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SOIL SUITABILITY EVALUATION OF THE SOKOTO-RIMA FLOOD PLAINS FOR RICE PRODUCTION: IMPLICATIONS FOR FOOD SECURITY IN SOKOTO STATE, NIGERIA

By

Patrick Ikpe Ukoh[1], Elisha Ikpe[2], Musa Inusa[3] and Suleiman Umar Bambale[3]

[1]Department of Soil Science and land Resources Management, Faculty of Agriculture, Usmanu Danfodio University, Sokoto State, Nigeria.
[2]Department of Geography, Federal College of Education, Odugbo, Benue State
[3]Department of Geography, Federal University of Education, Zaria

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Abstract

Land evaluation analysis is necessary to achieve optimum utilization of land resources for sustainable crop production. The aim of this study was to assess the soil suitability evaluation of the Sokoto-Rima flood plains for rice production in Sokoto State, Nigeria and its implication for food security. Qualitative and quantitative land suitability evaluations were conducted on two selected floodplains (Kolkolawa and Nasarawa). Soil samples were collected from the surface soils at the depth of 0-30 cm from the two locations. The collected soil samples were analyzed for physical and chemical properties using standard laboratory procedures. The land requirements for rice production were compared with the soil characteristics of the floodplains to determine the soil suitability using the FAO land evaluation method. The results showed that the Kolkolawa floodplain is currently permanently not suitable (N2) for rice production due to low annual rainfall, organic carbon, and effective cation exchange capacity (8.66 and 19.7 for Kolkolawa and Nasarawa floodplains respectively). However, it was found to be marginally suitable (S3) for rice production potentially. The Nasarawa floodplain was found to be marginally suitable (S3) for rice production both currently and potentially due to low annual rainfall. The results further stated that the soils in the Kolkolawa floodplain could be considered for alternative uses since low rainfall renders it marginally suitable due to low rainfall (<800 mm) or water from the nearby river could be used to augment the low rainfall. The study recommended that both Kolkolawa and Nasarawa floodplains could be improved from marginally suitable (S3) to moderately suitable (S2) for rice production through an increase in organic matter to improve soil quality and drainage, thereby enhancing the fertility of the soils.

***Keywords**: Flood plain; Food security; Soil Suitability, and Rice production.*

1.0 INTRODUCTION

Food security is a top priority for low-income nations, particularly those living in Sub-Saharan Africa. Based on projected estimate, the world population is to reach approximately 8.5 billion by 2030 (United Nations Population Division, 2015). Consequently, world economies, including Nigeria, are showing increased concern because agriculture serves as the primary source of livelihood for most of its population, especially those residing in rural areas, providing both food and income.

Consequence upon the rapidly increasing population, there is an urgent need to intensify efforts to meet the growing demand for food sustainably. However, the continuous population growth has put immense pressure on the limited upland soils, resulting in declining soil productivity and increased soil degradation due to continuous cropping. The issues of land scarcity and declining productivity from upland agriculture, stemming from excessive use, have led farmers to expand into floodplain soils (Jimoh et al., 2017).

*Corresponding Author: **Patrick Ikpe Ukoh**

Floodplain are areas of land adjacent to streams or rivers, stretching from the banks of the channel to the base of the enclosing valley wall, and experience flooding during periods of high discharge (Goudie, 2004). These soils are characterized by moderate to high contents of basic cations, organic carbon, and are rated moderate to high in fertility (Ogban and Babalola, 2009; Akpan-Idiok and Ogbaji, 2013). The unique properties of floodplain soils make them a valuable resource for agriculture, particularly in regions where food security is a pressing concern.

Land suitability evaluation involves predicting how well a specific parcel of land will perform over time for particular intended uses, such as agriculture, forestry, or urban development (Mohammed et al., 2011). This evaluation can inform farmers about the suitability of their land for specific crops, taking into account soil limitations, and recommended land use and management practices. Soil suitability classifications are therefore based on a comprehensive understanding of crop requirements, prevailing soil conditions, and defined soil management practices (Madrau et al., 2009).

In essence, soil suitability classifications specify the extent to which soil conditions match crop requirements under defined input and management circumstances (Jimoh et al., 2017). By assessing the suitability of land for specific crops, farmers and land-use planners can make informed decisions about land allocation, management, and conservation, ultimately contributing to sustainable agricultural practices and food security.

Rice (Oryza sativa) is a cereal grain and the most important staple food for a large portion of the world's population. As the second-highest produced grain globally, after maize, rice plays a vital role in human nutrition and caloric intake, providing over one-fifth of the calories consumed worldwide maize (Food and Agriculture Organization Statistical Database, 2005). Despite its importance, rice is in short supply, and there is a growing demand to increase its production in the Sokoto and its environs. To achieve sustainable rice production on the floodplains, a thorough suitability evaluation of the study area is necessary to guide farmers effectively.

Given that the study area is an agrarian community in Sokoto town with limited research on soil suitability evaluation, this study aims to fill this knowledge gap. The evaluation will provide valuable information for the sustainable management and use of the soils. The objective of this study is to assess the suitability of the floodplain soils for rice production using both qualitative (FAO, 1976) and quantitative (Ogunkule, 1993) land suitability evaluation methods.

2.0 MATERIALS AND METHOD

2.1 The Study Area

The study area has a typical Sudan Savanna vegetation type. The area is intensively cultivated to array of crops such as onion, tomato, cowpea and millet. The length of growing period is 90-150 days (Ojanuga, 2006). The climate of Sokoto State is wet and dry, generally hot semi-arid tropics in Koppen classification of A_w type. It is characterized by long dry season from October to May/June and a short but intensive wet season from May/June through September with a mean annual rainfall slightly below 750 mm. The rainfall pattern shows a marked seasonal variation with a single peak reaching maximum in August (Ikpe, 2021). The mean annual rainfall decreases gradually from the south to northern parts of the state. The rainy season is then followed by a short dry spell which could last for two to three months known as Harmattan. A period of cold, dry and dusty weather normally precedes the fairly long dry season. The temperature fluctuates within a range of 16 ^{0}C during cold nights to over 40 ^{0}C during the hot days. The relative humidity during dry season is about 15-20% and reaches up to 70-75% during the rainy season (Ikpe, 2021).

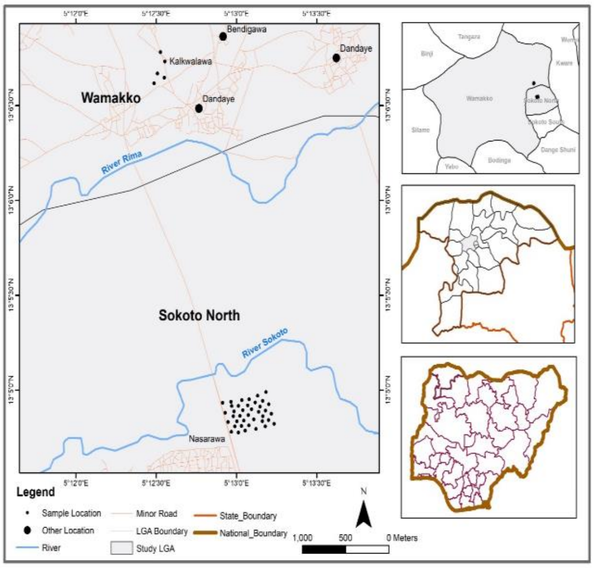

Figure 1: The Study Area
Source: Adapted from the Administrative Map of Sokoto State.

2.2 Soil Sampling

The study involved a detailed soil survey using rigid-grid method (100 m × 100 m) super imposed on the two floodplains (Kolkolawa and Nasarawa floodplains). Surface soil were collected at a depth of 30cm from the intersections of the grinds in the two locations using soil auger. Eighteen soil samples were collected from Kolkolawa floodplain while Thirty-nine samples were collected from Nasarawa floodplains. The difference in samples size was due to the size of the floodplains. The bulked samples was collected for laboratory analysis.

2.3 Laboratory Methods

The samples were air-dried, gently crushed using a wooden mortar and pestle and then sieved through a 2mm mesh. The sieved samples were stored for chemical and physical analyses. Particle size distribution was determined by the hydrometer method (Agbenin, 1995). Soil pH (1:1) in H_20 was determined using glass electrode pH meter (Jimoh, 2017). Organic carbon content of the soils was determined by the

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modified Walkley-Black method as described by Agbenin, (1995). Avail P was determined using Bray 1 method while TN was determined by the kjeldahl method. Exchangeable bases (calcium, magnesium, potassium and sodium) in the soil were determined using HCl extract from the CEC determination. Sodium and K were determined using flame photometer while Ca and Mg were determined using atomic absorption spectrometer. The effective cation exchange capacity (ECEC) was determined by summation methods (Agbenin, 1995).

Qualitative land suitability evaluation for rice production

Qualitative or Non-parametric method of land suitability evaluation for rice was carried out using the FAO method (FAO, 2006) (Table 1).

Table 1. Factor Ratings of Land Use Requirements for Rice Suitability

Factors/ Land Qualities /Characteristics	Unit	S1 (100)	S2 (85)	S3 (60)	N (40)
Climate (c)					
Annual rainfall	mm	> 1250	1000 – 1250	850 - 1000	<850
Mean Temperature	oC	29 - 32	21-29	18 – 21	< 18
Erosion Hazard (e)					
Slope	%	0 – 2	2 – 4	4 – 7	7 – 12
Wetness (w)					
Drainage		imperfectly, moderately	well to poorly	v. poorly	excessively
Rooting Condition (r)					
Effective soil depth	Cm	>100	75 – 100	50 75	< 50
Soil Physical Characteristics (s)					
Soil texture		SL, SCL, L, CL	SiCL, SC	SiC, LS	S, C
Chemical fertility (f)					
Soil Ph		5.5 – 7	4.5 – 5.4, 7.0 - 8.5	4.0 - 4.5, 8.5 - 9.0	<4.0, >9.0
Organic Carbon	(gkg-1)	20 – 40	10 – 20	5 – 10	< 5
Total Nitrogen	(gkg-1)	> 2	1 – 2	0.5 – 1	< 0.5
CEC	(cmolkg-1)	>18	12 – 18	6 – 12	< 6
Avail. P	(gkg-1)	> 15	10 – 5	5.0 – 10	< 5.0
Exchangeable K	(cmolkg-1)	> 0.2	0.1 – 0.2	< 0.1	< 0.1
Salinity Hazard (n)					
Electrical Conductivity	dS/m	< 3	4 – 8	8 – 12	12 – 16

SL: sandy loam, LS: loamy sand, SCL: sandy clay loam, L: loam, C: clay, gSL: gravelly sandy loam,

CL: clay loam, SiL: silt loam, SC: sandy clay, SiC: silty clay, S: sand, C: clay.

Table 1 presents the factor ratings for land use requirements for rice suitability, categorizing land qualities/characteristics into four suitability classes: S1 (highly suitable), S2 (moderately suitable), S3 (marginally suitable), and N (not suitable). Table 1 outlines the specific requirements for various factors, including climate, erosion hazard, wetness, rooting condition, soil physical characteristics, chemical fertility, and salinity hazard.

Climate (c)

- Annual rainfall: Rice requires high rainfall, with >1250 mm being highly suitable (S1). The suitability decreases as rainfall decreases, with <850 mm being not suitable (N).
- Mean temperature: The ideal temperature range for rice is 29-32°C (S1), with a slightly broader range (21-29°C) still considered moderately suitable (S2).

Erosion Hazard (e)

- Slope: Rice is highly suitable for flat lands with slopes between 0-2% (S1). As the slope increases, the suitability decreases, with slopes >7% being not suitable (N).

Wetness (w)

- Drainage: Rice requires well-drained soils, with imperfectly drained soils being moderately suitable (S2) and poorly drained soils being marginally suitable (S3). Very poorly drained soils are not suitable (N).

Rooting Condition (r)

- Effective soil depth: Rice requires deep soils, with >100 cm being highly suitable (S1). The suitability decreases as soil depth decreases, with <50 cm being not suitable (N).

Soil Physical Characteristics (s)

- Soil texture: Rice grows well in soils with textures ranging from sandy loam (SL) to clay loam (CL) (S1). Soils with textures like silty clay loam (SiCL) or sandy clay (SC) are moderately suitable (S2).

Chemical Fertility (f)

- Soil pH: The ideal pH range for rice is 5.5-7 (S1), with slightly acidic or alkaline soils still being moderately suitable (S2).
- Organic carbon: Rice requires high organic carbon content, with 20-40 g/kg being highly suitable (S1).
- Total nitrogen: Rice requires high total nitrogen content, with >2 g/kg being highly suitable (S1).
- CEC: A high cation exchange capacity (CEC) is desirable, with >18 cmol/kg being highly suitable (S1).
- Available phosphorus: Rice requires high available phosphorus, with >15 g/kg being highly suitable (S1).
- Exchangeable potassium: A high exchangeable potassium content is desirable, with >0.2 cmol/kg being highly suitable (S1).

Salinity Hazard (n)

- Electrical conductivity: Rice is sensitive to salinity, with electrical conductivity <3 dS/m being highly suitable (S1). As salinity increases, the suitability decreases, with >12 dS/m being not suitable (N).

Table 1 further provides a comprehensive framework for evaluating the suitability of land for rice production. By comparing the land characteristics with the specified requirements, farmers and land-use planners can determine the suitability of the land for rice cultivation. This information can be used to:

a. Identify areas with high potential for rice production
b. Determine the limitations and constraints of the land
c. Develop strategies for improving soil fertility and structure
d. Optimize irrigation and drainage systems
e. Select suitable rice varieties for specific land conditions

By using this framework, farmers and land-use planners can make informed decisions about land use and management, ultimately contributing to sustainable agricultural practices and food security.

2.3 Quantitative Land Suitability Evaluation for Rice Production

In quantitative (parametric) method of land evaluation, each limiting characteristic was rated as follows:

Table 2. Suitability index for the Crop Suitability Classes

Class	Suitability Index	Definition
S1	>75	Highly suitable
S2	50 – 74	Moderately suitable
S3	25 – 49	Marginally suitable
N1	15 – 24	Currently not suitable
N2	< 15	Permanently not suitable

Adapted from Ogunkunle (1993)

The index of productivity for each soil mapping units was calculated using Ogunkunle (1993) modified equations:

$$IP = A \times \sqrt{(B/100 \times C/100 \times D/100 \times E/100 \times F/100)} \quad ..... 1$$

Where;

A= overall lowest characteristic rating of all land quality groups (Nutrient availability), B, C, D, and E are lowest characteristic ratings for their respective land quality group.

The land characteristic was grouped into the following land qualities; climate (c), soil physical property (p), wetness (w), Nutrient availability (f) and Salinity (S).

The suitability classification was done separately for each soil unit identified in the study area.

Productivity index was calculated using the following methods:

i. Potential Index of Productivity (IPp): The calculation of IPp considered relatively stable soil properties, including cation exchange capacity, base saturation, pH, and organic matter, which are part of the fertility (f) group. Easily alterable chemical properties, such as exchangeable K, Ca, available P, and total N, were excluded from the calculation.
ii. Current Index of Productivity (IPc): In contrast, the calculation of IPc included both the stable soil properties (like cation exchange capacity, base saturation, pH, and organic matter) and the easily alterable chemical properties (such as exchangeable K, Ca, available P, and total N). This comprehensive approach provides a more detailed assessment of the soil's current productivity potential.

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3.0 RESULT AND DISCUSSION

The results of the soil physical and chemical analysis are presented in Table 3. The soil texture in Kolkolawa was classified as loamy sand, while the soils in Nasarawa were classified as silt clay loam. The soil pH in the Kolkolawa floodplains ranged from slightly alkaline to strongly alkaline (7.99), whereas the soils in the Nasarawa floodplains ranged from moderately acidic to strongly alkaline (7.28).

Table:3 Land Characteristics of soils in the study area

Location	Kolkolawa	Nasarawa
Climate (c)		
Annual rainfall	650 – 750	650 – 750
Mean Temperature	20 – 40	20 – 40
Land/soil physical property		
Slope (%)	0 – 2	0 – 2
Soil Depth (cm)	60 – 164	100 – 206
Soil Texture Class	SL, L, SiCL	CL, C, LC
Drainage	Well – imperfectly	imperfectly – poorly
Nutrient availability (top soil)		
pH (H_2O)	7.99	7.28
Organic Carbon (gkg^{-1})	5.27	9.72
Total Nitrogen (gkg^{-1})	1.27	1.48
Available P ($mgkg^{-1}$)	25.19	22.13
Exchangeable K ($mgkg^{-1}$)	0.14	0.91
ECEC (cmol(+)kg^{-1})	8.66	19.7
Base Saturation (%)	71.24	70.99
Electrical Conductivity (dS/m)	0.35	0.79

Source: Laboratory/Author's Analysis, 2024

The soil organic carbon (OC) content in the Kolkolawa floodplains was rated very low to medium, while the soils in the Nasarawa floodplains were rated low to high. The soil total nitrogen (TN) content in Kolkolawa ranged from very low to high, while the soils in Nasarawa were rated low to high in TN. The available phosphorus (AP) content in Kolkolawa ranged from very low to high (25.19), while the soils in Nasarawa were rated low to high (22.13).

The soil exchangeable potassium (K) content in Kolkolawa was rated low to high, while the soils in Nasarawa were rated low to very high. The effective cation exchange capacity (ECEC) of the soils in the Kolkolawa floodplains was rated low to high, while the soils in the Nasarawa floodplains were rated medium to high (0.91).

3.1 Qualitative Land Suitability Classification for Rice Production

A summary of the land qualities of the study area is presented in Table 3, while the assessment ratings resulting from matching the land qualities with the requirements for rice are shown in Table 4, using the FAO (1983) suitability ratings.

The mean annual rainfall of the two floodplains was rated marginally suitable due to low rainfall (<800 mm). In contrast, the temperature was considered moderately suitable (20 – 40ºC) (S2) for both floodplains. This finding confirms the report of Buji et al. (2022b), who also classified the floodplain soils of Rabah District, Sokoto State, as permanently not suitable (N2) for rice production, citing climate as a major limitation.

The slope of <2% made both floodplains highly suitable (S1) for rice cultivation. According to Fasina and Adeyanju (2006), a slope of <3% may favor mechanical operations. Additionally, Sys et al. (1993) classified slopes of 0-4% as optimal for annual arable farming and 0-8% for perennial crops and grassland.

In terms of soil depth, the soils in Kolkolawa had a depth of 60-164 cm, making them moderately suitable, while the soils in Nasarawa had an effective soil depth of >100 cm, making them highly suitable (S1) for rice cultivation. Based on soil texture, the soils in Kolkolawa were moderately suitable, while those in Nasarawa were highly suitable (S1) for rice. The entire floodplains were imperfectly drained, resulting in a rating of moderately to highly suitable (S2 to S1).

Regarding soil reaction (pH), the soils in both Kolkolawa and Nasarawa were moderately suitable (S2). In terms of organic carbon content, the soil in Kolkolawa was marginally suitable (S3), while the soil in Nasarawa was moderately suitable (S2) (Table 4).

Both Kolkolawa and Nasarawa soils were highly suitable (S1) with regards to available phosphorus and electrical conductivity. However, they were moderately suitable (S2) with regards to total nitrogen. In terms of exchangeable potassium, the soil in Kolkolawa was marginally suitable, while the soil in Nasarawa was highly suitable (S1). Considering nutrient retention ability (ECEC), the soil in Kolkolawa was marginally suitable (S3), whereas the soil in Nasarawa was highly suitable (S1).

Table 4: Suitability Class Scores and Aggregate Suitability of soils in the study area

Location	Kolkolawa	Nasarawa
Climate (c)		
Annual rainfall	S3 (60)	S3 (60)
Mean Temperature	S2 (85)	S2 (85)

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Land/soil physical property		
Slope (%)	S1 (100)	S1 (100)
Soil Depth (cm)	S2 (85)	S1 (100)
Soil Texture Class	S2 (85)	S1 (100)
Drainage	S1 (100)	S2 (85)
Nutrient availability (top soil)		
pH (H_2O)	S2 (85)	S2 (85)
Organic Carbon (gkg-1)	S3 (60)	S2 (85)
Total Nitrogen (gkg-1)	S2 (85)	S2 (85)
Available P ($mgkg^{-1}$)	S1 (100)	S1 (100)
Exchangeable K (cmolkg-1)	S2 (85)	S1 (100)
ECEC ($cmol(+)kg^{-1}$)	S3 (60)	S1 (100)
Electrical Conductivity (dS/m)	S1 (100)	S1 (100)
Qualitatively	S3	S3
Quantitatively Current Suitability	8 (N2)	27 (S3)
Potential Suitability	37 (S3)	43 (S3)

Source: Author's Analysis, 2024

The results as presented in Table 4 showed that, the soil in Kolkolawa was classified as marginally suitable (S3) for rice production due to limitations such as low organic carbon, ECEC, and rainfall. Similarly, the soils in Nasarawa were also marginally suitable (S3) due to low rainfall. This finding is consistent with previous studies by Oluwatosin (2005) and Jimoh et al. (2018), which reported that soil fertility is a major limitation to the suitability of Nigerian soils for crop production. Buji et al. (2022b) also found that the floodplain soils of Rabah District, Sokoto State, were permanently not suitable (N2) for rice production due to climate limitations.

Other limitations to rice production in the study area include low total nitrogen, organic carbon, available phosphorus, and base saturation. However, these limitations can be addressed through good management practices and improved drainage to optimize rice production. The overall suitability of the Kolkolawa and Nasarawa floodplains for rice production was classified as suitable (S), with a class rating of marginally suitable (S3) and a subclass rating of f/c (fertility/climate). The suitability units were fc-1 (fertility/climate) for Kolkolawa and c-1 (climate) for Nasarawa. Generally, the soils of the floodplains exhibit deficiencies in organic carbon, ECEC, and rainfall.

3.2 Quantitative Land Suitability Classification for Rice Production

Using the parametric method of land evaluation, the soils of the Kolkolawa floodplains were classified as permanently not suitable (N2) under current conditions, with a suitability aggregate score of 8. However, they were classified as marginally suitable (S3) potentially, with an aggregate score of 37, based on the current productivity index. In contrast, the soils of the Nasarawa floodplains were classified as marginally suitable (S3) for both current and potential suitability classifications (Table 4).

The results of the parametric and non-parametric suitability evaluations showed a mutual relationship, indicating that both methods were correlated, with similar suitability classes, except for the current suitability of the Kolkolawa floodplains. Climate, being a natural factor, cannot be easily corrected or manipulated (Buji et al., 2022a). Notably, although low rainfall was a major limiting factor, it may not be a significant issue in the floodplains due to the availability of water from the river, which can be used to supplement the low rainfall.

3.3 Overall Qualitative and Qualitative Suitability of the floodplains.

The crop requirements (Table 1) and soil qualities (Table 3) in the study area were matched with the rating of land use requirements for rice. The soils of the floodplains were rated low with respect to organic carbon, rainfall, and ECEC, which could significantly reduce productivity. Based on the climatic conditions, the floodplains were classified as marginally to moderately suitable. Considering soil factors, the floodplains were categorized into the order "suitable," class S3 (marginally suitable), subclass f/c (fertility/climate), with units fc-1 and c-1 (fertility and climate).

Generally, both parametric and non-parametric methods of evaluating the floodplain soils of Sokoto showed that the soil in Kolkolawa was ranked as marginally suitable (S3fc-1) qualitatively and permanently not suitable (N2, 8.0) to marginally suitable (S3, 27) for both current and potential productivity quantitatively (Table 4). The limiting factors for the suitability of the soil for rice production were climate and fertility status, specifically rainfall, organic carbon, and ECEC.

Similarly, the soil in Nasarawa was evaluated as marginally suitable (S3c-1) qualitatively and S3 (27-47) quantitatively for floodplain rice production (Table 4). These findings are consistent with those of Buji et al. (2022b), who reported that the floodplain soils of Rabah District, Sokoto State, were limited by climate and fertility.

The results in Table 4 have the following implications for rice production and food security:

3.4 Policy Implications of Results

3.4.1 Rice Production:

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i. Limited suitability: The soils in both Kolkolawa and Nasarawa are marginally suitable (S3) for rice production, indicating that there are limitations that need to be addressed.
ii. Climate limitation: Low rainfall is a major limitation in both locations, which can impact rice yields and productivity.
iii. Soil fertility constraints: Low organic carbon and ECEC in Kolkolawa, and to some extent in Nasarawa, can limit rice production.
iv. Potential for improvement: With proper management, such as irrigation and organic amendments, the suitability of the soils for rice production can be improved.

3.4.2 Food Security:

i. Food security challenges: The limited suitability of the soils for rice production can impact food security in the region, particularly if rice is a staple crop.
ii. Need for sustainable agriculture: To ensure food security, sustainable agricultural practices that address the limitations of the soils need to be implemented.
iii. Importance of irrigation: Irrigation can play a crucial role in improving rice productivity and ensuring food security in the region.
iv. Opportunities for development: The potential for improving soil suitability through proper management practices presents opportunities for agricultural development and food security in the region.

Overall, the results highlight the need for careful planning and management of rice production in the Sokoto-Rima floodplains to ensure food security and sustainable agricultural development.

CONCLUSION AND RECOMMENDATION

This paper has assessed soil suitability evaluation of the Sokoto-Rima flood plains for rice production: implications for food security in Sokoto State, Nigeria. The mean temperature, slope, soil depth, soil texture, and drainage factors were highly to moderately suitable for rice cultivation, while rainfall was marginally suitable in terms of the physical characteristics of the floodplains. In terms of soil nutrients, soil pH, total nitrogen, available phosphorus, potassium, and electrical conductivity were highly to moderately suitable for rice cultivation. However, soil organic carbon and ECEC were moderately suitable for Nasarawa but marginally suitable for Kolkolawa floodplains. The limiting factors for rice cultivation in Kolkolawa were rainfall, organic carbon, and ECEC, which rendered the soil marginally to not suitable. In contrast, rainfall was the only limiting factor in Nasarawa, rendering the soil marginally suitable. The major constraints to rice production in these soils are low rainfall, low levels of organic matter, and ECEC.

Based on the study's findings, the following recommendations are proposed:

a. Develop and implement effective irrigation systems to supplement low rainfall and support rice production.
b. Incorporate organic amendments such as farmyard manure, plant residues, and household refuse to enhance soil organic carbon and improve soil health.
c. Promote sustainable agricultural practices that support long-term soil fertility and productivity.
d. Strengthen soil fertility management strategies, including maintaining and improving existing practices.

By implementing these recommendations, the productivity and suitability of the Sokoto-Rima floodplains for rice production can be improved, contributing to food security and sustainable agricultural development in the region.

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*Corresponding Author: **Patrick Ikpe Ukoh**