
GEOSPATIAL ASSESSMENT OF SOIL TEXTURAL CLASSES AND THE IMPLICATIONS ON ACHIEVING SDG 2 IN NORTHWESTERN NIGERIA

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ABSTRACT

*This study presents a geospatial analysis of soil textural classes for Kaduna, Kano and Katsina States in the North-western region of Nigeria. Soil classification maps were digitized from the FAO Digital Soil Map of the World using ArcGIS 10.3.1. Results revealed that Sandy Loam is the dominant class in Kano and Katsina States, covering approximately 68% and 61% of the land area respectively. Kaduna State revealed a greater variation in soil textural classes, with Loam as the dominant class in the southern Guinea Savanna area, followed by Sandy Clay Loam and Sandy Loam in the northern Sudan Savanna zone. The spatial distribution of these classes has direct implications for agricultural management in the Sudan Savanna agro-ecological zone. The extensive Sandy Loam areas in Kano and Katsina are prone to rapid infiltration, low water retention and nutrient leaching. Therefore, these zones require soil-water conservation measures such as mulching, tied ridging, and micro-catchments and precision irrigation scheduling using drip or deficit irrigation to improve water use efficiency for drought-tolerant crops like millet, sorghum and cowpea. Furthermore, the Loam and Sandy Clay Loam areas in central and southern Kaduna, with higher water and nutrient holding capacity, are more suitable for crop-soil matching with maize, soybean and irrigated rice under controlled irrigation. The digitized maps provide a spatial decision-support framework for targeted erosion control structures in coarse-textured zones and for variable-rate fertilizer application under precision agriculture. This contributes to SDG 2: Zero Hunger by enabling site-specific input management and yield optimization. The study recommends ground-truthing through physico-chemical analysis of soil samples across representative map units in the three States to validate and refine the map for policy, engineering and extension purposes.***Keywords:** ArcGIS; FAO; Northwest; SDG 2; Soil; Soil Texture

1. INTRODUCTION

Soil is the uppermost part of the earth surface on which plants grow (Stephen et al., 2017). It is a mixture of mineral matter, organic matter, water and air. Soil quality is a major determinant of agricultural productivity Bichi & Khalil, (2025) and Ologunde & Nunes, (2026) and, thus, understanding the soil quality dynamics remains paramount in achieving food security in any region. Soil texture is the relative proportions of sand, silt, and clay in the soil. The optimization of a farming season can be greatly influenced by the soil textural classes. As this influences engineering properties, water movement, rooting depth of plants of a soil, Erosion resistance, nutrient retention, water infiltration and most importantly crop production Ahmed et al., (2020) and Sharu, M. B. et al., (2025). These soil properties often vary from time to time (Gambo et al., 2025), soil quality assessment is therefore an unending process. The Northwestern region of Nigeria is known as a hub of production of crops such as groundnut, millet sorghum and maize etc. However, an optimized production of these major crops is often limited by climatic variability and unsustainable local farming practices. Muhammad et al., (2026) highlighted the suitability of sandy loam and loamy soils for optimum productivity of maize plant which is a major crop in attaining SGD2- Food Security and Zero Hunger, in Northwestern Nigeria. A geospatial interpretation of soil types in this region is therefore, an important information required for an effective land use and land cover (Farming) planning as well as soil conservation strategies. Despite the availability of global soil database by the FAO, the localized application and interpretation of soil textural classes in this region is lacking. The study

therefore, aimed to analyze and classify the spatial distribution of soil textural classes of Kano, Kaduna and Katsina States all located in the Northwestern region of Nigeria.

2. METHODOLOGY

2.1 Description of Study Area

The study area include Kano, Kaduna Katsina, State located in the northwestern region of Nigeria. These are located between a latitude of 12.99°N to 10.52°N and a longitude of 7.44°E to 8.52°E (Muhammad et al., 2026). The states falls under the Sudan Savanna ecological Zones and are classified as a semi-arid climate. The zone experiences two distinct seasons known as dry season from October to May and a wet season from May to September. The annual average rainfall range between 500 mm to 1000 mm. The States are characterized by an average temperature ranging between 28°C to 40°C.

2.2 Data Source

The soil data was obtained from the Digital Soil Map of the World (DSMW)(FAO,2007).

2.3 Data Processing and Interpretation

This involves a preliminary desk-based study pending ground-truthing. This soil data was processed and digitized in ArcGIS 10.3.1 through the following steps;

a. **Projection:** The administrative boundary shapefiles of the States were projected to WGS 1984, UTM.ZONE-32N

b. **Extraction of Study Areas:** This was achieved by importing the DSMW soil polygon of Nigeria and Kano, Kaduna and Katsina states shapefiles into ArcGIS 10.3.1

c. **Clipping Raster Data:** The extraction by Mask tool in Spatial Analyst tool of ArcGIS 10.3.1 was used to extract the polygon layers of each States from the DSMW raster file.

d. **Soil Textural Interpretation and Classification:** The soil textural classes were interpreted based on Harmonized World Soil Database (FAO, 2012). The textural classes were defined by the USDA classification system into Loam, Sandy Loam, Sandy-Clay Loam etc. A suitable color range were chosen for cartographic and Legend representation for each state.

3. RESULTS AND DISCUSSION

The digitized soil classification maps for Kaduna, Kano and Katsina states are presented in Figures 3.1, 3.2 and 3.3. Table 3.1 also shows the distribution per square kilometre of soil textural classes for each state. Generally, the States were dominated with sand soils with some variations (sandy-clay, sand-loam etc). The occurrence of sandy soils and sandy loams soils is an expected classification due to the geological and climatic conditions of Sudan Savanna (Northwest) which supports the formation and accumulation of sand particles. This is in line with study findings by Ahmed & Yusuf, (2020); Danjuma, (2023); and Garba et al., (2023). The warm climate also increases the rate of organic matter decomposition which is required to improve the soil structure and fertility of sandy soils.

The dominance of high sand content in the states accounts for why soils have a high leaching loses and lower water holding capacity. A study by Bichi & Khalil (2025) conducted in Dutsin-Ma Local Government Area Katsina State similarly found out that all samples appear to fall under same soil type of Sandy Loam. This means that the variation in texture may not be significant and because of that same type of irrigation technique can be employed in Dutsin-Ma LGA the study area.

Note: The maps below show multiple colors for same textural class due to different soil components with similar texture but different parent material and drainage properties. This explains why same textural classes with different FAO/SWAT serial numbers.

Table 3.1: FAO/SWAT Soil Textural Distribution per Area

Kaduna		Katsina		Kano	
FAO/SWAT	Area	FAO/SWAT	Area	FAO/SWAT	Area
S/N	(sqkm)	S/N	(sqkm)	S/N	(sqkm)
1262	9.46E-05	1614	0.488632	1223	0.040306
1468	0.052095	1661	0.039299	1627	0.019334
1455	0.247078	1261	0.035534	1476	0.873694
1476	1.155892	1607	0.006329	1509	0.038442
1262	0.116334	1371	0.003422	1614	0.552739
1470	0.40213	1262	0.009245	1511	0.000889
1511	0.370328	1506	0.106213	1468	0.021657
1324	0.00692	1632	0.617808	1701	0.061098
1493	0.772149	1627	0.064105		
60	0.031797	1480	0.082659		
1020	0.013186	1468	0.053966		
1255	0.186579	1223	0.029994		
1268	0.030071	1509	0.130281		
1081	0.065486	1476	0.104445		
1528	0.016405	1470	0.054202		

3.1 Kaduna State

Kaduna State displayed the most heterogeneous soil profile. The most dominant soil types identified in Kaduna State were Loam, Sandy Clay Loam, and Sandy Loam. These were by same distributed in significant, contiguous patches. This is an indication that the state is of relatively favorable soil conditions. This correlates with the study findings by Garba et al., (2023) conducted in Birnin Yero Kaduna State that concluded soils in the study area were predominantly sandy loam and loamy. Smaller patches of Loamy Sand were also identified in some areas of the state. The presence of Loam and Sandy clay loam in most areas of Kaduna State indicates a possibility of growing a wider range of crop varieties due to favorable soil properties.

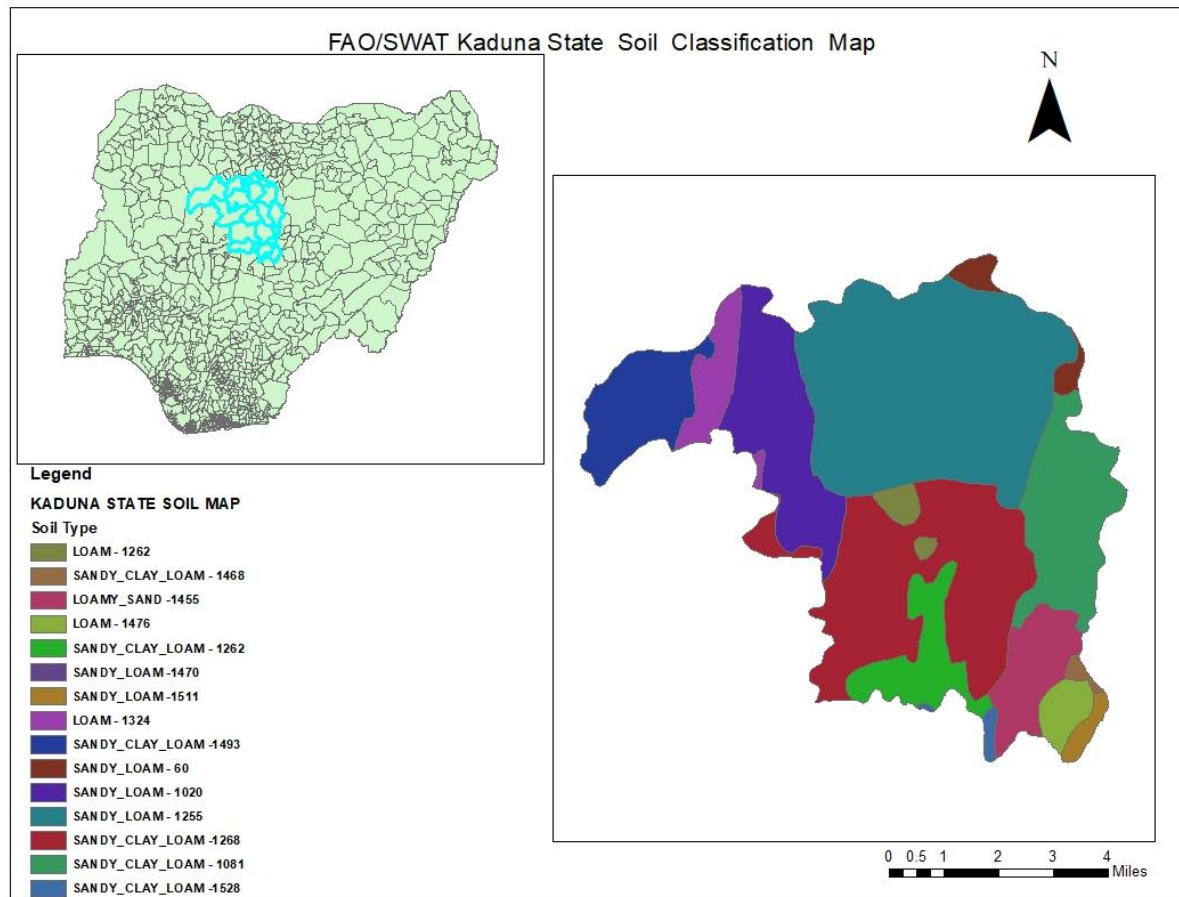


Figure 3.1: Kaduna State Soil Textural Classification Map

3.2 Kano State

Kano state was generally dominated by coarse-textured soils. Sandy Loam was the major soil class, covering 65% of the land area of the state. This was followed by Sandy Clay Loam. Muhammad et al., (2026) conducted a similar study in Kano State and found out that Six distinct soil textural classes were identified within the River Watari basin: loam, sandy loam, sandy clay loam, silty clay loam, clay loam, and clay. A very low water and nutrient-holding capacity soil known as Sand was identified at the central region of the state.

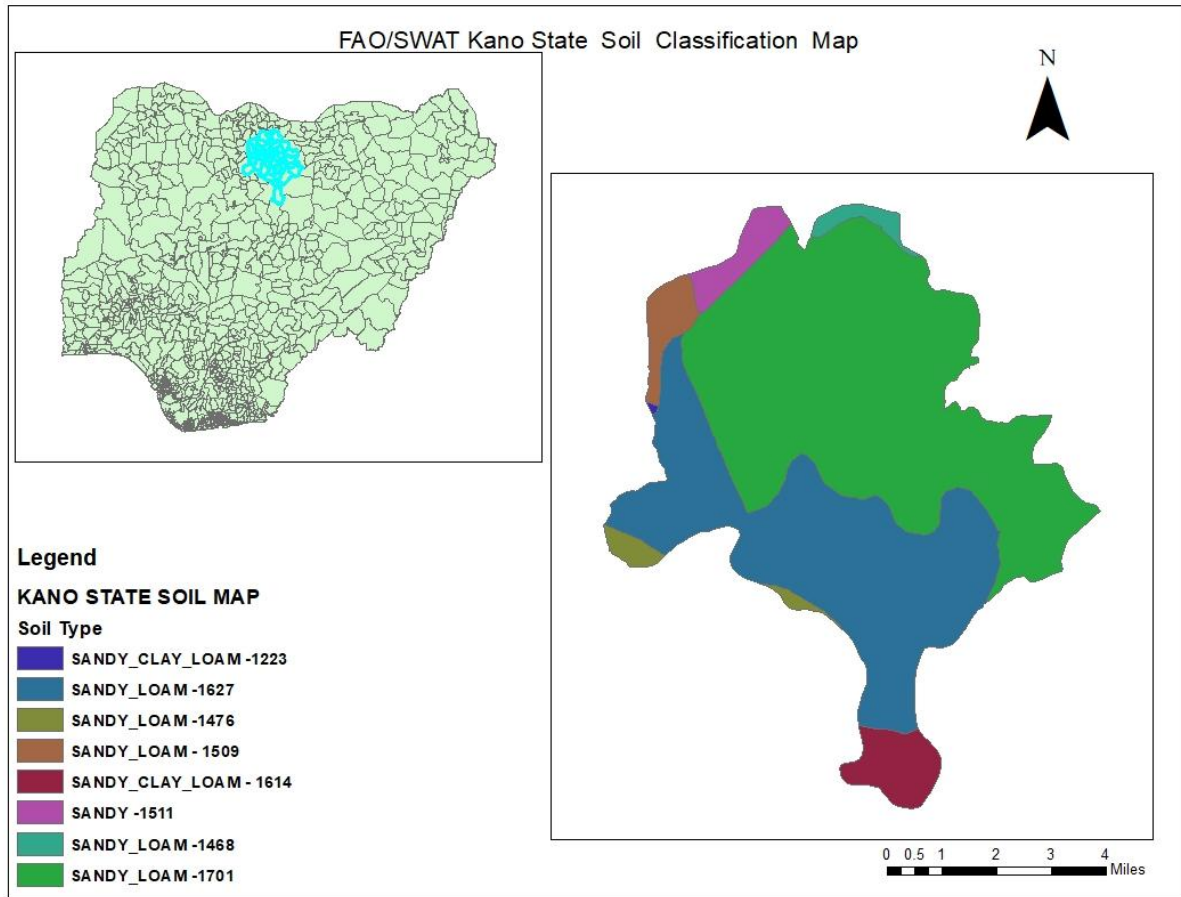


Figure 3.2: Kano State Soil Textural Classification Map

3.3 Katsina State

Katsina State also shows a predominant soil type of Sandy Loam in most parts of the State. However, the state showed a more varied composition than Kano, due to occurrences of larger areas with Sandy Clay Loam, Loam and Clay Loam. A study by Ahmed & Yusuf, (2020) presented similar results. This also correlates with the findings by Danjuma, (2023). The presence of Clay Loam soils is an indication that there are localized areas with higher water retention potential. For Clay soils are generally known to have higher porosity and lower permeability.

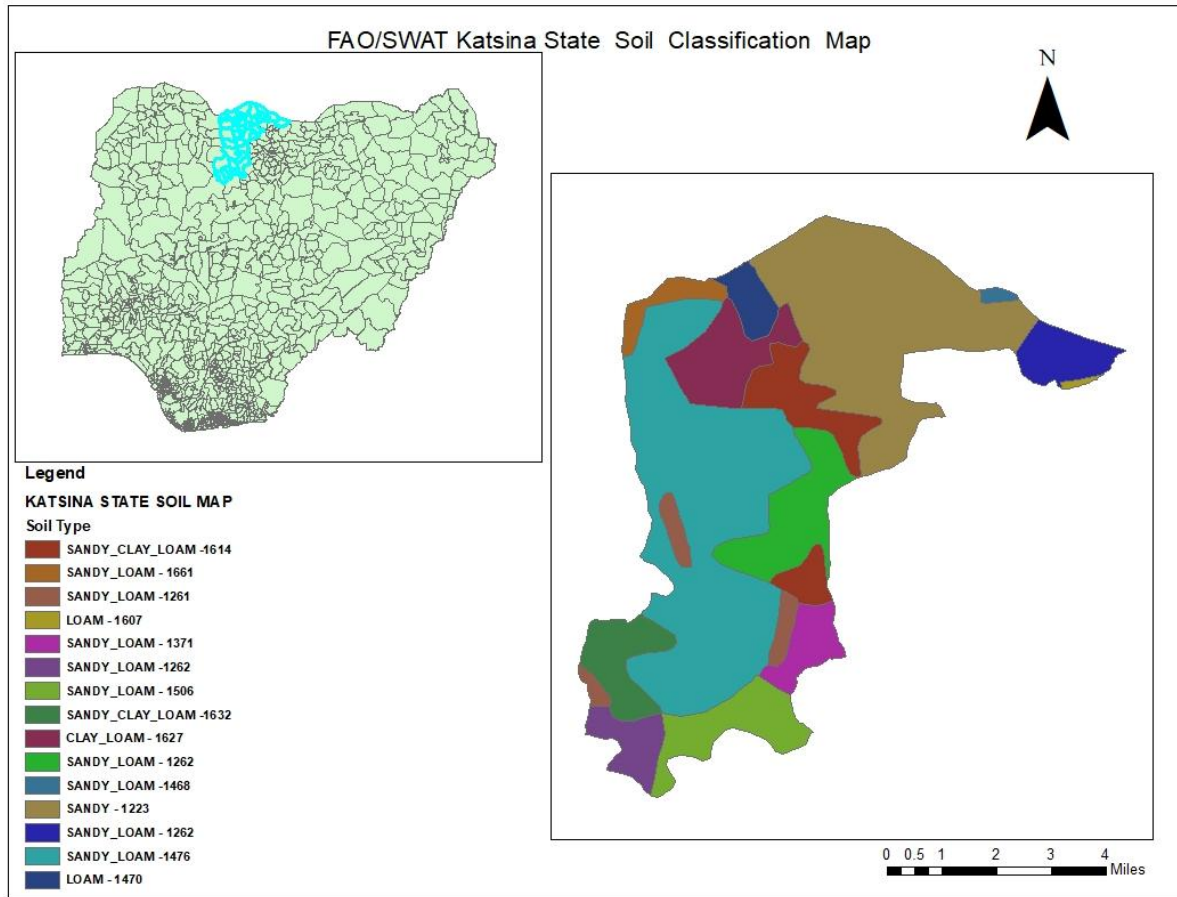


Figure 3.3: Katsina State Soil Textural Classification Map

4. CONCLUSION

The dominance of Sandy Loam in Kano and Katsina States indicates inherent constraints of low organic matter, poor water retention, and high susceptibility to wind and water erosion. For these areas, the maps directly support SDG 2 by guiding the adoption of specific soil-water conservation measures : contour stone bunds and zai pits to reduce runoff, and organic mulching to conserve soil moisture for rainfed cereals. In Kaduna State , the mosaic of Loam and Sandy Clay Loam provides opportunity for crop-soil matching . The Loam zones are recommended for high-value, water-responsive crops such as maize and irrigated vegetables, while Sandy Clay Loam areas are suitable for sorghum and groundnut with supplemental irrigation. For precision agriculture technologies , the digitized layers can be integrated into farm management systems to enable variable rate application of NPK fertilizer — lower rates on coarse Sandy Loam to prevent leaching, and higher rates on Loam areas to maximize yield. Irrigation scheduling can also be spatially optimized: more frequent, low-volume applications for Sandy Loam in Kano/Katsina, and less frequent applications for Loam in Kaduna. To operationalize these recommendations, future work should prioritize ground-truthing through physical-chemical analysis of soil samples across the mapped textural classes. This will be useful in validating the FAO-derived units and provide the fertility data needed for state-level agricultural policies on fertilizer subsidy targeting and erosion control planning.

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