4(S1)	4(S1)	4(S1)	4(S1)	4(S1)	4(S1)
Absolute temperature(ºC)	25(S1)	25(S1)	25(S1)	25(S1)	25(S1)	25(S1)
Topography(t)						
Slope (%)	4-6(S2)	5-7(S2)	0-2(S1)	5-7(S2)	2-5(S1)	5-7(S2)
Wetness(w)	Well drained(S1)	Well drained(S1)	Poorly drained(S3)	Well drained(S1)	Poorly drained(S3)	Well drained(S1)
Drainage	Drained(S1)	Drained(S1)	Drainable(S3)	Drained(S1)	Drained not (S2)	Drained(S1)
Flooding potentials	F0(S1)	F1(S2)	F2(S3)	F0(S1)	F2(S3)	F0(S1)
Soil physical characteristics						
Texture	SL,SC(S1)	SL, LS(S2)	SL,SC(S1)	SL,SC(S1)	SL, LS(S2)	SL,SC(S1)
Depth (cm)	180(S1)	150(S1)	107(S1)	155(S1)	85(S1)	150(S1)
Soil fertility (f)						
Apparent CEC (mol/kg)	3.25(NS)	6.22(NS)	2.20(NS)	8.85(S3)	5.84(NS)	7.65(NS)
Base saturation (%)	67.69(S1)	22.78(S2)	53.17(S1)	58.85(S1)	41.80(S1)	19.76(S3)
Organic matter (organic carbon in 0-15cm) %	1.42(S1)	4.05(S1)	2.75(S1)	7.08(S1)	6.64(S1)	4.5(S1)
pH	5.3(S3)	5.15(S3)	5.3(S3)	5.9(S1)	5.1(S3)	5.8(S1)
Actual	S3f	S3f	S3fw	S3f	S3fw	S3f
Potential	S2tc	S2ts	S3w	S2c	S3w	S2ct

S1, highly suitable; S2, moderately suitable; S3, marginally suitable; Ns, not suitable; f, low fertility status; w, wetness; s, soil physical characteristics; t, topography, c, climate.

Table 11. Parametric suitability classification for tropical leaf and fruit vegetables at Ikorodu and Epe study areas in Lagos State

Land qualities/characteristics	Pedons					
	Alagba	*Dodokindo*	*Idesan*	*Owode*	*Atan*	*Pakoto*
Rainfall(mm)	85(S2)	85(S2)	85(S2)	85(S2)	85(S2)	85(S2)
No of dry months	100(S1)	100(S1)	100(S1)	100(S1)	100(S1)	100(S1)
Absolute temperature(ºC)	100(S1)	100(S1)	100(S1)	100(S1)	100(S1)	100(S1)
Topography(t)						
Slope (%)	85(S2)	85(S2)	100(S1)	85(S2)	100(S1)	85(S2)
Wetness(w)	100(S1)	100(S1)	60(S3)	100(S1)	60(S3)	100(S1)
Drainage	100(S1)	100(S1)	60(S3)	100(S1)	85(S2)	100(S1)
Flooding potentials	100(S1)	85(S2)	60(S3)	100(S1)	60(S3)	100(S1)
Soil physical characteristics (s)						
Texture	100(S1)	85(S2)	100(S1)	100(S1)	85(S2)	100(S1)
Depth (cm)	100(S1)	100(S1)	100(S1)	100(S1)	100(S1)	100(S1)
Soil fertility (f)						
CEC (cmol/kg)	40(NS)	40(NS)	40(NS)	60(S3)	40(NS)	40(NS)
Base saturation (%)	100(S1)	85(S2)	100(S1)	100(S1)	100(S1)	60(S3)
Organic carbon (0-15cm) %	100(S1)	100(S1)	100(S1)	100(S1)	100(S1)	100(S1)
pH	60(S3)	60(S3)	60(S3)	100(S1)	60(S3)	100(S1)
Actual	34(S3)	28.9(S3)	17.14(N1)	51(S2)	18.81(N1)	34(S3)
Potential	78.37(S1)	66.61(S2)	33.19(S3)	78.37(S1)	36.42(S3)	78.37(S1)

S1, highly suitable; S2, moderately suitable; S3, marginally suitable; Ns, not suitable

Conclusion

Land suitability ranges from moderately suitable (S2) to marginally suitable (S3) for the three crops (maize, cassava and leafy vegetable). Major limitations are low soil fertility, drainage and surface texture. However, with proper management, the potential land suitability ranges from highly suitable (S1) to marginally suitable (S3) for the three crops in the study areas. In order to correct the major limitations, management practices such as incorporation of crop residues and organic manure to the soil should be adopted to improve soil physical and chemical properties. Application of organic and inorganic fertilizers to increase the nutrient in the soil and use of drainage operation or planting of water tolerant crops to control the waterlogging condition of some part of the land would ensure optimum productivity.

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