OPEN ACCESS
World Journal of Multidisciplinary Studies
ISSN (Online): 3049-0855 | Vol. 3, No. 4, Apr. 2026
Website: https://wasrpublication.com/index.php/wjms

The Use of Drones for Surveying Applications

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Received: 12/02/2026 | Accepted: 26/03/2026 | Published: 27/04/2026

Abstract: Drones, also known as Unmanned Aerial Vehicles (UAVs), are revolutionizing traditional surveying practices by providing rapid, cost-effective, and high-resolution data capture. This study examines the use of drones in surveying, emphasizing photogrammetry, Light Detection and Ranging (LiDAR), and real-time mapping techniques. Field data collected in Onitsha, Anambra State, demonstrates that drone-based surveys can reduce field time by up to 70% while achieving positional accuracy of ±3 cm horizontally and ±5 cm vertically compared to conventional Global Navigation Satellite System (GNSS) methods. Key advantages include safe access to hazardous or difficult terrain, reduced manpower requirements, and seamless integration with Geographic Information System (GIS) platforms. Limitations such as battery life, weather dependency, and regulatory constraints are also critically evaluated. The findings support drones as viable tools for cadastral, topographic, and construction surveys in Nigeria and similar developing regions, offering significant potential for enhancing spatial data acquisition efficiency.

Keywords: Drones, UAV, Surveying, Photogrammetry, LiDAR, GIS, Remote Sensing.

1. Introduction

Surveying is fundamental to engineering design, land administration, urban planning, and environmental monitoring. Traditional survey methods, including total stations, theodolites, and GNSS, provide accurate spatial data but are often time-consuming, labor-intensive, and logistically challenging, particularly in areas with difficult terrain, dense vegetation, or flood-prone regions (Micheletti et al., 2015).

The introduction of drones equipped with high-resolution optical sensors and LiDAR technology has transformed surveying practices worldwide. UAVs offer the capability to capture high-resolution geospatial data rapidly, reducing field time and operational costs while maintaining accuracy standards comparable to conventional methods (Colomina & Molina, 2014). In addition, drones enable access to areas that are otherwise dangerous or inaccessible, such as riverbanks, steep slopes, or construction sites.

In Nigeria, urbanization is occurring at an unprecedented rate, especially in commercial hubs like Onitsha, Anambra State. The need for up-to-date, accurate, and cost-effective spatial data has become critical for planning infrastructure, managing land disputes, and conducting environmental assessments (Obinna & Chukwudi, 2020). UAVs have emerged as a solution to these challenges, offering surveyors a combination of speed, flexibility, and accuracy.

This paper explores the application of drones in surveying, evaluating their accuracy, practical benefits, limitations, and potential for adoption in Nigerian surveying practice. We review current technologies, compare drone-based surveys with traditional GNSS and total station methods, and provide recommendations for their broader integration into local surveying frameworks.

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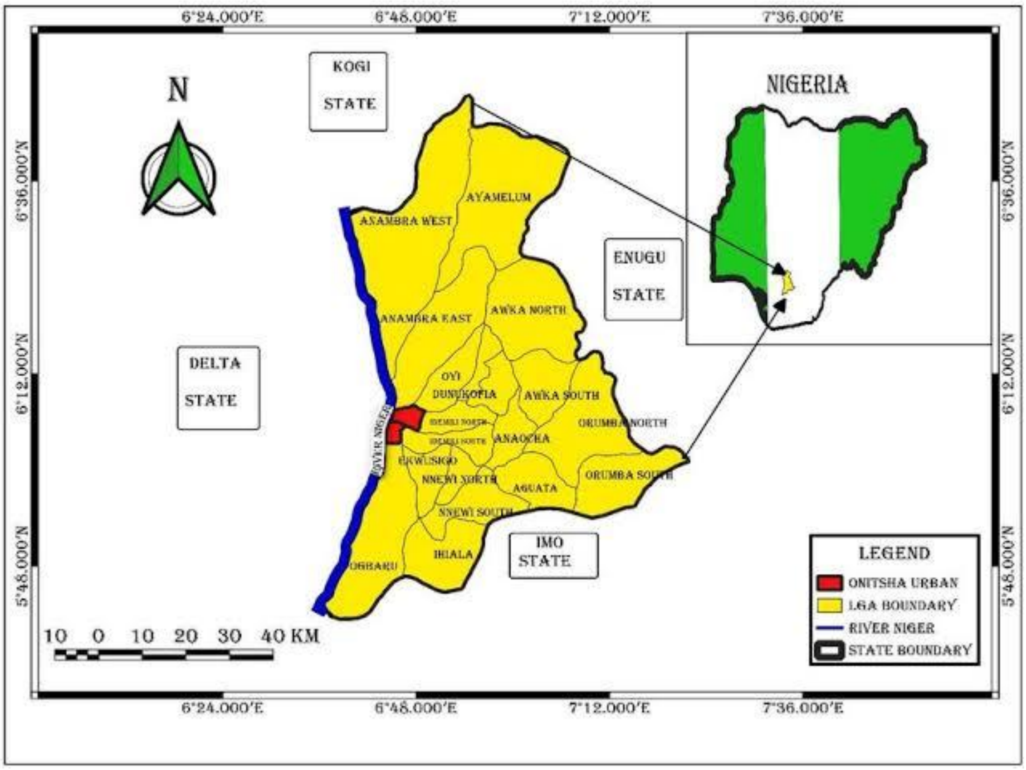
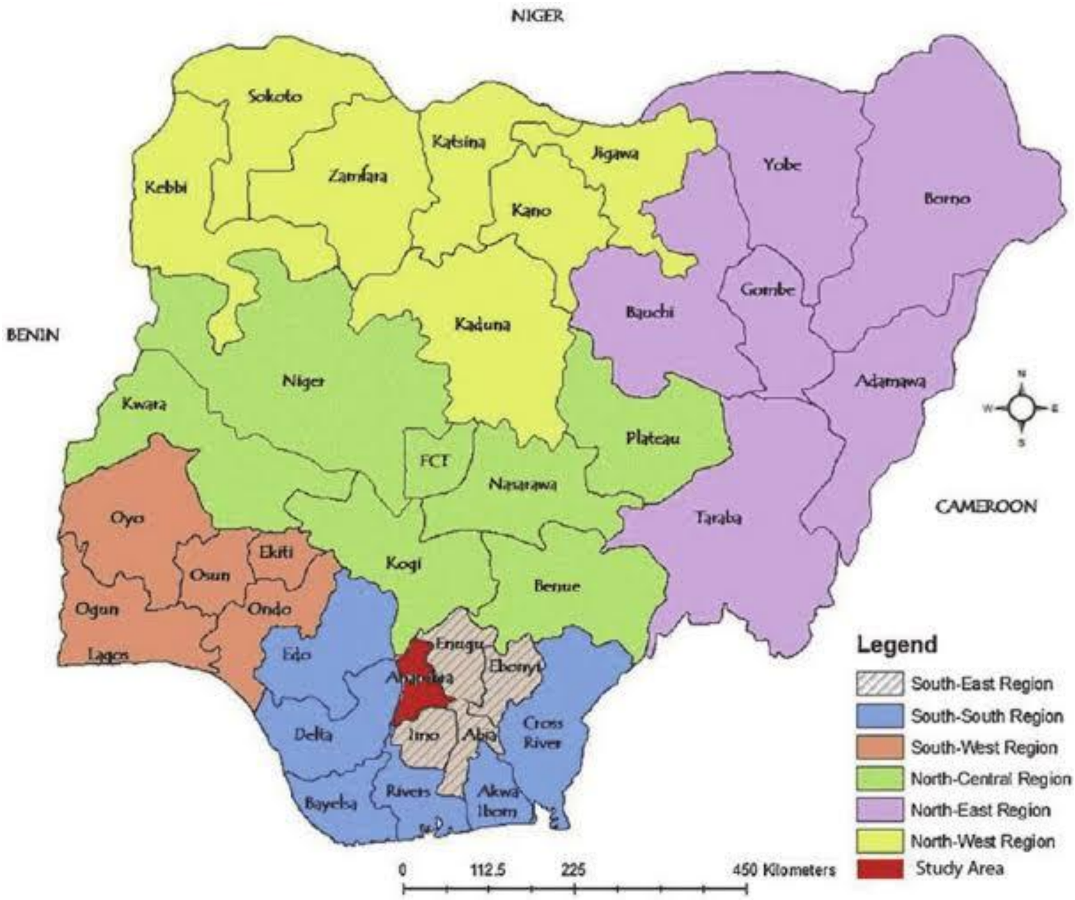
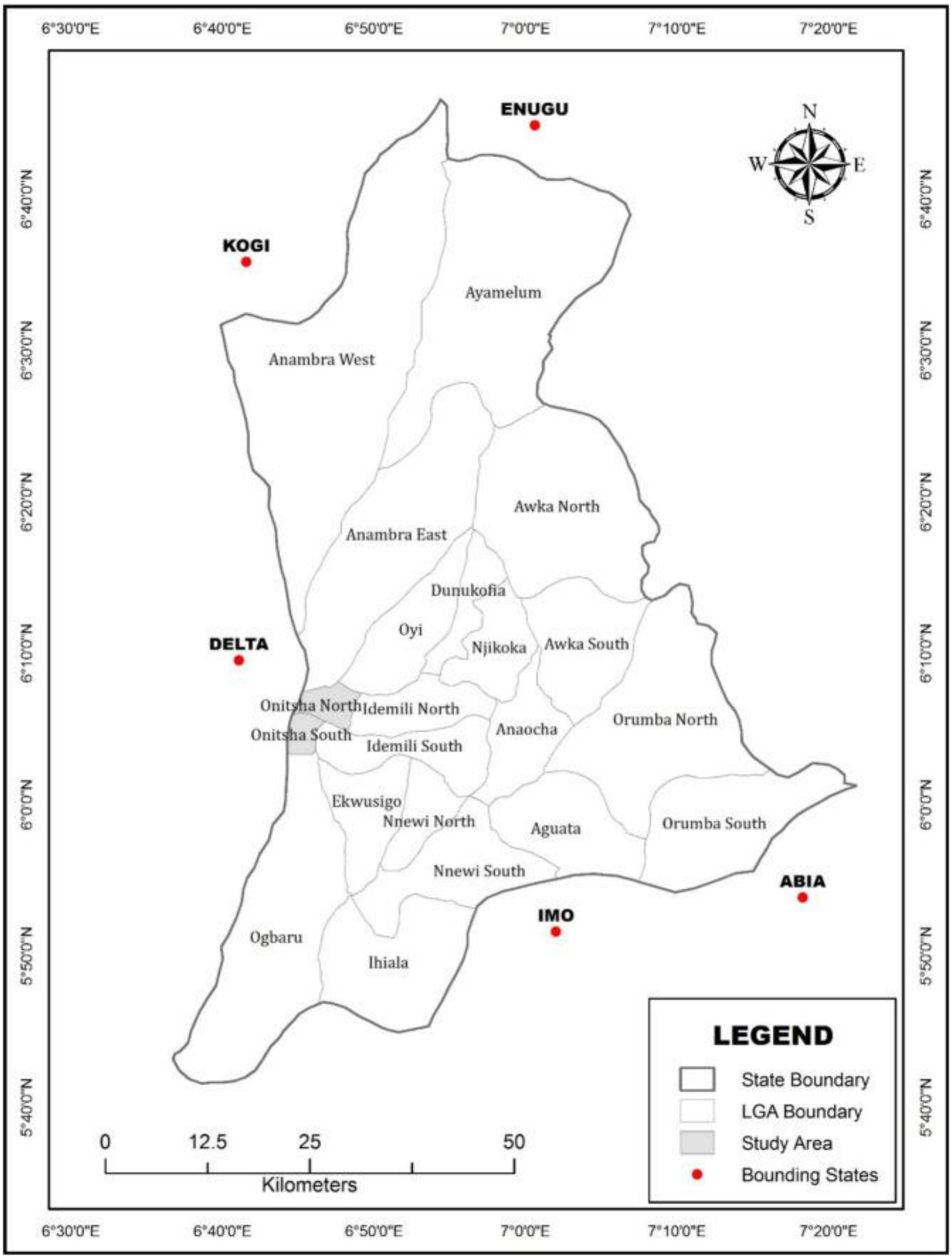
2. Methodology

2.1 Study Area



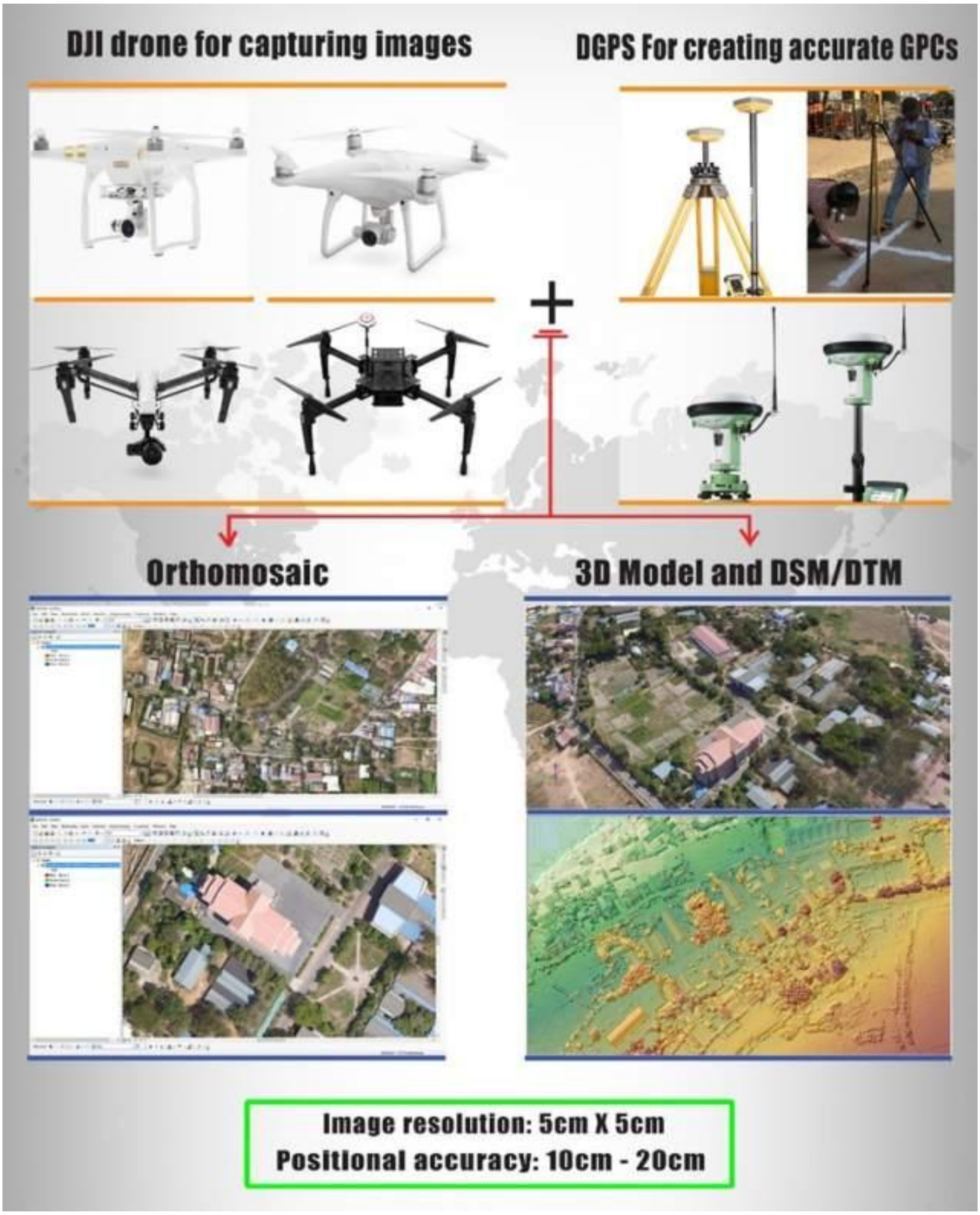
The study was conducted in Onitsha and its surrounding areas in Anambra State, southeastern Nigeria. Onitsha is characterized by dense urban infrastructure, riverine areas, and floodplains, providing a diverse range of surveying challenges. The region's terrain necessitates methods that minimize physical entry while maintaining high positional accuracy.





2.2 Equipment and Software

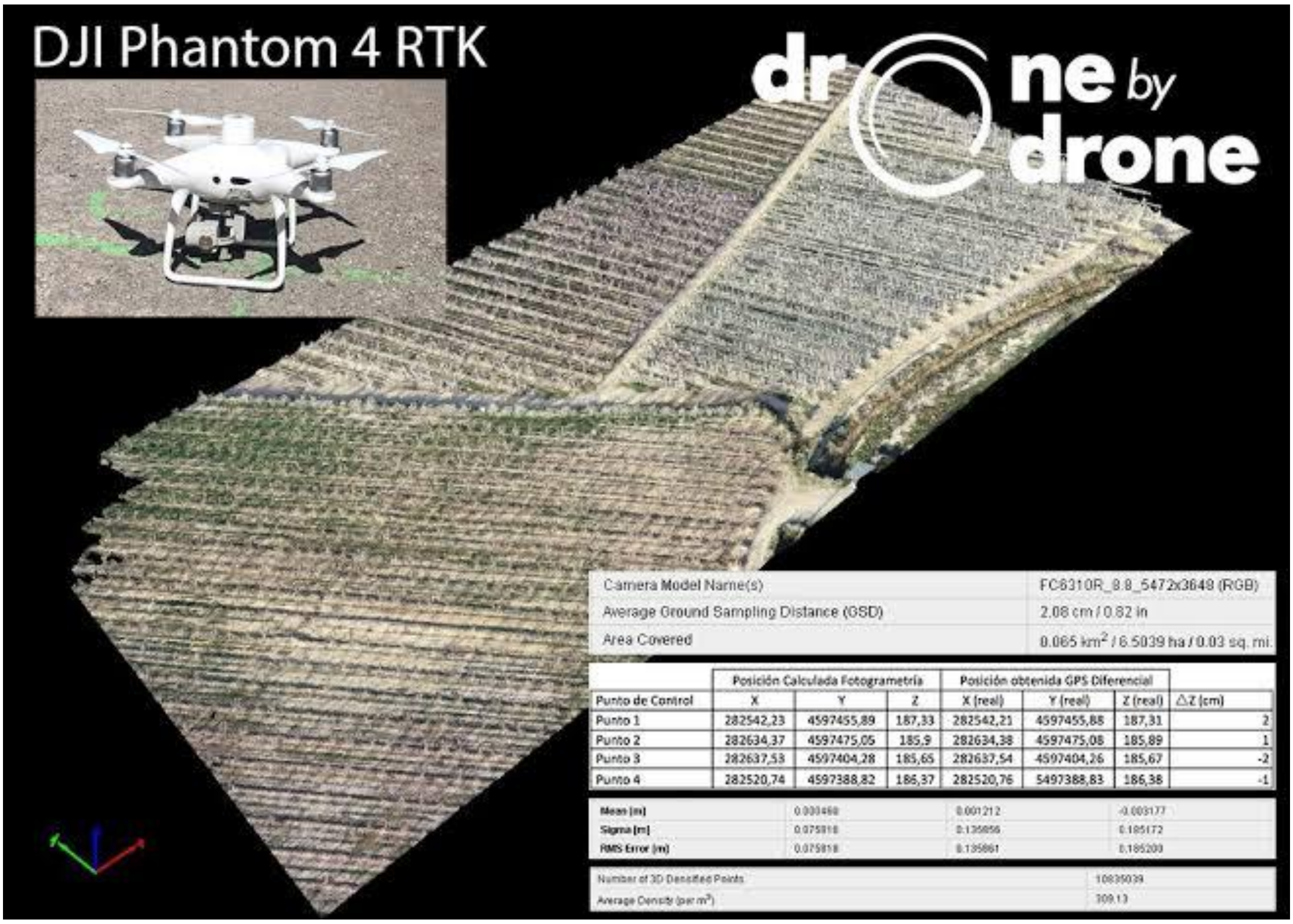
The survey was carried out using a DJI Phantom 4 RTK UAV, equipped with a 20-megapixel camera and integrated RTK system for precise georeferencing. Ground Control Points (GCPs) were established using Trimble R10 GNSS receivers, with a base station set up to ensure centimeter-level accuracy.



Flight planning was conducted using Pix4Dcapture software, ensuring an 80% front overlap and 70% side overlap to produce high-resolution orthomosaics. For data processing, Agisoft Metashape was employed to generate digital surface models (DSMs), orthophotos, and 3D point clouds. Validation of drone-derived coordinates was performed using GNSS checkpoints, allowing computation of Root Mean Square Error (RMSE) for both horizontal and vertical accuracy.

2.3 Data Acquisition

Drone flights were executed at an altitude of 120 meters, covering approximately 50 hectares per flight. Flight duration averaged 25 minutes per mission, significantly lower than traditional field survey methods, which typically require 3–4 hours for the same area using GNSS and total station equipment. All flights adhered to Nigerian Civil Aviation Authority (NCAA) regulations, including maintaining visual line-of-sight (VLOS) and avoiding restricted airspace.



2.4 Data Processing and Analysis

Photogrammetric processing involved aligning images, generating dense point clouds, and creating orthomosaics. LiDAR data (where applicable) was used to supplement photogrammetry in densely vegetated areas, enhancing vertical accuracy. Accuracy assessment was performed by comparing drone-derived coordinates with GNSS-measured checkpoints using RMSE calculations:

Where � and � are the drone coordinates, � and � are the reference GNSS coordinates, and � is the number of checkpoints.

3. Results and Discussion

3.1 Accuracy Assessment

The UAV surveys demonstrated horizontal RMSE of ±3 cm and vertical RMSE of ±5 cm when GCPs were employed. These results meet the accuracy requirements for large-scale topographic mapping and cadastral surveys, consistent with international UAV survey standards (Turner et al., 2016). Without GCPs, horizontal RMSE increased to ±10 cm, highlighting the importance of ground control in achieving high precision.

3.2 Efficiency and Operational Advantages

Drone surveys significantly reduced field time. For a 50-hectare area, UAV data acquisition took approximately 25 minutes, compared to 3–4 hours for conventional GNSS or total station surveys. Cost analysis indicated reduced labor and equipment mobilization expenses, although initial investment in UAV technology and software remains high.

3.3 Accessibility and Safety

Drones facilitated safe mapping of floodplains, riverbanks, and dense urban areas without physical entry. This is particularly valuable in regions with poor road infrastructure or hazardous terrain. UAVs also reduced manpower requirements, allowing a single operator to complete a survey that traditionally required a team of three to five surveyors.

3.4 Data Richness and Integration

Drone-based surveys generated multiple data products from a single flight, including high-resolution orthomosaics, DSMs, and 3D point clouds. These outputs are compatible with GIS software, enabling advanced spatial analysis, volume computation, and infrastructure planning.

3.5 Limitations and Challenges

Despite their advantages, UAV surveys face limitations. Battery life restricted flight duration to approximately 30 minutes per mission. Weather conditions, including heavy rain and strong winds, negatively affected data quality and operational safety. Regulatory constraints imposed by the NCAA, such as restrictions on beyond-visual-line-of-sight (BVLOS) flights, limit large-scale survey implementation. Additionally, photogrammetry in densely vegetated areas yielded lower vertical accuracy without LiDAR supplementation.

These findings align with global studies highlighting the trade-offs between UAV efficiency, cost, and regulatory compliance (Nex & Remondino, 2014; Hugenholtz et al., 2013). Local regulatory, infrastructural, and environmental factors further influence UAV adoption in Nigeria.

3.6 Comparative Analysis

Compared to conventional GNSS and total station surveys, drones offer:

Speed: UAVs reduce survey time by up to 70%.

Safety: Reduced need for personnel in hazardous terrain.

Data richness: Multiple deliverables from a single flight.

Cost-efficiency: Lower labor and mobilization costs after initial investment.

Challenges include dependency on weather, battery limitations, and regulatory compliance. Successful implementation requires skilled operators, proper GCP placement, and software proficiency for post-processing.

4. Conclusion and Recommendations

Drones represent a reliable, efficient alternative to traditional surveying techniques, particularly where speed, safety, and data richness are priorities. When used in conjunction with properly established GCPs and robust processing workflows, UAV surveys achieve accuracy suitable for cadastral, topographic, and engineering applications.

For wider adoption in Nigeria:

Regulatory frameworks must be clarified and streamlined to support commercial UAV operations.

Surveyors require training in UAV operation, photogrammetry, and LiDAR data processing.

Investment in RTK/PPK-enabled drones is recommended to enhance positional accuracy.

Future research should focus on long-term cost-benefit analyses, LiDAR drone performance in forested areas, and integration with national spatial data infrastructure to optimize UAV utilization in Nigerian surveying practice.

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