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Mapping Sustainability Status of Agricultural Soils of Abuja Nigeria and Implications for Sustainable Food Security

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Abstract **Original Research Article**

The sustainability of soils is a key consideration in devising soil management options for better productivity and sustained food security. The study was carried out to determine the sustainability status of agricultural soils in Abuja, Nigeria. Two Agricultural estates in each of the six Area Councils of The Federal capital Territory Abuja were selected and soil samples collected. The soil texture ranged from loamy sand, to sandy loam and sandy clay loam. Soil pH ranged from 5.8 (strongly acidic) to 6.7 (neutral), Organic carbon in the soils was low and ranged from 1.18 – 2.80 g kg-1. In terms of limitations, water stable aggregates, mean weight diameter and soil organic carbon imposed moderate to severe limitations in the soils of Abaji and AMAC. In the soils of Bwari, Gwagwalada Kuje and Kwali, Soil organic carbon, Water stable aggregates, mean weight diameter and pH posed severe to extreme limitations on the soils. For the sustainability classification, only the soils of Agena and Nuku in Abaji Area Council, Kaida and Ibwa in Gwagwgalada Area Council and Checheyi in Kwali Area council were classified as sustainable. The soils of Iddon Kasa and Karshi (AMAC), Kudu and Kawu (Bwari), Chibiri and Gaube (Kuje) and Wako (Kwali) were classified as sustainable with high input. It was observed that the soils are of low fertility status and would therefore require significantly high input of nutrients to maintain its productive capacity for a long time. Integrated nutrient management that requires incorporation of good NPK fertilizers and organic manures is highly recommended.

Keywords: Sustainability Status, Abuja, Agricultural Soils, Food Security.

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1.0 INTRODUCTION

Sustainable development goals numbers 1 and 2 (SDGs, 1 & 2) addresses the issues of poverty eradication and ending hunger. This concern is becoming more imperative now in the face of a geometric growing human population and this is intensifying the need to feed more mouths with limited or scarce resources such as food (1). For any country of the world to be accorded recognition in the committee of nations, it must be able to provide the food requirements of its citizenry sustainably.

Soil quality and productivity are key considerations in sustainable food production. Basic soil resource inventory is a prerequisite for proper soil management. This is because our soils are dynamic and fragile, and the pressure arising from competing land uses beyond agriculture has further limit the availability and sustainability of arable lands for crop production (2).

Over the years, the need for optimum production of food to meet the demand for human consumption, animal feed production and other industrial uses of food materials as raw materials has become imperative. This has put significant pressure on the soils of sub Saharan Africa, Nigeria inclusive. Consequently, this has resulted in the adoption of cropping systems and technologies that have exploited the soils and degraded its quality, resulting in declining yields and threat of impending food shortages and insecurity (3). At the base of all other forms of insecurity, lies food insecurity. This explains why the Sustainable Development Goals numbers 1 and 2 emphasized the concept of food security for all, covering availability and accessibility for nutritious food and poverty eradication. But for these goals to be attainable, the soil resource has to be conserved and properly managed.

According to the revised World Soil Charter (4) soil management is sustainable if the supporting, provisioning, regulating, and cultural services provided by soil are maintained or enhanced without significantly impairing the soil functions that enable those services or biodiversity. The Status of the World's Soil Resources Report identified ten threats that hamper the achievement of sustainable soil management (SSM). These threats are: soil erosion by water and wind, soil organic carbon loss, soil nutrient imbalance, soil salinization, soil contamination, acidification, loss of soil biodiversity, soil sealing, soil compaction and waterlogging (5). These different threats vary in terms of intensity and trend depending on geographical contexts, though they all need to be addressed in order to achieve sustainable soil management (6).

Land that is available for agricultural production is a finite and degradable resource. Already, there is widespread decline in the yields of most crops in Nigeria. Nina (7), observed that there was over 500 kg loss in yield of most grain crops per hectare of agricultural land due to improper soil management in sub Saharan Africa (SSA), amounting to over 60 tons per annum all over SSA. This is because poverty and the need to produce more food, the change in land use and farming practices resulted in soil organic matter depletion, nutrient mining and soil degradation (8). Similarly, Onyekwere *et al.* (9) observed that apart from the scarcity of upland soils for agriculture, available cultivated soils which used to be fertile, had become severely degraded by continuous cropping practiced now with high population and the prangs of climate change and global warming. It is quite obvious that agriculture, an indispensable sector of the economy, is facing serious constraints of scarcity of land and decline in soil fertility. This could underscore why we are having the current global food crisis. It is absolutely imperative that pragmatic steps must be taken to save mankind from an impending danger of more serious famine in the nearest future.

It has therefore become important that we evaluate the sustainability status of the agricultural soils of Abuja in a bid to device strategies for better management and improved crop yield. Abuja has continued to remain an important food basket servicing the north central states and the increasing population influx in the nation's capital. Also, the pressure of development activities such as residential buildings and industrial activities has encroached into designated agricultural estates in the FCT, forcing food production to shift into marginal and non-conventional agricultural lands as well as continuous cultivation of same piece of land year in year out. Hence the need to assess the sustainability status of the soils currently in use all over Abuja, Nigeria.

2.0 MATERIALS AND METHODS

Study was carried out in the six Area councils of the Federal Capital Territory (FCT) Abuja. The FCT is located in the Southern Guinea Savanna between longitudes 6° 20'E and 7° 33'E and latitudes 8° 30'N and 9° 20'N and occupies an area of about 8,000 km^2 (10). The area is characterized by two distinct seasons, the dry and wet seasons. The rains last from May to October with its peak in August and September having mean annual rainfall of 1300 mm. (11). According to Zubair *et al.* (12) the FCT records its highest temperatures and highest diurnal ranges during the dry season months when there are few clouds. Maximum temperature ranges between 30.41°C and 35.1°C during the dry season. During the rainy season on the other hand, the maximum temperature ranges between 25.8°C and 30.2°C. Also, the diurnal range is much reduced. In the FCT, the relative humidity rises to over 50 % during the rainy season everywhere, but it is as low as 20 % during the dry season in the southern part of the FCT. The geology is majorly undifferentiated basement complex with a fringe of sedimentary basin along the major Gurara floodplain.

Field Procedures

Two locations were picked in each area council. Study sites were georeferenced using a GPS to obtain coordinates. The coordinates and soil data were formed into attribute tables to generate a map for the suitability status. The QGIS version 3.32.0 was used for the GIS work. A mini pit was dug in each of the selected sites. Soil samples were collected at depth of 0 – 30 cm and labelled accordingly. Samples were prepared and taken to laboratory for analysis.

Laboratory Procedure

Samples for bulk density were weighed immediately before oven drying and weighed again. Particle size distribution was determined using the wet hydrometer method of Bouyoucous (13), saturated hydraulic conductivity was determined using fall head method (14), Soil aggregate stability was determined by the wet sieving method (15). mean weight diameter was achieved through calculation (16). Soil pH and electrical conductivity were determined by electrometric method using pH meter and EC meter (17). Organic carbon was determined by the modified Walkley – Black method as described by Nelson and Summers (18). Total nitrogen was determined by the macro-Kjeldahl digestion and distillation procedures as described by IITA (19). Available phosphorous was determined by using Sodium bicarbonate {Na $(HCO_3)_2$} extracting solution (20). Exchangeable Cations and Percentage base saturation was determined by ammonium acetate extraction method as described by IITA (21). Cation Exchange Capacity (CEC) was determined by neutral 1N ammonium acetate method (22).

Sustainability Assessment

The sustainability of the soil health values was assessed to know if the current soil health can be sustained by the current land use which was done through some selected soil physical properties under three attributes (mechanical, hydrological and thermal characteristics which include particle size distribution, aggregate stability and mean weight diameter) and chemical soil properties under three attribute also (soil acidity, nutrient capacity and intensity and humic properties). The assessment was done through the use of soil physical and chemical properties indicators which are bulk density, texture, coarse fraction surface (0-30 cm), WSA, mean weight diameter, soil hydraulic conductivity, pH in water, Electrical conductivity (dS m^{-1}), Al toxicity, organic carbon at surface horizon (0-30 cm).

The critical level according to Lal (23) was used to assign relative weighting factors to the selected indicators. The limitation ranges with relative weighting factors of 1 to 5 were then used as shown in Table 1. The sustainability rating was determined as shown in Table 2.

Table 1: Limitation rates for Sustainability Assessment

Weighting factor	**Limitation**	**Remarks**
1	No limitation	the negative effect of the indicator on sustainability of land use is nil
2	Slight limitation	the negative effect of the indicator on the sustainability of land use is slight
3	Moderate limitation	the negative effect of the indicator on sustainability of land use is moderate
4	Severe limitation	the negative effect of the indicator on sustainability of land use is severe
5	Extreme limitation	the negative effect of the indicator on sustainability of land use is extreme

Source: Lal (1994)

Table 2: Sustainability rating

Sustainability Rating	**Cumulative rating Index**
High sustainable	<20
Sustainable	20-25
Sustainable with high input	25-30
Sustainable with another land use	30-40
Unsustainable	>40

Sources: Lal (1994)

3.0 RESULTS AND DISCUSSION

Results of the sustainability status of agricultural soils of the FCT are presented in Tables 4.21 – Table 4.26.

Abaji Soils

The analysis of the sustainability status of the soils of Agena in Abaji the FCT shows that Ksat, EC, Al^{3+} and pH do not impose any constraint or limitation in the soils, and the level of coarse sand and bulk density posed only a slight limitation. However, WSA and soil texture posed a moderate level of limitation. The constraint imposed by MWD and SOC were severe. This placed the soil as being sustainable in status.

In the soils of Nuku, Ksat, EC, Al^{3+}, and pH posed no constraints or limitation to the soil. While coarse sand had a slight limitation. Other factors such as WSA, bulk density and soil texture had moderate limitations. Only MWD and SOC posed severe limitations. The cumulative weighing index placed the soils Nuku as being sustainable.

AMAC Soils

For the soils of Iddon Kasa, Ksat, EC, Al^{3+}, and pH do not impose any constraint or limitations to the soils of Iddon Kasa in Abuja Municipal Area Council of the FCT. Bulk density and texture imposed moderate level of constraint/limitations while coarse sand, MWD, WSA and SOC imposed severe level of limitations to the soils of Iddon Kasa in AMAC. The cumulative rating index has placed the soils as being sustainable but with a high input

Considering the soils of Karshi, Ksat, EC, Al^{3+}, and pH do not impose any constraint or limitations to the soils of Karshi in Abuja Municipal Area Council of the FCT. Bulk density and texture imposed moderate level of constraint/limitations while coarse sand, MWD, WSA and SOC imposed severe level of limitations to the soils of Karshi in AMAC. The cumulative rating index has placed the soils as being sustainable but with a high input.

Bwari Soils

In the soils of Kuduru in Bwari Area council of the FCT, Ksat, EC, Al^{3+} and pH do not impose any limitations on the soils, while coarse sand content only had a slight limitation for the soils. Bulk density and soil textural class imposed a moderate level of limitations on the soils. WSA and SOC imposed a severe level of limitations. Only MWD imposed an extreme level of limitation on the soils of Kuduru. The cumulative rating index placed the soils as being sustainable but with a high level of production input.

Table 3: Sustainability status of soils of Abaji

Location	Soil indicators (0 – 30 cm)	Soil indicator values	Weighing factor	Limitation
	Coarse sand %	12.04	2	Slight
Agena N=8.474786 E=6.911066 Alt. 172m	MWD (mm)	1.00	4	Severe
	WSA (%)	32	3	Moderate
	Ksat (cm hr^{-1})	5.00	1	None
	Bulk density (g cm^{-3})	1.34	2	Slight
	Texture	Sandy loam	3	Moderate
	EC (dS m^{-1})	1.3	1	None
	Al^{+3} (cmol kg^{-1})	0.29	1	None
	pH (H_2O)	6.2	1	None
	Soil organic carbon g kg^{-1}	2.04	4	Severe
	Cumulative index rating		*22*	*Sustainable*
	Coarse sand %	10.00	2	Slight
Nuku N=8.516282 E=7.036950 Alt. 296m	MWD (mm)	0.97	4	Severe
	WSA (%)	30	3	Moderate
	Ksat (cm hr^{-1})	5.13	1	None
	Bulk density (g cm^{-3})	1.41	3	Moderate
	Texture	Sandy loam	3	Moderate
	EC (dS m^{-1})	1.2	1	None
	Al^{+3} (cmol kg^{-1})	0.31	1	None
	pH (H_2O)	6.2	1	None
	Soil organic carbon g kg^{-1}	1.96	4	Severe
	Cumulative index rating		*23*	*Sustainable*

NB: MWD = mean weight diameter, WSA = water stable aggregate, Ksat = saturate hydraulic conductivity, EC = electrical conductivity, Al^{3+} = aluminium, pH = soil reaction

Table 4: Sustainability status of soils of AMAC

Location	Soil indicators (0 – 30 cm)	Soil indicator values	Weighing factor	Limitation
	Coarse sand %	25.22	4	Severe
Iddon Kasa N=9.036808 E=7.258710 Alt.= 317m	MWD (mm)	0.98	4	Severe
	WSA (%)	18	4	Severe
	Ksat (cm hr^{-1})	4.66	1	None
	Bulk density (g cm^{-3})	1.43	3	Moderate
	Texture	Sandy clay loam	3	Moderate
	EC (dS m^{-1})	1.5	1	None
	Al^{+3} (cmol kg^{-1})	0.25	1	None
	pH (H_2O)	6.5	1	None
	Soil organic carbon g kg^{-1}	1.25	4	severe
	Cumulative index rating		*26*	*Sustainable with high input*
	Coarse sand %	23.61	4	Severe
Karshi N=8.884216 E=7.516451 Alt. = 558m	MWD (mm)	1.00	4	Severe
	WSA (%)	11	4	Severe
	Ksat (cm hr^{-1})	5.13	1	None
	Bulk density (g cm^{-3})	1.41	3	moderate
	Texture	Sandy loam	3	Moderate
	EC (dS m^{-1})	1.2	1	None
	Al^{+3} (cmol kg^{-1})	0.30	1	None
	pH (H_2O)	6.3	1	None
	Soil organic carbon g kg^{-1}	1.18	4	Severe
	Cumulative index rating		*26*	*Sustainable with high input*

NB: MWD = mean weight diameter, WSA = water stable aggregate, Ksat = saturate hydraulic conductivity, EC = electrical conductivity, Al^{3+} = aluminium, pH = soil reaction

Table 5: Sustainability status of soils of Bwari

Location	Soil indicators (0 – 30 cm)	Soil indicator values	Weighing factor	Limitation
	Coarse sand %	12.22	2	Slight
Kuduru N=9.392583 E=7.103350 Alt. 650	MWD (mm)	0.29	5	Extreme
	WSA (%)	14.18	5	Severe
	Ksat (cm hr^{-1})	4.55	1	None
	Bulk density (g cm^{-3})	1.43	3	Moderate
	Texture	Sandy loam	3	Moderate
	EC (dS m^{-1})	1.5	1	None
	Al^{+3} (cmol kg^{-1})	0.20	1	None
	pH (H_2O)	6.5	1	None
	Soil organic carbon g kg^{-1}	1.66	4	severe
	Cumulative index rating		*26*	*Sustainable with high input*
	Coarse sand %	14.61	2	Slight
Kawu N=9.318296 7.525249 Alt. 694	MWD (mm)	0.20	5	Extreme
	WSA (%)	14.22	5	Extreme
	Ksat (cm hr^{-1})	4.33	1	None
	Bulk density (g cm^{-3})	1.41	3	Moderate
	Texture	Sandy clay loam	3	Moderate
	EC (dS m^{-1})	1.3	1	None
	Al^{+3} (cmol kg^{-1})	0.51	1	None
	pH (H_2O)	6.5	1	None
	Soil organic carbon g kg^{-1}	1.76	4	Severe
	Cumulative index rating		*26*	*Sustainable with high input*

NB: MWD = mean weight diameter, WSA = water stable aggregate, Ksat = saturate hydraulic conductivity, EC = electrical conductivity, Al^{3+} = aluminium, pH = soil reaction

Table 6: Sustainability status of soils of Gwagwalada

Location	Soil indicators (0 – 30 cm)	Soil indicator values	Weighing factor	Limitation
	Coarse sand %	8.4	1	None
Ibwa N=8.995267 E=7.103350 Alt. 229m	MWD (mm)	0.78	5	Extreme
	WSA (%)	30.1	4	Severe
	Ksat (cm hr^{-1})	4.84	1	None
	Bulk density (g cm^{-3})	1.39	2	Slight
	Texture	Sandy loam	3	moderate
	EC (dS m^{-1})	0.22	1	None
	Al^{+3} (cmol kg^{-1})	0.33	1	None
	pH (H_2O)	6.6	1	None
	Soil organic carbon g kg^{-1}	2.80	4	Severe
	Cumulative index rating		*23*	*Sustainable*
	Coarse sand %	6.7	1	None
Kaida N=8.948469 E=7.011734 Alt.= 250m	MWD (mm)	1.22	4	Severe
	WSA (%)	20.6	4	Severe
	Ksat (cm hr^{-1})	4.78	1	None
	Bulk density (g cm^{-3})	1.42	3	Moderate
	Texture	Sandy loam	3	Moderate
	EC (dS m^{-1})	2.4	1	None
	Al^{+3} (cmol kg^{-1})	0.20	1	None
	pH (H_2O)	6.2	1	None
	Soil organic carbon g kg^{-1}	2.24	4	Severe
	Cumulative index rating		*23*	*Sustainable*

NB: MWD = mean weight diameter, WSA = water stable aggregate, Ksat = saturate hydraulic conductivity, EC = electrical conductivity, Al^{3+} = aluminium, pH = soil reaction

Table 7: Sustainability status of soils of Kuje

Location	Soil indicators (0 – 30 cm)	Soil indicator values	Weighing factor	Limitation
	Coarse sand %	5.30	1	None
Chibiri N=8.560163 E=7.181191 Alt. 497 m	MWD (mm)	1.01	5	Extreme
	WSA (%)	15.39	5	Extreme
	Ksat (cm hr^{-1})	4.85	1	None
	Bulk density (g cm^{-3})	1.40	3	Moderate
	Texture	Sandy loam	3	Moderate
	EC (dS m^{-1})	1.7	1	None
	Al^{+3} (cmol kg^{-1})	0.32	1	None
	pH (H_2O)	6.7	1	None
	Soil organic carbon g kg^{-1}	2.38	4	Severe
	Cumulative index rating		*26*	*Sustainable with high input*
	Coarse sand %	7.04	1	None
Gaube N=8.803412 E=7.316720 Alt. = 497 m	MWD (mm)	0.30	5	Moderate
	WSA (%)	14.51	5	Moderate
	Ksat (cm hr^{-1})	4.37	1	None
	Bulk density (g cm^{-3})	1.39	2	Slight
	Texture	Loamy sand	4	Severe
	EC (dS m^{-1})	1.6	1	None
	Al^{+3} (cmol kg^{-1})	0.4	1	None
	pH (H_2O)	6.5	1	None
	Soil organic carbon g kg^{-1}	2.70	4	Severe
	Cumulative index rating		*25*	*Sustainable with high input*

NB: MWD = mean weight diameter, WSA = water stable aggregate, Ksat = saturate hydraulic conductivity, EC = electrical conductivity, Al^{3+} = aluminium, pH = soil reaction

Table 8: Sustainability status of soils of Kwali

Location	Soil indicators (0 – 30 cm)	Soil indicator values	Weighing factor	Limitation
	Coarse sand %	3.29	1	None
Wako N=8.736874 E=7.014672 Alt.= 172m	MWD (mm)	0.01	5	Extreme
	WSA (%)	0.41	5	Extreme
	Ksat (cm hr^{-1})	5.53	1	None
	Bulk density (g cm^{-3})	1.64	5	Extreme
	Texture	Silty loam	4	Severe
	EC (dS m^{-1})	2.44	1	None
	Al^{+3} (cmol kg^{-1})	0.32	1	None
	pH (H_2O)	5.8	2	Slight
	Soil organic carbon g kg^{-1}	2.50	3	moderate
	Cumulative index rating		*28*	*Sustainable with high input*
	Coarse sand %	11.20	2	Slight
Checheyi N=8.874494 E=6.976036 Alt. 163m	MWD (mm)	1.42	5	Extreme
	WSA (%)	35.22	3	Moderate
	Ksat (cm hr^{-1})	3.42	1	None
	Bulk density (g cm^{-3})	1.44	3	Moderate
	Texture	Sandy loam	3	Moderate
	EC (dS m^{-1})	1.7	1	None
	Al^{+3} (cmol kg^{-1})	0.22	1	None
	pH (H_2O)	6.3	1	None
	Soil organic carbon g kg^{-1}	2.07	3	Moderate
	Cumulative index rating		*23*	*Sustainable*

NB: MWD = mean weight diameter, WSA = water stable aggregate, Ksat = saturate hydraulic conductivity, EC = electrical conductivity, Al^{3+} = aluminium, pH = soil reaction

For the soils of Kawu area, Ksat, EC, Al^{3+}, and pH do not impose any limitations on the soils of the area, coarse sand content imposed only a slight limitation on the soils of the area. While bulk density and soil textural class had a moderate level of limitations on the soil. Soil organic carbon (SOC) imposed a severe limitation on the soils while MWD and WSA limitations imposed on the soils were extreme. The cumulative index rating placed the soils of Kawu as being sustainable with a high input level.

Gwagwalada Soils

In the soils of Ibwa, coarse sand, Ksat, EC, Al^{3+}, and pH do not impose any limitations on the soils of Ibwa in the Gwagwalada Area council of the FCT. Bulk density of the soil imposed only a slight limitation on the soils while soil texture imposed a moderate level of limitation on the soil. Also, WSA and SOC imposed a severe level of limitation on the soils while MWD imposed an extreme level of limitation on the soils. The cumulative index rating had placed the soils on the sustainable status.

For the soils of Kaida, Coarse sand, Ksat, EC, Al^{3+} and pH do not impose any limitations on the soil. While bulk density and soil textural class imposed a moderate level of limitation on the soils. The result also showed that MWD, WSA and SOC had imposed a severe level of limitations on the soils. The cumulative index rating placed the soils as being sustainable.

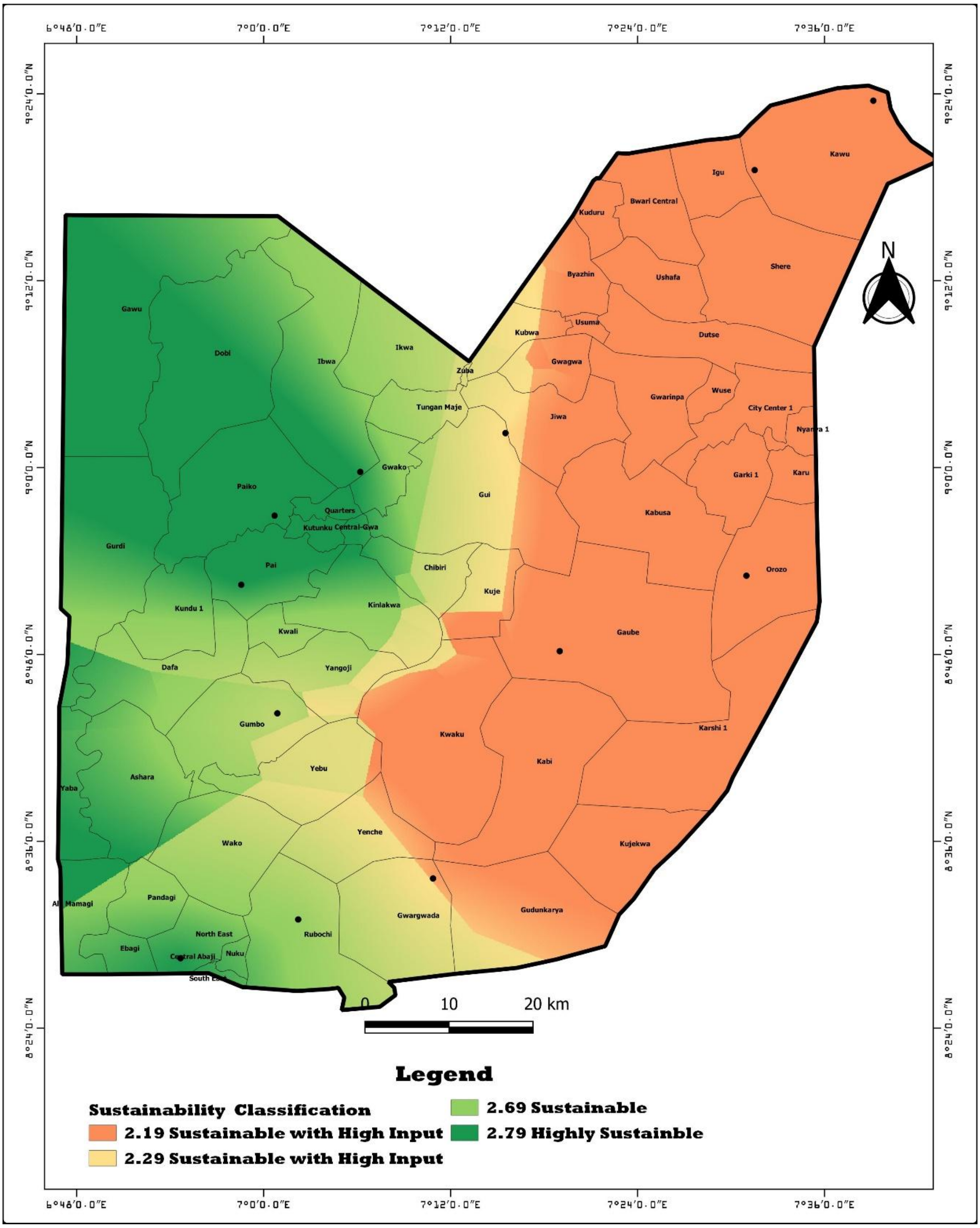

Fig. 1: Sustainability status of the soils of Abuja, Nigeria.

Kuje Soils

Results for the soils of Chibiri in Kuje area council of the FCT showed that coarse sand content, Ksat, EC, Al^{3+}, pH do not pose any limitation on the soils of the area. Bulk density and soil textural class had imposed a moderate level of limitation on the soils while SOC had a severe level of limitation on the soil. MWD and WSA had extreme level of limitation imposed on the soils of the area. The cumulative rating index placed the soils as being sustainable but with a high input of production resources.

For the soils of Gaube, coarse sand content, Ksat, EC, Al^{3+} and pH do not impose any constraint/limitation on the soil. Soil bulk density had only a slight limitation imposed on the soils while MWD and WSA had imposed a moderate level of limitation on the soils. Soil textural class and soil organic carbon had imposed a severe level of limitation on the soils of the area. The cumulative rating index placed the soils as being sustainable but with a high input of production resources.

Kwali Soils

Results for the soil of Wako showed that coarse sand, Ksat, EC and Al^{3+} do not impose any constraint or limitation on the soils, while organic carbon had a moderate limitation on the soil. Soil pH imposed only a slight limitation on the soils while soil texture did impose a severe limitation to the soil. Further, MWD, WSA and bulk density imposed an extreme level of limitation to the soils of the area. The overall cumulative index rating had placed the soils as being sustainable with a high level of input.

For the soils of Checheyi, Ksat, EC, Al^{3+} and pH did not impose any constraint or limitations to the soil, coarse sand content imposed a slight limitation while WSA, bulk density, texture and SOC imposed a moderate limitation to the soil's productivity. Only MWD imposed a severe limitation to the soils of Checheyi area in the Kwali Area council of the FCT. The cumulative index rating had placed the soils as being sustainable.

4.0 DISCUSSION

No field among the twelve farmers' estates within the FCT fell within the "highly sustainable" class (possess sustainability rating of < 20) using Lal, 1994 soil sustainability rating. The agricultural soils classified as sustainable (based on the rating index) had 42 % while sustainable with high input had 48 %. This implies that the productivity of the agricultural soil in Abuja under cultivation is low which has serious implications. It is an indication that the cultivated fields in Abuja considered as the "food basket" of the Federal Capital Territory (FCT) of Nigeria has some "soil health" challenges. Some critical soil properties contribution to structural build-up within the soil may not be functioning at optimal capacity. The soil under the traditional or usual farmers' practices with little or not adequate external input and sound soil management practice will continue to deteriorate or degrade to unsustainable status (24). Where this if allowed to continue, crop yields will drastically reduce, poverty will be widespread and the farmers will fail to contribute to meeting SDG 1 and 2, the land will not be able to lead the farmers to attain SDG 1 (poverty eradication), and SDG 2 (elimination of hunger). The soil units at Agena and Nuku in Abaji Area council, Ibwa and Kaida in Gwagwalada Area council and Checheyi in Kwali Area council are rated as "sustainable" has a soil sustainability rating of > 20 ≤ 25. Being just sustainable implies that some properties still constitute limitations to the productivity of the soil (25). The agricultural soils of Idoon Kasa and Karshi in Abuja Municipal Area Council, Kuduru and Kawu in Bwari Area council, Chibiri and Gaube in Kuje Area council and Wako Gada biyu irrigation site in Kwali Area council are in the class of "sustainable with high inputs" or unsustainable with a sustainability rating of > 26 ≤ 30 (26). This indicates that if the sustainable management system or technology are not introduced in no distant future, the soil is likely to enter into a state of "no return to a productive life".

Bulk density is one property that adds up to reduce the sustainability of the soil. This implies restriction to root growth, restriction to the transmission of water within the soil (27; 28). Water stable aggregate (WSA) and the size distribution of aggregates responsible for aggregation constituted limitations that ranged from severe to extreme. The limitations in WSA and MWD combines with unfavourable bulk density will render the soil prone to degradation and reduction in the sustainability of the soil. The soil organic carbon (SOC) levels in all the fields is a major concern and one major factor combining with other soil properties to imposed severe limitation and reduced the ability of the soil to continue to support crop production and other agronomic activities. Soil organic carbon is a property that serves as the "blood" of productive soil (29). The availability of nutrients in the soil to enhance crop productivity and enhance the environmental quality of the soil is linked to the level of SOC (30). The levels of SOC in the fields are low from the study of the fertility of the fields. Hence crop productivity in the field is also expected to below.

Sustainability of soil with the prediction "with high input" needs specialized expert-recommended soil management practices and inputs for the fields. The inputs must be incorporated with high-quality green materials and inorganic materials. The high bulk density needs to be improved upon by introducing tillage (31). The SOC must be improved with organic amendments. With the improvement in SOC, the water-stable aggregate will increase and reduce or eliminate the limitations imposed by MWD on the soil. From this study and some previous studies, there is a direct relationship between soil health and sustainable land management (32). This supports the submission of Karlen *et al.*, (33) and Doran and Zeiss (34). The critical component of sustainable agriculture and a farming system can only be sustainable when soil quality is maintained or improved (35, 36 & 37). When soils become degraded, more resources in terms of time, money, energy, and chemicals will be needed to produce less-abundant crops of lower quality.

CONCLUSION AND RECOMMENDATIONS

The soils are of low fertility status and would therefore require significantly high input of nutrients to maintain its productive capacity for a long time.

- Integrated nutrient management that requires incorporation of good NPK fertilizers and organic manures is highly recommended. This will enhance the nutrient supply to plants and also improve the physical quality of the soils. Uses of organic household waste such as vegetable peels, egg shells, fish and bones for compost, farm yard manure (FYM), incorporation of green manure and living roots (rhizosphere) will boost the nutrient capacity of the soil. Practicing of polyculture cropping which is multiple varieties with varying root depths holding the soil intact and absorbing nutrients from various levels of soil to enrich the top soil. In-situ manuring is recommend before the sowing and practicing of integrated soil fertility management (ISFM) which is knowledge-intensive rather than input-intensive approach that aims at raising productivity levels while maintaining the natural resource base, replenish soil nutrient pools, maximize on-farm recycling of nutrients, reduce nutrient losses to the environment and improve the efficiency of external inputs. The manure which is incorporated into the soil by basal application can be follow by the amendment of vermicompost as basal dressing at the root zone of each individual plant with drip irrigation system will help a lot in replenishing the soil.

REFERENCES

1. Barnabas I.M & Nwaka, G.I.C. (2014). Characterization of soils of Jiwa in the Federal Capital Territory Abuja, Nigeria. In: Ojeniyi, S. O., Agbede, O. O. and Jayeoba, O.J. (Eds.) *Soil Science, environment and food security*. Proceedings of the 37th Annual Conference of the Soil Science Society of Nigeria, held at Taal Conference Hotel, Lafia Nasarawa State, from 11 – 15th March, 2013. pp13 – 21.
2. Chauhan, R.P.; Pande, K.R.; Thakur, S. (2014). Soil properties affected by land use systems in Western Chitwan, Nepal. Int. J. Appl. Sci. *Biotechnol*, 2, 265–269
3. Onyekwere, I.N., Njoku, N.R., Chukwu, L.I. Ohaeri, E. J. & Nwokocha, C.C. (2020). Land Suitability Evaluation of Basaltic Soils for Cassava production in Cross River State Nigeria. *The Nigerian Agricultural Journal*, 51 (2):391-398.
4. FAO. (2015). Revised world soil charter. (Also available at http://www.fao.org/fileadmin/user_upload/GSP/docs/ITPS_Pillars/annexVII_WSC.pdf) (Retrieved June 2019)
5. Soil Survey Staff (2022). Keys to soil taxonomy: 13th edition. United States Department of Agriculture, Natural Resources Conservation Service, Washington, DC. 401pp.
6. FAO & ITPS. (2015). Status of the World's Soil Resources (SWSR). Food and Agricultural Organization of the United Nations and Intergovernmental Technical Panel on Soils, Rome, Italy.
7. Nina, S. L. (2008). Methodologies for Mapping Land Cover/Land Use and its Changes. *Springer*, 341-367.
8. Antoni Magri, Harold M, Michael A. & William J. (2005). Soil test - Aerial image and yield data as inputs for site-specific fertility and hybrid management under maize. *Springer Science, Precision Agriculture*, 6, 87-110. http://dx.doi.org/10.1007/s11119-004-0687-7
9. Onyekwere, I.N., Njoku, N.R., Chukwu, L.I. Ohaeri, E. J. & Nwokocha, C.C. (2020). Land Suitability Evaluation of Basaltic Soils for Cassava production in Cross River State Nigeria. *The Nigerian Agricultural Journal*, 51 (2):391-398.
10. FCDA (2019). (Federal Capital Development Authority). The geography of Abuja. http//www.fcda.gov.ng. (Retrieved December 2019).
11. Zubair, O.A., Ojigi, L.M. & Mbih, R. A. (2015). Urbanization: A Catalyst for the Emergence of Squatter Settlements and Squalor in the Vicinities of the Federal Capital City of Nigeria. *Journal of Sustainable. Development*, *8*, 134–148.
12. Zubair, O.A., Ojigi, L.M. & Mbih, R. A. (2015). Urbanization: A Catalyst for the Emergence of Squatter Settlements and Squalor in the Vicinities of the Federal Capital City of Nigeria. *Journal of Sustainable. Development*, *8*, 134–148.
13. Udo, E. J., Ibia, T. O., Ogunwale, J. A., Ano, A. O., & Esu, I. E. (2009). Manual of soil, plant and water analysis, Sibon books Ltd.
14. Hillel, D. (1980). Fundamentals of Soil Physics. New York: Academic Press Inc.
15. Hillel, D. (1980). Fundamentals of Soil Physics. New York: Academic Press Inc.
16. Obi, M. E. (2000). Soil Physics: A Compendium of Lectures. Atlanto publishers, Nsukka, Enugu State. Pp152
17. International Institute for Tropical Agriculture (IITA). (2015): Selected methods for soils and plant analysis manual series No. 1 IITA

18. Nelson, D.W. & Sommers, L.E. (1982). Total carbon, organic carbon, and organic matters. Method of soil analysis part 2. Agronomy 9-second edition American Society of Agronomy and Soil Society of America, Madison Wisconsin, 595-624.
19. International Institute for Tropical Agriculture (IITA). (2015): Selected methods for soils and plant analysis manual series No. 1 IITA
20. International Institute for Tropical Agriculture (IITA). (2015): Selected methods for soils and plant analysis manual series No. 1 IITA
21. International Institute for Tropical Agriculture (IITA). (2015): Selected methods for soils and plant analysis manual series No. 1 IITA
22. Udo, E. J., Ibia, T. O., Ogunwale, J. A., Ano, A. O., & Esu, I. E. (2009). Manual of soil, plant and water analysis, Sibon books Ltd.
23. Lal, R. (1994). Methods and guidelines for assessing sustainable use of soil and water resources in the tropics. Soil Management Support System, USDA-NRCS, Washington, DC. Pp, 1-88.
24. Pandey, S.; Bhatta, N.P.; Paudel, P.; Pariyar, R.; Maskey, K.H.; Khadka, J.; Thapa, T.B.; Rijal, B.; Panday, D. (2018). Improving fertilizer recommendations for Nepalese farmers with the help of soil-testing mobile van. *Journal of Crop Improvement*, 32, 19–32.
25. Sudarshan, K., Babu, R.K. and Dinesh, P. (2018). Assessment of Soil Fertility Under Different Land-Use Systems in Dhaning District of Nepal. Soil Systems, 2: 57 – 64.
26. Lal, R. (1994). Methods and guidelines for assessing sustainable use of soil and water resources in the tropics. Soil Management Support System, USDA-NRCS, Washington, DC. Pp, 1-88.
27. Larson, W.E. & Pierce, F.J. (1994). The dynamics of soil quality as a measure of sustainable management. Defining soil quality for a sustainable environment. *Soil Science Society of America*, Madison, Wisconsin, pp 37–52.
28. Oku, E.E., Emmanuel, S.A., Odoh, N.C. & Musa, B.I. (2020). Soil physical fertility status and management prescription for soil sustaining farms and ranches in Abuja, Nigeria. *Journal of Environmental and Agricultural Sciences*, 22 (1): 57-63.
29. Oku, E.E., Emmanuel, S.A., Odoh, N.C. & Musa, B.I. (2020). Soil physical fertility status and management prescription for soil sustaining farms and ranches in Abuja, Nigeria. *Journal of Environmental and Agricultural Sciences*, 22 (1): 57-63.
30. Harris, R.F., Karlen, D.L., and Mulla, D.J. (1996). A conceptual framework for the assessment and management of soil quality and health. In: Doran, J.W., Jones, A.J. (eds.), Methods for assessing soil quality. Soil Science Society of America, Special Publication No. 49, 61 ± 82.
31. AICC. Agriculture Information and Communication/Ministry of Agriculture, Land Management and Cooperatives. (2017). Hariharbhawan, Lalitpur, Nepal. Available online: http://www.aicc.gov.np/home/ (accessed on 30 August 2024).
32. Gregorich, E.G., Angers, D.A., Campbell, C.A., Carter, M.R., Drury, C.F. & Ellert, B.H., (1995). Changes in soil organic matter. In the health of our soils: Towards sustainable agriculture in Canada. D.F. Acton and L.J. Gregorich (eds.). Center for Land and Biological Resources Research, Research Branch, Agriculture and Agri-Food, Canada, Pp 41–50.
33. Karlen, D.L., Gardner, J.C. & Rosek, M.J. (1998). A soil quality framework for evaluating the impact of the crop. *Journal Product Agriculture*, 11: 56–60.
34. Doran, J.W., & Zeiss, M.R. (2000). Soil health and sustainability: managing the biotic component of soil quality. *Applied Soil Ecology*. 15.1, 3-11.
35. Larson, W.E. & Pierce, F.J. (1994). The dynamics of soil quality as a measure of sustainable management. Defining soil quality for a sustainable environment. *Soil Science Society of America*, Madison, Wisconsin, pp 37–52.
36. FAO (1994), Cherish the Earth. Soil Management for Sustainable Agric and Environmental Protection for the Tropics. Rome, Italy.
37. Uddin, K.M.; Murthy, S.R.; Wahid, S.M.; Matin, M.A. (2016). Estimation of soil erosion dynamics in the Koshi basin using gis and remote sensing to assess priority areas for conservation. PLoS ONE 2016, 11, e0150494.