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# Suitability Evaluation of Selected Soils for Cassava Production in Akwa Ibom State, Nigeria

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## ABSTRACT

*This study was conducted to evaluate the suitability of selected soils for the cultivation of cassava in Akwa Ibom State for food security. Based on parent material, topography and drainage, four soil types were selected for the study. Profile pits were dug in each soil type at representative location. A total of fifteen (15) profile pits were sunk and described based on FAO (2006) guidelines for profile description. Soil samples were collected based on genetic horizons for laboratory analysis. The result of land suitability evaluation revealed that the land was not suitable for the cultivation of cassava. Soil types 1 and 4 were not suitable (N1) (25.30) with fertility (low pH, Av. P, CEC and Exch. K) in soil type 1 and (low Av. P and Exch. K) in soil type 4 as major limitation, while soil types 2 and 3 were also not suitable (N1) (12.39) with wetness (drainage - inadequate oxygen availability) and fertility (Exch. K) in soil type 2 and (low Av. P and Exch. K) in soil type 3 as major limitations. Management techniques such as application of chemical fertilizer and organic matter to enhance nutrient holding capacity of the soils and supply deficient nutrients will in turn raise the productivity of these soils. In addition, it is highly recommended that regular soil tests should be carried out for proper fertilizer application as well as land suitability evaluation to ascertain whether the land is suitable for the cultivation of cassava or other crops.*

**Key words:** *Land suitability, evaluation, cassava production*

**INTRODUCTION:** In view of the dwindling available land for food production and in the face of the ever increasing population, efficient and effective use of land requires that soil should be used according to its suitability. Soil information on soil potentials is a pre-requisite for effective land use planning. Such information is necessary in the implementation of effective management strategies for sustainable agricultural production. Land suitability evaluation is a tool for predicting land performances in terms of expected proceeds, constraints and environmental problems from the productive use of land (Morales and de Vries, 2021; Mohammed and Suliman, 2023). While land evaluation is also defined as “the process of assessment of land performance when used for specific purposes, involving the execution and interpretation of surveys and studies of landforms, soils, vegetation, climate and other aspects of land in order to identify and make a comparison of promoting kinds of land use in terms applicable to the objectives of the evaluation (Mohammed, Lawal, Panti, Isah and Muntaka 2021). Land evaluation is often carried out in response to recognition of a need for changes in the way in which land is currently being used. The information and recommendations from land evaluation represent only one of the multiple inputs into the land use planning process (Mwendwa, Mbuvi and Kironchi, 2019). However, the evaluation is a vital link in the chain leading to sustainable management of land resource (Kefas, Maigida, Ezeaku, Ofem, Akwoga and Ezeaku, 2020). Making optimum agricultural land use decisions are vital to achieving sustainable productivity on land as well as ensuring environmental health (Kumar, Mahapatra and Surya, 2021). Land suitability analysis is one of the key processes of the land use planning (Shakya, Shrestha, Sharma, Gurung, Mihin, Yang, Jamir, Win, Han, Yang, Choudhury. and Schneider, 2019) and is prerequisite to achieving optimum utilization of the available land resources (Everest *et al*., 2021) as well as can establish strategies to increase agricultural productivity (Ustaoglu, 2022).

Cassava (*Manihot esculenta*) is a perennial woody shrub with edible root, was first cultivated in South America and introduced to Nigeria in the sixteenth century (Kégah and Ndjouenkeu, 2023). Nigeria remains the higher producer of cassava in the world with about 60 million metric tons (FAO, 2022) and cassava is available all year round, making it preferable over other seasonal crops as grains, peas and beans and other crops of food security (Adewole, Popoola, Obasoro and Adeoti, 2019). It is considered food for the poor and has been a widely criticized crop for its propensity to deplete soil nutrients and open the farmland to erosion (Simon, Olufemi, Oluwasegun. and Adetola, 2019). In view of this, a large proportion of cassava crops are grown on marginal lands (bad topography) that are usually not competitive (not too good for other crops) and some others are not tractor friendly. Nigeria is populated with about 200 million people and about 80 % of Nigerians consume at least a product of cassava once in a day (Salau, Noflu and Jimoh, 2019). The increasing importance of cassava (*Manihot esculenta*) among crops grown in Nigeria is not only connected to its increasing demand as food but also as food security (Adewole *et al*., 2019; Otekunrin and Sawicka, 2019; Saranraj *et al*., 2019). Since cassava plays important role in food security, it constitutes a staple food for more than 800 million people in this part of the globe (Nigeria) and Sub-Saharan African Countries (Munyahall, Birindwa, Pypers, Swennen, Vanlauwe and Merckx, 2023) and its usage cannot be underestimated. Therefore, cassava roots are either consumed boiled or processed into products such as cassava flakes (garri), cassava flour (pupuru and lafun), cassava paste (fufu), akpu, chips, attieke (cassava couscous), tapioca and sliced/dried cassava roots/chips (abacha) as well as industrial products such as ethanol and starch (Onyediako and Adiele, 2022; Kégah and Ndjouenkeu, 2023). Aside from food, cassava is very adaptable as its derivatives and starch are applicable in many types of products such as confectionery, sweeteners, glues, plywood, textiles, paper, biodegradable products, monosodium glutamate and drugs. Cassava chips and pellets are used in animal feed and alcohol production. In addition, cassava has many other benefits such as providing income to smallholders serving as famine reserved crop, a source of industrial raw materials for the production of starch, plywood, alcohol and animal feed as well as the leaves and shoots which are relatively high in protein, are often eaten in Asian and African countries (Ajala, Kpadonou, Adjadeh, Akponikpe and Olaniyan, 2020; Ravindran, 2021; Onyediako and Adiele, 2022). Furthermore, Omondi and Frediansyah (2021) also reported that the importance of cassava increases gradually in the beer and pharmaceutical industries due to demand for its starch.

However, ineffective cassava cultivation lies in the non-suitable land which brings about poor crop yields. Since cassava takes up soils essential nutrients without replenishment, the application of macro-elements through fertilization can increase cassava yields (Irianto, Mujiyo, Qonita, Ningsih and Riptanti, 2020; Irianto, Mujiyo, Qonita, Ningsih and Riptanti, 2020a; Calvallari, Fernandes, Mota, Leite and Piroli, 2021; Zhou, Yrjälä, Chen, Yu, Shi, Qin and Wu, 2022; as well as organic manure (Omenda, Ngetich, Kiboi, Muchenu-Muna and Mugendi, 2019) and adoption of good management practices (Okeoghene and Isiorhovoja, 2019; Gougodo de Mon-Zoni, Kosh-Komba, Omenda, Zaman, Mingabaye,-Bendima, Batawila and Akpagana, 2023). In addition, total N can be improved through the combined application of biological and chemical fertilizer to support the concept of sustainable and integrated agriculture and minimize the adverse effects of chemical fertilizers (Amalia, Budiasih, Ria, Widodo and Kuswati, 2020).

To address current and future food security through the efficient use of land resources, the assessment of the capability and suitability of disposable land is required through spatial based analytical and optimization approaches (Purnamasari, Ahamed and Noguchi, 2019; Yu, Shan and Wu, 2021). In addition, for sustainable agricultural development and food production, robust and efficient management of agricultural land is required (Viana, Freire, Abrantes, Rocha and Pereira, 2022) especially cassava which is a staple crop that is important for food security in Nigeria. Therefore, the objectives of this study was to evaluate the physical land suitability of cassava which will assist land managers and land planners to identify areas with physical constraints for a range of nominated land uses and to identify the management requirements that will ensure that a particular land use can be sustained for the production of cassava in the state.

**MATERIALS AND METHODS: Description of the Study Areas:** The study area lies between latitudes 4° 33" and 5° 33" North and Longitudes 7° 35" and 8° 25" East bounded by Rivers State, Cross River State, Abia and Gulf of Guinea on the East, West, North and South respectively (AKSG, 2023). The study areas cut across four (4) soil types (ST) overlain with Beach Ridge Sand, Coastal Plain Sand, Sandstone/Shalestone/Coastal Plain Sand and Alluvial Deposits (River Alluvium) parent materials in Akwa Ibom State. The sites overlain with beach ridge sand were (Ikot Abasi, Onna and Eket – soil type 1), alluvial deposits (river alluvium) (Uruan, Ini, Ini and Ini– soil type 2), coastal plain sand (Nsit Atai, Uruan, Uyo and Ibesikpo/Asutan – soil type 3) and sandstone/shalestone/coastal plain sand (Itu, Ibiono

Ibom, Ini and Ini - soil type 4). Originally, this region belonged to the humid tropical forest zone of southern Nigeria. The natural vegetation of this kind resulted from the interaction of climate, humidity, rainfall and soil (Adepoju, Adelabu and Fashae, 2019). However, on the account of prolonged human occupation and resource exploitation, the forest cover has largely been removed, modified and/or converted in line with the needs, aspirations and socio-economic realities of the inhabitants. On the land use pattern, there is a clear orientation towards arable crop production as the main agricultural enterprise across the entire State (Adepoju *et al*., 2019). The wet season usually starts from April to October; annual rainfall varies from 3000 mm along the coast to about 2250 mm at the extreme north; while dry spell sets in from November to March. Over the entire region, the mean annual temperature ranges between 27° C and 28° C. The mean annual relative humidity decreases steadily from the coast towards the interior reflecting the effects of the maritime (Weather Spark, 2022).

***Field Sampling***

Profile pits were sunk in the study area and in each profile pit, soil description was carried out in accordance with the FAO (2006) guidelines for soil profile description. A total of Fifteen (15) soil samples were collected based on genetic horizons. Cylindrical cores were used to vertically collect soil samples for bulk density and saturated hydraulic conductivity determinations using core rings in the laboratory. The sampling and laboratory analysis were conducted in March 2022.

***Laboratory analysis***

According to standard laboratory procedures, the soil samples were prepared for laboratory analyses as described by Udo, Ibia, Ogunwale, Ano and Esu (2009). The samples were air-dried under laboratory condition, then gently crushed with mortar and pestle and passed through a 2 mm mesh sieve. Particle size was determined by the Bouyoucos hydrometer method with sodium hexametaphosphate acting as a dispersing agent, bulk density was evaluated using the core method. Soil pH was determined in 1: 2.5 soil: water ratio using a glass electrode pH metre. Organic carbon was determined by the Walkley and Black wet oxidation method and total Nitrogen by macro Kjeldahl digestion method, while. Available P was determined by the Bray 1 method. Exchangeable cations (Ca, Mg, K and Na) were extracted with neutral ammonium acetate $NH_4OAc$ (pH 7.0). Calcium and Magnesium in the extract were determined by EDTA titration method, while Sodium and Potassium from the extract were determined using the flame photometer. Exchangeable acidity (exchangeable $H^+ + Al^{3+}$) was extracted with 1 M KCl solution. The exchange Hydrogen and the exchangeable Aluminium were determined by titration. Exchangeable Hydrogen was obtained by subtracting exchangeable Aluminium from exchangeable acidity. Exchange acidity ($Al^{3+} + H^+$) – Exchangeable Al = Exchangeable H. Effective Cation Exchange Capacity (ECEC) was calculated by the summation of the values of all exchangeable bases ($Ca^{2+} + Mg^{2+} + K^+ + Na^+$) and the exchangeable acidity ($Al^{3+} + H^+$). Percentage base saturation was computed using the formula:

$$\% \text{ Base Saturation} = \frac{\text{Total Exchangeable Bases}}{\text{ECEC}} \times 100$$

***Soil suitability evaluation for cassava production/cultivation:*** Evaluation of the suitability of the soils in the study area for cassava cultivation was based on the soil parameters analysed. This was done by matching the soil requirements for cassava cultivation as presented by Irianto *et al*. (2020), with the observed nutrient status of soils in the various study areas. Irianto *et al*. (2020), while evaluating the land quality and factor rating for cassava cultivation stated that the test crop can thrive maximally on slightly fine, medium and slightly coarse textured soils. The following chemical characteristics were however specified in nutritional requirements for cassava in accordance with Irianto *et al*. (2020): soil pH (5.9-7.0), organic matter (>2.5), Total N (>0.21). Index of productivity (IP) (actual and potential) was calculated using the following equation:

$$IP = A \times \sqrt{\frac{A}{100} \times \frac{B}{100} \times \frac{C}{100} \times \frac{D}{100} \ldots\ldots\ldots n}$$

Where, A is overall fertility limiting and B, C, D…n is the lowest characteristic ratings for each land quality group. The five (5) land quality groups: climate (c), topography (t), soil physical properties (s), wetness (w) and fertility (f) were used in this method of evaluation. For calculation purpose, only one member in each group was used because there are strong correlations among members of the same group (e.g. texture and structure).

For actual productivity index, all the lowest characteristics ratings for each land quality group were substituted into the equation above. Conversely, for potential productivity index, it was assumed that the corrective fertility measure will no longer have fertility constraints. Suitability classes S1 (highly suitable), S2 (moderately suitable), S3 (marginally suitable) and N (currently not suitable) are equivalent to IP values of 100-85, 84-60, 59-40 and 39-0 were used for the rating

**Table 1: Land quality and factor rating for cassava (*Manihot esculenta crantz*)**

| Soil and Land Characteristics | Land class, degree of limitations and rating scale | | | |
|---|---|---|---|---|
| | **S1 (100 %)** | **S2 (85 %)** | **S3 (60 %)** | **N (40 %)** |
| | **(1)** | **(2)** | **(3)** | **(4)** |
| **Climate (c)** | | | | |
| **Temperature (ºC)** | | | | |
| Average temperature | 18-20 | 20-22 | 16-18<br>22-24 | >24<br><16 |
| **Water availability (wa)** | | | | |
| Rainfall (mm/year) | 3000-4000 | 2000-3000<br>4000-4500 | 1000-2000<br>4500-5000 | <1000<br>>5000 |
| **Wetness (w)** | | | | |
| **Oxygen availability (oa)**<br>Drainage | Well-drained, slightly well-drained, slightly obstructed | Somewhat excessively drained | Obstructed | very obstructed, excessively drained |
| **Soil Physical Characteristics (s)** | | | | |
| **Root capacity (rc)** | | | | |
| Texture | Slightly fine, medium, slightly coarse | Fine | Very fine | Coarse |
| Coarse material (%) | <15 | 15-35 | 35-55 | >55 |
| Soil depth (cm) | >75 | 50-75 | 20-50 | <20 |
| **Fertility (f)**<br>**Nutrient availability (na)** | | | | |
| Total N (%) | >0.21 | 0.1-0.20 | <0.10 | - |
| $P_2O_5$ ($MgKg^{-1}$) | >21 | 15-20 | <15 | - |
| $K_2O$ ($MgKg^{-1}$) | >21 | 10-20 | <10 | |
| **Nutrient retention (nr)**<br>CEC ($CmolKg^{-1}$)<br>Base saturation (%)<br>pH ($H_2O$)<br><br>Organic carbon (%) | <br>>27<br>>52<br>5.9-7.0<br><br>>2.5 | <br>16-27<br><52<br>5.5-5.9<br>7.0-7.6<br>2.0-2.5 | <br><16<br><5.5<br>>7.6<br><br><2.0 | <br>-<br>-<br>-<br><br>- |
| **Erosion Hazards (eh)**<br>Slope (%)<br>Erosion hazards | <br>0-15<br>Very light, light | <br>15-30<br>Medium | <br>30-45<br>Heavy | <br>>45-<br>Very heavy |
| **Land Preparation (lp)**<br>Rock surface (%)<br>Rock outcrop (%) | <br><0.1<br><0 | <br>0.1-3.0<br>1-10 | <br>3.0-25.0<br>10-20 | <br>>25.0<br>>20 |

S1: Highly Suitable; S2: Moderately Suitable; S3: Marginally Suitable; N: Not Suitable
**Source**: Irianto *et al.* (2020)

**RESULTS AND DISCUSSION:** ***Procedure for data analysis***: Descriptive statistics such as mean and standard deviation were employed to analyze the data.

***Physico-chemical characteristics of soils:*** The morphological, physical and chemical characteristics of the soil profiles are presented as follows. Colour varied in all the soil types. In soil type 1, the colour ranged from dark brown (7.5YR 3/2) to brown (7.5YR 4/2) in the Ap horizon, while the B horizon ranged from reddish yellow (7.5YR 4/6), light brown (7.5YR 6/3) to reddish brown (7.5YR 6/8). In soil type 2, soil colour ranged from dark brown (7.5YR 3/3), dark red (7.5YR 4/1) to brown (7.5YR 4/3) in the Ap horizon; while at the B horizon, soil colour varied from very dark gray

(7.5YR 3/1), gray (7.5YR 5/1), pinkish gray (5YR 6/4) to light reddish brown (5YR 6/4). In soil type 3, soil colour ranged from brown (10YR 4/3), brown (7.5YR 4/3) to dark brown (7.5YR 3/2) in the Ap horizon; while it ranged from brown (7.5YR 4/4), strong brown (7.5YR 4/6) to strong brown (7.5YR 5/6) in the B horizon. In soil type 4, the colour of soils ranged from black (7.5YR 2.5/1), dark brown (7.5YR 3/3) to brown (7.5YR 4/3) in the Ap horizon; whereas soil colour varied from red (2.5YR 4/8), dark brown (7.5YR 3/2), dark gray (7.5YR 4/1) to strong brown (7.5 YR 5/6) in the B horizon. The black to dark brown colours in the Ap horizons could be attributed to humification and decomposition of plant and animal remains (Kefas *et al*., 2020) as well as the submission of Zhang, Hartemink, Huang and Minasny (2021) that soil colour is determined by mineral composition, elemental concentration, organic matter and moisture content.. The consistency ranged from friable to firm. Generally, the particle size distribution of sand, silt and clay varied from profile to profile. Very high sand contents were recorded across profiles studied. In soil type 1, sand fraction ranged from 89.32 to 93.33 % (mean 92.29 %) in the Ap horizon and 83.32 to 93.68 % (mean 89.56 %) in the B horizon. The clay fraction ranged from 4.74 to 5.04 % (mean 4.94 %) in the Ap horizon and 5.04 to10.74 % (mean 7.93 %) in the B horizon. The silt fraction ranged from 1.28 to 5.94 % (mean 2.83 %) in the Ap horizon and 0.32 to 5.94 % (mean 2.51 %) in the B horizon. In soil type 2, sand fraction ranged from 73.00 to 89.00 % (mean 83.67 %) in the Ap horizon and 67.00 to 81.68 % (mean 72.17 %) in the B horizon. The clay fraction ranged from 6.00 to 10.00 % (mean 7.76 %) in the Ap horizon and 13.04 to 26.00 % (mean 19.26 %) in the B horizon, while silt fraction ranged from 5.00 to 17.00 % (mean 8.57 %) in the Ap horizon and 5.28 to 11.00 % (mean 8.57 %) in the B horizon. In soil type 3, sand fraction ranged from 79.68 to 89.68 % (mean 84.18 %) in the Ap horizon and 73.68 to 81.68 % (mean 77.68 %) in the B horizon. The clay fraction ranged from 7.04 to 17.04 % (mean 10.54 %) in the Ap horizon and 11.04 to19.04 % (mean 16.54 %) in the B horizon. The silt fraction ranged from 3.28 to 9.28 % (mean 5.28 %) in the Ap horizon and 3.28 to 7.28 % (mean 5.78 %) in the B horizon. In soil type 4, sand fraction ranged from 94.44 to 95.44 % (mean 95.08 %) in the Ap horizon and 83.20 to 95.44 % (mean 89.16 %) in the B horizon. The clay fraction ranged from 2.70 to 4.68 % (mean 3.87 %) in the Ap horizon and 4.56 to14.80 % (mean 8.80 %) in the B horizon. The silt fraction ranged from 0.00 to 2.18 % (mean 0.93 %) in the Ap horizon and 0.00 to 4.00 % (mean 2.05 %) in the B horizon. There was no significant difference ($p < 0.05$) established between the Ap and B horizons of all the soil fractions determined across the study area. The high percentage sand in all soil types studied is a good indication of the observable high infiltration rate (Osinuga, Aiboni and Oyegoke, 2020).

The pH indicated that soils were very strongly acid (4.5-5.0) in soil types 1 and 4, while soil type 2 and 3 were strongly acid (5.1-6.0) (Enwezor, Udo, Usoro, Ayotade, Chude and Udegbe, 1989). This could be attributed to leaching or weathering of soils and plant uptake of basic cations (Ugwa, Ekpenkhio and Orobator, 2022). The mean values of electrical conductivity in the different soil types studied indicated that the soils were salt free or non-saline. Organic matter varied across the sites studied. It ranged from moderate (1.72-2.6 %) in soil types 1, 3 and 4 in the B horizon to high (2.6-3.4 %) (Enwezor *et al*., 1989) in soil types 2 and 4 in Ap horizon. Total Nitrogen was low (< 0.15 %) in all the soil types studied. Available P was rated low (<10 $mgkg^{-1}$) in soil types 1and 4 and high (> 20 $mgkg^{-1}$) (Esu, 1991) in soil types 2 and 3 (medium in B horizon). Exchangeable bases were as follows: Ca was low (2-5 $cmolkg^{-1}$) in soil type 1, moderate (5-10 $cmolkg^{-1}$) in soil types 2 and 4, very low (< 2 $cmolkg^{-1}$) in soil type 3. Mg contents was moderate (1 -3 $cmolkg^{-1}$) in soil types 1, 3 and 4, high (3-8 $cmolkg^{-1}$) (Enwezor *et al*., 1989) in soil type 2. Exchangeable K contents were very low (0.2 $cmolkg^{-1}$) (Enwezor *et al*., 1989) across the soil types. This could be attributed to the fact that soils of humid tropical rain forests are highly K deficient due to intense leaching by the high tropical rainfall (Uzoho, Ahukamere, Egboka, Afangide, Okoli, Irokwe and Ubakwe, 2022). Exchangeable Na was high (0.7-2 $cmolkg^{-1}$) in soil type 1 basically the Ap horizon and low B horizon, moderate (0.3-0.7 $cmolkg^{-1}$) (Enwezor *et al*., 1989) in soil type 2, 3 and 4. Base Saturation mean values were generally rated from moderate (40-60 %) to very high (90-100 %) across the soil types. The high base saturation in the different soil types studied could be attributed to low ECEC where the little bases saturate all the exchange sites (Landon, 1991). The ratings of these soils indicate that they are fertile and potentially productive soils. This is in agreement with the submissions of Landon (1991) that soils having greater than 60 % base saturation are rated as fertile and productive soils. The very high base saturation could be attributed to low ECEC where the little bases saturate all the exchange sites (Landon, 1991). The Exchangeable acidity of these soils though rated medium and low at the Ap and B horizon brings about the very high ratings for these soils according to Landon (1991). While, Ugwa *et al*. (2020) and Okoli *et al*. (2023) asserted that the high base saturation in the soils studied reflect the dominance of non-acid cations on exchange sites which are released to plants. However, there was no significant difference ($p < 0.05$) between the Ap and

B horizon in all the parameters analyzed across the entire study area.
Results on the outcome of the suitability evaluation for cassava cultivation indicated that climate, topography and wetness were highly suitable (S1) except in soil type 2 which was poorly-imperfectly drained and considered not suitable (N) for the cultivation of cassava. However, the suitability class score for Total N (%) was marginally suitable (S3) in the entire soil types studied. This portrayed that the soil required more inputs to correct it to moderately suitable (S2) land. This is as a result of the fact that, cassava requires high to medium level of total N availability for high performance and yield. With the level of total N observed, its maintenance should be upheld through regular application of organic matter every planting season. This is revealed in the report of Zhou *et al*. (2022), that high level of nitrogen and phosphorus should be maintained in the soils to ensure high cassava yield. The level of total N can be improved through the application of chemical fertilizers (Zhou *et al*., 2022) and organic manure (Omenda *et al*., 2019; Irianto *et al*., 2020) to correct the deficiencies in nitrogen and the adoption of good management practices (Okeoghene and Isiorhovoja, 2019; Gougodo de Mon-Zoni *et al*., 2023) in these soil types for good cassava production. In addition, total N can be improved through the combined application of biological and chemical fertilizer to support the concept of sustainable and integrated agriculture and minimize the adverse effects of chemical fertilizers (Amalia *et al*., 2020). The availability of Phosphorus in the area studied was revealed in their suitability class scores as follows: highly suitable (S1) in soil type 3, marginally suitable (S2) in soil types 2 and not suitable (N) in soil types 1 and 4 for the cultivation of cassava. However, it is pertinent to ensure high level of phosphorus since it is required at a medium level for high performance and yield (Calvallari *et al*., 2021). The low level of available P can be raised for effective cultivation through the application of chemical fertilizers to correct its deficiency in the soil types studied. The level of K in the study area revealed that it was very low and this fell into the suitability class score of N indicating that these study sites are not suitable for the cultivation of cassava. The level of K in the study area is in line with the submission of Uzoho *et al*., (2022) that soils of humid tropical rain forests are highly K deficient due to intense leaching by the high tropical rainfall. The availability of the nutrient K can be maintained through increase use of K fertilizers.
For cassava cultivation, soil types 1 and 4 were not suitable (N) (25.30) and the major limitation for the cultivation of cassava was fertility (low pH, Av. P, CEC and Exch. K) in soil type 1 and fertility (low Av. P and Exch. K) in soil type 4, while soil types 2 and 3 were also not suitable (N) (12.39) and major limitations for cassava cultivation were wetness (drainage - inadequate oxygen availability) and fertility (low Exch. K) in soil type 2 and fertility (low Exch. K) in soil type 3. The wetness (drainage - inadequate oxygen availability) can be maintained through the creation of terraces (Irianto *et al*., 2020) as well as the cultivation of cassava on mounds.

**Table 2: Actual land suitability class for soils of the study area for cassava cultivation**

| Soil and Land Characteristics | Soil Type 1 | Soil Type 2 | Soil Type 3 | Soil Type 4 |
|---|---|---|---|---|
| **Climate (c)** | | | | |
| Average Temperature | S1 (100) | S1 (100) | S1 (100) | S1 (100) |
| **Water availability (wa)** | | | | |
| Rainfall | S1 (100) | S1 (100) | S1 (100) | S1 (100) |
| **Wetness (w)**<br>**Oxygen availability (oa)** | | | | |
| Drainage | S1 (100) | S3 (60) | S1 (100) | S1 (100) |
| **Soil Physical Characteristics (s)** | | | | |
| **Root capacity (rc)** | | | | |
| Texture | S1 (100) | S1 (100) | S1 (100) | S1 (100) |
| Coarse material (%) | - | - | - | - |
| Soil depth (cm) | S1 (100) | S1 (100) | S1 (100) | S1 (100) |
| **Fertility (f)** | | | | |
| Nutrient availability (na) | | | | |
| Total N (%) | S3 (60) | S3 (60) | S3 (60) | S3 (60) |
| $P_2O_5$ ($MgKg^{-1}$) | N (40) | S2 (85) | S1 (100) | N (40) |
| $K_2O$ ($MgKg^{-1}$) | N (40) | N (40) | N (40) | N (40) |
| **Nutrient retention (nr)** | | | | |

| | | | | |
|---|---|---|---|---|
| CEC (CmolKg$^{-1}$) | N (40) | S2 (85) | N1 (40) | S3 (60) |
| Base saturation (%) | S1 (100) | S1 (100) | S1 (100) | S1 (100) |
| pH ($H_2O$) | N (40) | S2 (85) | S3 (60) | S3 (60) |
| Organic carbon (%) | S3 (60) | S1 (100) | S2 (85) | S1 (100) |
| **Erosion hazards (eh)** | | | | |
| Slope (%) | S1 (100) | S1 (100) | S1 (100) | S1 (100) |
| Erosion hazards | S1 (100) | S1 (100) | S1 (100) | S1 (100) |
| **Land Preparations (lp)** | | | | |
| Rock surface (%) | S1 (100) | S1 (100) | S1 (100) | S1 (100) |
| Rock outcrop (%) | S1 (100) | S1 (100) | S1 (100) | S1 (100) |
| **Productivity Index** | | | | |
| **Non-parametric Method** | | | | |
| Current (Actual) Productivity | **N (40) f** | **N (40) wf** | **N (40) f** | **N (40) f** |
| Potential productivity | **N (40) f** | **N (40) wf** | **N (40) f** | **N (40) f** |
| **Parametric Method** | | | | |
| Current (Actual) productivity | **N (25.30)** | **N (12.39)** | **N (12.39)** | **N (25.30)** |
| Potential Productivity | **N (25.30)** | **N (12.39)** | **N (12.39)** | **N (25.30)** |

**Source: Field data (2022)**

***Conclusion:*** Arising from the study to evaluate the suitability of soils in Akwa Ibom State for cassava production and appropriate soil management recommendations for improved production. Land suitability evaluation for cassava cultivation in Akwa Ibom State showed suitability class ranging from S1 to S2, S3 and N by the parametric and non-parametric approaches. Soil types 1 and 4 were not suitable (N) (25.30) with fertility constraint while soil types 2 and 3 were also not suitable (N) (12.39) with wetness and fertility constraints. Therefore, it is pertinent to note that the study portrayed the importance of maintaining high level of nitrogen, phosphorus and potassium as essential nutrients in the soils studied in order to ensure high cassava performance and yield. As a result, chemical fertilizers, biological fertilizers and organic manures should be incorporated into these soils to correct the deficiencies in phosphorus and potassium as well as the combined application of liming materials and organic sources of amendments such as plant residue, organic waste compost, vermicomposts, animal residue and biochar to raise the soil pH and the adoption of good management practices for good cassava production to improve food security, nutrition and promote sustainable agriculture. Furthermore, it is highly recommended that regular soil tests should be carried out for proper chemical fertilizer application as well as land suitability evaluation to ascertain whether the land is suitable for the cultivation of cassava or other crops.

## REFERENCES


Adepoju, K., Adelabu, S. and Fashae, O. (2019). Vegetation response to recent trends in climate and land use dynamics in a typical humid and dry tropical region under global change. *Advances in Meteorology*, 2019: 1-16. https://doi.org/10.1155/2019/4946127

Adewole, S. O., Popoola, O. A., Obasoro, O. A. and Adeoti, A. I. (2019). Impact of adoption of improved cassava variety on household food insecurity in Oyo State, Nigeria. *6th African Conference of Agricultural Economists. On: Rising to Meet New Challenges: Africa's Agricultural Development Beyond 2020 Vision*, September 23-26, 2019, Abuja, Nigeria.

Ajala, O. N., Kpadonou, G. E., Adjadeh, T. A., Akponikpe, P. Bp. I. and Olaniyan, J. O. (2020). Soil suitability evaluation for production of impaired cassava (*Manihot esculenta*) varieties in Kwara State, Nigeria: A GIS-based and multi-criteria analysis. *West African Journal of Applied Ecology*, 28(1): 158-172.

AKSG (Akwa Ibom State Government) (2023). Our culture, our pride, quick facts about Akwa Ibom. ARISE: ICT and Digital Services AKSG. https://doi/Akwaibomstate.gov.ng

Amalia, L., Budiasih, R., Ria, E. R., Widodo, R. W. and Kuswati, U.

(2020). Fermented compost and N-fertilizer for enhancing the growth and productivity of purple eggplant on vertisols. *Open Agriculture Journal*, 5: 898-904. https://doi.org/10.1515/opag-2020-0084 Retrieved December 8, 2023.

Calvallari, L. G., Fernandes, A. M., Mota, L. H. O., Leite, H. M. F. and Piroli, V. L. B. (2021). Growth and phosphorus uptake by cassava in P-deficient soil in response to mycorrhizal inoculation. *Revvista Bras Cienc Solo*, 45: 1-14. https://doi.org/10.36783/18069657rbcs20210060

Enwezor, W. O., Udo, E. J., Usoro, N. J., Ayotade, K. A., Chude, V. O. and Udegbe, C. I. (1989). Fertilizer use and management practices for crops in Nigeria. Series 2. Federal Ministry of Agriculture, Water Resources and Rural Development. Lagos 18.

Esu, I. E. (1991). Detailed soil survey of NIHORT farm Bunkure Kano State, Nigerian institute for Agricultural Research. Ahmadu Bello University Zaria, pp. 7.

Everest, T., Sungur, A. and Özcan, H. (2021). Determination of agricultural land suitability with a multiple-criteria decision-making method in Northwestern Turkey. *International Journal of Environmental Science and Technology*, 18: 1073-1088.

FAO (Food and Agricultural Organization) (2006). Guidelines for soil description. 4th Edition. Italy, Rome: Food and Agricultural Organization of the United Nations, p. 109.

FAO (Food and Agricultural Organization) (2022). Data on cassava production. Available at https://www.fao.org/faostat/en/#data/QCL/visualize. Accessed on December 8, 2023.

Gougodo de Mon-Zoni, L. J., Kosh-Komba, E., Omenda, J. A., Zaman, M., Mingabaye,-Bendima, B., Batawila, K. and Akpagana, K. (2023). Fertilization options for improved cassava productivity and economic profitability in the Pissa and Damara Areas, Central African Republic: Comparative approach. *African Journal of Agricultural Research*, 19(1): 67-80. http://www.academicjournals.org/AJAR

Irianto H, Mujiyo, Qonita A, Sulistyo A. and Riptanti, E. W. (2020a). The development of jarak towo cassava as a high economical raw material in sustainability based food processing industry. *AIMS Agriculture and Food*, 6(1): 125–141.

Irianto, H., Mujiyo, Qonita, A., Ningsih, H. and Riptanti, E. W. (2020). Land suitability assessment for Jarak towo cassava development (case studies in Tawangmangu and Ngargoyoso Sub-District, Karanganyar Regency, Indonesia). *African Journal of Food, Agriculture, Nutrition and Development*, 22(9): 21548-21567.

Kefas, P. K., Maigida, E., Ezeaku, V. I., Ofem, K. I., Akwoga, J. A. and Ezeaku, P. I. (2020). Land suitability evaluation for maize production and taxonomic classification of soils overlying undifferentiated basement complex in Northeast Nigeria. *Nigerian Journal of Soil Science*, 30(1): 42-52.

Kégah, F. N., Ndjouenkeu, R. (2023). Garri, a cassava (*Manihot esculenta Crantz*) derived product: Review on its quality and their determinants. Journal of Food Quality 2023: 1-17. https://doi.org/10.1155/2023/7238309

Kumar, A., Mahapatra, S. K. and Surya, J, N, (2021). Soil suitability of some major fruit crops for sustainable production in the IGP region of India: a case study. *Biological*

*Forum – An International Journal*, 13(1): 200-210.

Landon, J. R. (1991). Booker Tropical Soil Manual: A Handbook for Soil Survey and Agricultural Land Evaluation in the Tropics and Subtropics. Booker Tate Ltd. 474p.

Mohammed, R. and Suliman, A. A. (2023). Land suitability assessment for wheat production using analyticalhierarchy process and parametric methods in Babylon Province. *Journal of Ecological Engineering*, 24(7): 75-87.

Mohammed, T., Lawal, B. A., Panti, A. A., Isah, S. and Muntaka, A. H. (2021). Evaluation of Kudu Land of Niger State for mango (*Mangifera indica*) production. *World Journal of Applied Science and Technology*, 13(2): 148-155.

Montgomery, B., Dragićević, S., Dujmović, J. J. and Schmidt, M. (2016). A GIS-based logic scoring of preference method for evaluation of land capability and suitability for agriculture. *Computers and Electronics in Agriculture*, 124(C): 340-353. http://doi.org/10.1016/j.compag.2016.04.013

Morales, F. and de Vries, W. T. (2021). Establishment of land use suitability mapping criteria using analytical hierarchy process (AHP) with practitioners and beneficiaries. *Land*, 10: 235. https://doi.org/10.3390/land10030235

Munyahall, W., Birindwa, D., Pypers, P., Swennen, R., Vanlauwe, B. and Merckx, R. (2023). Increased cassava growth yields through improved variety use and fertilizer application in the highlands of Kivu, Democratic Republic of Congo, *Field crops Research*, 302: 1-9. https://doi.org/10.1016/j.fcr.2023.109056

Mwendwa, S. M., Mbuvi, J. P. and Kironchi, G. (2019). Land evaluation for crop production in Upper Kabete Campus field, University of Nairobi, Kenya. *Chemical and Biological Technologies in Agriculture*, 6(16): 1-10. https://doi.org/10.1186/s40538-019-0156-1

Okeoghene, S. and Isiorhovoja, R. A. (2019). Knowledge status and disease control practices of cassava farmers in Delta State, Nigeria: Implications for extension delivery. *Open Agriculture*, 4: 173-186. Retrieved December 8, 2023.

Okoli, D. C., Yakubu, M., Lawal, B. A. and Abdulkadir, A. (2023). Pedological study of hilly soils developed on basement complex terrain in Minna, Niger State, Nigeria. *Journal of Agripreneurship and Sustainable Development*, 6(1): 113-121.

Omenda, J. A., Ngetich, K. F., Kiboi, M. N., Muchenu-Muna, M. W. and Mugendi, D. N. (2019). Soil organic carbon and acid phosphatase enzyme activity response to phosphate rock and organic imputs in acid soils of central highlands of Kenya in maize. *International Journal of Plant and Soil Science*, 30: 1-13.

Omondi, J. O. and Yermiyahu, U. (2021). Improvement in cassavayield per area by fertilizer application. Pp 186. In: *A. Fediansyah (Editor) Cassava: Biology, production and use*. www.intechopen https://doi.10.5772/intechopen.87488

Onyediako, P. O. and Adiele, J. G. (2022). Enhanced cassava production for food security and economic development in Nigeria: A review. *Nigerian Agricultural Journal*, 53(3): 204-211.

Osinuga, O. A., Aiboni, V. U. and Oyegoke, C. O. (2020).Classification and suitability evaluation of soils along a toposequence for rice productionin Alabata, Southwest Nigeria. *Agro-Science*, 19: 43-50.

Otekunrin, O. A. and Sawicka, B. (2019). Cassava, a 21st Century staple crop: How can Nigeria Harness its enormous trade potentials? *Accta Scientific Agriculture*, 3(8): 1-9.

Purnamasari, R. A., Ahamed, T. and Noguchi, R. (2019). Land suitability assessment for cassava production in Indonesia using GIS, remote sensing and multi-criteria analysis. *Asia-Pacific Journal of Regional Science*. 3(1): 1–32.

Ravindran, V. O. (2021). Preparation of cassava leaf products and their use as animal feeds. Available at https://www.fao.org/livestock/agap/frg/AHPP95/95-111.pdf. Accessed on November 27, 2023.

Salau, S. A., Noflu, B. N. and Jimoh, T. A. (2019). Effect of cassava products consumption on food security of farming households in Kwara State, Nigeria. *Journal of Agriculture and Environment Science*, 4(2): 36-45.

Saranraj, (2019). Traditional foods from tropical roots and tuber crops: Innovations and challenges. *Innovations in the Traditional Foods*. 2019: 159-191.

Shakya, B., Shrestha, A., Sharma, G., Gurung, T., Mihin, D., Yang, S., Jamir, A., Win, S., Han, X., Yang, Y., Choudhury, D. and Schneider, F. (2019). Visualizing suitability of selective mountain farming systems from far-eastern Himalayas to support decision making. *Sustainability*, 11: 1714.

Shehu, A.S., Noflu, B. N. and Taiwo, A. J. (2019). Effect of cassava products consumption on food security of farming households in Kwara State, Nigeria.

Simon, A. O., Olufemi, P. A., Oluwasegun, O. A. and Adetola, A. (2019). Impact of adaptation of improved cassava variety on household food insecurity in Oyo State, Nigeria.

Udo, E. J., Ibia, T. O., Ogunwale, J. A., Ano, A. O. an Esu, I. E. (2009). Manual of Soil, Plant and Water Analysis. Sibon Books Limited, Lagos, p. 183.

Ugwa, I. K., Ekpenkhio, E. and Orobator, P. O. (2022). Distribution of exchangeable cations in soils under different agricultural land uses of similar lithology in Edo State, Nigeria. *Journal of Agriculture*, 34(3): 93-109.

Ustaoglu, E. (2022). An assessment of land use /cover suitable for peri-urban green space development: an example of an integration of Geographic Information System (GIS) with the multi-criteria analysis (MCA) approach. *European Scientific Journal*, 18(35): 1-27.

Uzoho, B. U., Ahukamere, C. M., Egboka, N. T., Afangide, I. A., Okoli, H. N., Irokwe, I. F. and Ubakwe, R. C. (2022). Potassium quantity-intensity concepts of soils of contrasting landscape positions in the humid rain forest, Southeastern, Nigeria. *Advanced Journal of Science, Engineering and technology*, 7(10): 1-21. https://aspjournals.org/ajset/index.php/ajset

Viana, C. M., Freire, D., Abrantes, P., Rocha, J. and Pereira, P. (2022). Agricultural land systems importance for supporting food security and sustainable development goals: A systematic review. *Science of the Total Environment*, 806: 1-13.

Weather Spark (2022). Akwa Ibom climate, weather by month, average temperature (Nigeria) – Weather Spark. https://weatherspark.com/y/52989/average weatherinakwaibomnigeriayearround.

Yu, X., Shan, Z. and Wu, Y. (2021). Land use optimization in a resources-exhausted city based on simulation of the food, energy and water (F-E-W) nexus. *Land*, 10(1013): 1-32.

Zhang, Y., Hartemink, A. E., Huang, U. and Minasny, B. (2021). Digital soil morphometrics. In: Reference Module in Earth System and Environmental Science, Zhang, Y., Hartemink, A. E., Huang, U. and Minasny, B. (Editors), Elsevier, Amsterdam, Netherlands, ISBN: 9780124095489

Zhou, Z., Yrjälä, K., Chen, J., Yu, C., Shi, W., Qin, H. and Wu, J. (2022). Amendment combined with biochar for improving soil and water quality in a Torreya gradis plantation. *Journal of Soils and Sediments*, 22(4): 1080-1094.