RGA Global Journal of Multidisciplinary Research
ISSN : XXXX-XXXX | Vol 1, Issue 1, Jan – Feb, 2026
Published by RGA Research Publications

UNLOCKING LAND RESTORATION POTENTIAL OF SOUTH EAST NIGERIA THROUGH AGRICULTURAL LAND USE MAPPING

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Received: 12 Jan 2026 | Accepted: 30 Jan 2026 | Published: 16 Feb 2026

Abstract

Land degradation poses a critical threat to agricultural productivity, food security, and ecological stability in sub-Saharan Africa, with Southeast Nigeria experiencing acute challenges due to unsustainable land use practices. This study explores the application of Agricultural land use and Soil Nutrient Mapping(SNM) as strategic tools for restoring degraded landscapes in the region. Using geospatial analysis, the research identifies key degradation patterns, delineates flood-prone zones, and classifies land suitability for various crops. Soil nutrient assessments reveal widespread deficiencies in nitrogen (N), phosphorus (P), and potassium (K), particularly in communities such as Ngodo, Lekwesi, and Ohambele. These findings are corroborated by recent studies, which emphasize the need for site-specific nutrient management and precision fertilization. The integration of land use mapping with soil fertility data provides a robust framework for sustainable land recovery, enabling targeted interventions and informed agricultural planning. By bridging the gap between spatial evidence and policy implementation, this study highlights the transformative potential of geospatial technologies in reversing degradation trends and enhancing resilience in Southeast Nigeria’s agro-ecosystems.

Keywords: land degradation, soil nutrient mapping, restoration strategies, ecosystem resilience

1.0 Introduction

Land degradation remains a pressing environmental and socio-economic challenge in sub-Saharan Africa, with over 65% of productive land affected to varying degrees (FAO, 2015; UNCCD, 2022). In Southeast Nigeria, unsustainable agricultural practices, deforestation, overgrazing, and rapid urbanization have exacerbated soil erosion, nutrient depletion, and vegetation loss (Nwajiuba & Onyeneke, 2010; Ezeaku & Davidson, 2018). These factors have not only compromised agricultural productivity but also hindered ecosystem services critical to climate regulation, water retention, and biodiversity conservation. Land restoration, as emphasized by the United Nations Decade on Ecosystem Restoration (2021–2030), is central to reversing these degradation trends and achieving regional sustainability targets (UNEP & FAO, 2020). However, effective restoration planning requires a robust understanding of current land use patterns, degradation hotspots, and restoration opportunities. Existing efforts lack spatial precision, making interventions inefficient. Hence, Agricultural land use mapping—through geospatial technologies and field-based assessments—offers a powerful tool for spatially assessing land degradation and guiding targeted interventions (Chen et al., 2020; Ahmed et al., 2023). In the context of Southeast Nigeria, integrating land use mapping into restoration strategies is critical, given the region's diverse agro-ecological zones and increasing land pressure from intensive farming and settlement expansion. Accurate land use maps enable the identification of degraded agricultural lands, facilitate the prioritization of restoration zones, and inform policy decisions on sustainable land management (Chukwu et al., 2021; Olalekan et al., 2022). Furthermore, such mapping supports the development of data-driven frameworks that align local land use practices with broader climate-smart agricultural goals.This study investigates the role of agricultural land use mapping in unlocking the restoration potential of Southeast Nigeria. It aims to assess current land use dynamics, identify key degradation patterns, and propose actionable strategies for sustainable land recovery through precision mapping and land management planning

2.0 LITERATURE REVIEW

The application of agricultural land use mapping in land restoration has been widely documented across various ecological zones globally. Remote sensing and GIS technologies have emerged as critical tools in detecting land degradation, assessing land cover changes, and informing targeted restoration strategies (Chen et al., 2020; Uuemaa et al., 2013). These spatial tools provide temporal and geographic insights into how land is utilized and the extent to which anthropogenic pressures alter natural systems (Zhou et al., 2021).

In sub-Saharan Africa, the value of land use mapping is particularly evident due to the scale of degradation and the urgent need for food security and sustainable livelihoods (Ouedraogo et al., 2016). Studies conducted in the Sahel, East Africa, and parts of West Africa show that integrating land use data with restoration planning significantly enhances soil rehabilitation, agroforestry initiatives, and reforestation success (Bai et al., 2008; Aynekulu et al., 2016). Land use mapping also enables governments and local institutions to monitor compliance with land management regulations and design location-specific interventions. In Nigeria, agricultural expansion has been the primary driver of deforestation and land degradation, especially in the southeastern region characterized by high population density and smallholder farming systems (Nwajiuba & Onyeneke, 2010; Ezeaku & Davidson, 2018). Despite government efforts, including policies such as the National Agricultural Resilience Framework and the Great Green Wall initiative, implementation has been hampered by a lack of spatial data for guiding decisions (Adekalu et al., 2020).Several local studies underscore the role of geospatial analysis in identifying degradation hotspots. Chukwu et al. (2021) employed satellite imagery to track land cover transitions in Imo and Abia States, highlighting areas most affected by erosion and unsustainable cultivation. Olalekan et al. (2022) mapped land degradation risk zones in the southeastern region and found a strong correlation between intensive agriculture and soil quality decline. Globally, the utility of agricultural land use mapping extends to carbon sequestration modeling, biodiversity conservation, and disaster risk reduction (Gao & Liu, 2010; Hengl et al., 2017). In regions like Southeast Nigeria, where climate variability exacerbates degradation, land use data serve as a foundation for integrating ecological restoration with climate adaptation strategies. Overall, the literature highlights the necessity of coupling land restoration frameworks with accurate, high-resolution land use data. There remains a significant research gap in localized mapping efforts in Southeast Nigeria, particularly those that integrate socio-economic variables and indigenous land management practices. This study aims to bridge that gap by providing spatial evidence to support region-specific restoration planning.

3.0 Study Area

Abia State, located in southeastern Nigeria between latitudes 4°47'N–6°12'N and longitudes 7°23'E–8°02'E, spans approximately 6,320 km² and shares borders with six neighboring states. It comprises 17 LGAs, with Umuahia as the capital. The state experiences a **humid tropical climate** with a rainy season from March to October and a dry season from November to February. Annual rainfall ranges from 1,800–2,400 mm, and temperatures typically range between 22°C and 32°C—ideal for crops like cassava, yam, maize, oil palm, and vegetables. Abia's landscape is mostly **undulating plains with isolated hills**, and its ferrallitic soils, derived from sedimentary rocks, are highly weathered and vulnerable to erosion and fertility loss due to intensive land use and poor conservation. The state's vegetation is predominantly rainforest, although extensive deforestation has transformed large portions into derived savannah and secondary regrowth. Land use in Abia is largely agricultural, with over 70% of the population engaged in farming. Rapid urbanization in cities like Aba and Umuahia has intensified land pressure, contributing to land fragmentation and increased vulnerability to degradation (Chukwu et al., 2021).Abia State was selected as the focal area for this study due to its representative agro-ecological and socio-economic characteristics within Southeast Nigeria. The state exemplifies the challenges and opportunities associated with land restoration through agricultural land use planning and serves as a suitable model for similar regions in the country.

3.1 Data Collection

This study employed a multi-source data acquisition strategy to ensure spatial and contextual accuracy. A mixed-method approach was used to ensure comprehensive spatial and contextual analysis: **Remote Sensing Data**: Multi-temporal satellite imagery was sourced from **Sentinel-2** (10 m resolution) and **Landsat 8 (**30 m resolution), covering the years 2015 to 2025. These datasets were chosen for their suitability in detecting land cover changes and agricultural patterns. **Ground Truthing:** Targeted **field surveys** were carried out across selected agricultural zones to validate remote sensing classifications. GPS devices were used to record land features, while photographs and land notes helped contextualize findings. **Socioeconomic Interviews: Semi-structured interviews** with over 100 local farmers and agricultural extension officers captured indigenous knowledge, cropping patterns, land management practices, and perceptions of land restoration. This ensured the study addressed both ecological and socio-cultural dimensions.

3.2 Data Processing and Analysis

Image Preprocessing: Atmospheric corrections, cloud masking, and image stacking were performed using **ArcGIS** and **Google Earth Engine. Land Use Classification**: A **supervised classification** approach with the Random Forest algorithm was employed. Training samples were derived from field data and high-resolution base maps. Land cover categories included cropland, forest, degraded land, and built-up areas. **Change Detection**: Land use transitions were quantified using post-classification comparison techniques. Maps were generated to highlight zones of degradation and agricultural expansion. **Validation**: Accuracy assessments were performed using **confusion matrices**, achieving an overall classification accuracy of 90%. Stakeholder validation workshops were also held to refine interpretation and recommendations.

3.3 Agricultural Land Use Mapping

The study yielded valuable insights into the spatial arrangement, land use activities, and available resources within different land cover types during the assessment period. This information serves as a foundational basis for driving sustainable change or conserving existing land systems to promote human welfare and environmental resilience. Furthermore, the mapping exercise offers a practical framework for classifying the state into zones such as flood plains, areas with high flood risk, and moderately flood-prone regions. These delineations highlight zones suitable for specific agricultural pursuits—including rice, soya beans, sugarcane, maize, raffia palm, and vegetable cultivation—as well as areas identified as viable for non-arable crop production (Ikwa et al., 2024).

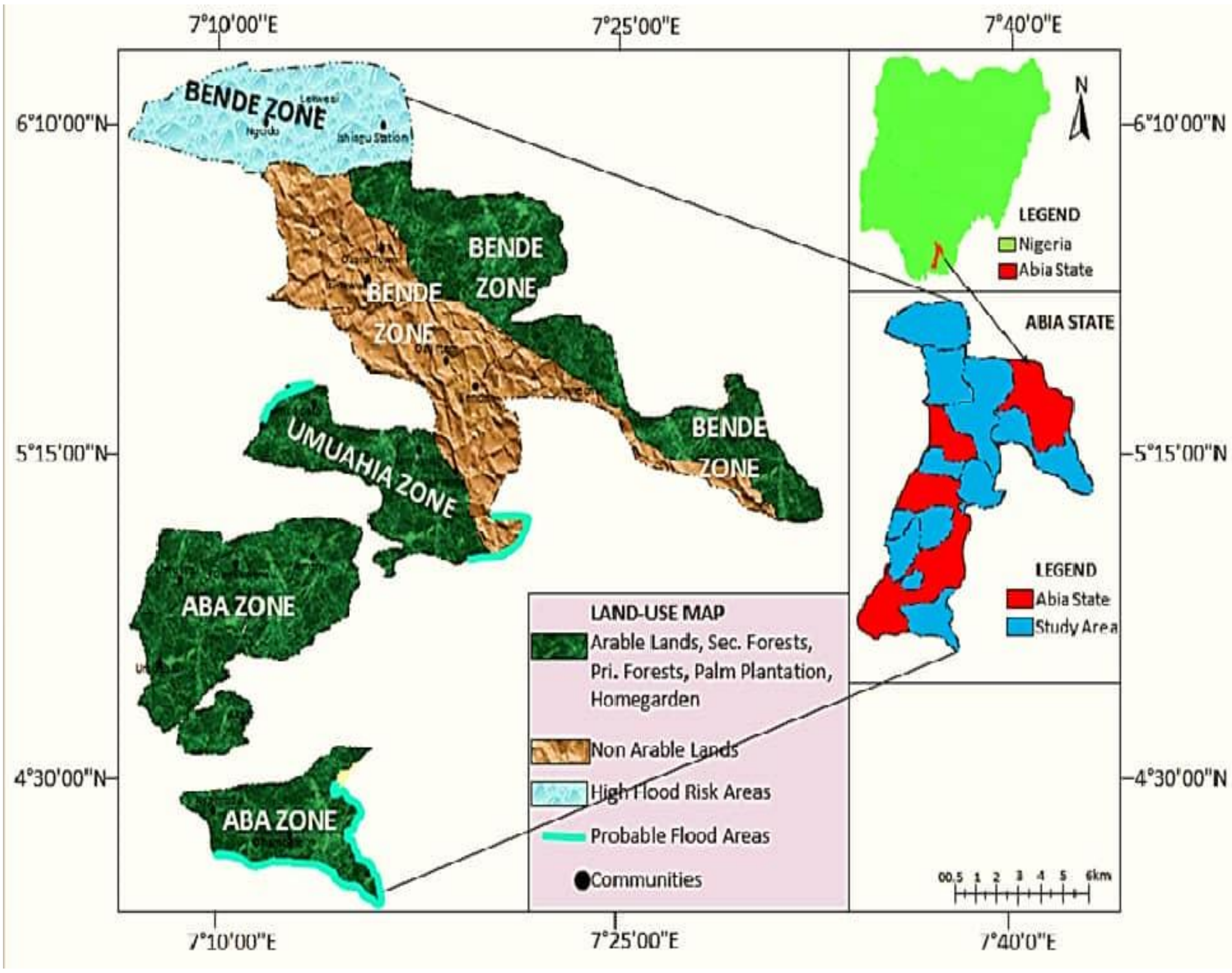

Fig. 3.1 Land use map of Abia state.

3.4 Crop Inventory of Abia State

This refers to the record and / or map showing crop distribution and types that are seen, documented and established in a region at a given time. With its adequate seasonal rainfall, Abia has much arable land that produces yams, maize, potatoes, rice, cashews, plantains, taro, sugar cane, cocoa, potatoes and cassava. Oil palm is the most important cash crop. Also vegetables are grown in home gardens and in low land areas. They include amaranthus, pumpkin, eggplant, cucumber, okra, water melon.

In spite of the region's species richness , not much has been documented about them such as their culinary use, cultural value and general ethno botany. A good number of them are still regarded as underdeveloped crops due to paucity of research input and commercial investment (Chweya and Eyzgurree, 1990; Adeboye *et al*., 2003, Ikwa et al., 2024).

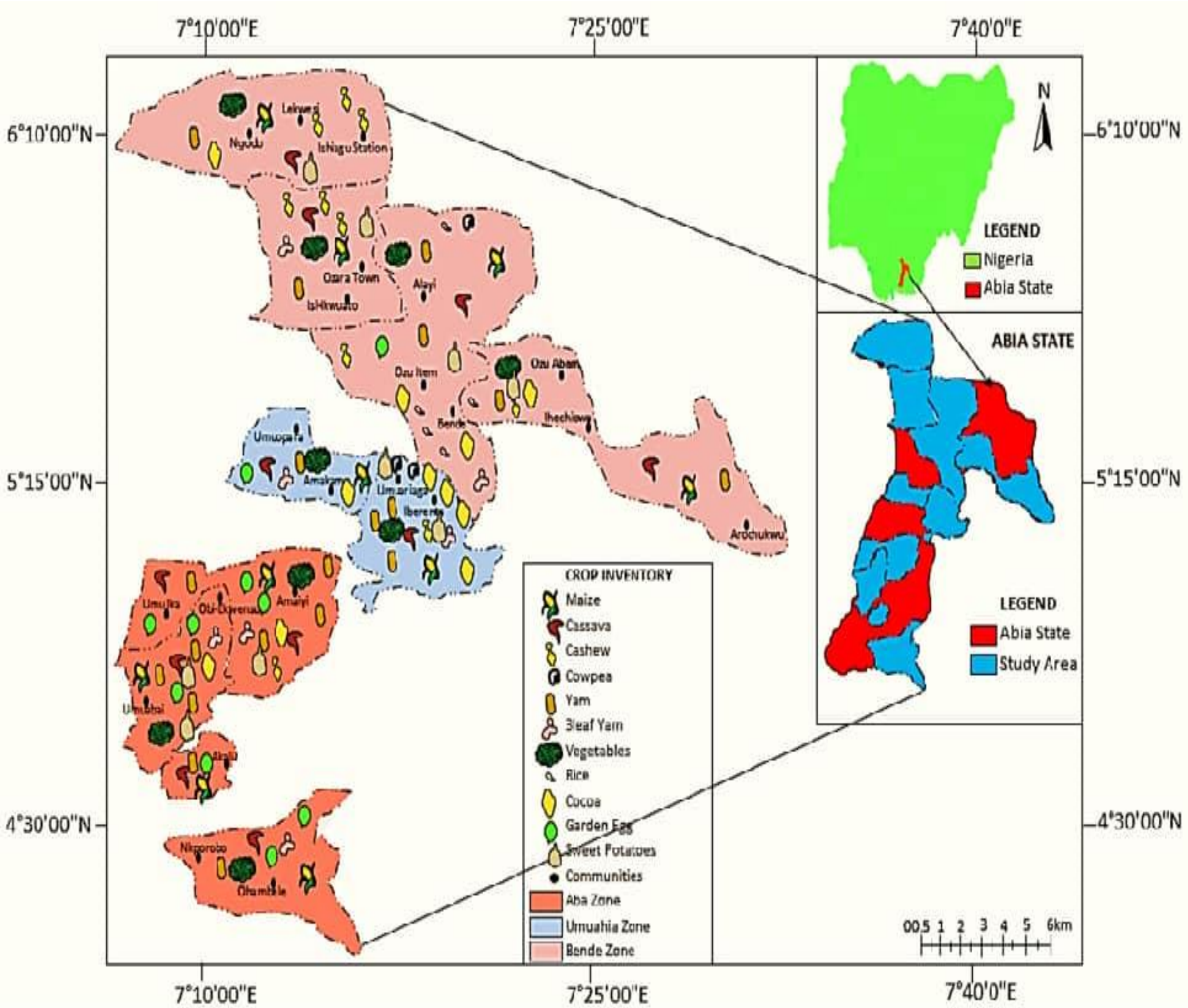

Fig. 3.4.1: Crop inventory Map of Abia state

4.0 RESULTS AND DISCUSSION

Soil Nutrient mapping (N.P.K)

Results of Primary Nutrients N.P.K Were Mapped and represented as follow:

Nitrogen (g/kg) (N): The N content in soils across Abia State varies significantly, with concentrations categorized as follows: low (≤ 0.14 g/kg), medium (0.15–0.27 g/kg), and high (≥ 0.28 g/kg). Several communities—including Ngodo, Lekwesi, Isihagi Station, Ozumba, Umuika, Amaiyi, and Ohambele—fall within the low nitrogen bracket, indicating a widespread nutrient deficiency in these areas. This observation aligns with earlier findings by Chukwu and Asawalam (2001), and has been reaffirmed by more recent studies. Recent Findings by Obasi et al. (2025), Ikwa et al., (2024) in Ikwuano LGA reported total nitrogen levels ranging from 0.10 to 0.20%, classifying most soils as low to moderate in nitrogen content. The authors emphasized the need for targeted nutrient management to support cassava production. Adesemuyi and Ifunaya (2025) investigated Acrisol soils in Obehie, Ukwa West, and found nitrogen levels to be inherently low, with values around 0.94–1.3 g/kg, further confirming the nutrient-poor status of soils in southeastern Nigeria. Udi and Okon (2025) assessed agricultural soils in Isialangwa North and ranked them as weak to degrade in terms of chemical health, particularly due to low nitrogen and organic matter levels. These findings underscore the urgent need for soil fertility enhancement strategies—such as organic amendments, split fertilizer applications, and sustainable land management—to improve crop productivity and restore soil health across Abia State. See Nitrogen Distribution and Agronomic Practices across Communities

Nitrogen Distribution and Agronomic Practices across Communities

Nitrogen Level	N Range (g/kg)	Communities	Recommended Agronomic Practices
Low	≤ 0.14	Ngodo, Lekwesi, Isihagi Station, Ozumba, Umuika, Amaiyi, Ohambele	Apply organic amendments (e.g., compost, poultry manure) - Use split nitrogen applications to reduce leaching - Introduce legume-based crop rotations for biological N fixation - Consider controlled-release fertilizers to improve nitrogen use efficiency (NUE) - Incorporate cover crops to enhance soil organic matter
Medium	0.15 – 0.27	(Not specified; inferred to include transitional zones)	- Maintain fertility with moderate NPK rates - Use precision agriculture tools (e.g., Leaf Color Chart, SPAD meter) - Monitor soil N levels seasonally - Combine organic and inorganic sources for balanced nutrition
High	≥ 0.28	(Not specified; likely limited to isolated pockets)	- Avoid excessive N application to prevent leaching - Use crop removal-based fertilization - Promote conservation tillage to retain N - Encourage microbial inoculants to stabilize N cycling

Phosphorus (P)

The value for P ranged from ≤ 10.0 to 16.79 g/kg (low), 16.0 to 18.99 g/kg (medium) and ≥ 19.0 g/kg (high). The following communities is believe to low P availability Isukwuato, part of Bende and Ohambele. While Ngodo, Lekwesi, Isiagu Station, Umuaki and Nkporobo are believed to have moderate P availability. Whereas Umuaba, Obi-Ekwensu, Umuokpara, Amakama, Umuariaga, Iberenta, Ihechiowa, Ozuitem and Ozara Town tend to have high P availability .Recent studies have provided compelling insights into the distribution, dynamics, and management implications of phosphorus (P) in agricultural soils across southeastern Nigeria: Uzoho & Oti examined the phosphorus adsorption capacity of soils in Bende and surrounding areas. Their findings revealed

ISSN : XXXX-XXXX | Vol 1, Issue 1, Jan – Feb, 2026
Published by RGA Research Publications

that soils in this region exhibit low P availability, primarily due to high clay content and elevated levels of aluminum and iron oxides, which enhance P fixation. This aligns with observed nutrient limitations in Bende, Isukwuato, and Ohambele, suggesting the need for amendments that reduce P sorption and increase its bioavailability. El Attar et al**.,** (2022) provided a broader review of phosphorus dynamics in tropical soils, highlighting the challenge of low bioavailable P despite moderate total P levels. The authors emphasized the importance of site-specific nutrient management using organic amendments and beneficial microorganisms to enhance soil fertility—an approach particularly relevant for moderately P-endowed communities such as Ngodo, Isiagu Station, and Nkporobo. Soremia et al. (2017) investigated phosphorus behavior in organically amended soils in southwestern Nigeria. The application of poultry manure was shown to significantly increase available P while simultaneously reducing P fixation. These results offer promising implications for P management in zones with moderate to borderline deficiencies, such as Lekwesi and Umuaki.Cao et al., (2024) explored the relationship between phosphorus availability and rhizosphere microbial activity. Their study demonstrated that high P availability enhances microbial diversity and disease suppression, which could support greater plant productivity in communities with relatively elevated P levels, including Umuaba, Obi-Ekwensu, Amakama, and Ozara Town.

Phosphorus Distribution and Agronomic Practices across Communities

P Availability Level	P Range (g/kg)	Communities	Recommended Agronomic Practices
Low	≤ 10.0 – 16.79	Isukwuato, Bende (part), Ohambele	- Apply P fertilizers based on soil test results - Use band placement to reduce fixation - Incorporate organic amendments (e.g., compost, poultry manure) - Introduce phosphate-solubilizing microorganisms (PSMs)
Medium	16.0 – 18.99	Ngodo, Lekwesi, Isiagu Station, Umuaki, Nkporobo	- Maintain P levels with moderate fertilizer rates - Use split applications during crop growth - Practice crop rotation with legumes - Monitor soil P levels regularly
High	≥ 19.0	Umuaba, Obi-Ekwensu, Umuokpara, Amakama, Umuariaga, Iberenta, Ihechiowa, Ozuitem, Ozara Town	- Avoid excessive P application - Focus on crop removal-based fertilization - Use cover crops to prevent erosion - Implement conservation tillage to retain P in soil

These practices are aligned with sustainable phosphorus management strategies recommended by agricultural extension services and recent research

Potassium

while K has value that ranged from ≤ 0.3 to 0.39 g/kg (low), 0.40 to 0.49 g/kg (moderate) and ≥ 50 g/kg (high). Notable communities with low K contents include part of Ibere-Nta, Umuopara, Amaiyi and Nkorobo. While those having moderate K presences include Umunbai, Ozuitem and Ohambele (figure 4.13). Finally those with high K presence in soil include Ozara Town, Alayi, Isukwato, Umuariaga, Akali and Arochukwu. The area described above could be good for for cassava and yam production based on the recommendations of SPFS (2004) and (Sobulo and Adepetu, 1987), is medium. Application of 200 to 300 kg/ha (4 to 6 bags) of NPK fertilizer 15:15:15 is economic fertilizer rate to maximize cassava and yam production on Unit A. However, unit B has low fertility and requires about 500 to 600 kg/ha (10 to 12 bags) of NPK fertilizer 15:15:15 to sustain cassava and yam production.

Potassium (K) Distribution across Communities

Potassium levels in soil are critical for root development, water regulation, and crop resilience. Based on your classification:

K Level	Range (g/kg)	Communities	Agronomic Implication
Low	≤ 0.30–0.39	Ibere-Nta, Umuopara, Amaiyi, Nkorobo	Poor crop performance; requires high fertilizer input
Moderate	0.40–0.49	Umunbai, Ozuitem, Ohambele	Suitable for moderate fertilizer application
High	≥ 0.50	Ozara Town, Alayi, Isukwato, Umuariaga, Akali, Arochukwu	Ideal for cassava/yam with minimal fertilizer input

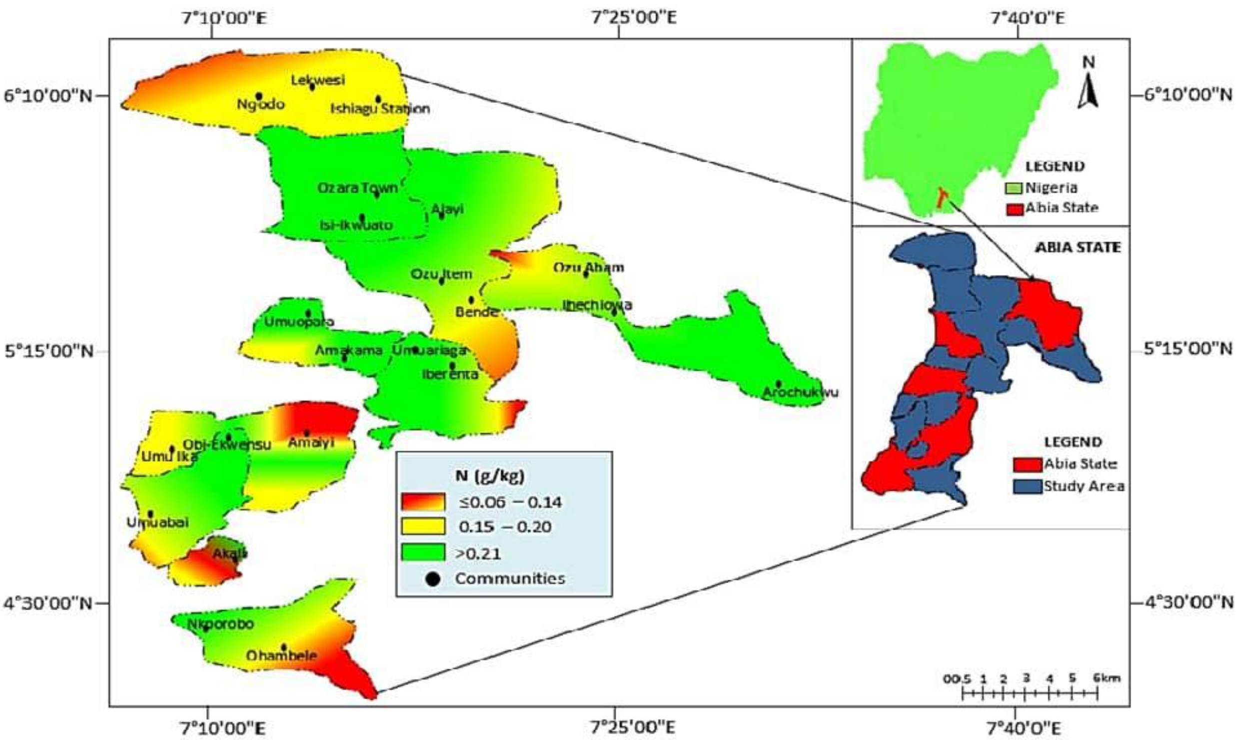

Figure 4.11: Total Nitrogen Map of the study area

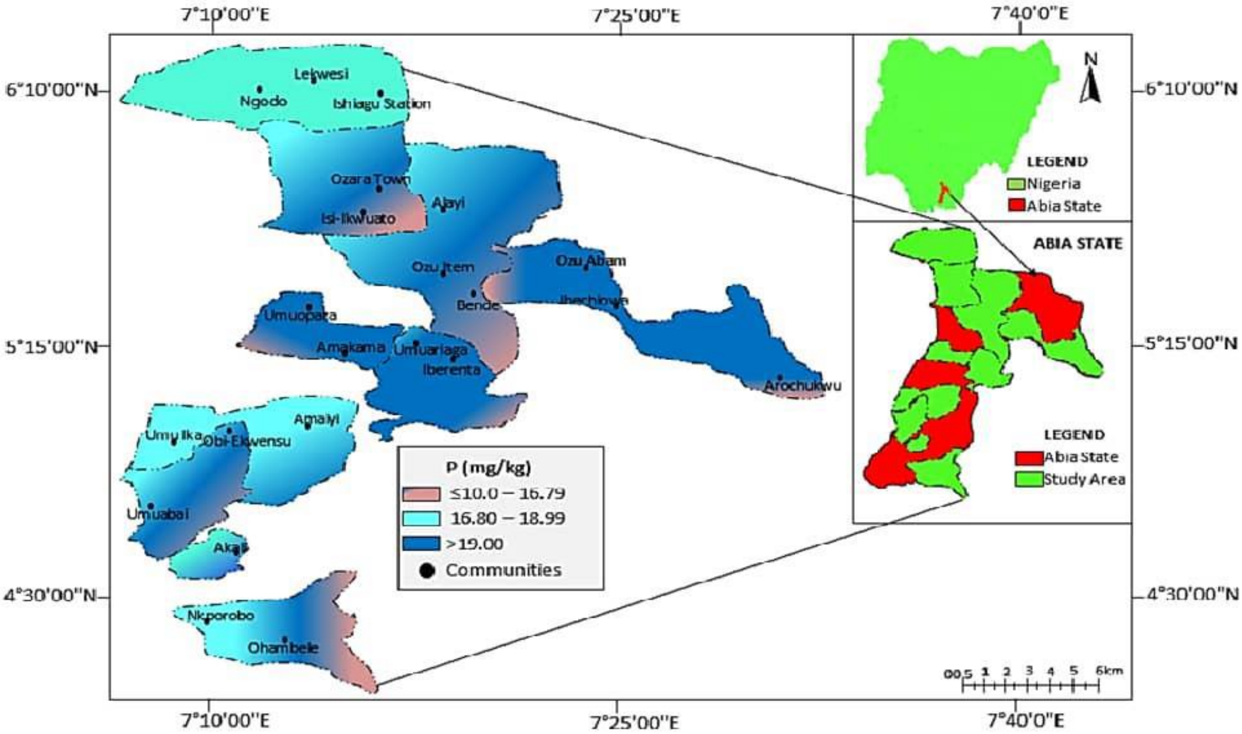

Figure 4.12: Avaliable P Map of the study area

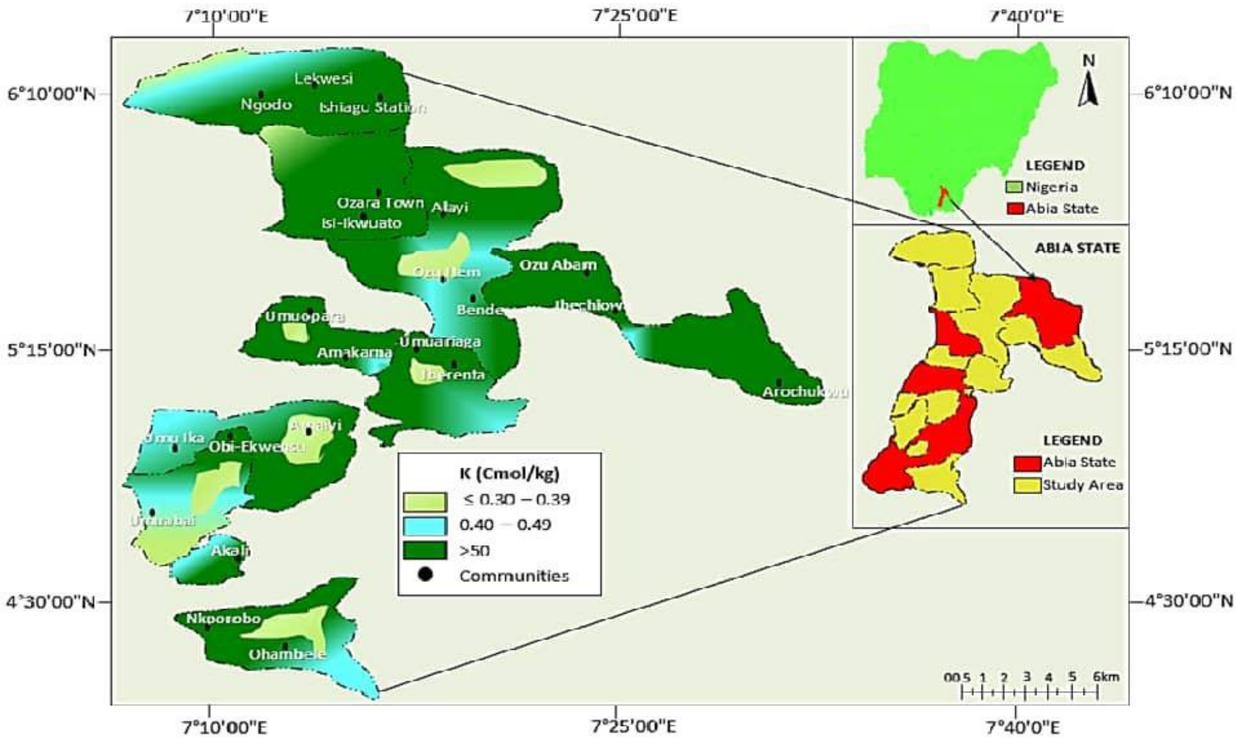

Figure 4.13: Exchangeable K Map of the study area

CONCLUSION

This study underscores the transformative potential of agricultural land use and soil nutrient mapping in addressing land degradation across Southeast Nigeria. By integrating geospatial technologies with localized soil data, it becomes possible to identify degradation hotspots, optimize land suitability for various crops, and guide targeted restoration interventions. The findings reveal that nitrogen, phosphorus, and potassium deficiencies are widespread, particularly in communities such as Ngodo, Lekwesi, and Ohambele, where nutrient levels fall below agronomic thresholds. These deficiencies not only threaten food security but also compromise long-term soil health and ecosystem resilience. The delineation of flood-prone zones and crop-specific suitability areas offers a strategic framework for climate-smart agriculture and land management planning. Moreover, the incorporation of recent studies validates the urgency of adopting site-specific nutrient management practices, including organic amendments and precision fertilization, to enhance bioavailability and reduce nutrient fixation. In conclusion, **agricultural land use mapping is not merely a diagnostic tool—it is a catalyst for sustainable land recovery**. To fully harness its benefits, stakeholders must invest in high-resolution spatial data, strengthen institutional capacity, and promote community-led restoration initiatives. Bridging the gap between scientific evidence and policy implementation will be key to reversing degradation trends and unlocking the region's agricultural potential.

Article Publication Details

This article is published in the **RGA Global Journal of Multidisciplinary Research**, ISSN XXXX-XXXX (Online). In Volume 1 (2026), Issue 1 (January - February)

The journal is published and managed by **RGA Research Publications**.

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Appendix

Plate4.11.1a: Rice farm at Ibere

Plate4.11.1b: Yam barn at Bende

Plate4.11.1c: Maize farm at Abam Bende Integrated Farm Ikwuano

Plate4.11.1d: Cucumber farm (NALDA Abia, at Ariam Elu Elu

Plate4.11.1e: Cocoa farm at Bende

ISSN : XXXX-XXXX | Vol 1, Issue 1, Jan – Feb, 2026
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Plate4.11.1g: Oil palm nursery at Isialangwa Plate4.11.1h: Casaava farm in Ikwuano