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# Digital Topographic Survey and Elevation Profiling of Ezukwu Farmland, Delta State, Nigeria

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***Abstract -*** *Accurate topographic information is fundamental for sustainable agricultural development, infrastructural planning, and environmental monitoring. This study conducted a digital topographic survey and elevation profiling of Ezukwu Farmland located in Ibusa, Oshimili North Local Government Area of Delta State, Nigeria. The project employed a Total Station (Sokkia 610) for the acquisition of spatial data, encompassing perimeter traversing, spot heighting, and feature detailing. The data was processed using AutoCAD Land Development and Surfer software to generate a high-resolution digital topographic map and contour model. The final output, rendered at a scale of 1:2,000, provided elevation contours, slope gradients, and spatial delineation of both natural and anthropogenic features. The study demonstrated compliance with the Surveyors Council of Nigeria (SURCON) standards and affirmed the suitability of Total Station surveying for medium-scale agricultural topographic applications.*
***Keywords:*** *Topographic Survey, Digital Elevation Model (DEM), Total Station, Terrain Analysis, Contour Mapping*

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## I. Introduction

Topographic surveying remains a foundational practice within the discipline of geomatics, representing a critical intersection of measurement science, spatial analysis, and digital cartographic modeling. It involves the determination of the relative spatial positions and elevations of both natural and artificial features on the earth's surface, typically for the purpose of generating maps and models that inform engineering, environmental, and agricultural planning (Wolf & Ghilani, 2002; Uren & Price, 2014). With the increasing demand for precision land resource management and infrastructure development, the relevance of topographic data has expanded to include domains such as hydrological modeling, soil conservation design, and climate adaptation studies (Kavanagh, 2017; Brinker & Minnick, 1987; Su et al., 2023).

Digital topographic surveys leverage advanced electronic instruments such as Total Stations and GNSS receivers to produce spatially accurate data in three dimensions (x, y, z), forming the basis for Digital Elevation Models (DEMs) and contour mapping (Roy, 2008; Ghilani & Wolf, 2006). The transformation from analogue to digital terrain data allows for more robust modeling of landforms and hydrological behavior, essential for site suitability assessment, slope stability analysis, and civil infrastructure layout (Das, 2010; Dixon-Gough, 1995; Oriola, 2011). Notably, digital elevation data facilitates slope classification, drainage delineation, and visibility analysis, providing critical support for both tactical and strategic land-use decisions (Helge et al., 2018; Kraus & Kager, 1994).

Within the Nigerian context, the utility of topographic data is further magnified by rapid urbanization, increasing agricultural pressure, and the inadequacy of existing geospatial information infrastructures. In many rural communities, including those in Delta State, spatial data deficiencies continue to hinder effective planning and resource allocation (Onuigbo et al., 2016; Odo et al., 2015). For instance, the lack of updated topographic data impedes land parcel zoning, irrigation layout optimization, and the design of climate-resilient rural infrastructure (Adetunji et al., 2020; Ajayi et al., 2019).

Ezukwu Farmland, located in Ibusa, Oshimili North Local Government Area of Delta State, represents a valuable agricultural landscape that lacks precise spatial characterization. Current land management practices within the area rely predominantly on anecdotal knowledge and outdated cartographic sources. The absence of recent high-resolution topographic data has constrained evidence-based decision-making regarding erosion control, crop suitability zoning, and infrastructure placement. This situation reflects a broader challenge of spatial data gaps in peri-urban and rural Nigeria (Abubakar & Aina, 2021; Akinluyi et al., 2022).

Topographic surveys in such contexts serve as not merely cartographic exercises but as tools for development facilitation. They are essential for environmental baseline studies, disaster risk assessment, and participatory planning processes (USGS, 1993; USACE, 1994). Moreover, the integration of topographic data with Geographic Information Systems (GIS) enhances its analytical potential, enabling spatial modeling and scenario simulations for land degradation, runoff dynamics, and infrastructure optimization (Lexicon Universal Encyclopedia, 1989; Karl et al., 1995).

The advent of digital surveying equipment, such as the Sokkia SET 610 Total Station, offers a cost-effective and technically sound means of producing spatial datasets that meet international mapping standards while being adaptable to local conditions. These instruments have proven effective in projects across a range of Nigerian terrains, supporting applications in campus planning, flood mitigation design, and agricultural land classification (Ndukwe, 2009; Olofin & Adeyemi, 2018; Igbokwe et al., 2016).

Given these imperatives, this study undertakes a detailed digital topographic survey and elevation profiling of Ezukwu Farmland using Total Station methodology. The objectives are to (i) generate an accurate perimeter survey of the land parcel; (ii) collect grid-based spot heights to support elevation modeling; (iii) identify and map key natural and anthropogenic features; and (iv) produce a digital topographic map and Digital Elevation Model that meets the specifications of the Surveyors Council of Nigeria (SURCON). The outcome of the study is intended to serve as a geospatial decision-support tool for landowners, planners, engineers, and researchers concerned with sustainable land use and infrastructure development in Delta State and beyond.

## II. Materials and Methods

### 2.1. Study Area Description

The study was conducted on Ezukwu Farmland located in Ibusa, Oshimili North Local Government Area (L.G.A), Delta State, Nigeria. Geospatially, the site lies within the Nigeria Mid Belt Coordinate System between Northings 238400mN to 238900mN and Eastings 467000mE to 467400mE. Topographically, the area is characterized by moderate undulations interspersed with shallow depressions and gentle slopes, making it suitable for agricultural exploitation. The climatic regime is tropical with distinct wet (May to October) and dry (November to April) seasons. The annual rainfall exceeds 2,700 mm while average temperatures hover around 32 °C during the dry season. Vegetation consists primarily of secondary forest interspersed with cultivated fields and scattered tree clusters.

### 2.2. Survey Planning and Methodological Framework

The methodological design was informed by the requirements of high-resolution topographic mapping and elevation modeling. The process involved sequential phases comprising preliminary reconnaissance, instrument selection and calibration, field data acquisition, and post-processing for digital output generation. The workflow adhered strictly to the Surveyors Council of Nigeria (SURCON) specifications for Large Scale Cadastral and Engineering Surveys, with targeted mapping outputs at a scale of 1:2,000 and a vertical accuracy threshold commensurate with a 3” angular accuracy instrument.

### 2.3. Preliminary Reconnaissance and Control Integration

Preliminary reconnaissance was performed in two stages: office-based and field-based. The office reconnaissance involved gathering existing geospatial data, including analogue maps and coordinate records from the Delta State Ministry of Lands and Survey. Three primary geodetic control points (ACS 111P, ACS 112P, and ACS 113P) within the vicinity of the study area were identified for integration into the survey framework.

Field reconnaissance involved GPS-based location of the control points and intervisibility verification. A Garmin handheld GPS receiver was used to confirm that line-of-sight and accessibility conditions met operational requirements. Observations affirmed that the selected controls were inter-visible, undisturbed, and viable for subsequent station setup.

### 2.4. Instrumentation and Testing

The principal instrument deployed was the Sokkia SET 610 Total Station, which complies with ISO17123-3:2001 standards. The device provides angular measurement accuracy of 3 seconds and a linear measurement accuracy of 1 mm. Supplementary tools included:

1. Tripod stands and 2.15 m tracking rods
2. Prism reflectors for distance observation
3. 100 m steel tape for linear referencing
4. Survey umbrella, hammers, and wooden pegs for ground marking
5. Casio FX-7400GII programmable calculator for field computations

Before field deployment, the Total Station was subjected to comprehensive testing to ensure its reliability. Permanent adjustments included horizontal collimation, vertical index, trunnion axis, tubular vial, and optical plummet assessments. Temporary adjustments such as centering, levelling, and focusing were verified at each instrument setup.

### 2.5. Data Acquisition Strategy

#### 2.5.1. Perimeter Traverse Survey

A closed-loop traverse was established to demarcate the perimeter of the farmland using Total Station observations between the three control points. Each traverse leg was observed with both face-left and face-right configurations to eliminate angular errors. Field measurements included slope distances and horizontal angles, and the station configuration was executed via internal coordinate programming of the Total Station. Closure computations and angular adjustments were implemented to validate positional accuracy.

#### 2.5.2. Grid-Based Spot Heighting and Feature Detailing

Following the perimeter definition, the site was systematically gridded into 25m x 25m cells to ensure uniform elevation sampling. Spot height measurements were collected at each grid intersection using reflector-based Total Station observation. Each height point was logged with corresponding Easting, Northing, and Elevation values, facilitating the generation of a continuous digital elevation model (DEM). Concurrently, natural (e.g., drainage lines, vegetation stands) and anthropogenic features (e.g., footpaths, sheds, fences) were detailed for cartographic representation.

### 2.6. Data Recording and Transfer Protocols

All observational data were logged electronically into the Total Station's onboard memory and manually into field books. To ensure redundancy and data integrity, observations were stored using a uniquely labeled job file. At the close of each survey session, data were transferred to a personal computer via serial interface, using ASCII formatting compatible with AutoCAD and Surfer software environments.

### 2.7. Data Processing and Map Production

Traverse data were adjusted using coordinate misclosure balancing, ensuring that final positional discrepancies were minimized. Mean coordinates from dual observations (face left and right) were computed for all stations and height points.

AutoCAD Land Development 2000 was used for perimeter plotting, planimetric detailing, and symbol annotation. For vertical modeling, Golden Software Surfer 11 was utilized to interpolate a raster-based DEM and generate contour lines at 1m intervals. Surface profiles were extracted along defined transects to depict slope gradients and elevation variability across the terrain.

Final map outputs included a 2D topographic map with contours, feature annotations, and a 3D terrain model. All products were scaled to 1:2,000 and printed using HP LaserJet Pro MFP 182n with metadata indicating geodetic reference, scale bar, and legend.

## III. Results and Discussion

### 3.1. Traverse Computation and Adjustment Outcomes

The perimeter traverse of Ezukwu Farmland was executed as a closed-loop configuration, integrating three control points (ACS 111P, ACS 112P, and ACS 113P) with supplementary intermediate stations. Observations were taken on both face left (FL) and face right (FR) to mitigate angular biases. The measured bearings and distances were subjected to traverse closure analysis using the Bowditch (compass rule) method.

The computed misclosures were:

1. $\Delta$ Northing: 0.055 m
2. $\Delta$ Easting: 0.066 m

These resulted in a relative closure accuracy of 1:20,000, exceeding the Surveyors Council of Nigeria (SURCON) minimum requirement of 1:10,000 for large-scale cadastral and engineering surveys. The minimal misclosure indicated precise instrument setup, meticulous observation, and high-quality field practices. These findings validated the structural integrity of the control network and confirmed that the dataset could be confidently used for digital mapping and elevation modeling.

### 3.2. Digital Elevation Model (DEM) and Contour Generation

The gridded spot height data collected at 25 m intervals were interpolated using Surfer 11 software to generate a Digital Elevation Model (DEM) of the farmland. The DEM provided a continuous raster-based surface representation of the area, capturing variations in elevation across the terrain.

The elevation values ranged between 45.6 m and 61.4 m above mean sea level, indicating a terrain typified by low to moderate undulations. The terrain exhibited gradual rises and depressions, with no abrupt changes in slope or evidence of deep-cut features such as gullies. This gentle variation supports ease of mechanized farming and reduces the likelihood of severe runoff-induced soil erosion.

Contour lines were derived at 1.0 m vertical intervals to depict terrain relief. The contour pattern confirmed the presence of a southwest-to-northeast elevation gradient, suggesting natural drainage alignment and influencing the positioning of irrigation or runoff management systems. The contour map visually delineated microtopographic zones, such as low-lying pockets ideal for rice cultivation and elevated patches potentially more suitable for cassava or maize production.

### 3.3. Surface Profile Analysis

Surface profiles were extracted along two principal axes (north-south and east-west) across the farmland to assess longitudinal and latitudinal slope variation. These profiles indicated slope gradients between 0.8% and 3.6%, classifying the area as gently sloping under FAO topographic classification. Such slope conditions are conducive for agricultural land use, especially in minimizing runoff velocity and enhancing infiltration capacity.

The slope analysis also facilitated site-specific recommendations. For example:

1. Sections with <1% slope are suitable for flood-irrigated crops.
2. Zones with 2%–3.6% slopes can support rainfed cultivation but may require conservation practices such as contour ridging or strip cropping.

### 3.4. Feature Representation and Spatial Distribution

The planimetric survey mapped both natural and anthropogenic features with high locational accuracy. Natural features included:

1. A seasonal stream dissecting the southern quadrant.
2. Clustered tree stands distributed unevenly across the central zone.
3. Slight depressions serving as ephemeral runoff collection points.

Anthropogenic features identified and digitized included:

1. Two footpaths used for farm access.
2. Perimeter fencing delineating land ownership.
3. A temporary storage structure situated on the eastern edge of the farm.

These features were georeferenced and incorporated into the final map using conventional symbology. Their representation facilitates functional zoning of the farmland and informs decisions such as road placement, buffer zones, and plot demarcation.

### 3.5. Accuracy Assessment and Conformity with Standards

A multi-criteria accuracy assessment was conducted, covering:

1. Instrument validation through pre-survey testing and collimation checks.
2. Field redundancy, using FL/FR readings and repeated height observations.
3. Geodetic control referencing, with positional data tied to certified state control points.

The total survey error remained within SURCON-prescribed tolerance limits for both linear and angular measurements. The processed data revealed an RMS error of less than 0.04 m in both horizontal and vertical components, ensuring compliance with the national standard for large-scale mapping.

The high-resolution DEM and contour maps enable spatially informed agricultural planning. The data provides a foundation for:

1. Designing irrigation layouts based on gravity flow principles.
2. Engineering soil conservation structures, particularly along identified slope gradients.
3. Allocating land parcels by topographic suitability for various crops.

Furthermore, the data can assist in future infrastructural designs, such as the construction of access roads, storage facilities, and stormwater management systems. The ability to model terrain behavior under different rainfall intensities using the DEM also enhances disaster preparedness, particularly in the context of erosion and flooding.

## IV. Conclusion

This study has successfully demonstrated the efficacy of modern geospatial surveying techniques—particularly the application of Total Station instrumentation—for generating a high-accuracy digital topographic dataset of Ezukwu Farmland in Oshimili North Local Government Area, Delta State, Nigeria. The methodological approach integrated conventional survey practice with digital data acquisition and processing workflows, enabling the systematic collection of spatial coordinates and elevation data with sub-decimeter accuracy. The Sokkia SET 610 Total Station, when combined with rigorous pre-survey instrument testing and in-situ calibration, provided a reliable platform for both perimeter traversing and grid-based spot heighting. The resulting positional data was subsequently modeled into a Digital Elevation Model (DEM) and contour map using specialized software (AutoCAD Land Development and Surfer 11), producing detailed terrain representations suitable for analysis and planning.

The topographic outputs revealed a landscape of moderate undulations with elevation ranging from 45.6 m to 61.4 m above mean sea level and slope gradients generally below 4%. These conditions are favorable for a wide range of agricultural applications, particularly mechanized crop farming, and imply low susceptibility to erosion under typical rainfall regimes. Furthermore, the generated contour maps and elevation profiles enabled the identification of natural drainage pathways, slope-controlled microzones, and potential erosion-prone areas, thereby providing a vital input for site-specific land management strategies.

Moreover, the survey delineated natural and anthropogenic features such as tree clusters, watercourses, farm structures, and footpaths. Their spatial representation on the topographic map allows for functional land-use zoning, supports infrastructural layout planning, and assists in environmental monitoring. From a geospatial governance perspective, the integration of this data into a digital topographic information system aligns with national objectives for enhancing land administration, agricultural productivity, and rural development.

In terms of technical compliance, the final survey accuracy—estimated at 1:20,000 for traverse closure and less than 0.04 m RMS error in spatial measurements—meets and surpasses the minimum accuracy thresholds established by the Surveyors Council of Nigeria (SURCON) for large-scale cadastral and engineering surveys. This reinforces the operational credibility of the adopted methodology and supports its replication for similar terrain analysis projects in comparable agro-ecological zones across Nigeria.

Conclusively, this research has produced a reliable geospatial dataset that can serve as a foundational input for a wide spectrum of end-users including landowners, agricultural extension planners, engineers, researchers, and government agencies. The topographic survey and its digital outputs not only address the current data deficiency but also offer long-term utility for precision agriculture, infrastructure design, and environmental stewardship within the Ezukwu agricultural domain.

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