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LAND SUITABILITY CLASSIFICATION OF OKOKO ITEM, ABIA STATE, NIGERIA, FOR UPLAND RICE (*ORIZA SATIVA* (L.) PRODUCTION

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ABSTRACT
Land suitability evaluation was carried out to evaluate the suitability of soils of Okoko Item, Abia State, South-eastern Nigeria, for upland rice production. Free method of soil survey was adopted. Qualitative land suitability of the area for rain-fed rice production was done using FAO Land Suitability Classification System. The study area was delineated into four mapping units designated as OK I, OK II, OK III and OK IV. Mapping units OK I and OK II were generally flat, deep and well drained. Mapping unit OK III was generally flat, shallow to moderately deep and poorly to imperfectly drained while mapping unit OK IV was undulating with deep, well drained and gravelly soils. Soils were classified as Typic Rhodudults for OK I, Rhodic Paleudults for OK II, Mollic Epiaquents for OK III and Typic Plinthaqualfs for OK IV. Mapping units OK I and OK II were moderately suitable (S2), mapping unit OK III was permanently not suitable (N2) while mapping unit OK IV was marginally suitable (S3) for upland rice production. Majority of the area (61 %) is permanently not suitable (N2) for sustainable upland rice cultivation due to poor drainage. However, 26 % of the area is moderately suitable (S2) while 13% of the area is marginally suitable (S3) for sustainable upland rice cultivation due to dominance of rock outcrop and boulders.

Keywords: Rice production, Land Suitability, Soil Classification, Mapping, Okoko Item.

INTRODUCTION
Rice is a staple food crop in Nigeria and among the main crops being promoted under the Agriculture Promotion Policy (APP) (2016 – 2020) of Buhari's administration (FMARD, 2016). It has become a cereal that constitutes a major source of calories for the rural and urban population (Ajiboye *et al.*, 2011). In Nigeria, rice production has been reported to be far below demand due to rapid population growth, reduction in farmlands in terms of size and quality, and poor rice cultivars (Ajiboye *et al.*, 2011). This led to considerable importation to augment the deficit in demand in Nigeria.

According to FAO (2018), Africa is a big competitor in the international rice markets, collecting up to 36.9% of the world imports in 2017, with a record of 16.1 million tonnes in that particular year. Nigeria is the highest importer of the commodity in West African sub-region with rice importation of 2.7 tonnes in 2017 (FAO, 2018). Conversely, Nigeria is leading in the production of rice in the West Africa sub-region with the production of 7.0 million tonnes in the year 2017 (FAO, 2018).

This necessitated land suitability evaluation of a rice producing community in Abia State in order to expand the country's production capacity for rice. Land suitability evaluation determines the quality of a given area for optimum production of specific crops. Thus, the suitability classification results of the area for rice production will be beneficial to farmers and the community at large as it could guide their farming system and improve their production efficiency. The resultant increase in crop yield and income will motivate the local farmers to

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aspire into medium to large scale production to reduce importation of rice in Nigeria. The objective of the study was to characterize some soils of Okoko Item, Abia State, and data from which were used to assess their suitability for sustainable upland rice production.

MATERIALS AND METHODS

The Study Area

Okoko Item is in Bende Local Government Area of Abia State. It is located between latitudes 5°43´10.2´´ to 5°47´22.0´´ N and Longitudes 7°37´40.4´´ to 7°39´24.2´´ E with an elevation ranging from 75 m – 210 m above sea level. The area is about 1,885 ha. The soil parent materials are sandstone and shale of the Bende-Ameki formation (FDALR, 1990a). The area is situated in the rainforest zone of Southeastern agricultural zone. The climate is humid tropical, having distinct rainy and dry seasons. The rainfall pattern is bimodal with peaks in July and September. The mean annual minimum rainfall is 1,200 mm while the mean annual maximum rainfall is 2,000 mm, spread between April and early November (Asadu, 2002). The average minimum and maximum temperatures are 22°C and 30°C, respectively; and relative humidity varies from 90.2% to minimum of 52.5%. The vegetation is typical of rainforest; mapping unit OK I was mostly of derived savannah which was under fallow covered by grasses such as elephant grass (*Pennisetum purpureum*), beard grass (Andropogon spp.), carpet grass or savannah grass (*Axonopus compressus*), caesarweed (*Urena lobata* (**L.**), wireweed (*Sida acuta*), cogon grass (*Imperata cylindrical* (**L.**), mapping unit OK II was a fallow ground covered by medium to short grasses such as elephant grass, carpet grass and few tress like oil palm (Elaeis guineensis Jack.), with some areas under cultivation of cassava, mapping unit OK III was a forest land under fallow with the prevalence of trees such as oil palm, raffia palm (Raphia spp.), Mango tree (Mangifera indica), Beech wood or Kashmir tree (*Gmelina arborea*), mapping unit OK IV was fallow covered with grasses like elephant grass, beard grass, carpet grass and trees like oil palm.

Field and Laboratory Studies

Free soil survey method was adopted in mapping the area. Geographical Positioning System (GPS) was used to generate the map of the study area. Soil auger investigation was carried out in line with changes in topography, soil colour, drainage and vegetation. Soils of similar characteristics were correlated and four (4) mapping units delineated. A profile pit was dug on each mapping unit and characterized using FAO (2006) guideline. Morphological characteristics of the soils such as colour, texture, structure, depth of horizons, root presence and inclusions were recorded for each genetic horizon. Soil samples were collected from genetic horizons for laboratory analyses using standard procedures as recommended by Udo *et al.* (2009).

Based on the results of field and laboratory studies, soils were classified based on USDA Soil Taxonomy (Soil Survey Staff, 2014) and World Reference Base for soil Resources (FAO/IUSS, 2015). The land suitability evaluation was carried out using the framework for land evaluation (FAO, 2007) and Sys *et al.* (1991, 1993) guidelines for land qualities (Table 1) for rice production. The key factors considered in the evaluation are climate (annual rainfall, temperature), topography (slope) and soil properties which included depth, texture, drainage, pH, available P, organic C, CEC and base saturation (Fasina and Adeyanju, 2006; Ritung *et al.*, 2007; Ajiboye *et al.*, 2011). The soils of the study site were evaluated using simple limitation method, which involves matching land qualities of the area (Table 2) with crop (rice) requirements (Table 1). The most limiting factor dictated the overall suitability class for each mapping unit. Suitability class (es) are designated as follows: highly suitable (S1), moderately

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suitable (S2), marginally suitable S3), currently not suitable (N1) or permanently not suitable (N2).

Table 1: Land Requirements for Suitability Classes for Rainfed Upland Rice Cultivation

Land qualities	S1	S2	S3	N1	N2
Climate (c):					
Rainfall growing season (mm)	>1400	>1000	>800	<800	<800
Mean temp °C, crop dev. Stage	24-36	18-42	10-45	-	-
Relative humidity (%) vegetative stage	50-90	Any			
Topography (t)					
Slope (%) (1)	<4	<8	<16	<25	<25
(2)	<8	<16	<30	<30	≤ 30
Wetness (w)					
Flooding	No	No	no-slight	no-slight	Any
Drainage (3)	Good	moderate/better	imperfect/better	poor/better	Very poor /better
(4)	Imperfect	imperfect/moderate	good, moderate or imperfect	good, moderate or imperfect	
Soil Physical Properties (s):					
Surface Coarse fragments (Vol. %)	<15	<35	<55	<55	<55
Depth (cm) to impermeable layer	>90	>50	>20	>20	>20
Subsurface coarse fragments.	<35	<55	<55	<55	<55
Fertility (f):					
Cation exchange capacity (Cmol/Kg)	>16	>0, - charge	>0, - charge		
Base saturation (%) 0-15 cm	>50	>35	>15		
Organic carbon (%), 0-15cm	>1.5	> 0.8	> 0.8		

(1) Intensive fully mechanized agriculture (2) primitive farming (3) fine loamy or clayey families (4)
(2) coarse loamy or sandy families.
Source: Modified from Sys (1985)

Table 2: Land Qualities/Characteristics of the Study Sites

	Mapping Unit			
Parameters	**OK I**	**OK II**	**OK III**	**OK IV**
Mean annual rainfall (mm)	2000	2000	2000	2000
Temperature (°C)	22.3 – 30.0	22.3 – 30.0	22.3 – 30.0	22.3 – 30.0
Relative Humidity (%)	52.5 – 90.2	52.5 – 90.2	52.5 – 90.2	52.5 – 90.2
Slope (%)	0 – 2	0 – 2	0 – 2	0 – 4
Flooding	No flooding	No flooding	Seasonally flooded	No flooding
Drainage	Well drained	Well drained	Imperfectly drained	Well drained
Surface texture	LS	SL – SCL	CL – C	SCL
Soil depth (cm)	170	170	40	106
Organic C (g/kg) (0 – 15cm)	13	22	29	7
ECEC (cmol/kg)	5.1 – 6.5	5.4 – 6.3	6.3 – 8.0	5.5 – 7.4
% Base saturation (0 – 15cm)	55.6	56.3	90.0	84.0

*LS = loamy sand; SL = sandy loam; SCL = sandy clay loam; CL = clay loam; C = clay.

RESULTS AND DISCUSSION

Morphological Properties of the Soil

The morphological properties of the pedons are shown on Table 3. The pedons of mapping units OK I, OK II and OK IV were deep, well drained and the colour of the epipedons observed under moist condition were black (5YR 2/1), dark reddish brown (5YR 3/2), reddish brown (5YR 4/4), respectively (Table 3). These observations collaborated with the results of soil colours derived from sandstone-shale intercalated parent materials (Nsor, 2011), the findings of Moberg and Esu (1991) and FDALR (1990b). On the other hand, the pedon of mapping unit OK III was shallow to moderately deep, poorly to imperfectly drained and the epipedon colour observed was dark brown (10YR 3/3) (Table 3). The colour agrees with the observations of Ahukaemere *et al.* (2014) in their study of wetland soils of Abia State in Southeastern Nigeria. The pedon of OK IV had cemented plinthite horizons from depth of 66 – 106cm where an impenetrable layer was encountered. The plinthic horizons have massive structure which also could have developed due to strong aggregation caused by cementing agents of sesquioxides and silica (Alexander and Cady, 1962). The seasonal saturation of the subsoil especially in the peak period of rainy season could be attributed to strong aggregation and cementation in the plinthitic horizons. Bosch *et al.* (1994) posited that strong aggregation and cementation may restrict vertical flow of water and induce horizontal water flow in soils.

Physical and Chemical Properties of the Soil

Particle size analysis showed dominance of sand fraction over other soil separates in pedons OK I and OK II. Clay fractions dominate pedons OK III and pedon OK IV (Table 4). The pedons generally had a decrease in sand content down the profiles as clay increased down the profiles. Udoh *et al*. (2008) and Chikezie *et al.* (2009) had reported increased clay content with increase in soil depth. According to Schaetzi and Anderson (2005), increase of clay down the soil profile is as a result of pedogenic processes of eluviations and illuviation of clay particles, neo-formation and transformation of primary minerals in subsurface horizons. The surface soil texture of pedon OK I was loamy sand underlain by sandy loam with increasing soil depth. Pedon OK II was sandy loam in the epipedon underlain by sandy clay loam in the subsoil. Pedon OK III had clay loam in the soil surface and clay in the subsoil while pedon OK IV had sandy clay loam in the epipedon over clay in the endopedon (Table 4).

The soils are generally acidic based on the ratings of Soil Survey Staff (1993). The soil acidity generally increases with increase in soil depth in all the pedons except in OK IV, where it fluctuated irregularly with depth (Table 4). Eshett *et al.* (1990) had stated that acidic soil reaction is characteristic of soils of Southeastern Nigeria and it is the consequence of the acidic nature of the parent rocks, coupled with the influence of the leached profile under high annual rainfall condition. Organic carbon in the soil surface were rated moderate for OK I and OK II, very high for OK III and very low for OK IV. The variation in organic carbon levels in the mapping units is as result of the vegetation pattern of the area which is a determinant of the organic matter supply to the soil; and also, the slope of the area which influences the erosive impact of rainfall on the soil surface. Available P in the soil surface was rated high in pedons of OK I, OK II and OK III and was rated moderate for pedon OK IV. This makes application of P fertilizers not necessary for successful cultivation of rainfed rice. Total N was rated low in the soil surface of all the pedons. This confirmed the report of Eshett (1987) and Eshett *et al.* (1990) on N deficiency of soils of Southeastern Nigeria. Therefore, this necessitates the application of N fertilizers to supply the deficient nutrient N_2.

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Table 3: Morphological Properties of the Soil

Mapping Unit	Horizon Designation	Depth (cm)	Colour (moist)	Mottles	Structure	Consistency (Wet)	Inclusions	Root	Boundary
	Ap	0 – 12	5YR 2/1	Absent	1, c, g	Ns-Np	Absent	Mfir-Fmr	Clear, wavy
	AB	12 – 30	2.5YR 3/3	Absent	1, c, sbk	Ns-Np	Absent	Mfir-Fmr	Clear, wavy
OK I	Bt1	30 – 75	2.5YR 4/6	Absent	1, c, g	Ss-Sp	Absent	Mfir-Mmr	Clear, wavy
	Bt2	75 - 117	2.5YR 4/6	Absent	1, me, sbk	Ss-Sp	Absent	Mmr	Clear, wavy
	BC	117 - 170	2.5YR 5/6	Absent	1, c, sbk	Ss-Sp	Absent	Fmr-Ffir	-
	Ap	0 – 10	5YR 3/2	Absent	1, f, g	Ns-Np	Absent	Mfir	Clear, smooth
	AB	10 – 35	2.5YR ¾	Absent	1, f, g	Ss-Sp	Absent	Ffir	Gradual, wavy
OK II	Bt1	35 – 69	2.5YR 4/6	Absent	2, me, sbk	Vs-Vp	Absent	None	Clear, wavy
	Bt2	69 - 100	2.5YR 4/8	Absent	2, me, sbk	Vs-Vp	Absent	Fmr	Clear, wavy
	BC	100 - 170	2.5YR 4/6	Absent	2, me, sbk	Vs-Vp	Absent	None	-
OK III	Ap	0 – 16	10YR 3/3	Absent	2, me, sbk	Vs-Vp	Absent	Ffir	Gradual, wavy
	ABg	16 – 40	7.5YR 4/4	Faint	2, me, sbk	Vs-Vp	Absent	Ffir-Fmr	-
	Ap	0 – 25	5YR 4/4	Absent	2, me, g	Vs-Vp	gr, st, bld	Ffir	Clear, wavy
OK IV	Bt1	25 - 45	10YR 5/6	Absent	2, me, g	Vs-Vp	gr, st, bld	None	Gradual, wavy
	Bt2	45 - 66	7.5YR 6/4	Absent	2, me, g	Vs-Vp	gr, st, bld	None	Clear, wavy
	BCcg	66 - 106	7.5YR 6/8	Faint	2, me, g	Vs-Vp	gr, c, st, bld	None	-

Structure: 1 = weak, 2 = moderate, 3= strong, f = fine, me = medium, c = coarse, g = granular, abk = angular blocky, sbk = sub-angular blocky.
Consistency: Vs-Vp= Very sticky and very plastic, Ns - Np = non sticky and non-plastic, Ss - Sp = slightly sticky and slightly plastic.
Inclusions: gr = gravel, st = stones, bld = boulders, c = concretions. Roots: Mfir-Fmr = Many fine and few medium roots, Mfir-Mmr = Many fine and medium roots, Mmr = Many medium roots, Fmr-Ffir = Few medium and few fine roots, Mfir = Many fine roots, Ffir = few fine roots, Fmr = Few medium roots.

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Table 4: Physical and Chemical Properties of the Soil

Mapping Unit	Horizon	Depth (cm)	Sand	Silt g/kg	Clay	Texture	pH (H_2O)	Av. P (mg/kg)	TN (g/kg)	Org C (g/kg)	Ca	Mg	K	Na cmol/kg	EA	ECEC	BS (%)
OK I	Ap	0 – 12	876	54.0	70.0	LS	5.60	28.5	1.30	12.9	1.80	1.60	0.06	0.14	2.88	6.48	55.6
	AB	12 – 30	836	34.0	130	LS	4.60	15.5	0.70	5.90	1.60	1.40	0.04	0.10	3.04	6.18	50.8
	Bt1	30 – 75	756	54.0	190	SL	4.60	9.60	0.60	3.30	1.00	0.70	0.04	0.11	3.88	5.73	32.3
	Bt2	75 - 117	776	54.0	170	SL	4.50	9.30	0.40	2.20	1.30	1.00	0.03	0.10	3.12	5.55	43.8
	BC	117 - 170	756	44.0	200	SCL	4.70	6.90	0.30	1.80	1.80	0.80	0.04	0.10	3.00	5.14	47.7
OK II	Ap	0 – 10	776	154	70.0	SL	5.40	40.2	1.80	22.0	1.85	1.50	0.07	0.09	2.72	6.28	56.3
	AB	10 – 35	716	74.0	210	SCL	5.70	17.9	1.10	8.10	1.70	1.30	0.05	0.11	2.96	6.12	51.6
	Bt1	35 – 69	556	114	330	SCL	4.70	11.5	0.60	3.30	1.10	0.07	0.04	0.12	3.48	5.44	36.0
	Bt2	69 - 100	636	114	250	SCL	5.30	9.70	0.60	4.40	1.40	1.10	0.03	0.11	3.10	5.74	46.0
	BC	100 - 170	656	14.0	330	SCL	3.90	13.7	0.40	6.20	1.80	0.80	0.04	0.10	2.94	5.68	48.2
OK III	Ap	0 – 16	336	274	390	CL	4.70	34.1	1.50	29.0	4.40	2.40	0.21	0.17	0.80	7.97	90.0
	ABg	16 – 40	296	194	510	C	4.50	45.5	1.40	20.6	3.60	1.60	0.18	0.15	0.72	6.25	88.0
OK IV	Ap	0 – 25	596	134	270	SCL	4.20	15.5	0.80	7.00	2.80	1.60	0.14	0.10	0.88	5.53	84.0
	Bt1	25 - 45	516	54.0	430	SCL	4.30	13.7	0.60	6.20	3.20	2.00	0.20	0.17	1.04	6.61	84.3
	Bt2	45 - 66	424	100	476	C	4.40	28.5	0.70	12.9	3.60	2.40	0.15	0.21	0.88	7.24	87.8
	BCcg	66 - 106	424	80.0	496	C	4.20	27.6	0.60	12.5	4.00	2.00	0.18	0.13	1.12	7.43	84.9

Textural class: LS – loamy sand, SL – sandy loam, SCL – sandy clay loam, CL – clay loam, C – clay.
Av. P = Available Phosphorus, TN= Total Nitrogen, Org. C= Ogarnic Carbon, EA= Exchangeable Acidity, ECEC= Effective Cation Exchange Capacity, BS= Base Saturation

Soil Classification and Suitability Evaluation for Upland Rice

The soils of the study site were classified (Table 5) as Typic Rhodudults, Rhodic Paleudults, Mollic Epiaquents and Typic Plinthaqualfs (USDA) and Haplic Acrisol (Arenic), Haplic Acrisol (Loamic), Euric Gleysols (Humic) and Pisoplinthic Plinthosols (Clayic) (WRB) for mapping units OK I, OK II, OK III and OK IV, respectively. The summary of land qualities/land characteristics for rice used in evaluation is shown in Table 1.

Table 5: Soil Classification of the Study Area

	Soil Classification	
Soil Mapping Unit	**USDA Soil Taxonomy**	**World Reference Base (WRB)**
OKIT I	Typic Rhodudults	Haplic Acrisol (Arenic)
OKIT II	Rhodic Paleudults	Haplic Acrisol (Loamic)
OKIT III	Mollic Epiaquents	Eutric Gleysols (Humic)
OKIT IV	Typic Plinthaqualfs	Pisoplinthic Plinthosols (Clayic)

The land qualities of Okoko Item are shown on Table 2 and was compared with the land requirement for upland rice production shown in Table 1. The overall land suitability of the area for upland rice is shown in Table 6. Mapping units OK I and OK II covering 489 ha or 26 % of the study area were moderately suitable (S2) because of fertility limitations (effective cation exchange capacity (ECEC) and organic carbon), OK III covering 1,150 ha or 61 % of the area were permanently not suitable (N2) because of poor drainage (Figure 1) while mapping unit OK IV which covers 246 ha or 13 % of the area were marginally suitable (S3) due to fertility limitations in terms of organic carbon requirement for upland rice production (Figure 1). The low level of organic carbon of OK IV could be attributed to the sloping land which encourages runoff water carrying away organic residues in the rainy season and cyclic annual bush burning of the area. This low level of organic carbon can be corrected through management practices such as incorporation of organic residues such as manure into the soil and mulching to maintain favourable soil structure for sustainable rice cultivation. Soil erosion should also be controlled through the adoption of sloping agricultural land technology (SALT).

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Table 6: Land Suitability Classification of the Study Site for Upland Rice

	Suitability Rating for the Study Site			
Land qualities/Land Characteristics	**OK I**	**OK II**	**OK III**	**OK IV**
Climate ©:				
Rainfall	S1	S1	S1	S1
Temperature	S1	S1	S1	S1
Relative Humidity	S1	S1	S1	S1
Soil physical properties (s):				
Soil depth	S1	S1	S3	S1
Soil texture	S1	S1	S1	S1
Topography (t) slope (%):	S1	S1	S1	S2
Wetness (w):				
Flooding	S1	S1	N2	S1
Drainage	S1	S1	N2	S1
Fertility (f):				
Organic Carbon	S2	S2	S1	S3
Effective Cation Exchange Capacity	S2	S2	S2	S2
Base Saturation	S1	S1	S1	S1
Aggregate Suitability	S2(f)	S2(f)	N2 (w)	S3 (f)
Area covered (ha)	230.5	224.9	1202.9	227.2

*S1 = highly suitable, S2 = moderately suitable, S3 = marginally suitable, N2 = permanently not suitable. Limitations (restrictive features): f = fertility limitation; w = wetness/oxygen availability limitation; s = soil physical characteristics limitation; t = topography.

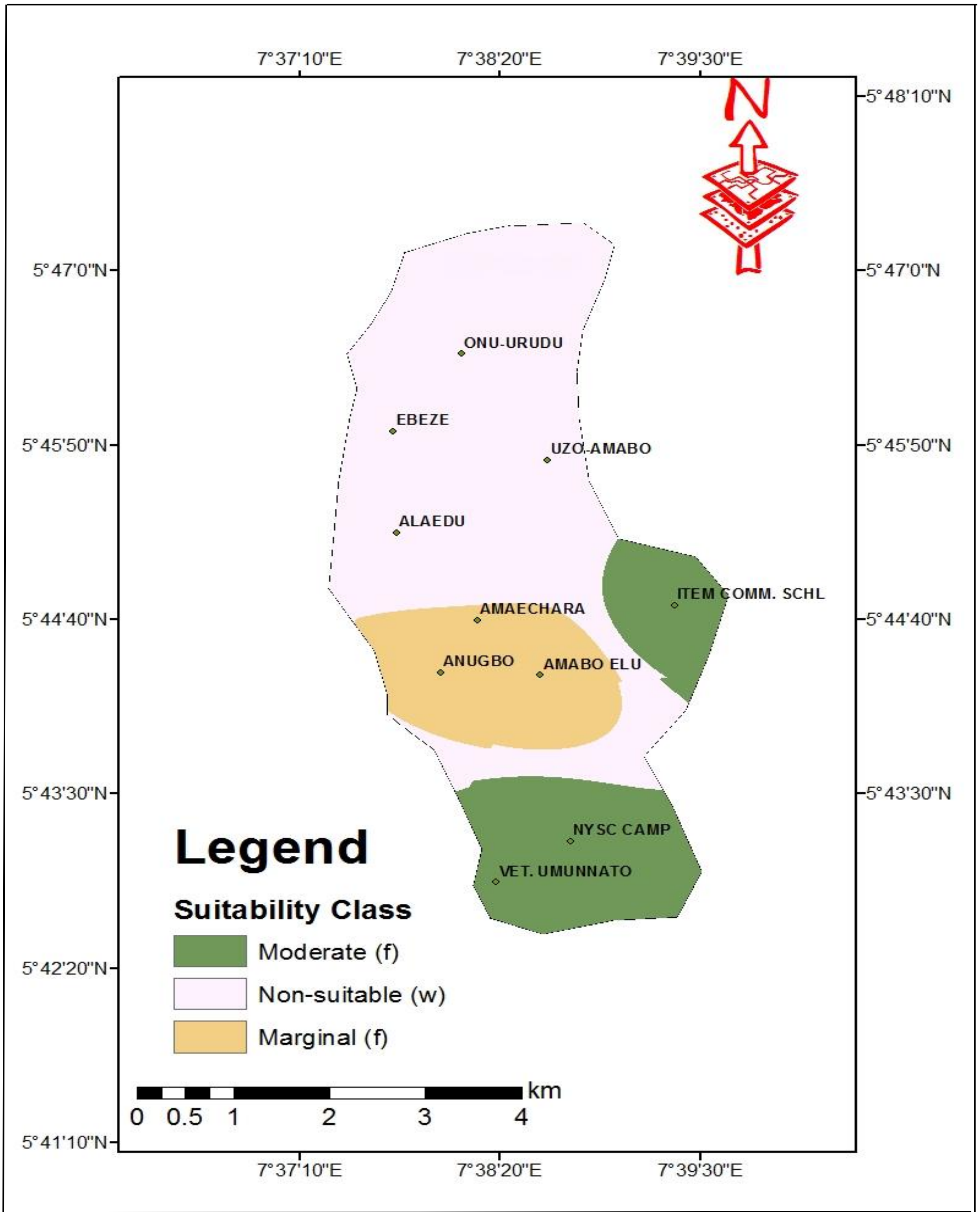

Figure 1: *Land Suitability Map of Okoko Item for Upland Rice Production*

CONCLUSION AND RECOMMENDATIONS

The major constraints of soils in the study site for upland rice cultivation are nutrient deficiency except for OK III with drainage as its major limitation factor. Therefore, the adoption of agronomic management practices such as crop residue management and incorporation of legumes that encourage the return of nutrient into the soil and the use of organic and inorganic manures will improve the nutrient capability of the soil. However, the soils of OK IV with prevalence of coarse fragments (gravels, stones and boulders) has naturally been precluded from cultivation despite its marginal suitability as any soil improvement in the area covered may not be cost effective. The soils of OK III classified as permanently not suitable due to drainage limitation covering the largest part of the study area can be cultivated with water tolerant crops like lowland rice and vegetables.

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