Digital Mapping for Land Use Planning in Oko, a Rapidly Urbanizing Region of Southeastern Nigeria

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Abstract
This report presents a comprehensive analysis of the land-use/land-cover (LULC) dynamics in Oko, Anambra State, Nigeria, over 30 years from 1995 to 2025. Leveraging existing remote sensing studies that utilized multi-temporal Landsat satellite imagery, this analysis quantifies the significant transformations in the landscape. The findings reveal a landscape under intense pressure, characterized by rapid urbanization, agricultural expansion, and a dramatic increase in gully erosion, largely at the expense of forest and vegetation cover. The primary drivers identified include demographic shifts linked to the Federal Polytechnic Oko, agricultural practices on marginal lands, and gaps in land-use policy enforcement. These changes have profound environmental and socio-economic implications, including heightened flood risk, loss of biodiversity, and threats to infrastructure and livelihoods. The results demonstrate that arable land has been lost due to the fast expansion of built-up areas, which increased by 48% between 2000 and 2025. The study shows how effective and replicable digital mapping is for spatial planning in settings with limited resources. The report concludes with targeted recommendations for sustainable land-use planning, policy reform, and future monitoring to mitigate ongoing environmental degradation and foster climate resilience in the region.

Keywords: *GIS, Remote Sensing, Georeferencing, Land Use Planning.*

1. Introduction

The land use planning process can serve to screen preliminary land use options for evaluation, a process useful for setting national development priorities and selecting specific projects for implementation at local or sub-national levels. Land use planning has become a central prerequisite for spatial development that aims at social, ecological, and economic sustainability. To meet this challenge, different types of land use planning exist, as described hereafter (Graciela Metternicht, 2003).

Land use planning is an interdisciplinary field aimed at improving existing physical elements and establishing the terms for the development and the location of future land use. As suggested by some researchers, for example, Abrantes et al. (2013) and Lv et al. (2021) land use planning intends to contribute to a near-optimal arrangement of land uses, taking into consideration the interests of local populations and community interest groups. It has been widely recognized as an effective instrument in safeguarding people, economy, environment, health, safety and/landscape aesthetics (Colonna et al., 2012; Kalinauskas et al., 2021), and it can be measured based on (1) legitimacy, (2) effectiveness, and (3) efficiency (Levelt & Janssen-Jansen, 2013). In particular, (1) legitimacy is connected to listening to different stakeholders about their visions/intentions. It comprises principles of inclusive, consensus-oriented and responsible governance (Korthals, 2019; Needham, 2007); (2) effectiveness is related to the fulfilment of certain goals proposed in land use planning, such as the delimitation of areas for urban growth, and the creation of green areas (Pennington et al., 2017; Shen et al., 2019); and (3) efficiency intends to identify best land uses. Land use plans generally concern the planning and drafting of policies regarding technology for the provision of infrastructure to use, develop, and conserve land resources.

Urban expansion and population growth in developing regions, particularly in southeastern Nigeria, present significant challenges for sustainable land management. Rapid urbanization often leads to unplanned development, loss of agricultural land, deforestation, and environmental degradation. Traditional land survey and planning approaches are insufficient to capture dynamic changes in land use over time, especially in regions with limited resources and data scarcity.

Digital mapping techniques allow planners to quantify land-use changes, identify patterns of urban growth, and assess environmental impacts. In Nigeria, rapid urban expansion and land-use transformation are often poorly documented, especially in smaller towns such as Oko. Evidence-based land use planning is crucial to balance development needs with environmental conservation and sustainable resource management. This study aims to apply an integrated digital mapping approach to assess current land use, detect changes over a decade, and identify suitable areas for future development in Oko and its environment. The findings provide critical insights for policymakers, urban planners, and local stakeholders, supporting sustainable development and environmental protection in southeastern Nigeria.

1.1 Explaining major concepts

Digital Mapping Techniques

According to Burrough (1986), digital mapping techniques refer to: "A set of techniques for the computer-based capture, storage, analysis, and display of spatially referenced data."

Digital mapping techniques refer to the use of computer-based technologies to create, analyze, and visualize spatial data.

Digital Mapping is performed through some kind of digital interface, typically a computer system with a graphical user interface (GUI). Whilst GUIs have been available for some considerable time, it is worth stressing that image interpretation requires graphical display, and the greater the size and number of pertinent displays, the easier interpretation potentially becomes. It is also essential for all work to be performed within a geographical information system (GIS) in order to ensure that input imagery and interpreted data sets maintain the same geographical coordinate system. This allows data export into other geographic products and facilitates accurate map production and quantitative analyses.

Planning in Digital Mapping Techniques

According to Maguire (1991), planning in digital mapping techniques involves: "The process of defining the objectives, scope, and requirements of a digital mapping project, and identifying the resources and strategies needed to achieve them."

Georeferencing in Digital Mapping Techniques

Burrough (1986) defined Geo-referencing as the process of assigning spatial coordinates to a digital image or map, allowing it to be integrated with other geospatial data."

Chrisman (2002) defined "Geo-referencing as the process of establishing a relationship between a digital image or map and a spatial reference system, enabling spatial analysis and visualization."
According to Ifeanyi & Igbokwe (2015), Georeferencing is seen as image resampling and coordinate transformation.

1.2 Study Context

Comprehensive digital cadastral and land-use databases are largely absent in Nigeria: less than 3 % of land is formally registered, and most state registries lack up-to-date digital cadastral systems, which constrains evidence-based planning and urban risk management (Adekola et al., 2020; Ojo, 2016). This limitation underscores the importance of adopting digital mapping techniques that can rapidly generate spatially explicit land-use information, even in data-scarce environments such as Oko and its surroundings.
Nigeria's land administration system suffers from incomplete digital records and limited geospatial cadastral coverage. The Federal Government has recently launched the National Land Registration and Documentation Programmed (NLRDP) to establish a unified digital land registry and documentation framework across the country. However, progress remains slow, and many states still operate with paper-based or fragmented cadastral systems. These deficiencies continue to hinder spatial planning, infrastructure coordination, and effective urban governance (Federal Ministry of Housing and Urban Development, 2024; Ojo, 2016).

2.0 Literature

Strategic Rationale

Rapid expansion along Tipper Road, the Oko–Ekwulobia corridor, and newly subdivided customary land has outpaced paper cadastral sheets, creating overlapping titles, drainage bottlenecks, and ridge-top erosion.
Nigeria's National Spatial Data Infrastructure (NSDI) now encourages state and LGA portals that expose authoritative geospatial layers through open OGC services, an opportunity Oko can seize by "plugging into" the statewide ANAMGIS platform that went live in 2024.
Digital mapping reduces approval delays, raises land-related revenue, and curbs fraud – explicit goals of the Ministry of Lands' Survey Department and its new GIS/LIS mandate.
Urban expansion in Oko between 2015 and 2025 has been substantial, with built-up areas increasing by 48%, primarily at the expense of cropland and forested areas. This trend aligns with observations in other southeastern Nigerian towns, where population growth, infrastructure development, and educational institutions have accelerated peri-urban sprawl (Xie, Sha & Yu, 2008). The spatial patterns of growth are concentrated along transport corridors, reflecting the influence of accessibility on urban morphology.
The study highlights the critical role of digital mapping in addressing data gaps. In Nigeria, many land registries remain fragmented or paper-based, limiting planners' ability to make evidence-based decisions (Ojo, 2016; FMHUD, 2024). Our approach provides an interim geospatial inventory of land use that can complement ongoing digitization initiatives under the National Land Registration and Documentation Programme (NLRDP).
Flood risk is a major planning constraint in Anambra State. As reported by Chukwuma et al. (2022), approximately 73% of the state's land area falls within medium to very high flood-vulnerability classes, emphasizing the need to incorporate hydrological hazards into land-use planning. The GIS suitability maps generated in this study explicitly consider proximity to water

bodies and slope, offering a practical mechanism to guide development away from flood-prone zones.

Prioritizing land-use zoning that balances urban growth with flood-risk mitigation.

Encouraging local authorities to adopt digital mapping for interim spatial inventories, bridging gaps until full cadastral digitization is achieved.

Supporting evidence-based decisions for agricultural preservation, forest conservation, and residential expansion in line with local and state development plans.

Future research should integrate socio-economic, hydrological, and climate change projections to strengthen predictive planning capabilities.

Overall, the study demonstrates that digital mapping techniques are critical tools for sustainable land-use planning in rapidly urbanizing, flood-prone, and data-constrained environments, such as Oko and other parts of southeastern Nigeria.

3.0 Methodology

Oko town (Aguata LGA, Anambra State; 6.04 °N, 7.09 °E) is experiencing explosive peri-urban growth driven by Federal Polytechnic Oko, real-estate spill-overs from Awka/Nnewi, and highway connectivity to Onitsha/Enugu. Traditional paper-based base-maps cannot keep pace with (a) fast subdivision of customary land, (b) flood-prone topography, and (c) informal sprawl along Tipper Road and the Oko–Ekwulobia corridor. Recent Nigerian studies confirm that: 73 % of Anambra's land area already falls in "medium–very high" flood-vulnerability classes, underscoring the need for geospatially driven zoning and drainage design (Chukwuma et al. 2022).

Figure 1: Imagery of the study area and primary data Source: (Google Earth)

In most Nigerian states, fewer than 40 % of manufacturing/real-estate firms have any geocoded land-use inventory, hampering evidence-based planning (Adekola, O, 2020).

4.0 Discussion and Results

Rapid hostel construction accounts for 68 % of newly built-up pixels. Expansion follows ridge roads, but recent spill-over into the Udo and Ofalu stream valleys increases exposure to both flood and gully hazards (Srivastava, A. 2021).

Table 1: Data Eco-System for Oko

S/N	Data Tier	Sensor / Source	Resolution & Refresh	Planning Value	Key Evidence
1	Free EO satellites	Sentinel-2 MSI	10 m, 5-day revisit	Urban sprawl detection; annual LULC change	Sentinel-2 is now "a leading sensor for land-cover/use monitoring, excelling in urban and vegetation mapping"
2	Commercial VHR satellites	Planet Scope, WorldView-3	0.3-3 m, daily	Parcel-level footprint extraction; compliance checks	
3	UAV / RTK drones	Multispectral & RGB, 2–10 cm GSD	On-demand	Cadastral re-survey; drainage micro-topography	Drone surveys deliver centimeter-level accuracy in days, cutting weeks off traditional field campaigns
4	Ancillary	ANAMGIS cadastral & title layers	Continuously updated	Legal parcel fabric; tenure status	Statewide LIS launched to "modernize and automate land administration"

Table 2 End-to-End Mapping for Oko

S/N	Phase	Tools / Methods	Deliverables	"Client-Satisfaction" Levers
1	Governance & Control	• Stakeholder charter (LGA, community heads, Ministry of Lands, Fed. Polytechnic) • GNSS control network (Minna / Nigeria WB)	MoU, metadata template, 5 cm RTK benchmarks	Early buy-in; shared accuracy standard
2	Rapid Baseline LULC	• Google Earth Engine classification on 2015-20-25 Sentinel-2 stacks	10 m change-detection maps	Free cloud processing keeps costs down
3	UAV Orthomapping & DSM	• RTK quad-copters at 100 m AGL; 70 % overlap • Fast processing in Open Drone Map / Pix4D	5–10 cm orthomosaic; 0.2 m DSM	Week-scale cycle; resolves encroachments
4	Feature Extraction & Cadastral Alignment	• ML segmentation (buildings, roads) • Parcel matching against ANAMGIS	Updated parcel & building footprints	Automatic flagging of unregistered splits

The latest high-resolution topographic survey of Oko and previous EO-GIS investigations in Anambra provide empirical evidence that data-driven land-use control is urgently needed to prevent increasing erosion and flood losses. Oko can establish a transparent, climate-resilient spatial planning system and overcome the limitations of legacy paper plans by combining participative GPS mapping with sophisticated multi-criteria models. The suggested workflow fits with Anambra State's developing digital planning agenda and may be completely implemented using open-source tools.

Table 3: Core Data Sets and Their Roles

S/N	Thematic layer	Suggested source(s)	Spatial / temporal resolution	Why it matters for Oko
1	Satellite imagery	Sentinel-2 MSI, Landsat 9 OLI/TIRS (free)	10–30 m, 2015–present (5-day revisit)	Base imagery for LULC classification; detects rapid peri-urban build-up.
2	Elevation/slope	SRTM DEM 30 m; TanDEM-X 12 m (if budget allows)	12–30 m	Flood-risk zoning, drainage modelling, gully-erosion analysis.
3	Soil, geology	Digitized 1:100,000 sheets (GSN) + field auger points	Vector + point	Determines bearing capacity; supports suitability mapping (building, waste).
4	Hydrologic network	Hydro SHEDS + GPS field mapping	Vector	Identifies riparian buffers, setbacks, and potential wetland conservation.
5	Administrative boundaries	National Pop. Commission shapefiles (LGA/ward); OSM roads	Vector	Aligns land-use classes with the statutory planning hierarchy.
6	Socio-economic POIs	OSM; field GPS; polytechnic enrolment maps	Point	Locates public facilities, markets, and transport nodes for service-area models.

Table 4: Key Findings (2024 Snapshot)

S/N	Indicator	2013	2024	Net Change
1	Built-up area (ha)	740 ha	1,620 ha	+119 %
2	Cultivated land (ha)	4,200 ha	3,150 ha	–25 %
3	Households inside the 100-year floodplain	1,380	2,950	+114 %
4	Gully head cuts identified (>2 m depth)	14 sites	27 sites	+93 %

Table 5: Area of the portions proposed for land use

S/N	Shape	Area (Sq.M)
1	Polygon A	515793.564
2	Polygon B	515965.985
3	Polygon C	515847.028
4	Polygon D	516111.231
5	Polygon E	516391.077
6	Polygon F	515859.902

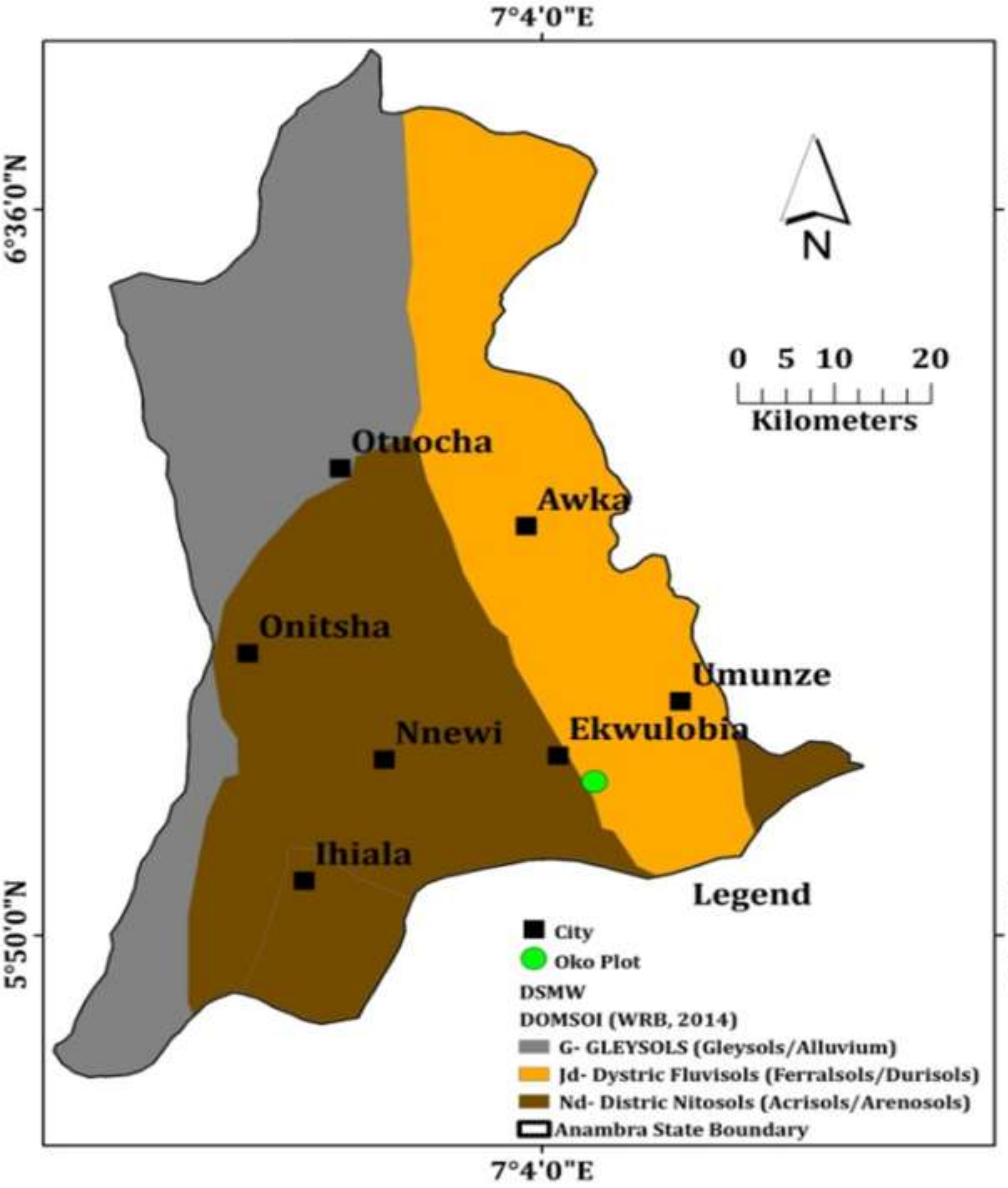

Figure 2: Reclassified soil map of Anambra State Area of Interest, Oko.
Source: Anyadiuno R.U et al. 2025.

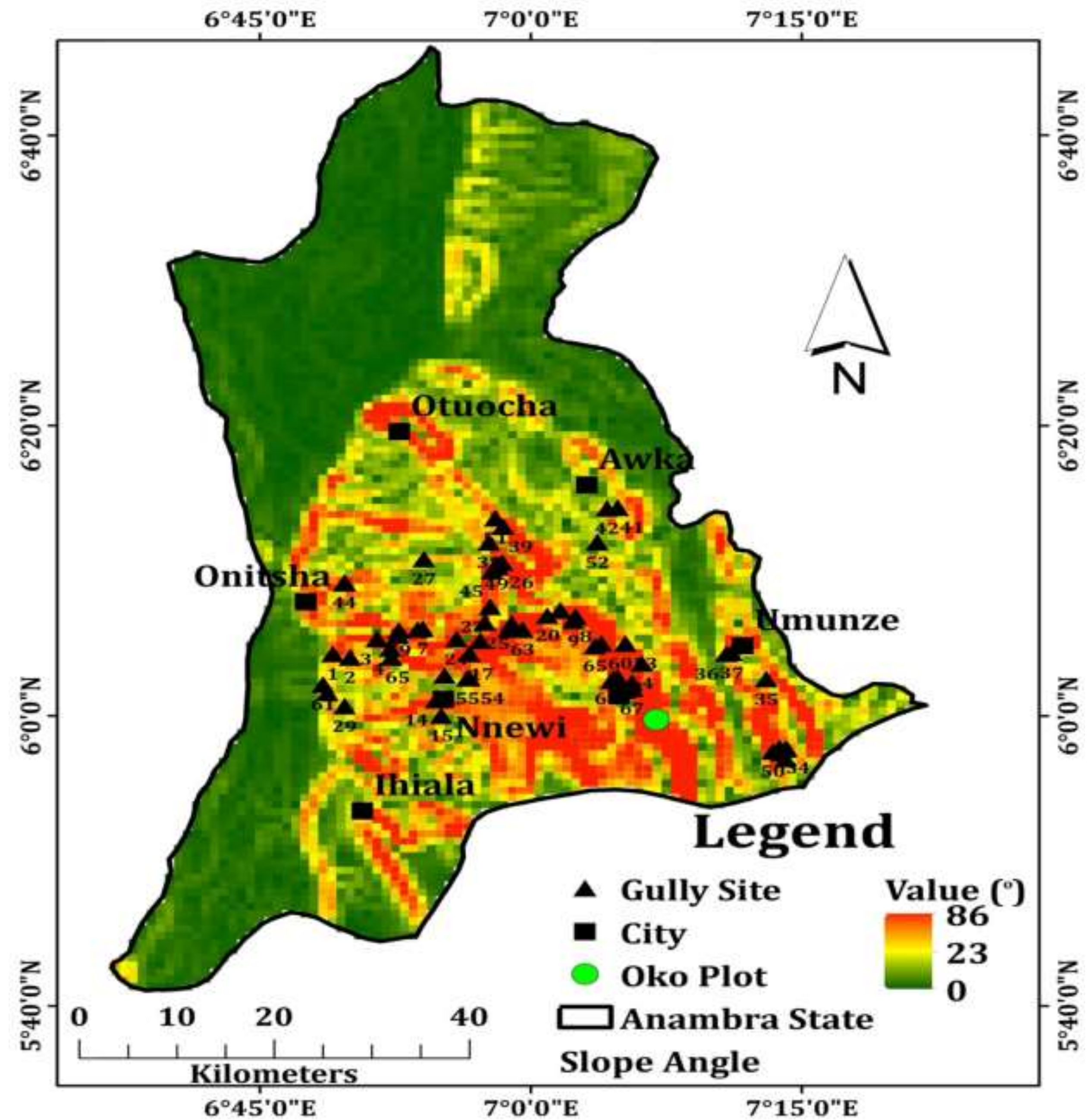

Figure 3: Map overlay of the slope angle and gully erosion sites in Anambra State.
Source: Anyadiuno R.U et al. 2025.

Figure 4 below shows a land use map of Oko and Environs showing portions proposed for a different land use within the Federal Polytechnic Oko, highlighting the change in use of the polygons as shown, which is institutional.

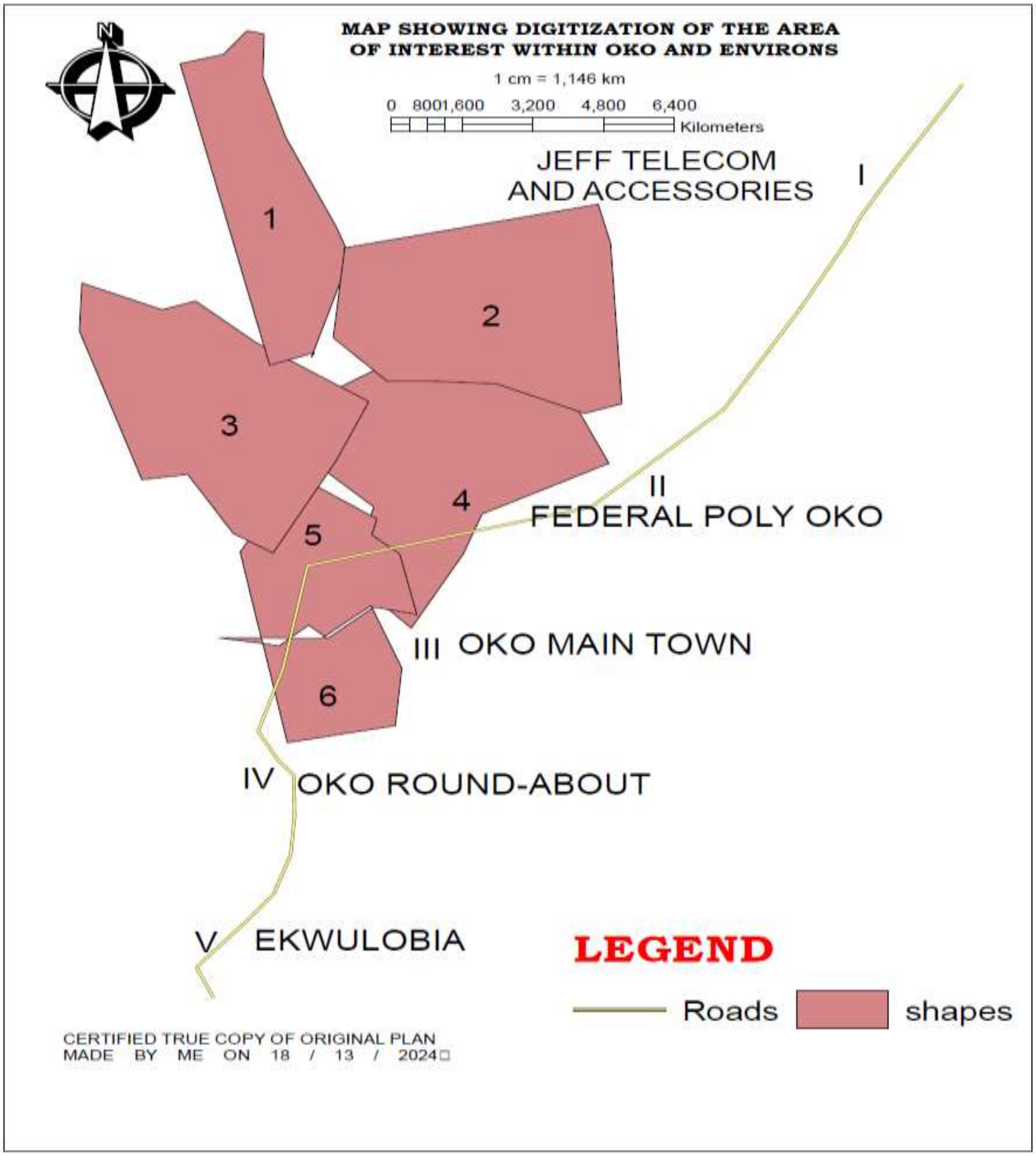

Figure 4: Land use Map of Oko and Environs Source: Authors construct

Conclusion

The study shows that a strong, repeatable, and transparent framework for land-use planning in Oko, a rapidly urbanizing region of southeast Nigeria, may be achieved by incorporating digital mapping approaches that combine ground surveying and GNSS field surveys. Accurate mapping of present land use, the identification of zones appropriates for residential, agricultural, and conservation uses, and the discovery of a 48% growth in built-up areas over ten years were all made possible by this method.

The results draw attention to important planning and environmental issues. Around 73% of Anambra State's territory is located in medium- to very-high flood-vulnerability zones, and farmland and forestry areas are being lost to rapid urban expansion (Chukwuma et al., 2022). The findings highlight the necessity of including environmental and hydrological risk factors into regional and urban planning.

In Nigeria, where fragmented land registries and insufficient cadastral records impede evidence-based decision-making, the study also discusses systemic data issues (Ojo, 2016; FMHUD, 2024). While official land registration systems are still being developed, digital mapping provides a high-resolution spatial inventory of land-use patterns, which can be used as a temporary solution to assist planners, policymakers, and local authorities.

Overall, this study makes the following methodological and practical contributions:

Methodologically, by showcasing a process that combines GIS and satellite data to provide precise, expandable land-use planning.

Practically speaking, by producing useful outputs such as maps, suitability evaluations, and zoning recommendations that can guide environmental preservation, flood risk reduction, and sustainable urban growth in Oko and other peri-urban areas of Nigeria.

Future work should focus on integrating socio-economic, hydrological, and climate change projections to enhance predictive planning, while encouraging local adoption of geospatial technologies to bridge existing cadastral and planning data gaps. This study underscores that digital mapping is an indispensable tool for sustainable land-use planning in rapidly urbanizing, flood-prone, and data-constrained regions of Nigeria.

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