DOI: https://doi.org/10.67042/njss.2022.h41copo9 Osujieke et al. *NJSS 32(2) 2022 33-41*

# Nigerian Journal of Soil Science

Journal homepage:www.soilsjournalnigeria.com

# Land Suitability Evaluation for the production of Maize (*Zea mays*) and Groundnut (*Arachis hypogaea* L.) using parametric and non-parametric methods in Mambilla Plateau, Nigeria

**[*1]Osujieke, D.N., [2]Idoga, S., [2]Abagyeh, S. O. I. and [3]Ugese, F. D.**

[1]Department of Soil Science and Land Resources Management, Federal University Wukari, PMB 1020 Wukari, Taraba State Nigeria

[2]Department of Soil Science, Joseph Sarwuan Tarka University, Makurdi, P.M.B. 2373 Makurdi, Benue State Nigeria

[3]Department of Crop Production, Joseph Sarwuan Tarka University, Makurdi, P.M.B. 2373 Makurdi, Benue State Nigeria

**ARTICLE INFO**

*Article history:*
*Received August 12th, 2022*
*Received in revised form August 30th, 2022*
*Accepted September 6th, 2022*
*Available online September 25th, 2022*

***Keywords:***

*Land suitability*
*Evaluate*
*Horizon*
*Parametric*
*Pedons*

Corresponding Author's E-mail Address:
bigdonax@yahoo.com; +2348030877200

njss.2022.320205
ISSN– Online **2736-1411**
Print **2736-142X**



**ABSTRACT**

The study aimed to evaluate the land suitability for the production of maize (*Zea mays*) and groundnut (*Arachis hypogaea L.*) in selected soils of Mambilla Plateau in Sardauna local government area in Taraba State Northeast, Nigeria. Land suitability for maize and groundnut production was evaluated both by the conventional (non-parametric) and parametric methods. A total of 12 pedons were dug to represent sampling units. Soil samples from the pedogenetic horizons of the pedons were collected after profile description, processed and analyzed in the laboratory. The result showed that the pedons were very deep (> 150 cm) except for pedon 3, which was shallow. The soil texture of the pedons varied from sandy clay loam, sandy loam, sandy clay, loamy sand and clay across the surface and sub-surface horizons. Soil pH was slight to strongly acidic, organic carbon varied from low to high, while, pedons' available phosphorus and cation exchange capacity of the pedons varied from low to medium. Base saturation was rated high in the soils. The land suitability for maize and groundnut production was evaluated by conventional (non-parametric) and parametric methods. The suitability evaluation of the pedons shows that the soils of the entire Mambilla Plateau are marginally suitable (S3) for producing maize and groundnut, with climate and fertility being the major limiting factors.

## 1.0 Introduction

Land suitability evaluation involves characterizing the soils in a given area for a specific land use type. Ozcan (2006) observed that all lands could be used for the utmost purpose if sufficient inputs were supplied. Esu (2004) stated that studying soils in detail through processes of soil characterization and land evaluation for various land utilization types is one of the strategies for achieving food security and a sustainable environment. However, despite the importance of sustainable land management, enhanced crop production, specific soil suitability studies; such as suitability assessment for groundnut and maize production within and surroundings of the Mambilla Plateau, have not been documented.

Land suitability assessment for agriculture is meant to evaluate the ability of a piece of land to provide the optimal ecological requirements of a specific crop variety (Ande, 2011). In other words, assessing land suitability will enable optimum crop development and maximum productivity. Hence, land suitability evaluation requires the specification of the respective crop and calibrating them with the climate and soil properties.

The limiting factors as observed could be managed to suit the various crop requirements and enhance crop productivity. This is a prerequisite to productivity optimization in the agricultural sector. Optimal crop growth and productivity are based amongst other factors on soil conditions, the climate and agricultural practices. The initial point toward sustainable land management is adequate information on land resources. Similarly, Ogunkunle (2004) opined that land suitability evaluation is relevant but these are not in proper form in Nigeria despite several spots studies.

The need for sustainable increase in crop production per unit area in Nigeria has resulted to more soil being opened up for large scale crop production. The study area may be considered for commercial maize and groundnut production due to new initiative for more maize and groundnut production for exportation in Nigeria. To increase productivity of agriculture in the Mambilla Plateau and Nigeria in general, there is a need for suitability assessment of the land which will assist in identifying key soil properties for optimum yield of groundnut and maize production. These crops are among the stable food being consumed globally and also more predominantly by the people living in the Mambilla Plateau. Many farmers have been producing the crops with no basic data to guide them on the most suitable soils that will guarantee optimum yield within the Mambilla Plateau. Hence, there is a need to evaluate the soils of the Mambilla Plateau according to their suitability for maize and groundnut.

## 2.0 Materials and Methods

The Mambilla Plateau is located between latitude 6° 30′ 24″ to 7° 19′ 48″ N and longitude 11° 02′ 42″ to 11° 37′ 12″ E, with a total land mass of 3,765.2 km$^2$ forming the southernmost tip of the Northeastern part of Nigeria. The entire plateau area falls under the Sardauna Local Government Area in Taraba State Northeast, Nigeria. The mean annual Rainfall ranges from 1780 mm to 2200 mm, with peaks in June/July and September (Chapman and Chapman, 2000). The mean annual temperature ranges from 25 °C to 35 °C (Bami, 2013). The Mambilla Plateau belongs to the Montane Guinea Savanna zone of Nigeria. Vegetation on the plateau comprises averagely short grasses with trees being noticeably absent except for artificial forests. The geology of the Mambilla Plateau is developed on Basement Complex rocks.

A total of 12 pedons measuring 2 m × 1.8 m × 2 m were dug, on each of the grid using a flexible grid sampling technique. The pedons were described and sampled according to the guideline of the Soil Science Division Staff (2017). The samples were air-dried, crushed, and made to pass through a 2.0 mm and 0.5 mm mesh sieve for routine laboratory analyses. The following soil parameters were determined Particle size distribution was determined by the Bouyoucos hydrometer method (Gee and Or, 2002). Soil pH was determined electrometrically using the glass electrode pH meter in a solid-liquid (water) ratio of 1:2.5 (Thomas, 1996). Exchangeable acidity was determined by a method described by McLean (1982). Exchangeable bases were determined by the neutral ammonium acetate procedure buffered at pH 7.0 as described by Thomas (1982). Cation exchange capacity (CEC) was determined by ammonium acetate ($NH_4OAc$) of 1.0M leaching at pH 7 (Summer and Miller, 1996). Total carbon was determined by the wet digestion method as described by Nelson and Sommers (1982). Total nitrogen was determined by the Kjeldahl digestion method as described by Bremner (1996). Available phosphorus was determined using Bray I method as described by Olson and Sommers (1982).

### *2.1 Land Suitability Evaluation (LSE)*

The land suitability for maize and groundnut production was evaluated both by the conventional (non-parametric) (FAO, 1976) and parametric methods (Ogunkunle, 1993; Udoh *et al.,* 2006). For the non-parametric evaluation, the soils were first placed in suitability classes by matching their characteristics with the established requirements. The aggregate suitability classes were indicated by the most limiting characteristic(s) of the pedon. Suitability classes established were S1, S2, S3 and N.

For the actual (current) productivity index, all the lowest characteristic ratings for each land quality group were substituted into the index of productivity equation above. However, regarding the potential productivity index, it was assumed that the corrective fertility measure would no longer have fertility constraints. Hence, other qualities with fertility (f) being excluded were used to calculate the potential productivity index. Suitability classes S1, S2, S3, N1 and N2 are equivalent to IP values of S1= 100 – 75, S2= 74 – 50, S3= 49 – 25, N1= 24 – 15 and N2= 14 – 0, respectively.

The land suitability was evaluated by considering the soil characteristics related to land qualities affecting the land use types. The soil drainage conditions were rated using soil depth and soil textural classes, as against the percolation test. The soils were placed in suitability classes by matching their characteristics with the land suitability requirements for each crop using the rating of limiting characteristics as presented in Tables 1 and 2. The aggregate suitability class indicates the most limiting characteristics of the pedons. The parameters used for the land quality calculation include rainfall, mean annual temperature, slope, wetness and drainage. At the same time, the soil characteristics were texture, soil pH, soil depth and fertility indicators: organic carbon, base saturation, available phosphorus and cation exchange capacity.

## 3.0 Results and Discussion

Land quality/characteristics of the study area and land use requirements for maize and groundnut cultivation.

### *3.1 Climate (C)*

The result of matching the land characteristics (Tables 1 and 2) with the requirements for maize and groundnut production (Tables 3 and 5, respectively) rated the land as being only 60 % suitable for maize and groundnut production due to rainfall. Furthermore, the mean annual temperature (Tables 3 and 5) was rated 95 % for maize and groundnut production.

Climatic parameters considered were annual rainfall and mean annual temperature. In the Mambilla Plateau, annual rainfall is a limiting factor to maize and groundnut production. The level of suitability of the study area for the production of maize and groundnut could be associated with excessive rainfall. The annual rainfall amount (1950 mm) is excessively higher than the required 900 mm and 975 mm as Sys *et al.* (1993) recommended for optimum production of groundnut and maize, respectively. Furthermore, the annual temperature is optimal for groundnut and maize production.

### *3.2 Topography and Wetness (t & w)*

The topography of the studied sites falls within the slope percentage range of 0 to 4 %, as stated in Tables 16 and 18. The entire pedons were rated moderate (94 – 85 %) for producing maize and groundnut.

The drainage condition of the soils of the Mambilla Plateau shows that 9 (or 75 %) of the 12 pedons were rated as highly suitable, 1 (or 8.3 %) of the 12 pedons were moderately suitable, and 2 (16.7 %) of the 12 pedons were marginally suitable for maize and groundnut production.

The topography of the Mambilla Plateau was moderately suitable for maize and groundnut production. The pedons were well-drained, with the exception of pedons 3 and 4, which are poorly drained due to the shallow water table of

Table 1: Factor Rating of Land Use Requirements for Maize

| Land Qualities | Land Characteristics | Unit | S1<br>100 – 95 | S2<br>94 – 85 | S3<br>84 – 40 | N1<br>39 – 20 |
|---|---|---|---|---|---|---|
| Climate (c) | | | | | | |
| Water Availability | Mean annual rainfall | mm | 750 – 1200<br>750 – 500 | 1200 – 1600<br>500 – 400 | >1600<br>400 – 300 | –<br><300 |
| Temperature Regime | Mean annual temperature | $^{o}C$ | 24 – 18<br>24 – 32 | 18 – 16<br>32 – 35 | 16 – 14<br>35 – 40 | <14<br><40 |
| Topography (t) | Slope | % | 0 – 4 | 4 – 8 | 8 – 16 | >16 |
| Wetness (w) | | | | | | |
| Oxygen Availability | Soil drainage | Class | Well Drained | Imperfectly Drained | Poorly Drained | Very Poorly Drained |
| Fertility (f) | | | | | | |
| Nutrient Availability | Organic carbon | % | >1.2 | 1.2 – 0.8 | 0.8 – 0.4 | <0.4 |
| | Available P | mg/kg | >25 | 6 – 25 | <6 | – |
| | pH | $H_2O$ | 5.5 – 7.5 | 5.0 – 5.5 or 7.5 – 8.0 | 4.0 – 5.0 or 8.0 – 8.5 | <4.0 or >8.5 |
| Nutrient retention | CEC | cmol/kg | >24 | 16 – 24 | <16(-) | <16(+) |
| | Base saturation | % | >50 | 50 – 35 | 35 – 20 | <20 |
| Soil Physical Characteristics (s) | | | | | | |
| Water Retention Capacity | Soil texture | Class | SiC, SiCL, Si, SiL, CL, SC, L, SCL | C, SL, LS | S | – |
| Rooting Condition | Soil depth | cm | >75 | >50 | >20 | <20 |

Key: SL= sandy loam, LS= loamy sand, SiC= silt clay, Si= silt, SiCL= silt clay loam, SiL= silt loam, CL= clay loam, SC= sandy clay, C= clay, L= loam, S= sand, CEC= cation exchange capacity
Modified from Sys et al., 1991; 1993

Table 2: Factor Rating of Land Use Requirements for Groundnut

| Land Qualities | Land Characteristics | Unit | S1<br>100 – 95 | S2<br>94 – 85 | S3<br>84 – 40 | N1<br>39 – 20 |
|---|---|---|---|---|---|---|
| Climate (c) | | | | | | |
| Water Availability | Mean annual rainfall | mm | 700 – 400<br>700 – 1100 | 400 – 300<br>1100 – 1600 | 300 – 200<br>>1600 | – |
| Temperature Regime | Mean annual temperature | $^{o}C$ | 24 – 18<br>24 – 30 | 18 – 14<br>30 – 34 | 14 – 10<br>>34 | <10 |
| Wetness (w) | | | | | | |
| Oxygen Availability | Soil drainage | Class | Well Drained | Imperfectly Drained | Poorly Drained | Very Poorly Drained |
| Soil Fertility (f) | | | | | | |
| Nutrient Availability | Organic carbon | % | >0.8 | 0.8 – 0.4 | <0.4 | – |
| | Available P | mg/kg | >25 | 6 – 25 | <6 | – |
| | pH | $H_2O$ | 6.8 - 6.0 or 7.0 – 7.5 | 6.0 – 5.6 or 7.5 – 8.0 | <5.6 or 8.0 – 8.2 | – |
| Nutrient retention | CEC | cmol/kg | >24 | 16 – 24 | <16(-) | <16(+) |
| | Base saturation | % | >50 | 50 – 35 | <35 | – |
| Soil Physical Characteristics (s) | | | | | | |
| Water Retention Capacity | Soil texture | Class | L, SCL, SL | SiL, SiCL, SC, Si, CL | LS, SiC, C | S |
| Rooting Condition | Soil depth | cm | 100 – 75 | 75 – 50 | 50 – 25 | <25 |
| Topography (t) | Slope | % | 0 – 2 | 2 – 4 | 4 – 6 | >6 |

Key: CL: clay loam, L= loam, SiC= silt clay, SL= sandy loam, LS= loamy sand, SiCL= silt clay loam, S= sand, SC= sandy clay, SiL= silt loam, SiCL= silt clay loam, Si= silt, CEC= cation exchange capacity
Modified from Sys et al., 1991; 1993

Table 3: Land characteristics used for suitability ratings of sites for Maize (*Zea mays*) production in the Mambilla Plateau cont'd

| | Unit | P07 | P08 | P09 | P10 | P11 | P12 |
|---|---|---|---|---|---|---|---|
| Climate (c) | | | | | | | |
| Annual rainfall | mm | 1780 – 2200 | 1780 – 2200 | 1780 – 2200 | 1780 – 2200 | 1780 – 2200 | 1780 – 2200 |
| Mean annual temperature | $^oC$ | 25 – 35 | 25 – 35 | 25 – 35 | 25 – 35 | 25 – 35 | 25 – 35 |
| Topography (t) | | | | | | | |
| Slope | % | 0 – 4 | 0 – 4 | 0 – 4 | 0 – 4 | 0 – 4 | 0 – 4 |
| Wetness (w) | | | | | | | |
| Soil drainage | Class | Imperfectly drained | Well drained | Well drained | Well drained | Imperfectly drained | Well drained |
| Soil Physical Characteristics (s) | | | | | | | |
| Soil texture | Class | SCL | SC | SL | SC | SCL | SL |
| Soil depth | cm | 210 | 200 | 200 | 180 | 200 | 200 |
| Soil Fertility (f) | | | | | | | |
| Organic carbon | % | 2.61 | 1.42 | 1.76 | 1.79 | 2.04 | 2.57 |
| Available P | mg/kg | 8.91 | 4.92 | 4.56 | 6.52 | 5.69 | 7.05 |
| pH | $H_2O$ | 5.67 | 5.96 | 5.85 | 6.14 | 5.95 | 6.07 |
| CEC | cmol/kg | 10.0 | 12.33 | 8.90 | 10.0 | 9.54 | 8.0 |
| Base saturation | % | 80.02 | 78.56 | 73.18 | 71.12 | 61.35 | 62.65 |

Aggregate suitability scores: S1=100-75, S2=74-50, S3=49-25, N1=24-15, N2=14-0

Table 4: Land Suitability Class Scores of the Mambilla Plateau for Maize (*Zea mays*) production

| | P01 | P02 | P03 | P04 | P05 | P06 |
|---|---|---|---|---|---|---|
| Climate (c) | | | | | | |
| Annual rainfall (mm) | S3(60) | S3(60) | S3(60) | S3(60) | S3(60) | S3(60) |
| Mean annual temperature ($^oC$) | S1(95) | S1(95) | S1(95) | S1(95) | S1(95) | S1(95) |
| Topography (t) | | | | | | |
| Slope (%) | S2(85) | S2(85) | S2(90) | S2(90) | S2(85) | S2(90) |
| Wetness (w) | | | | | | |
| Soil drainage | S1(95) | S1(95) | S3(60) | S3(70) | S1(95) | S1(95) |
| Soil Physical Characteristics (s) | | | | | | |
| Soil texture | S1(95) | S1(95) | S2(90) | S1(95) | S2(90) | S2(90) |
| Soil depth (%) | S1(98) | S1(97) | S1(95) | S1(100) | S1(100) | S1(100) |
| Soil Fertility (f) | | | | | | |
| Organic carbon (%) | S1(100) | S1(96) | S1(96) | S2(92) | S1(96) | S3(60) |
| Avail. P (mg/kg) | S2(85) | S3(80) | S3(80) | S3(75) | S3(80) | S3(65) |
| pH($H_2O$) | S1(99) | S1(99) | S1(98) | S1(100) | S1(99) | S1(100) |
| CEC (cmol/kg) | S3(60) | S3(60) | S2(92) | S3(60) | S3(60) | S3(55) |
| Base saturation (%) | S1(97) | S1(97) | S1(97) | S1(97) | S1(97) | S1(97) |
| Aggregate Suitability: | | | | | | |
| Potential | S2(53) | S2(53) | S3(42) | S3(46) | S2(51) | S2(53) |
| Actual (current) | S3(41) | S3(41) | S3(37) | S3(36) | S3(40) | S3(37) |

Aggregate suitability scores: S1=100-75, S2=74-50, S3=49-25, N1=24-15, N2=14-0

Table 4: Land Suitability Class Scores of the Mambilla Plateau for Maize (*Zea mays*) production cont'd

| | P07 | P08 | P09 | P10 | P11 | P12 |
|---|---|---|---|---|---|---|
| Climate (c) | | | | | | |
| Annual rainfall (mm) | S3(60) | S3(60) | S3(60) | S3(60) | S3(60) | S3(60) |
| Mean annual temperature ($^oC$) | S1(95) | S1(95) | S1(95) | S1(95) | S1(95) | S1(95) |
| Topography (t) | | | | | | |
| Slope (%) | S2(90) | S2(85) | S2(85) | S2(85) | S2(90) | S2(90) |
| Wetness (w) | | | | | | |
| Soil drainage | S2(90) | S1(95) | S1(95) | S1(95) | S1(97) | S1(95) |
| Soil Physical Characteristics (s) | | | | | | |
| Soil texture | S1(95) | S1(95) | S2(90) | S1(95) | S1(95) | S2(90) |
| Soil depth (%) | S1(100) | S1(100) | S1(100) | S1(98) | S1(100) | S1(100) |
| Soil Fertility (f) | | | | | | |
| Organic carbon (%) | S1(100) | S1(96) | S1(96) | S1(96) | S1(100) | S1(100) |
| Available P (mg/kg) | S2(86) | S3(75) | S3(70) | S2(85) | S3(80) | S2(85) |
| pH($H_2O$) | S1(100) | S1(100) | S1(100) | S1(98) | S1(98) | S1(98) |
| CEC (cmol/kg) | S3(65) | S3(70) | S3(60) | S3(65) | S3(63) | S3(60) |
| Base saturation (%) | S1(98) | S1(97) | S1(97) | S1(97) | S1(96) | S1(96) |
| Aggregate Suitability: | | | | | | |
| Potential | S2(53) | S2(53) | S2(51) | S2(53) | S2(55) | S2(53) |
| Actual (current) | S3(42) | S3(44) | S3(40) | S3(42) | S3(31) | S3(41) |

Aggregate suitability scores: S1=100-75, S2=74-50, S3=49-25, N1=24-15, N2=14-0

Table 5: Land characteristics used for suitability ratings of sites for groundnut (*Arachis hypogaea* L.) production in the Mambilla Plateau

| | Unit | P01 | P02 | P03 | P04 | P05 | P06 |
|---|---|---|---|---|---|---|---|
| Climate (c) | | | | | | | |
| Annual rainfall | mm | 1780 – 2200 | 1780 – 2200 | 1780 – 2200 | 1780 – 2200 | 1780 – 2200 | 1780 – 2200 |
| Mean annual temperature | °C | 25 – 35 | 25 – 35 | 25 – 35 | 25 – 35 | 25 – 35 | 25 – 35 |
| Topography (t) | | | | | | | |
| Slope | % | 0 – 4 | 0 – 4 | 0 – 4 | 0 – 4 | 0 – 4 | 0 – 4 |
| Wetness (w) | | | | | | | |
| Soil drainage | Class | Well drained | Well drained | Poorly drained | Poorly drained | Well drained | Well drained |
| Soil Physical Characteristics (s) | | | | | | | |
| Soil texture | Class | SCL | SC | SL | SCL | SL | C |
| Soil depth | cm | 180 | 160 | 106 | 200 | 200 | 200 |
| Soil Fertility (f) | | | | | | | |
| Organic carbon | % | 2.03 | 1.92 | 1.52 | 1.17 | 1.62 | 0.65 |
| Avail. P | mg/kg | 6.04 | 5.71 | 5.09 | 4.82 | 5.32 | 3.61 |
| pH | $H_2O$ | 5.79 | 5.71 | 6.18 | 5.57 | 5.71 | 5.61 |
| CEC | cmol/kg | 8.92 | 8.84 | 20.02 | 8.0 | 8.0 | 7.0 |
| Base saturation | % | 79.44 | 78.49 | 73.86 | 76.49 | 79.70 | 76.97 |

Aggregate suitability scores: S1=100-75, S2=74-50, S3=49-25, N1=24-15, N2=14-0

Table 5: Land characteristics used for suitability ratings of sites for groundnut (*Arachis hypogaea* L.) production in Mambilla Plateau (cont'd)

| | Unit | P07 | P08 | P09 | P10 | P11 | P12 |
|---|---|---|---|---|---|---|---|
| Climate (c) | | | | | | | |
| Annual rainfall | mm | 1780 – 2200 | 1780 – 2200 | 1780 – 2200 | 1780 – 2200 | 1780 – 2200 | 1780 – 2200 |
| Mean annual temperature | °C | 25 – 35 | 25 – 35 | 25 – 35 | 25 – 35 | 25 – 35 | 25 – 35 |
| Topography (t) | | | | | | | |
| Slope | % | 0 – 4 | 0 – 4 | 0 – 4 | 0 – 4 | 0 – 4 | 0 – 4 |
| Wetness (w) | | | | | | | |
| Soil drainage | Class | Imperfectly drained | Well drained | Well drained | Well drained | Imperfectly drained | Well drained |
| Soil Physical Characteristics (s) | | | | | | | |
| Soil texture | Class | SCL | SC | SL | SC | SCL | SL |
| Soil depth | cm | 210 | 200 | 200 | 180 | 200 | 200 |
| Soil Fertility (f) | | | | | | | |
| Organic carbon | % | 2.61 | 1.42 | 1.76 | 1.79 | 2.04 | 2.57 |
| Avail. P | mg/kg | 8.91 | 4.92 | 4.56 | 6.52 | 5.69 | 7.05 |
| pH | $H_2O$ | 5.67 | 5.96 | 5.85 | 6.14 | 5.95 | 6.07 |
| CEC | cmol/kg | 10.0 | 12.33 | 8.90 | 10.0 | 9.54 | 8.0 |
| Base saturation | % | 80.02 | 78.56 | 73.18 | 71.12 | 61.35 | 62.65 |

Aggregate suitability scores: S1=100-75, S2=74-50, S3=49-25, N1=24-15, N2=14-0

Table 6: Land Suitability Class Scores of the Mambilla Plateau for groundnut (*Arachis hypogaea* L.) production

| | P01 | P02 | P03 | P04 | P05 | P06 |
|---|---|---|---|---|---|---|
| Climate (c) | | | | | | |
| Annual rainfall (mm) | S3(60) | S3(60) | S3(60) | S3(60) | S3(60) | S3(60) |
| Mean annual temperature (°C) | S1(95) | S1(95) | S1(95) | S1(95) | S1(95) | S1(95) |
| Topography (t) | | | | | | |
| Slope (%) | S2(85) | S2(85) | S2(90) | S2(90) | S2(85) | S2(90) |
| Wetness (w) | | | | | | |
| Soil drainage | S1(95) | S1(95) | S3(60) | S3(70) | S1(95) | S1(95) |
| Soil Physical Characteristics (s) | | | | | | |
| Soil texture | S1(95) | S2(85) | S1(95) | S1(95) | S1(95) | S3(60) |
| Soil depth (%) | S1(98) | S1(97) | S1(95) | S1(100) | S1(100) | S1(100) |
| Soil Fertility (f) | | | | | | |
| Organic carbon (%) | S1(100) | S1(98) | S1(96) | S2(92) | S1(96) | S2(90) |
| Available P (mg/kg) | S2(85) | S3(82) | S3(80) | S3(75) | S3(80) | S3(65) |
| pH($H_2O$) | S2(86) | S2(88) | S1(96) | S1(100) | S3(70) | S2(85) |
| CEC (cmol/kg) | S3(62) | S3(62) | S2(90) | S3(60) | S3(60) | S3(55) |
| Base saturation (%) | S1(97) | S1(97) | S1(97) | S1(97) | S1(97) | S1(97) |
| Aggregate Suitability: | | | | | | |
| Potential | S2(53) | S2(50) | S3(43) | S3(46) | S2(50) | S3(43) |
| Actual (current) | S3(41) | S3(39) | S3(38) | S3(36) | S3(41) | S3(31) |

Aggregate suitability scores: S1=100-75, S2=74-50, S3=49-25, N1=24-15, N2=14-0

Table 6: Land Suitability Class Scores of the Mambilla Plateau for groundnut (*Arachis hypogaea* L.) production (cont'd)

| | P07 | P08 | P09 | P10 | P11 | P12 |
|---|---|---|---|---|---|---|
| Climate (c) | | | | | | |
| Annual rainfall (mm) | S3(60) | S3(60) | S3(60) | S3(60) | S3(60) | S3(60) |
| Mean annual temperature ($^oC$) | S1(95) | S1(95) | S1(95) | S1(95) | S1(95) | S1(95) |
| Topography (t) | | | | | | |
| Slope (%) | S2(90) | S2(85) | S2(85) | S2(85) | S2(90) | S2(90) |
| Wetness (w) | | | | | | |
| Soil drainage | S2(90) | S1(95) | S1(95) | S1(95) | S1(97) | S1(95) |
| Soil Physical Characteristics (s) | | | | | | |
| Soil texture | S1(95) | S2(85) | S1(95) | S2(85) | S1(95) | S1(95) |
| Soil depth (%) | S1(100) | S1(100) | S1(100) | S1(98) | S1(100) | S1(100) |
| Soil Fertility (f) | | | | | | |
| Organic carbon (%) | S1(100) | S1(98) | S1(98) | S1(98) | S1(100) | S1(100) |
| Available P (mg/kg) | S2(86) | S3(75) | S3(75) | S2(85) | S3(82) | S2(85) |
| pH($H_2O$) | S2(86) | S2(92) | S2(90) | S1(96) | S2(92) | S1(95) |
| CEC (cmol/kg) | S3(65) | S3(70) | S3(62) | S3(65) | S3(63) | S3(60) |
| Base saturation (%) | S1(98) | S1(97) | S1(97) | S1(97) | S1(96) | S1(96) |
| Aggregate Suitability: | | | | | | |
| Potential | S2(53) | S2(50) | S2(53) | S2(50) | S2(55) | S2(54) |
| Actual (current) | S3(42) | S3(42) | S3(41) | S3(40) | S3(42) | S3(42) |

Aggregate suitability scores: S1=100-75, S2=74-50, S3=49-25, N1=24-15, N2=14-0

the area. More so, pedons 3 and 4 are marginally suitable for maize and groundnut production.

*3.3 Soil physical characteristics (s)*

Soil physical characteristics evaluated were soil texture and soil depth. Soil depth as evaluated indicated that the 12 pedons were rated highly suitable for the production of groundnut and maize.However, in terms of soil texture 8 (or 66.67 %) of the 12 pedons were sandy clay loam or sandy loam and were rated highly suitable, 3 (or 25 %) of the 12 pedons were sandy clay and were rated moderately suitable and 1 (or 8.33 %) of the 12 pedons were clay and were rated marginally suitable for groundnut production. Also, the soil texture as evaluated showed that 7 (or 58.33 %) of the 12 pedons were rated highly suitable and 5 (or 41.67 %) of the 12 pedons were sandy loam of clay and were rated moderately suitable for the production of maize.

Soil physical characteristics evaluated were soil texture and soil depth. The matching of land qualities (Tables 1 and 2) with the requirements for maize and groundnut production (Tables 3 and 5) shows that the land of the Mambilla Plateau is nearly optimal for maize and groundnut production in terms of soil texture and soil depth. According to the ratings of Sys *et al.* (1993), sandy clay loam or sandy clay is highly suitable for optimum production of maize, while sandy clay and sandy loam are highly suitable for optimum production of groundnut in the Mambilla Plateau.

*3.4 Soil fertility (f)*

The availability of phosphorus in 8 (or 66.67 %) of the 12 pedons was marginally suitable, and that of 4 (or 33.33 %) of the 12 pedons was moderately suitable for maize and groundnut production. Evaluated, organic carbon content of the soil as shows that 10 (or 83.33 %) of the 12 pedons were highly suitable, and 2 (or 16.67 %) of the 12 pedons were moderately suitable for maize and groundnut production. The soil pH was 100 % highly suitable for the production of maize while 4 (or 33.33 %) of the 12 pedons were highly suitable, 7 (or 58.33 %) of the 12 pedons were moderately suitable, and 1 (or 8.33 %) of the 12 pedons was marginally suitable for the production of groundnut. The cation exchange capacity of the soils of the Mambilla Plateau as evaluated shows that 11 (or 91.67 %) of the 12 pedons were marginally suitable and 1 (or 8.33 %) of the 12 pedons was moderately suitable for maize and groundnut production. The percentage base saturation is 100 % highly suitable for the production of maize and groundnut.

The soil fertility as evaluated indicates that the matching of the land qualities/characteristics (Tables 3 and 5) with the requirement for maize and groundnut production shows that available phosphorus and cation exchange capacity are the most severe constraints in maize and groundnut production in Mambilla Plateau.

*3.5 Land suitability classes in the study area*

Table 7 is summaries of the suitability aggregate scores and suitability classifications under the potential and actual (current) evaluation by the parametric and non-parametric methods for the 12 pedons in the study area.

*3.6 Parametric evaluation*

The result in Table 7 shows that by the parametric method, potentially, up to 83.33 % (10 out of 12 pedons) of the soils in the study area are moderately suitable (S2) while 16.67 % (2 out of 12 pedons) of the soils are marginally suitable (S3) for maize production. However, up to 75 % (9 out of 12 pedons) of the soils of the study area were moderately suitable (S2), while 25 % (3 out of 12 pedons) of the soils were marginally suitable (S3) for groundnut

Table 7: Aggregate suitability scores and suitability classification of the soil profile indicating limitation characteristics

| | P01 | | P02 | | P03 | | P04 | | P05 | | P06 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Parametric | Non-P | Parametric | Non-P | Parametric | Non-P | Parametric | Non-P | Parametric | Non-P | Parametric | Non-P |
| MAIZE | | | | | | | | | | | | |
| Actual (current) | S3(41) | S3cf | S3(41) | S3cf | S3(37) | S3cwf | S3(36) | S3cwf | S3(40) | S3cf | S3(37) | S3cf |
| Potential | S2(53) | S2c | S2(53) | S2c | S3(42) | S3cw | S3(46) | S3cf | S2(51) | S2c | S2(53) | S2c |
| GROUNDNUT | | | | | | | | | | | | |
| Actual (current) | S3(41) | S3cf | S3(39) | S3cf | S3(38) | S3cwf | S3(36) | S3cwf | S3(41) | S3cf | S3(31) | S3csf |
| Potential | S2(53) | S2c | S2(50) | S2c | S3(43) | S3cw | S3(46) | S3cw | S2(50) | S2c | S3(41) | S3cs |

Non-P=Non-parametric; f=fertility limitation; w=wetness limitation; s=soil physical characteristic limitation

Table 7: Aggregate suitability scores and suitability classification of the soil profile indicating limitation characteristics cont'd

| | P07 | | P08 | | P09 | | P10 | | P11 | | P12 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Parametric | Non-P | Parametric | Non-P | Parametric | Non-P | Parametric | Non-P | Parametric | Non-P | Parametric | Non-P |
| MAIZE | | | | | | | | | | | | |
| Actual (current) | S3(42) | S3cf | S3(44) | S3cf | S3(40) | S3cf | S3(42) | S3cf | S3(31) | S3cf | S3(41) | S3cf |
| Potential | S2(53) | S2c | S2(53) | S2c | S2(51) | S2c | S2(53) | S2c | S2(55) | S3c | S2(53) | S2c |
| GROUNDNUT | | | | | | | | | | | | |
| Actual (current) | S3(42) | S3cf | S3(42) | S3cf | S3(41) | S3cf | S3(40) | S3cf | S3(42) | S3cf | S3(42) | S3cf |
| Potential | S2(53) | S2c | S2(50) | S2c | S2(53) | S2c | S2(50) | S2c | S2(55) | S2c | S2(54) | S2c |

Non-P=Non-parametric; f=fertility limitation; w=wetness limitation; s=soil physical characteristic limitation

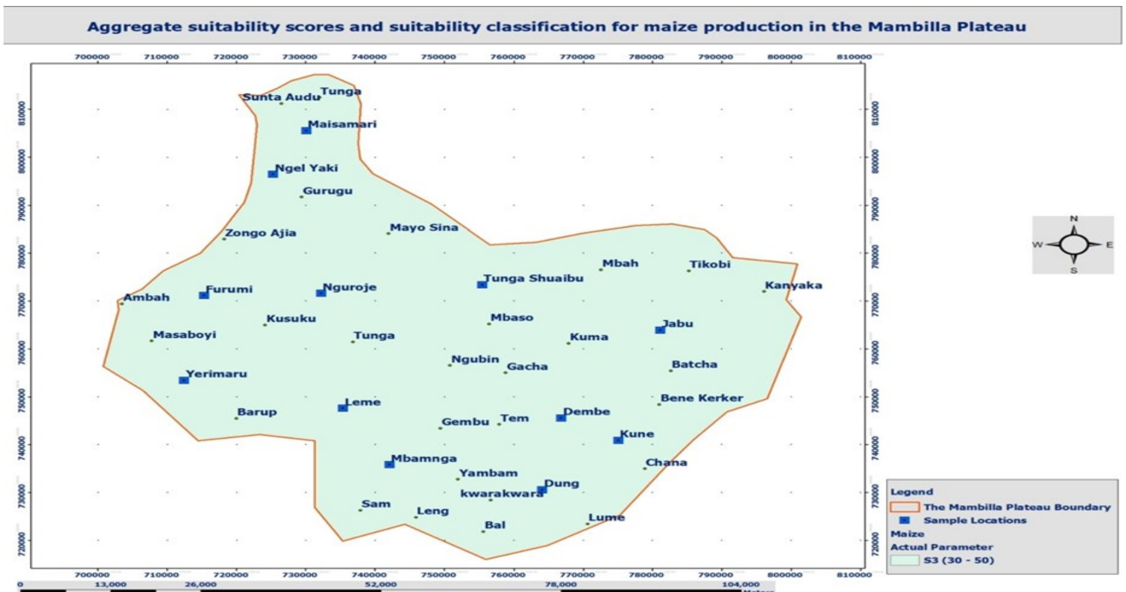


Fig 1: Map of Land suitability for maize production in the Mambilla plateau

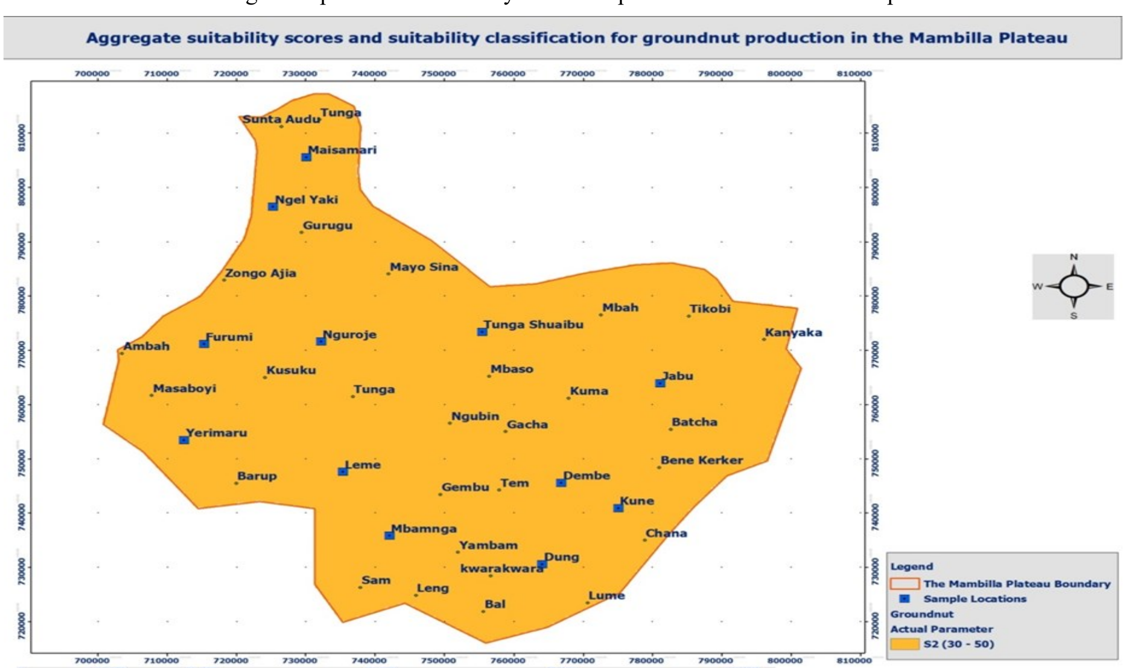


Fig 2: Map of Land suitability for groundnut production in the Mambilla plateau

production.

However, the actual (current) suitability class indicated that the soils were 100 % marginally suitable (S3) for producing of maize and groundnut.

*3.7 Non-parametric evaluation*

The non-parametric evaluation shows that the entire soils of the study area were potentially moderately suitable (S2) for maize production with climatic limitations (high amount of rainfall), while pedons 3 and 4 also have wetness and fertility limitations as an inclusion. However, the soils of the study area were potentially moderately suitable (S2) for groundnut production with climatic limitations while pedons 3 and 4 have wetness limitations as an inclusion.

The non-parametric evaluation also shows that the actual land suitability scores of the study area soils were marginally suitable (S3) for the production of maize and groundnut with climatic and fertility limitations. At the same time, pedons 3 and 4 also have wetness limitations.

*3.8 Major limitation to land suitability for maize and groundnut production*

The result of the land suitability as evaluated shows that topography (t) and soil physical characteristics (s) are nearly optimum for maize and groundnut production in the Mambilla Plateau. Also, the mean annual temperature as an aspect of climate was optimum for maize and groundnut production in the study area compared with the ratings of Sys *et al.* (1993). The annual rainfall is one of the limiting characteristics of maize and groundnut production in the Mambilla Plateau. The annual rainfall amount in the study area ranges from 1780 to 2200 mm (Tables 3 and 5), which is more than 700 to 1100 mm and 750 to 1200 mm recommended as the optimum requirement for the production of groundnut and maize respectively (Sys *et al.,* 1993). Wetness is another limiting characteristic predominantly in pedons 3 and 4. The soil drainage is marginally suitable for producing maize and groundnut on the Mambilla Plateau. Soil fertility is another land quality, limiting maize and groundnut production in the Mambilla Plateau. The CEC and available phosphorus were the most limiting soil fertility characteristics. The available phosphorus varies from low to medium, according to the ratings of Landon (1991), while CEC was low and predominantly marginally suitable (S3). The presence of heavy rainfall and poor nutrient holding capacity, as expressed by low CEC, shows that the leaching rate is high. Excessive rainfall is also a notable constraint to maize and groundnut production in the Mambilla Plateau; hence excessive moisture would encourage pest and disease outbreaks and hamper grain maturity and ripening.

## 4.0 Conclusion

The land suitability for maize and groundnut production was evaluated both by the conventional (non-parametric) and parametric methods. The land suitability was evaluated by considering the soil characteristics related to land qualities affecting the land use types. The soils were placed in suitability classes by matching their characteristics with the land suitability requirements for each crop using the rating of limiting characteristics. Five land quality groups: climate (c), topography (t), soil physical properties (s), wetness (w) and fertility (f), were used in this method of evaluation. The suitability evaluation of the pedons shows that the soils of the entire Mambilla Plateau are marginally suitable (S3) for producing maize and groundnut, with climate and fertility being the major limiting factors.

For optimum performance and upgrade of the suitability of the Mambilla Plateau soils to moderate/highly suitable. Management practices that will encourage the return of crop residues into these soils, crop rotation and manure application to improve the physical and chemical properties of soil should be practiced.

## References

Ande, O.T. (2011). Soil Suitability Evaluation and Management for Cassava Production in the Derived Savanna Area of Southwestern Nigeria. *International Journal of Soil Science,* 6: 142 – 149.

Bami, Y. (2013). The Mambilla Region in African History (ms ed) Nzikachia: Unpublished 360p.

Chapman, J.D. and Chapman, H.M. (2000). The forest flora of Taraba and Adamawa States, Nigeria: An ecological account and plant species checklist. University of Canterbury, New Zealand.

FAO (1976). A framework for land evaluation. Soils Bulletin 32. Food and Agriculture Organization of the United Nations, Rome, Italy.

Landon, J. R. (1991). Booker tropical soil manual, Hand Book for soil survey and agricultural land evaluation in Tropics and sub-tropics. Longman. New York. 74p.

Ogunkunle, A. O. (1993). Soil in land suitability evaluation: An example with oil palm in Nigeria. *Soil Use and Management,* 9: 35 – 40.

Ogunkunle, A.O. (2004). Soil survey and sustainable land management. Proceedings of the 29th Annual Conference of the Soil Science Society of Nigeria, December 6-10, 2004, University of Agriculture, Abeokuta, Nigeria, 12 – 16.

Olsen, S.R. and Sommers, L.E. (1982). Phosphorus. In: Methods of soil analysis part 2. Page, A.L, Miller, R.H., Keeney, D.R. (eds). America Society of Agronomy Madison Wisconsin, 15 – 72.

Ozcan, H. (2006). GIS-based land evaluation of the high land in the eastern Mediterranean region, Turkey. *Journal of Agriculture,* 10(1 - 2): 17 – 27.

Schoeneberger, P.J., Wysocki, D.A. Benham, E.C. and Soil Survey Staff. (2017). Field book for describing and sampling soils, Version 3.0. Natural Resources Conservation Service, National Soil Survey Center, Lincoln, NE.

Summer, M.E. and Miller, W.P. (1996). Cation exchange capacity. In: D.L. Sparks (ed) Methods of soil analysis. Part 2: Chemical Properties. (3rded) ASA, SSSA, CSSA, Madison, W.I., 1201 – 1229.

Sys, C., van Ranst, E. and Debaveye, J. (1993). Land Evaluation, Part III: Crop Requirements. General Administration for Development Cooperation; International Training Centre for Post-graduate Soil Scientists, University Ghent: Gent, Belgium.

Sys, C., Van Ranst, E. and Debaveye, J. (1991). Land evaluation, Part l, Principles in land evaluation and crop production calculations. International Training Centre for Post-graduate Soil Scientists, University Ghent, Belgium.

Thomas, G.W. (1996). Soil pH and soil acidity. In: Methods of soil analysis, Part 3- Chemical methods. L. D. Sparks (eds) SSSA book series, 159 – 165.

Udoh, B.T. and Ogunkunle, A.O. (2012). Land Suitability Evaluation for Maize (*Zea mays*) Cultivated in a Humid Tropical Area of South Eastern Nigeria. *Nig. J. Soil Sci.,* 22(1): 1 – 10.