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Full Length Research Paper

Unmanned Aerial Vehicles for Geographic Data Capture in Edo North Nigeria

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ABSTRACT: Data capture is one of the most time-consuming Geographic Information Systems (GIS) tasks. The method and quality of data collection are critical. These include GPS, LiDAR, Total Station and Aerial Photogrammetry. Unmanned Aerial Vehicles (UAVs) have become more common in recent years, with more applications. More ways to collect geographic data using UAVs will emerge as technology advances. UAV photogrammetry, for example, uses a UAV with a camera and photogrammetric software to create three-dimensional models and orthophotos of the ground surface. This research uses UAV photogrammetry to capture the terrestrial environment for agricultural purposes in selected areas in Edo-North, Nigeria. The aim is to review how UAVs are currently used to collect geographic data and how they can replace or complement traditional methods. A coupled UAV is used in this study. Our literature review focuses on three main areas: environmental monitoring, urban environment and infrastructure, and natural resources. Literature reviews show that using a UAV can replace or complement other surveying and data collection methods. The use allows proximity to objects without settling to the ground, and access to dangerous, difficult areas from a distance. Data can be collected more quickly, cheaply, and frequently. The measurement stage saves time, but the post-processing stage takes longer than the terrestrial methods.

Keywords: UAV, GIS, Elections, Photogrammetry, Surveying, Edo-North

INTRODUCTION

Throughout history, the invention of disruptive technology has transformed the way we live and work: the steam engine, the vehicle, the personal computer, the tablet, and now the drone (Gallacher, 2017). Drones have been widely used in the military since the 1980s, while drones have been used for non-military uses in the last ten years, with a significant rise in commercial use in the previous five years (El Meouche et al., 2016 (Kinghan, Kavanagh, Scott, and Pattulo, 2019). The first military use of unmanned vehicles, or air drones, goes back to 1849, when Austrian soldiers attacked the city of Venice with unmanned explosive-filled balloons (Gallacher, 2017). The word 'drone' may derive from the 1935 wartime aircraft named the Queen Bee, or may be an acronym for remotely controlled dynamic navigation equipment (El Meouche, Hijazi, Poncet, Abunemeh, and Rezoug, 2016; Unmanned aerial vehicles for environmental applications, 2017b). Several businesses have opened up to the potential that drones can bring. This is how these smaller aircraft structures, operating at lower altitudes than satellites and manned aircraft, lead to data democratization and address the difficulties, such as cloud cover, faced by these more

traditional networks (El Meouche et al., 2016). All types of sensors include ultra-high-resolution (UHD) film, optical cameras (red, green and blue (RGB)), thermal, LiDAR, and multispectral and hyperspectral optical gas imaging (El Meouche et al., 2016). Many of these have gone through the testing stages and are now accepted inventions. Impressive imaging applications, such as photogrammetry of motion structure (SfM), provide these systems with an added benefit (El Meouche et al., 2016). Drones are still in their infancy amid fast-moving advances. The regulatory framework plays 'catch-up' as the technology evolves, and governments struggle to manage the industry's professionals, suppliers and processes (Kinghan et al., 2019). As the various standardization bodies ensure that the technology is fit for use and can work smoothly in everyday life, there is also a growing need for simplicity (Kinghan et al., 2019).

Recently developed unmanned aerial vehicles (UAVs), platforms, positional and attitude measurement sensors, imaging sensors, and processing approaches have opened up a vast new area of opportunities in remote sensing for observation, measurement, mapping, monitoring, and management in various natural (e.g. forests), production (e.g. agriculture), and built environments (e.g. urban). Unmanned aerial vehicles (UAVs) are also known as drones, unmanned aerial systems (UAS), or remotely piloted aerial vehicles (RPAVs) (EO). ("Unmanned Aerial Vehicles for Environmental Applications," 2017)

Initially, aerial photography was relatively expensive and was done mainly by national mapping agencies. Still, it is done primarily by private companies using digital systems and is often augmented or replaced by airborne lidar. Then came Earth-orbiting satellites around 30–40 years ago, and the term 'remote sensing' now includes smaller and higher-spatial-resolution cube-sats. Developing and operating the technology was costly, but acquiring and using the data was relatively inexpensive ("Unmanned Aerial Vehicles for Environmental Applications," 2017).

It was generally borne by governments or, more recently, private companies to develop, build, launch, and operate the spacecraft. As a result, the new technology outperformed aerial photography. Since 2000, coarse- and moderate-spatial-resolution multispectral images have been freely available to scientists in rapidly expanding global public archives. Thus, previously inaccessible areas of the Earth's surface could be studied (Shahbazi et al., 2014, 2015). The ability to image and match the spatial scale at which most field or ground-based measurements are needed, namely 1 m pixels, became possible. In recent years, drones for the mass market and highly specialized and task-specific drones have been developed (Crusiol et al., 2017; Cummings et al., 2017). What began as a radio-controlled model aeroplane hobby decades ago has evolved into more? Initially, it used fixed-wing model aircraft and small gasoline motors ("Unmanned Aerial Vehicles for Environmental Applications," 2017).

It is now possible to control the motive power by using light, low-power electric motors and modern rechargeable lightweight batteries (Coveney and Roberts, 2017; Cracknell, 2017). The ability to VTOL (vertically take off and land) and maintain position has made helicopter-style drones increasingly popular. The UAV flight control systems, incorporating GNSSs like GPS, have become more stable and reliable (Castillo-Carrión and Guerrero-Ginel, 2017; Coveney and Roberts, 2017). Cameras and other instruments have shrunk in size and weight, making them suitable for remote control. The constraints imposed by satellite orbital considerations have been removed by being controlled by a local operator (Brenner et al., 2017; Bühler et al., 2017). After purchasing a UAV, an observer can collect data as desired. The use of code repositories to collect data and process it into supposedly ortho-rectified image mosaics is possible.

In the meantime, researchers are working on ways to collect appropriate datasets and turn them into usable, accurate, and reproducible geospatial information. Drone operating at low altitudes and improved visual-spatial resolution over satellites or artificial aviation line-of-sight UAVs are only suitable for studies over small areas, typically ranging from several hectares to several km^2(Bi et al., 2017; Brenner et al., 2017). Using a UAV to gather data for a project also means the team must have all the necessary equipment and qualifications: platform, sensors, measurement systems, controllers, software, capabilities, operating protocols, and experience (Barlow et al., 2017; Bernard et al., 2017).

Experience in processing airborne image data to deliver geospatial data and derived products. Ordering airborne or space-borne EO data or downloading data from public archives may be more accessible. If a project uses a UAV to collect data, it is responsible for complying with all legal requirements associated with operating a UAV, which can be complex in many countries (Bakuła et al., 2017; Barlow et al., 2017; "Unmanned Aerial Vehicles for Environmental Applications," 2017b). One paper in this special issue addresses legal issues (Cracknell 2017). It is probably true that the development of UAVs has been so rapid that many countries have been unable to keep up with the changing situation (Aguirre-Gómez et al., 2017; "Unmanned Aerial Vehicles for Environmental Applications," 2017a). A project manager or pilot of a UAV must also consider their responsibility to the public and the need for third-party insurance in case of damage or injury ("Unmanned Aerial Vehicles for Environmental Applications," 2017a).

Objectives

This study aims to investigate how a coupled UAV is used to collect geographic data from selected areas in Edo-North, Nigeria. The different regions of applications consider the advantages, limitations, efficiency, and economic aspects of using UAVs.

Also, the research evaluated the performance of the UAV system in terms of benefits, limitations, efficiency and financial elements for Mapping and EIA applications. Regulations were also considered and discussed.

Applications of UAVS

Studies show that a practical application of UAVs is forestry. In Forestry applications of UAVs in Europe: a review by Torresan et al., an overview of applications in forest research is presented, followed by a discussion of the results obtained from the analysis of different case studies. The study shows that successful implementation of UAVs in forestry depends on UAV features, such as flexibility of use in flight planning, low cost, reliability and autonomy, and capability of timely provision of high-resolution data.

Another application of UAVs is in the field of remote sensing. In a study, Pajares discusses the use of UAVs in collaboration, coordination and cooperation in remote sensing. The study also proposes a collection of applications in several areas. It shows that a combination of unmanned platforms and sensors and methods, algorithms, and procedures provide an overview of different remote sensing applications. With the advancement of geospatial technology, it is possible to map the boundaries of base parcel fabric in an entire country. This can be done using high-resolution satellite images or high-resolution orthophotos created using low flying photogrammetry with a UAV. Low flying soft photogrammetry is also known as UAV photogrammetry. The paper" A Pragmatic Approach to Establishing the Cadastral Parcel Fabric for Sustainable Land Management in Sri Lanka" written by Rupasinghe introduces a practical approach to creating the cadastral parcel fabric in Sri Lanka efficiently, using the state-of-the-art UAV photogrammetry technology proposing a methodology to reengineer the workflow of an existing title-registration system.

In an article by Sauerbier et al., the practical application of UAV based photogrammetry under economical aspects is investigated. A test data set is used to analyze cost-effectiveness and identify weak points of UAV photogrammetry. It should be noted that the test is based on digital customer cameras. The situation would be different for larger UAVs equipped with medium format cameras. The conclusion in the article is that the efficiency of UAV photogrammetry in comparison to other measurement technologies depends on several factors, such as the size of the area of interest, which in turn influences the number of involved images. The UAV based photogrammetry is considered good in smaller areas, up to 100 hectares. While flight planning and flight operation are already quite efficient processes, the bottlenecks identified in the article are mainly related to image processing (Ajayi et al., 2017; Arif et al., 2017).

METHODOLOGY

Design and construction

In this research, UAV frames were fabricated using 3D printers from fibres and equipped with a Panasonic GH4 with an Olympus lens for a total weight of less than 1 kg. The UAVs were designed to use SolidWorks software as the conceptualised design is shown in (Figures 1-2). All electrically components like the transmitter, receiver, ESP-32 Wroover, ESC (Electronic Speed Controls), Flight Controllers, rotor, propeller, battery was locally sourced and the algorithm built to match the function of the drone, which is to perform mapping and EIA tests on some of the selected site.

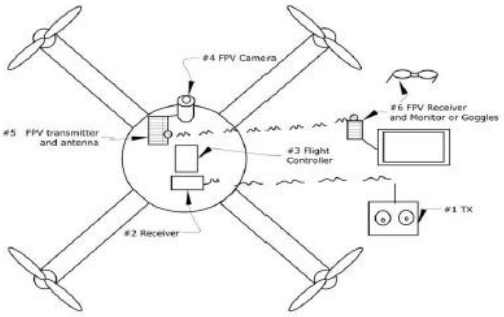

Figure 1: The CAD Diagram for The Circuit Connection of the Drone Adapted from (droneflyers.com, 2021).

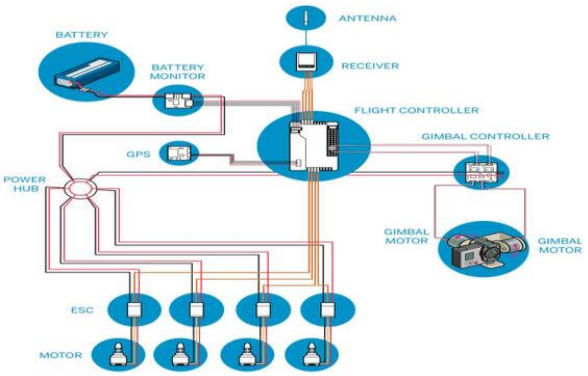

Figure 2: Drone wiring diagram detail(droneflyers.com, 2021).

Principle of operation

The drone's camera is calibrated before the flight to take pictures of the selected sites (Figures 3-4) for the sites). Sharp images with no burnt or underexposed area can be loaded onto the drone. The place to be covered determines the number of flight lines. Several factors influencing the flight plan of a drone, including the desired resolution, the site to be covered, and the height variations

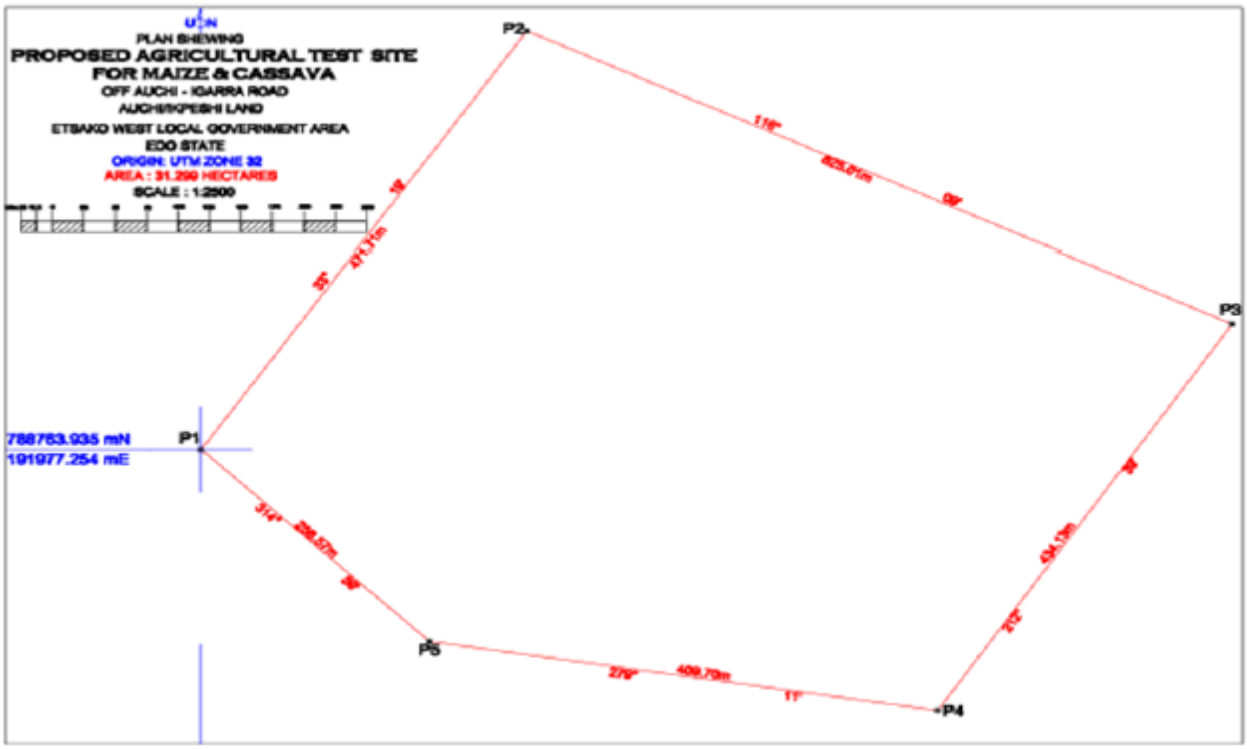

Figure 3: Mapped Sites in Auchi-Akoko-Edo Axis (Covering Isami-Barracks and the Ikpeshi mineral exploration and mining).

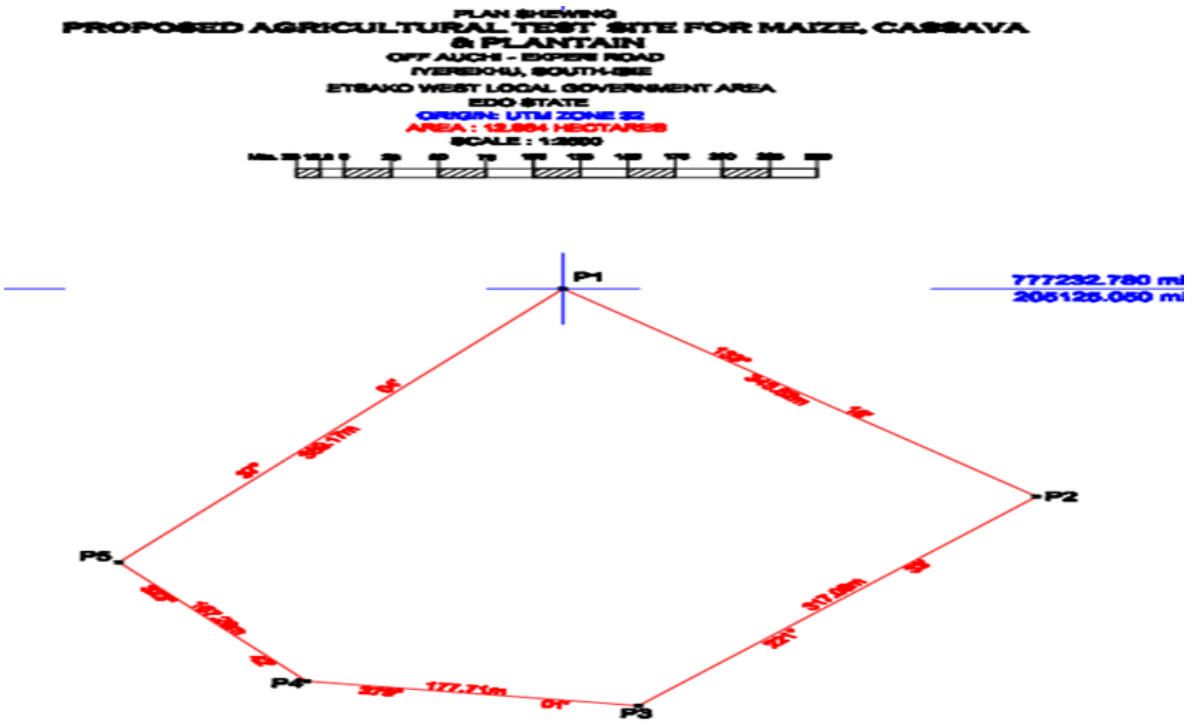

Figure 4: Mapped Sites in Ibienafe-Ekperi axis all in the Edo-North area.

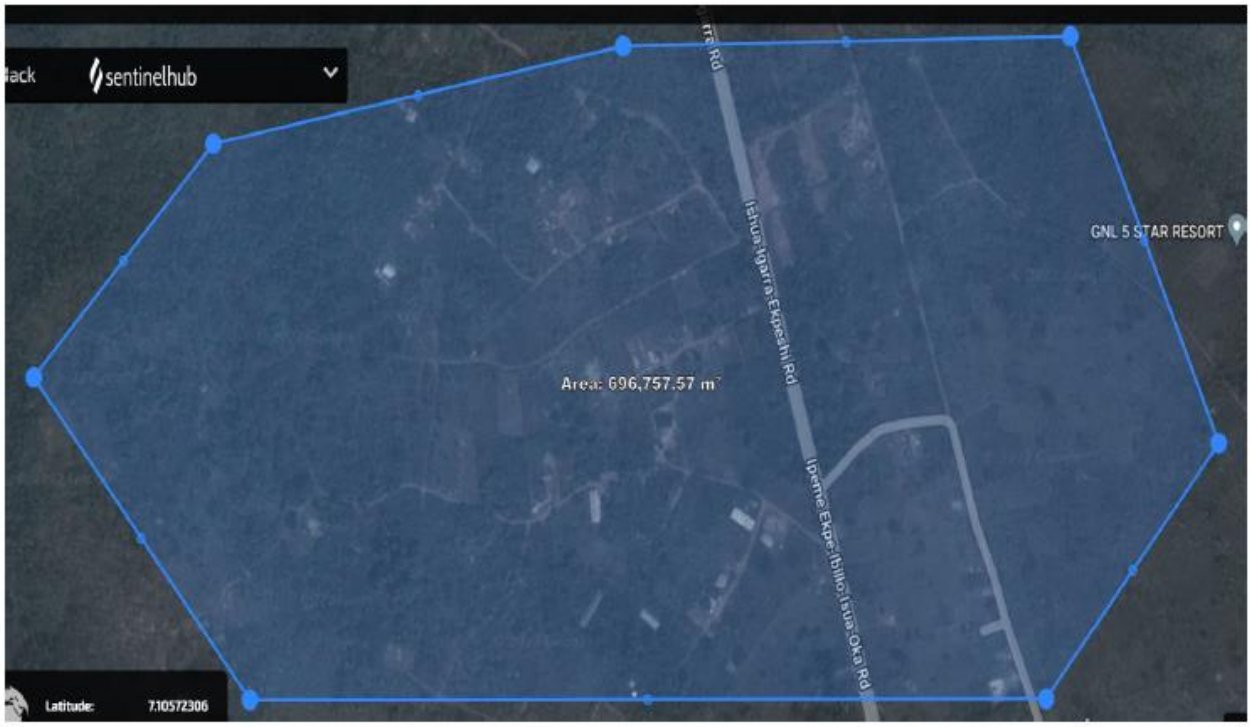

Figure 5: 700 sqm Mapped area covered by the Drone in Auchi-Akoko-Edo Axis (Covering Isami-Barracks and the Ikpeshi mineral exploration and mining).

over the terrain, are considered during this operation and testing. The expected solution has a direct impact on the height of flight. Moreover, the variation in flight height influences the overlapping values between images. The flight plan of the constructed drone was set in advance to determine the flight height required for a given ground resolution. And from our design permutations, the drone can fly for up to 40 minutes within a range of 3.0 km from the designated base station. The images taken across the selected areas (Figures 3-4) were analysed accordingly. This research did not attempt to cover sites for the UAV analysis comprehensively.

Test site and data collection

The coupled drone was used in aerial photogrammetry of two selected areas, as shown in (Figures 5-9). Two test sites in Auchi-Akoko-Edo Axis (covering Isami-Barracks and Ikpeshi mineral exploration and mining) and the Ibienafe-Ekperi axis in Edo-North were chosen after field mapping. The Auchi-Akoko-Edo Axis sites are in an undulating, mineral-rich agricultural area with sparse tree canopies. Ibienafe-Ekperi forest plots include Palms and Gmelina Arborea. Ibienafe-dense Ekperi's canopy structure made it ideal for testing photogrammetry in closed canopies. Auchi-Akoko-Edo and Ibienafe-Ekperi will be used for mapping and EIA.

RESULTS

Analysis of the data

Earth photogrammetry programme. The total images collected from the drone memory are downloaded and processed using Soar to provide near-real-time imagery all across Earth at a 10-meter resolution per pixel. It allows high-definition aerial views of anywhere on Earth to observe events as they happen. Multispectral camera remote sensing imaging technology upon which the Soar is built uses green, red, and near-infrared wavebands to capture both visible and invisible images. The human eye is only sensitive to wavelengths between 400nm and 700nm, known as the visible RGB spectrum (Cummings et al., 2017).

System integration and data acquisition

The UAV is used as a platform, camera, navigation, and control system. The control system was in charge of power, data acquisition parameters, logging, storage, and time synchronisation. This study's control system hardware consists of a computer and power supply. In this study, data were collected from two sites in Edo North, Nigeria (Auchi-Akoko-Edo Axis; Isami-Barracks, Ikpeshi mineral exploration and mining, and Ibienafe-Ekperi axis).

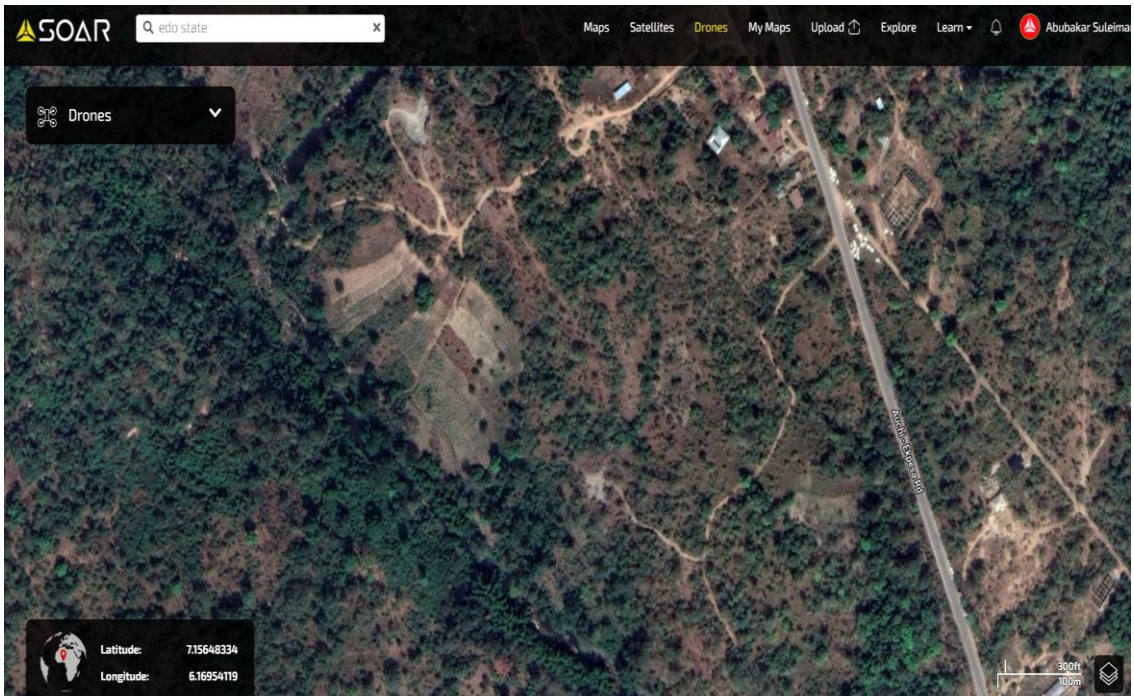

Figure 6: Zoomed area of the Auchi-Akoko-Edo Axis (Covering Isami-Barracks and the Ikpeshi mineral exploration and mining).

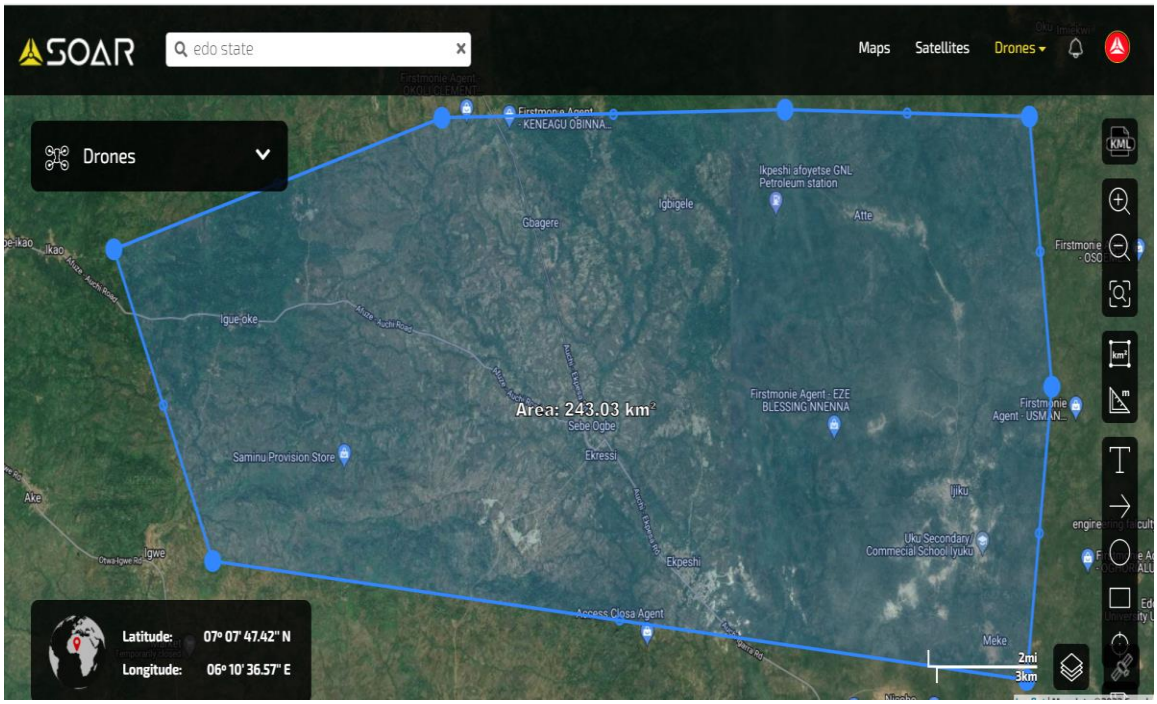

Figure 7: 243 sqm of the Auchi-Akoko-Edo Axis (Covering Isami-Barracks and the Ikpeshi mineral exploration and mining).

Figure 5-7 shows the Auchi-Akoko-Edo Axes used in mineral exploration and mining. The two selected areas provided November and December 2021 data. Two sites were analysed (Figures 5-9). Figures 5-7 represent one

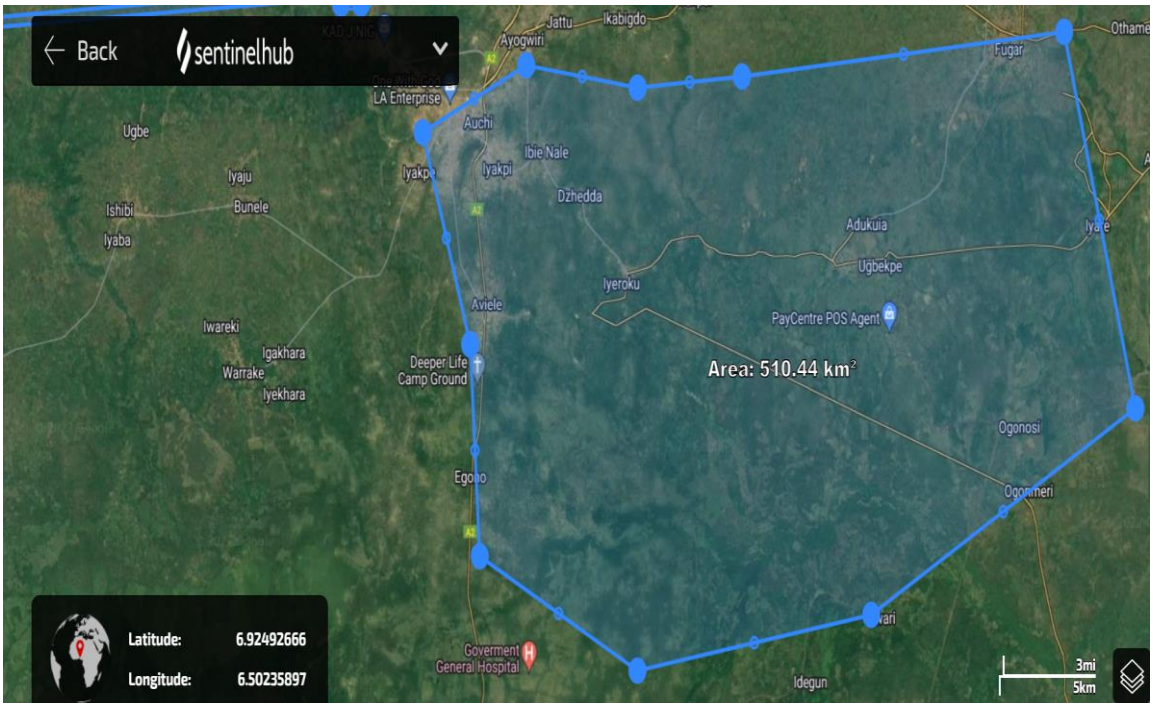

Figure 8: 510 sqm of the Ibienafe-Ekperi axis, all in the Edo-North area.

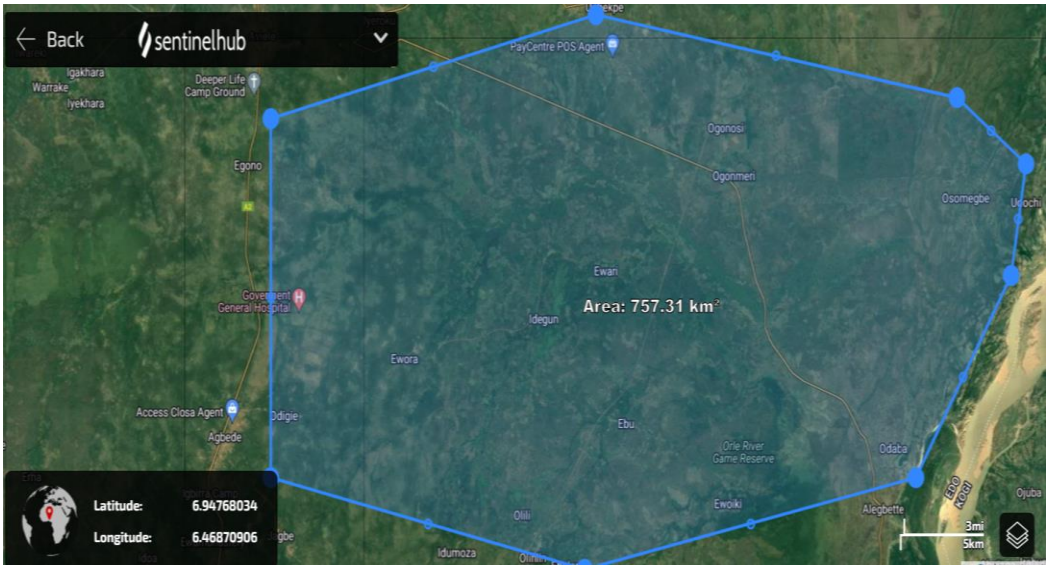

Figure 9: 757 sqm Ibienafe-Ekperi axis all in the Edo-North area.

part of the Auchi-Akoko-Edo Axis, covering Isami-Barracks and Ikpeshi mineral exploration/mining. Figures 8-9 illustrate the zone covered by the Ibienafe-Ekperi axis in Edo-North, predominantly agricultural.

Fieldwork

The first fieldwork task was to set up the GPS base receiver for aerial photography of the two areas. The UAV determined the area's absolute coordinates with 2–5 mm accuracy. The next step was to match aerial photos with Soar (see figures 5-9). The small ground coverage of such cameras is one of the main issues. This characteristic makes the image sequence susceptible to photometric variations despite the short flight time. These field images were analysed and evaluated. The UAV imagery could be used to determine parcel areas. Because the areas are rocky, UAV images and remote sensing methods indicated

that more sites were available for future exploration than agriculture (Figures 5-7)—the UAV imagery from the Soar. Earth software shows a 700sqm area around the Akoko-Edo axes. These 510 and 757 sqm rural areas (Figures 8-9) show large areas available for agricultural activities.

DISCUSSION

UAVs fill the gap between terrestrial and aerial methods. UAVs can cover large areas with intermediate-scale features. So it was with the paired drone. The UAV was used for vegetation and mineral exploration analysis of selected sites. Using a UAV allowed close data capture without being on the ground. UAV complements terrestrial and aerial methods. UAV images can be updated more frequently than regular aerial images. UAVs are better, cheaper, and more time-efficient than planes or helicopters.

Conclusion

The imagery obtained in this study shows that UAVs can bridge the gap between terrestrial and aerial data collection methods and replace or complement other methods. Using UAVs allows proximity to objects without being stuck on the ground. This benefits the workplace because dangerous and difficult areas can be accessed safely from a distance. With UAVs, data can be collected faster, cheaper and more frequently than other methods, depending on the project area and data requirements. The use of drones in Edo-North is limited due to capacity and image quality issues. This study discussed various aspects of developing and implementing a UAV-field survey. Planned flights and fieldwork included data acquisition, photogrammetric processing and application in the two selected areas. Based on the experiments, the UAV with the Soar. In terms of indirect georeferencing and point cloud spatial accuracy, the Earth system outperformed the field survey. The UAV was put through its paces in addition to photogrammetric tests.

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Conflicts of interest

The authors declare no conflict of interest.

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