IOP Conference Series: Earth and Environmental Science

PAPER • OPEN ACCESS

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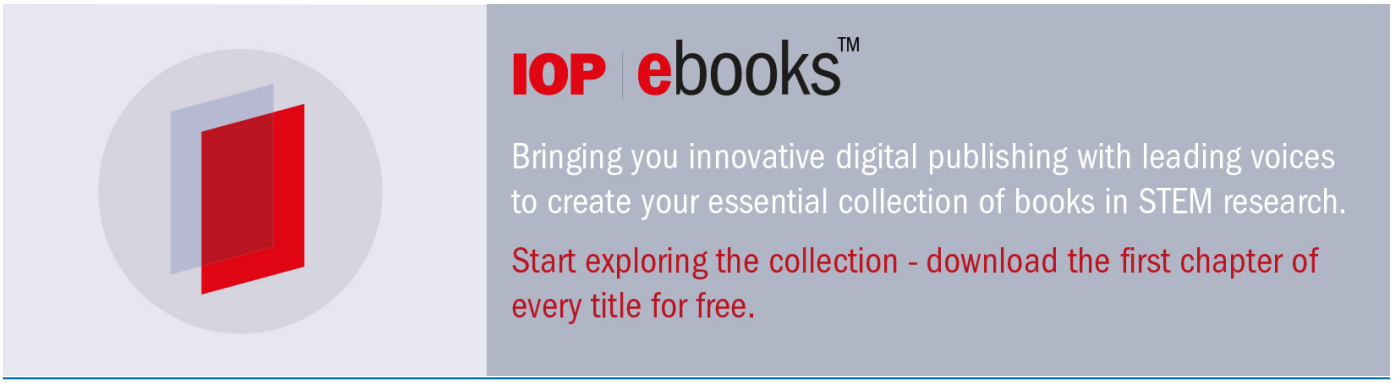
To cite this article: A P Aizebeokhai *et al* 2018 *IOP Conf. Ser.: Earth Environ. Sci.* **173** 012027



Soil characterization using satellite remote sensing in southwestern Nigeria: Implications for precision agriculture

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Abstract. Timely and reliable soil information with respect to their nature extent and spatial distribution is very essential for the optimal utilization of available natural resources in sustained bases. The technology advances in the field of remote sensing; Geographical Information System (GIS) have augmented the efficiency of soil survey. The use of advanced computer technologies with database can be used in decision making, risk assessment and environmental modelling. Precisely this project aims at the application of high spatial resolution satellite data (LANDAT 7) for assessing soil properties which include soil pH, soil texture and soil drainage. This study was carried out in South Western Nigeria in order to map out some soil characteristics with the use of remotely sensed data to assess their variability within the area in order to improve precision agriculture within the area.

Keywords: Remote sensing, GIS, Soil characterization, Spatial distribution, Southwestern Nigeria.

1. Introduction

The growth of plant is very essential to human as it serves a lot of purpose such as the supply of food for mankind, provision of oxygen for humans, animals and the environment, protection of the soil from erosion, protection of vegetation from desertification and reduction of CO_2 present in the atmosphere. Soil, being the topmost layer of the surface of the crust, has numerous characteristic which influence its property. These characteristics such as texture, class, acidity, alkalinity, hydrology, moisture, porosity, resistivity and consistency has relative effect on their individual property such as aeration, resistance to pH change, drainage rates susceptibility to water erosion. Soil survey is a prognostic study of soil as geographic bodies; however it governs the special relations of the set of soil properties that are perceived in nature. Soil data and interpretation are very important in precision agriculture research effort. Interpretation of soil data has been essential to the development of better management practices that makes agricultural productivity effective. The interpretations of soil data are can be applied to soil with desired characteristics for specific experiments and uses.

Precise and accurate spatial characterization of soil information is critical for the modelling of environment, assessment of risk and making of decision. Several works have been done using geophysical and remotely sensed data to solve problems involving environmental contamination, groundwater, agriculture (salinity) and geotechnical engineering [1-9]. Data obtained from remote sensing is being used as a secondary source of information in digital soil mapping is being presented as a feasible substitute to the traditional form of mapping methods this is because remote sensing is cost effective and less time consuming. Digital mapping method is defined as formation and population of

soil spatial data using the observational methods within laboratory within either non-spatial or spatial inference technique of soil [10] [11] [12]. This research is aimed at soil characterization in some parts of the southwestern Nigeria using remote sensing technique with a view to making recommendations as to the level of soil fertility in the area of study towards improving crop yields and agricultural productivity. The study area covers the six states in the western Nigeria (Figure 1).

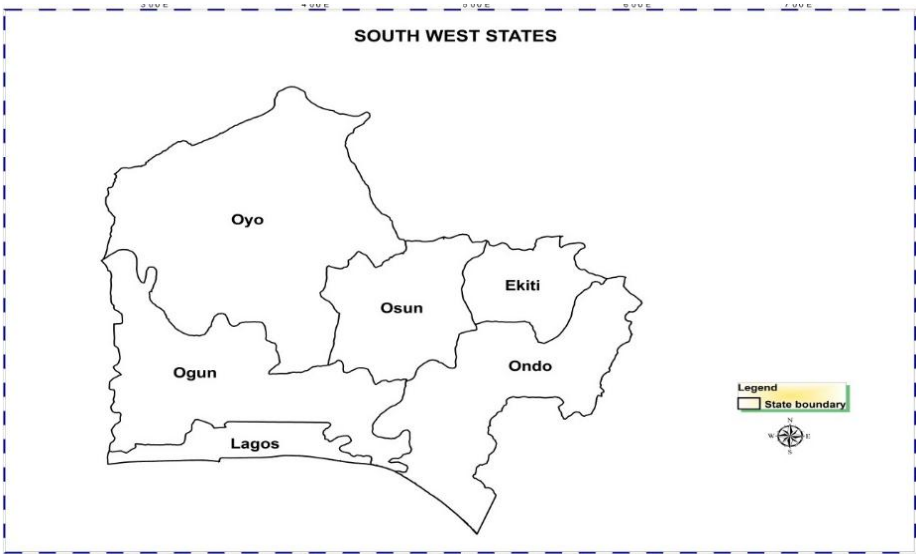

Figure 1: Location map of the study area

2. Methodology

The main datasets used for this project were Sheets 1 to 8 existing hardcopy soil map of Nigeria, each of these sheet were at a visible scale of 1:650000 acquired from the Federal Department of Agricultural Land Resource (FDALR) Abuja, and four Sheets of political map of Nigeria acquired from Office of the Surveyor General of federation of Abuja Nigeria. Leica Geosystem ERDAS IMAGINE 9.1 and ESRI ArcGIS 9.3 were both use to carry out GIS operation. The data was first studied with a view to have optimal quality control of the data. Then they were scanned and spatially referenced to identifying their weakness. The scanned data were spatially referenced to WGS (1984) UTM geographic coordinate system. In GIS interface, the resulting raster images were subset, checked and vectorized on the screen. A non-spatial data base was created consisting soil parameters such as drainage, geology and pH values were generated.

3. Results and Discussion

3.1. Soil pH

Soil pH is defined as the measure of soil acidity or alkalinity and it affects the soil nutrient; the range of soil pH determines how best the nutrients in the soil and the choice of the best crop to plant in the soil. Soil pH distribution in the study area is presented in Figure 2. In Lagos, there is high dominance of acidity that ranges between 4.5 to 5.0 pH units. In Ogun state it is observed that the soil pH ranges between the acidic and alkaline. In the western part of Ogun state towards central the soil pH of 6.6 to 9.1 pH unit is of high dominance, while in the eastern part Ogun state the soil pH of 5.1 to 5.5 pH unit dominates the region, in the western part of Ogun state (especially Ota) has acidic pH unit that ranges from 3.9 to 4.5 pH unit. Considering Ondo state, the result shows that the soil pH ranges from 3.9 to 6.6 pH unit, the acidic soil pH ranges between 3.9 to 5.0 pH unit with high dominance of acidity in the northward, southward and eastern part of Ondo. It was also observed that the eastern part of the soil ranges between 6.5 to 6.6 pH unit and it is of high prominence. Ekiti state has the soil pH ranging from 3.9 to 5.6. It was observed that soil pH of value 5.1 pH unit is of high dominance while soil pH of 3.9 to

4.2 is scanty. Osun generally ranges from 3.4 to 9.1 pH unit, soil pH of 3.9 to 4.5 is of high dominance in the west while in the east the soil pH value is 5.1, and there is an even distribution of soil acidity and alkalinity. Oyo on the other hand generally ranges from 4.5 to 9.1 pH unit.

Soil pH influences the measure of chemicals and nutrients that can be dissolved in soil water, and in this way the measure of nutrients available to crops. Some nutrients are more obtainable in acidic soil while others are more obtainable in the alkaline soil. The increase of strongly acidic soils (that is less than 5 pH units) can result in poor crop productivity as a result of the following factors: manganese toxicity, aluminum toxicity, deficiency in calcium and magnesium, low levels of vital plant nutrients such as molybdenum and phosphorus.

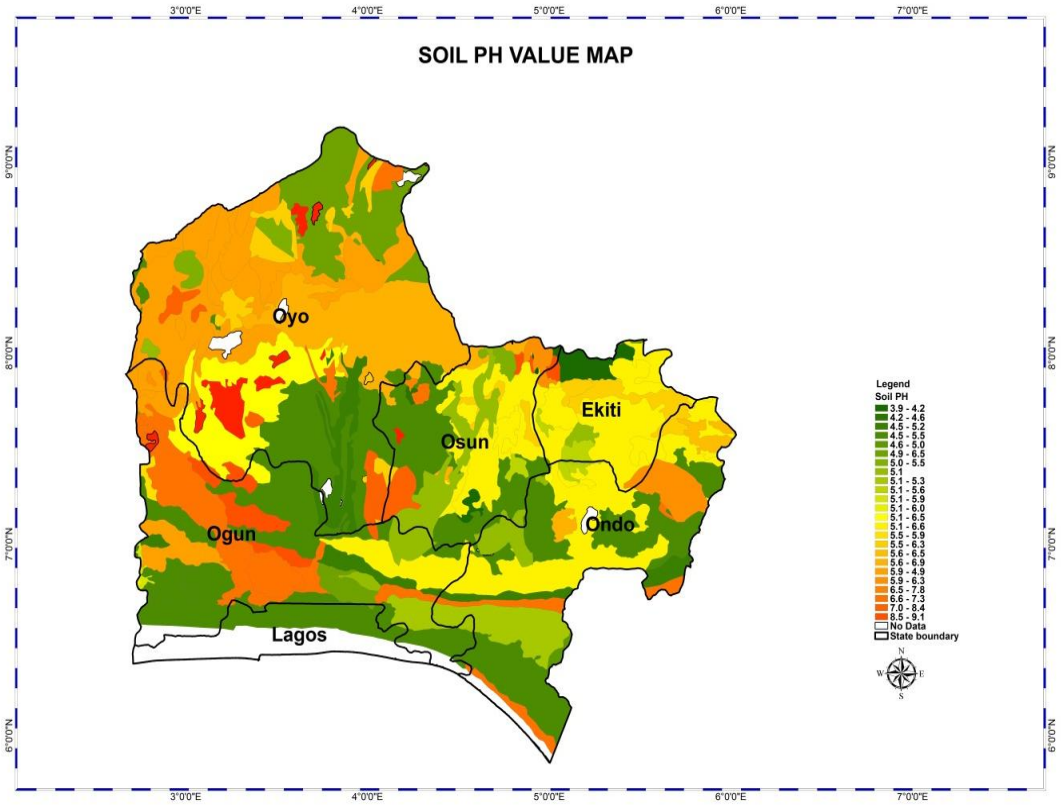

Figure 2: Soil pH map of southwestern Nigeria

3.2. Soil Texture

Soil texture is defined as the potion of sad, silt and clay size particle that make up the mineral fraction. Soil texture distribution in the study area is presented in Figure 3. The soil in Lagos has a texture of sandy clay. In Oyo, it is observed the texture sandy clay is of high dominance followed by the sandy loam, it is also observed that the texture of soil northward is mostly loamy sand and the texture of soil southward is clay loam. Considering Ogun, it is observed that the texture of sandy clay is dominating followed by the sandy loam and then the loamy sand. In Ekiti state, the texture loamy sand is predominant and then there are some traces of clay loam, sandy and concretionary clay. Ondo has an even distribution among the soil texture sand clay, sandy loam and loamy sand. In Osun, the texture loamy sand is prominent; the soil texture on the west is shown to be sandy clay while the south is composed of texture sandy loam and sandy. South western Nigeria has soil texture mostly composed of sandy loam, sandy clay, loamy sand and clay loam this indicates that it is composed of both sand and clay but there's more percentage of sand in the soil, sandy soil have larger particles than clay and very unrestricted draining due to the air space in between particles; they are easy to work on and till but they dry out very fast and usually have poor productivity as the nutrients are basically washed away. Clayey soils are poised of minute mineral particles that shrink the air space in the soil; and cause the soil to

absorb water and become easily compacted. Clayey soils are usually very fertile but need some enhancement to reveal some nutrients.

Sandy loam are predominated by sand particles, but contain sufficient clay and sediment to deliver some structure and fertility, they have the capability of draining water quickly and cannot retain significant amount of water and nutrients. Growing of plants in this soil type would necessitate regular irrigation and fertilization than soils with a greater clay concentration and sediments. Sandy loam soils are often poor in specific nutrients and may require additional fertilization to support healthy crop productivity. Loamy sand comprises of more than 25 percent of medium particles, less than 25 percent of the two coarsest particle types and less than 50 percent of fine or very fine particles. Clay loam is a mixture of soil that contains mostly clay than any other type of rocks or minerals; the particles of clay are very minor, which is one of its most significant characteristics; for this reason, loams that contain excessive clay have a tendency to be heavy, because they are so dense. Usually clay loam contains a good deal of plant nutrients and supports most types of plants and crop.

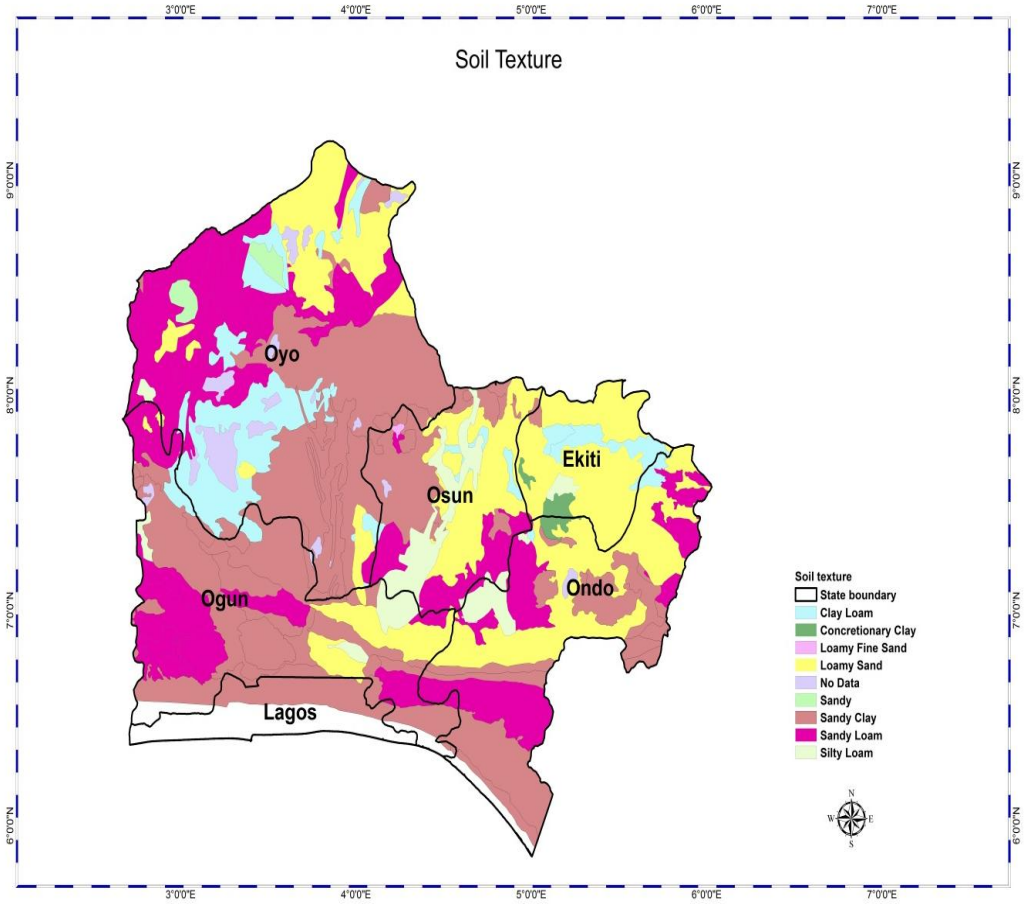

Figure 3: Soil texture map of southwestern Nigeria

3.3. Drainage Pattern

The soil in Lagos is observed to be well drained; majority of the soil in Ogun is shown to vary from well drained to somewhat poorly drained, some areas varies from moderately to poorly drained to very poorly drained. In Ekiti state, the soil varies from well drained to moderately to poorly drained soil. In Osun, the majority of the soil is well drained. In Ondo state, the soil varies from well drained to somewhat poorly drained and then to poorly drained. Well-drained soil is most prominent. In Oyo state, it is observed that the soil in the east varies from well drained to very poorly drained soil; in the west, the soil is shown to be moderately well drained. Soil drainage distribution in the study area is presented in Figure 4. In the south western, Nigeria the soil drainage varies from well drained to poorly drained

soil. One of the major physical properties of soil which is important to crop production is drainage through the rooting zone. This characteristic greatly influences aeration in the rooting zone, and the degree of aeration greatly influences several important biochemical reactions of economic importance to crop production.

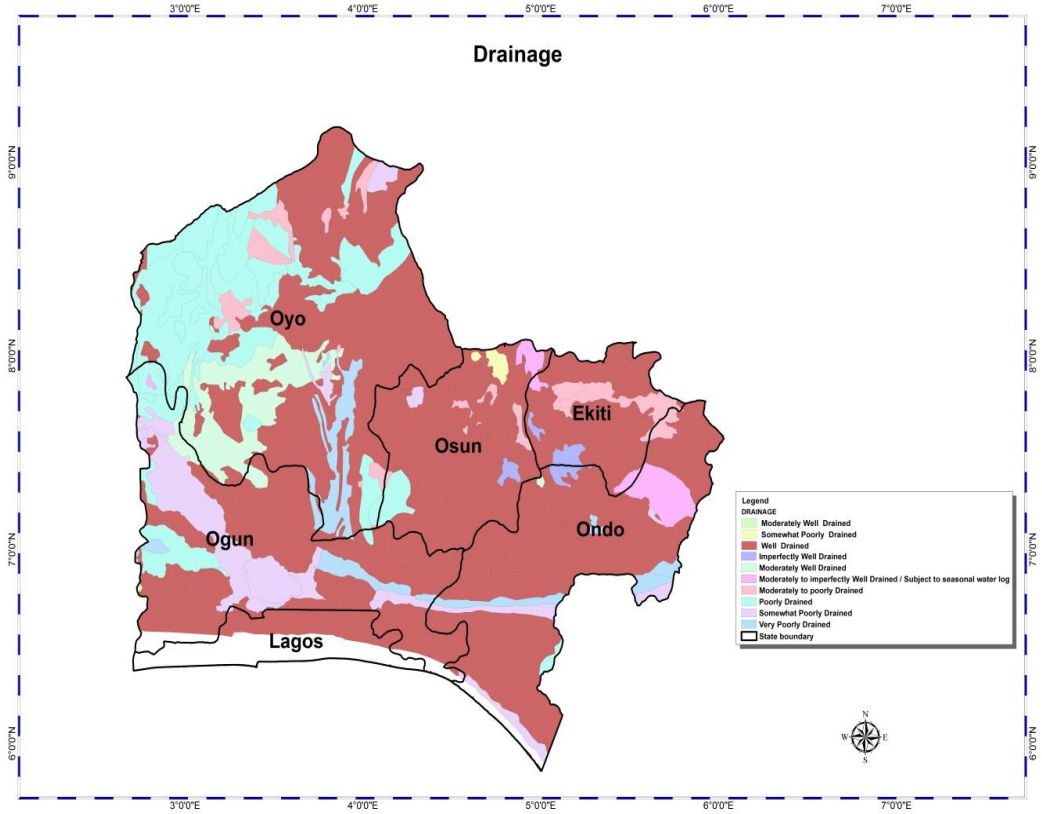

Figure 4: Soil drainage map of southwestern Nigeria.

4. Conclusion

Accurate and detailed spatial information of soil is important for modelling environment, risk assessment and decision making. This study explored the use of remote sensed data and geographic information system to map the spatial distribution of the soil properties such as soil pH, soil texture and soil drainage in southwestern Nigeria towards efficient precision farming and improved crop productivity. It is recommended that crops such as oranges, peaches, and pears are suitably for planting in Lagos state. In Ogun, it is recommended that crops such as bean, cabbage, and lettuce and water melon can be planted. In Ondo as potatoes is suitable for planting, in Ekiti crops like black berry and blue berries are recommend. It is also recommended that high resolution spatial information technique using remote sensing for digital soil mapping is more efficient than the traditional soil mapping technique which involves ground based study and laboratory analysis. This is because it is less time consuming and inexpensive.

Acknowledgements
The authors wish to appreciate the Covenant University Centre for Research, Innovation and Discovery for the conference support sponsorship.

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