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*RESEARCH ARTICLE*

# EXPLORING THE CLASSIFICATION AND LAND USE ATTRIBUTES OF SOILS FOR OPTIMAL FERTILITY IN IMO STATE, NIGERIA

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## ABSTRACT

Myriads of studies have corroborated significant issues of poor soil fertility and acidification in the soils of Imo state. Low soil fertility spells doom for crop productivity. This study explored the classification and land use attributes of soils, for optimal fertility in Imo state. It adopted the synthesis of statistical research and GIS, to achieve its aim. Data were obtained from both primary and secondary sources. The study population included: the three senatorial zones, the twenty seven local government areas and the seventy nine communities in the study area. Purposive sampling was used to sample six out of the twenty seven local government areas of the study. It was also leveraged to sample six from the seventy nine communities in the area. Data analysis was done with the F.A.O system of soil classification. The soil types were based on the dominant pedogenetic (soil-forming) processes in the Reference Soil Groups (RSGs). The mapping was done with the Arc GIS (10.9) software. The results showed that only the Dystric Ferralsols found in Orji, Owerri, Umu-Ikoro, and Umu-Akpa, were infertile for many crops. The infertilities were predicated on the high acidity, aluminum toxicity and nutrient deficiency of the Ferralsols found in the aforementioned study locations. The other soil classifications found in Okigwe and Obiakpu had suitable land use attributes. The study concluded that there will be low soil fertility in Orji, Owerri, Umu-Ikoro, and Umu-Akpa while a dissimilar scenario of optimal soil fertility will be recorded in Okigwe and Obiakpu in the study area.

**Keywords:** Classification, land use, attributes, soils, fertility.

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## 1.0. INTRODUCTION

This paper is aimed at exploring the classification and land use attributes of soils, for optimal fertility in Imo State. To this end, the paper was divided into five sections. The sections captured introduction, study area, research methodology, results and discussions, conclusion and recommendations. These were topically addressed subsequently.

Soil is the by-product of the weathering of rocks, generally orchestrated by the influence of physical, chemical and biological processes over time, on the Earth's continental crust. Similarly, Buckman and Brady, (1969) defined soil as the natural, dynamic medium on the Earth's surface, consisting of a mixture of minerals, organic matter, water, gases, and living organisms. It forms through the complex interaction of climate, relief (topography), and organisms acting on parent material (like bedrock) over time (Sposito, 2025). Soils are characterized by distinct layers, known as soil horizons, which reflect this ongoing process and are crucial for supporting plant life and forming the foundation of most terrestrial ecosystems.

Soil comprises: minerals (inorganic particles such as: sand, silt, and clay, derived from weathered rocks and parent material), organic matter (decomposed plant and animal residues, which contribute to nutrient cycling and provide structure), water (plays a vital role in weathering, chemical processes, and the transport of nutrients within the soil), gases (mixture of gases, including oxygen and carbon dioxide, that fill the pore spaces in the soil) and living organisms (microorganisms, insects, earthworms, and plant roots that contribute to soil formation and function).

The formation of soil, is a slow, multi-faceted process that includes: weathering (the breakdown of rocks and minerals by physical, e.g. freeze-thaw, chemical, and biological processes), organic activity (the decomposition of organic matter and the activity of soil organisms, which alter the physical and chemical composition of the soil), addition of materials (the accumulation of organic matter and other materials from the atmosphere), loss and transfer (the movement of nutrients and particles, e.g. leaching, down through the soil profile).

Generally, soil types are closely related to the geology of their regions. The geology of the study area is characterized by five main Cenozoic stratigraphic units of the Niger Delta Basin, including: the Imo Shale Formation (Paleocene), Ameki Formation (Eocene), Ogwashi-Asaba Formation (Oligocene to Miocene), and the overlying continental Benin Formation, which is composed of coarse-grained, poorly sorted, gravelly sands with minor clay and lignite streaks, forming extensive aquifers (Short and Stauble, 1967; Avbovbo, 1978).

Stratigraphic formations are dominant (American Association of Petroleum Geologists, 1961). The authors added that they encompass the youngest and oldest forms. Precisely,

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Akaolisa and Selemo (2009); Nwosu, Nwankwo and Ekine, (2010) identified Imo Shale Formation (A Paleocene-aged, blue-gray, fossiliferous shale, often containing sand lenses), Ameki Formation (An Early Eocene to Oligocene formation, characterized by alternating, heterogeneous sandstone and shale, with calcareous shale, marl, and limestone), and Ogwashi-Asaba Formation (A succession of clays, sands, grits, and streaks of lignite from the Oligocene to Miocene epochs). Onyeaguocha, (1980); Short and Stauble, (1976) accentuated Benin Formation (Also known as Coastal Plain Sands, from a Miocene to recent continental deposit, consists of poorly sorted, coarse-grained sands and gravels, with thin clay/shale horizons and lignite).

Generally, different geologic formations give rise to different soil types (Adekiya, Ajayi, and Ibaba, 2024). Also, Adegbite, Okafor, Aruna, Alori, and Adebiyi, (2019) asserted that the topography of a region constitutes a principal factor responsible for the different soil types in the region. However, Udokporo, Anikwe and Chukwu, (2015) identified the main problem with the soil in Imo state as gulley erosion, a form of soil degradation caused by water runoff, which is worsened by human activities like: road construction and unsustainable land use. The authors added that, poor soil fertility and acidification were significant issues. These were contributory to low crop yields (Udokporo, et al., 2015). The authors concluded that soil compaction and removal of top soil, were encompassed in the problems faced by the study area.

Studies like: Okorie, Chinyere, Ifeanyi and Lazarus, (2020), Nkwopara, Osisi, Onwudike, and Ihem, (2020), etc. have been done on soil in Imo state. The former, geospatially analyzed the effects of soil physical and chemical properties on production of maize and cassava in Ohaji/ Egbema of Imo State while the latter, evaluated the fertility status of some land use types in Orlu area of Imo State using elemental ratio. These studies were only delimited to specific local government areas in the study area. Their perspectives were narrow in scope. This orchestrates a gap in knowledge in the excluded areas of their studies. This study, sets out to fill the gap.

To this end, it explored the classification and land use attributes of soils, for optimal fertility in Imo State. In essence, the study will acquaint the farmers with the land use attributes of the soil classification in the study area. The emergent posterior knowledge will facilitate geo-spatial decisions that are laced with sustainability in their applications among the end users. Eventually, optimal fertility will be ingrained in the soils as their attribute in the area.

## 2.0. THE STUDY AREA

The study area lies within latitudes $4^{0}45^{1}$N and $7^{0}15^{1}$N, and longitude $6^{0}50^{1}$E and $7^{0}25^{1}$E with an area of around 5,100km$^{2}$. It is bordered by Abia State on the East, by the River Niger and Delta State on the West, by Anambra State to the North and Rivers State to the South (Fig. 1).

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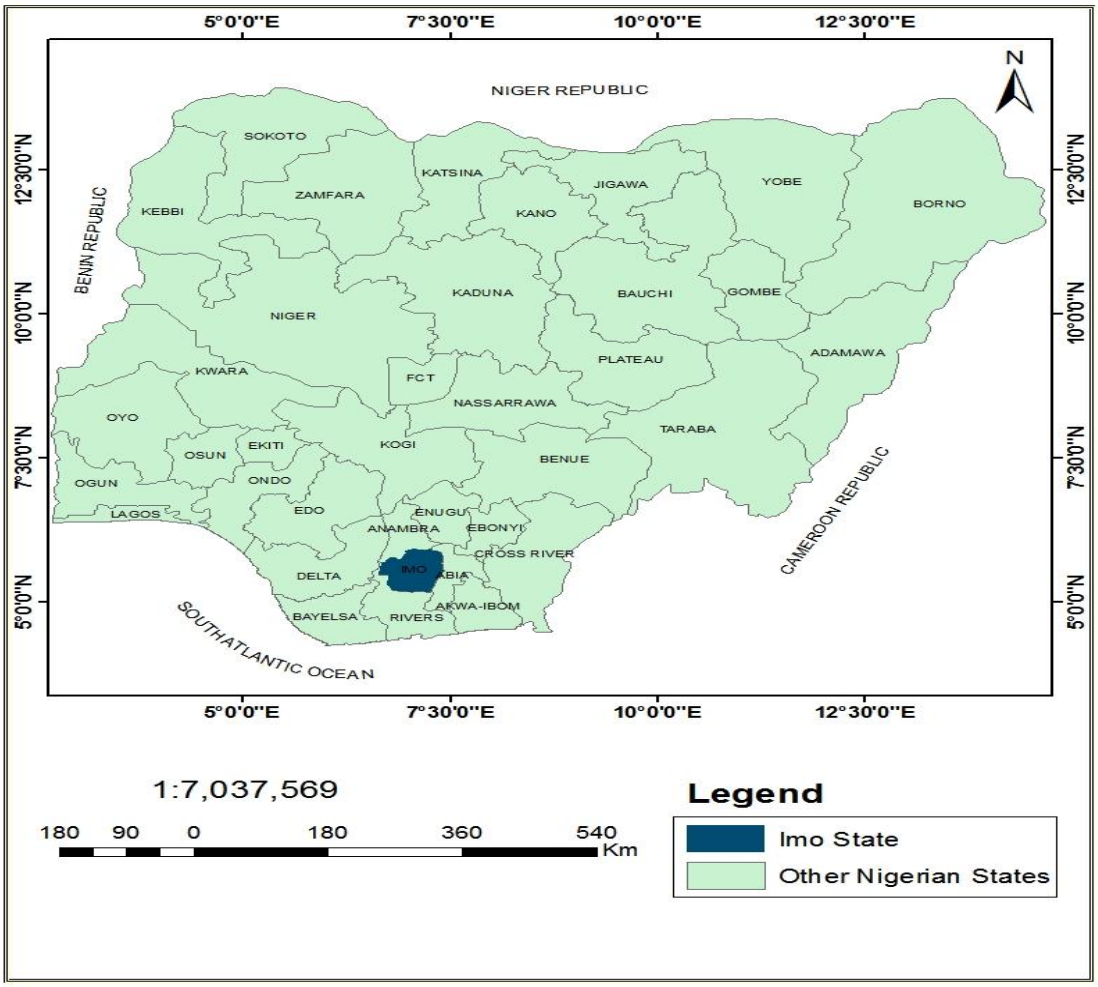


Figure 1: Nigeria showing Imo State
Source: Agiriga, (2025)

## 3.0. RESEARCH METHODOLOGY

This study adopted the synthesis of statistical research and GIS to explore the classification and land use attributes of Soils, for optimal fertility in Imo State.

Data acquisition involved the collection of data from primary and secondary sources. Hand-held GPS was leveraged for the collection of the location points of the local government areas (Table 3) while Google Earth was for the extraction of the various imageries. Secondary data were obtained from the Ministry of Lands and Survey for the base maps. The base maps depicted both the Geology and Soil in the study area.

The study population included: the three senatorial zones, the twenty seven local government areas and the seventy nine communities in the study area.

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Purposive sampling was used to sample six out of the twenty seven local government areas of the study (Table 1). In the same vein, it was leveraged to sample six from the seventy nine communities in the area (Table 2). The sampled areas were predicated on the researcher's judgment of the populations of the locations that were depicted in the geological and soil base maps of the study area.

The geology of the area was analyzed according to the respective stratigraphic units in the strata. Synergistically, the soil was analyzed with the F.A.O. (1974) and F.A.O. (1988) system of soil classification. The soil types were based on the dominant pedogenetic (soil-forming) processes in the Reference Soil Groups (RSGs). The mapping was done with the Arc GIS (10.9) software. The results were thematic maps depicting the geological strata and the soil types in the area.

**Table 1: Selection of the Local Government Areas (L.G.As) in the Study Area**

| S/N | Zones | Selected L.G.As | Data | |
|---|---|---|---|---|
| | | | Population | Sample |
| 1 | Okigwe | 1 | 6 | 1 |
| 2 | Orlu | 1 | 12 | 1 |
| 3 | Owerri | 4 | 9 | 4 |
| | **Total** | **6** | **27** | **6** |

**Source: Researcher's Field Studies, (2025)**

**Table 2: Selection of the Communities in the Study Area**

| S/N | L.G.As | Selected Communities | Data | |
|---|---|---|---|---|
| | | | Population | Sample |
| 1 | Okigwe | 1 | 12 | 1 |
| 2 | Owerri Municipal | 1 | 5 | 1 |
| 3 | Ohaji/Egbema | 2 | 17 | 2 |
| 4 | Owerri North | 1 | 19 | 1 |
| 5 | Ngor-Okpala | 1 | 26 | 1 |
| | **Total** | **6** | **79** | **6** |

**Source: Researcher's Field Studies, (2025)**

**Table 3: Global Positioning System's Coordinates of the Selected Communities**

| S/N | Selected Communities | Location | |
|---|---|---|---|
| | | Latitude | Longitude |
| 1 | Okigwe | $5^0\ 49^1\ 13.4^{11}$N | $7^0\ 21^1\ 1.1^{11}$E |
| 2 | Umu-Akpa | $5^0\ 52^1 08^{11}$ N | $6^0\ 54^1\ 12^{11}$E |
| 3 | Umu-Ikoro | $5^0\ 13^1\ 60^{11}$ N | $7^0\ 6^1\ 0^{11}$E |
| 4 | Orji | $5^0\ 31^1\ 60^{11}$N | $7^0\ 4^1\ 0^{11}$ E |
| 5 | Owerri | $5^0\ 28^1\ 60^{11}$N | $7^0\ 01^1\ 60^{11}$ E |
| 6 | Obiakpu | $5^0\ 53^1\ 59^{11}$N | $7^0\ 18^1\ 29^{11}$E |

**Source: Researcher's Field Studies, (2025)**

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## 4.0. RESULTS AND DISCUSSIONS

This section showed the results of the analysis of the Geology and Soil in the study area (Fig. 2 and 3 below). Correspondingly, the Soil classifications and land use attributes in the study area, were clearly depicted in Table 4 below.

Figure 2, unraveled the Geology of the study area. From the map, Okigwe had False-Bedded Sandstone, Upper Coal Measures, Imo Shale Group, Imo Shale Group (Inc. Igbaku, Ebenebe and Ameki Group). Urualla had Bende Ameki Group while Coastal Plain Sands were in Orji, Owerri, Umu Akpa and Umu Ikoro. Moreover, Obiakpu had Alluvium in general. This implies that the stratigraphic unit of Okigwe is predominantly underlain with sedimentary rocks while Coastal Plain sands were ubiquitous in the area.

Sedimentary rocks are formed from the deposition, accumulation and cementation of sediments. That is, particles from existing rocks, organisms, or dissolved minerals that are compacted and cemented over time, into layers. They are classified into: clastic, chemical and organic types. The clastic sedimentary rock is exemplified in the sandstone and shale in the study area while the organic sedimentary rock is exemplified in the coal in the area. Analogously, Anumaka, Anozie, Ahaneku,, Okpara, Odinye, Onuchukwu, and Oshim, (2024) noted that the primary rock formations in Imo state, such as the Benin Formation, Ameki Formation and Imo Shale, are mostly clastic sedimentary rocks (like: sandstones, shales and mudstones). The authors added that these sedimentary rocks contain specific interbedded chemical deposits and minerals. In other words, the chemical sedimentary rocks are components of the clastic and organic sedimentary rocks in the study area.

These layered rocks are significant because they preserve the Earth's surface history, including fossils, and are found in the various geological formations in the study area.

Figure 3, accentuated the soil in the study area. From the map, the Rhodic Ferralsols, Eutric Nitosols, Lithosols, Eutric Gleysols and Dystric Fluvisols were found in Okigwe. In the same vein, Hystic Fluvisols, and Eutric Fluvisols were peculiar to Obiakpu while Orji, Owerri, Umu-Ikoro, and Umu-Akpa were covered with Dystric Ferralsols.

A strong correlation exists between the geologic structure of an area and its soil types. Rock weathering, eventually orchestrates pedogenesis (process of soil formation). It involves the weathering of parent material, the decomposition of organic matter, and the biological, physical and chemical processes that gradually create soil layers, or horizons over time.

Table 4 shows the soil classifications and land use attributes in the study area. Among the soil classifications, only the Dystric Ferralsols found in Orji, Owerri, Umu-Ikoro, and Umu-Akpa, were infertile for many crops due to their high acidity, nutrient deficiency (low cat ion exchange capacity), and aluminum toxicity. The other soil classifications found in Okigwe and Obiakpu had suitable land use attributes. This implies that there will be low soil fertility

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in Orji, Owerri, Umu-Ikoro, and Umu Akpa while a dissimilar scenario of optimal fertility will be recorded in Okigwe and Obiakpu in the study area.

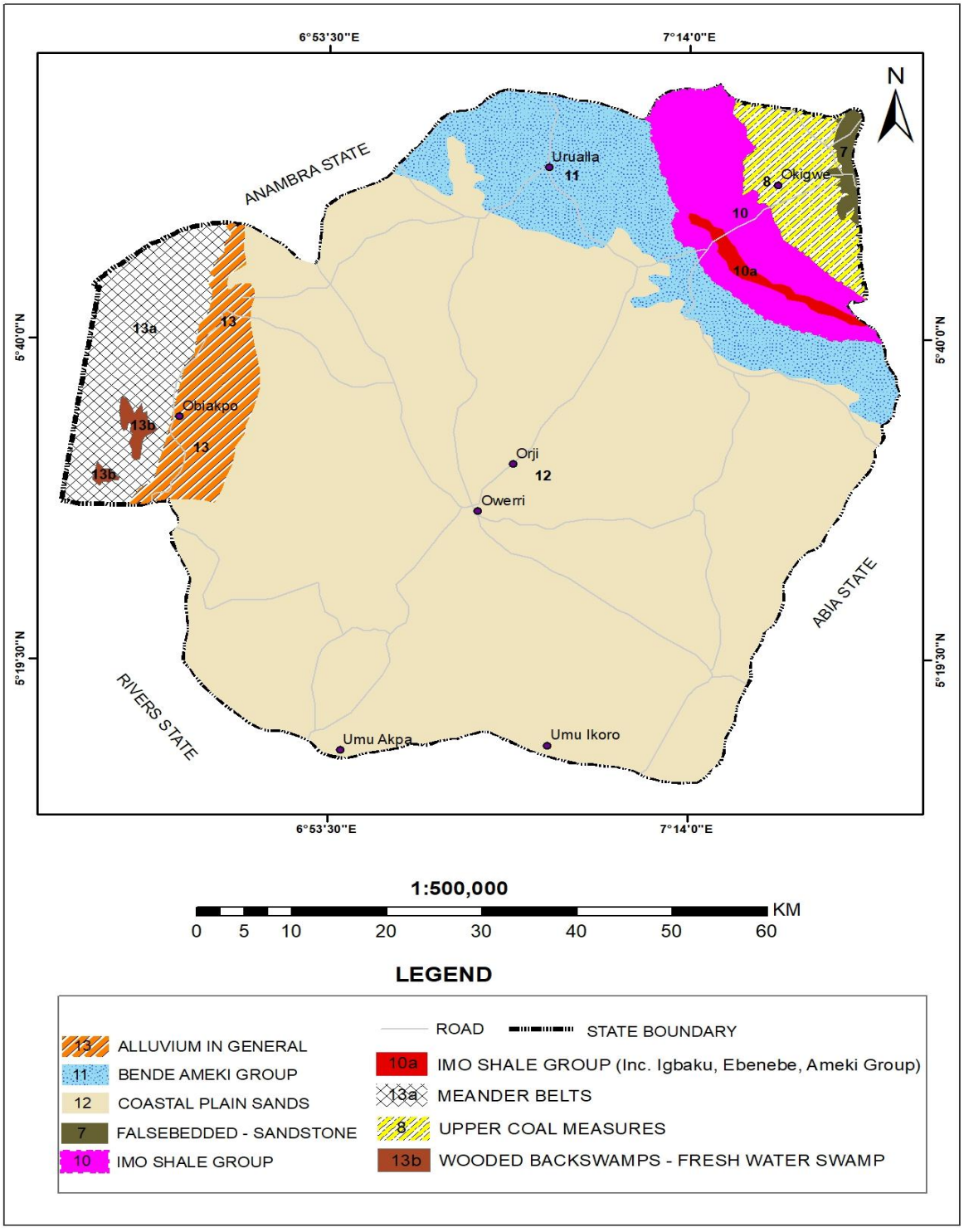


**Figure 2:** The Geology of the Study Area
**Source:** Researcher's Field Studies, (2025).

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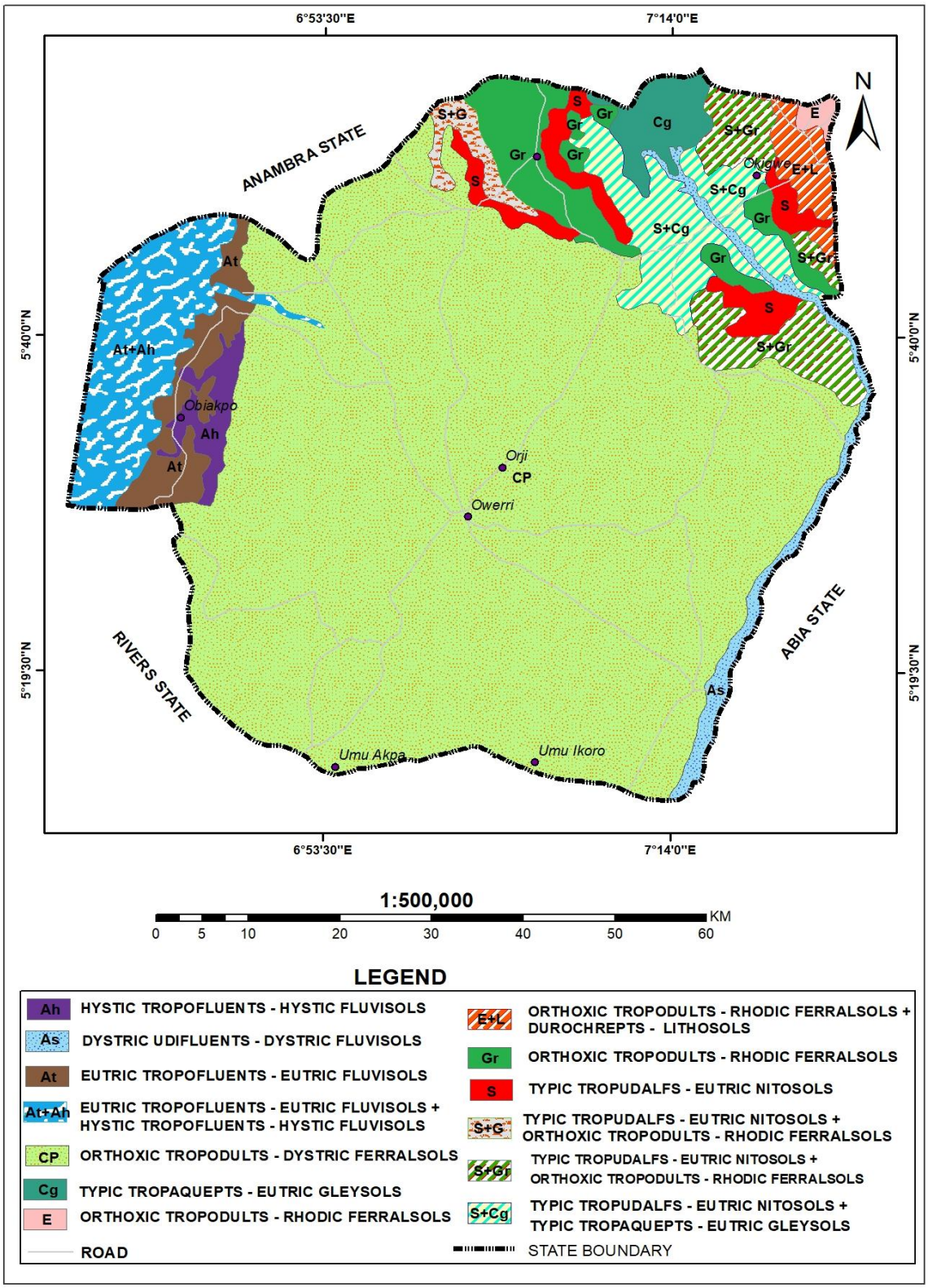


**Fig. 3: Map of the Study Area showing the Soil**
**Source: Researcher's Field Studies, (2025).**

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**Table 4: Soil Classifications and Land Use Attributes in the Study Area**

| S/N | Location | Classifications | Land Use Attributes |
|---|---|---|---|
| 1 | Okigwe | Rhodic Ferralsols | Sugarcane plantation due to their good porosity and infiltration, which favour root growth. |
| | | Eutric Nitosols | Cultivation of maize, coffee and cocoa, oilseeds, and fruit as well as timber and cattle ranching in some regions. |
| | | Lithosols | Planting of orchards and permanent grassland. |
| | | Eutric Gleysols | Maize, sorghum and rice, due to their high ground water levels. |
| | | Dystric Fluvisols | Rice cultivation, due to their high natural fertility and organic carbon content. |
| 2 | Obiakpu | Hystic Fluvisols | Paddy rice cultivation, sugarcane, Melaleuca plantations and other dry land crops due to their high organic carbon content. |
| | | Eutric Fluvisols | Cultivation of cereals, fiber crops, potatoes, and pasture/meadows. |
| 3 | Orji | Dystric Ferralsols | Infertile for many crops, due to their high acidity, nutrient deficiency (low cat ion exchange capacity), and aluminum toxicity. |
| 4 | Owerri | | |
| 5 | Umu-Ikoro | | |
| 6 | Umu-Akpa | | |

**Source: Researcher's Field Studies, (2025).**

## 5.0. CONCLUSION AND RECOMMENDATIONS

Soil is the bedrock of farming activities. Its fertility is ineluctable for optimal yield in crops. A counter-intuition is simply, a blurring of the lines between fantasy and reality. Rock weathering, frontiers the formation of soil. From the study, the Rhodic Ferralsols, Eutric Nitosols, Lithosols, Eutric Gleysols, and Dystric Fluvisols in Okigwe and the Hystic Fluvisols and Eutric Fluvisols in Obiakpu, are suitable for agricultural productivity (Table 4). However, the Dystric Ferralsols in Orji, Owerri, Umu-Ikoro and Umu-Akpa are not fertile for crop production due to their heightened level of acidity, nutrient deficiency and aluminum toxicity. These attributes, leave much to be desired.

To improve the fertility of the Dystric Ferralsols, sustainable practices were extensively discussed subsequently.

**Systematized Technique**: Cover crops should be planted in Orji, Owerri, Umu-Ikoro and Umu-Akpa to add organic matter and improve the soil structure in the areas. Moreover, leguminous crops like: groundnut, cowpea, or soya bean as green manure should be incorporated and grown, to biologically fix nitrogen and add nutrients to the Dystric Ferralsols in the aforementioned areas.

Thereafter, implement agroforestry systems to improve nutrient cycling and provide topsoil protection. Similarly, organic manure should be integrated to provide a significant source of nitrogen and buffer chemical changes in the soil.

**Application of Lime**: Table 4 established that Dystric Ferralsols are acidic. So, moderate liming is beneficial. Preferably, dolomite, in order to supply both calcium and magnesium in the soil type in Orji, Owerri, Umu-Ikoro and Umu-Akpa. However, be careful to avoid excessive liming, which can accelerate organic matter decomposition or lead to micro-nutrient deficiencies.

**Utilization of Mineral Fertilizers**: Due to the nutrient deficiency of the Dystric Ferralsols (Table 4), regular soil tests should be conducted to identify specific nutrient deficiencies, including phosphorus (often fixed in Ferralsols). And to determine the necessary fertilizer application in Orji, Owerri, Umu-Ikoro and Umu-Akpa. This should be strategically executed to forestall erosion. And support intensive agriculture in the areas.

**Adoption of Sustainable Tillage Practices**: Table 4 depicted that the Dystric Ferralsols in Orji, Owerri, Umu-Ikoro and Umu-Akpu are infertile. Therefore, reduced tillage should be implemented in the afore-cited areas. The practice is effective in improving the soil fertility indicators over time. Moreover, minimize intensive cultivation, in order to prevent accelerated loss of soil organic carbon, which is critical for sustaining soil quality.

## Conflict of Interest

The author declares that no conflict of interest exist in this manuscript..

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