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AN ACCURACY ASSESSMENT OF REMOTELY SENSED AND CONVENTIONAL FIELD DATASETS FOR LAND TITLE REGISTRATION

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ABSTRACT

In Nigeria, the transition from the sporadic Land Title Registration (SLR) to the Systematic Land Title Registration (SLTR) is aimed to enhance effectiveness and ability to create wealth with land. It is often said that “land without registration is a dead asset”. This study compares field and remotely sensed datasets for SLTR in Kwara State, Nigeria. Orthophotos from UAV and remote sensing were used to delineate land boundaries, compared against field measurements using differential GPS and Total Station. Positional accuracy was assessed for both methods, Pearson correlation index, Standard deviation and T-test were used to analyze and test if there is a significant difference between coordinates of boundary points computed from the three methods. The coordinates of the points generated through digitizing of UAV image and Google earth image gave positive correlation coefficients 0.95 and 0.98 respectively. The google earth data had 62% of its displacements outside the expected displacement while Drone data has only 5%. Analysis showed that while digitized boundaries from UAV images closely matched field data, Google Earth digitization differed more. Statistical tests indicated significant differences between coordinates from all three methods, highlighting challenges and strengths in cadastral survey accuracy from remote sensing data.

I. INTRODUCTION

Land is a fundamental resource without which life on earth cannot exist. It provides space, materials, shelter, and the means for livelihood for the existence of all living beings. Access to land is essential for human beings. "The availability of land is the key to human existence, its distribution and use are of vital importance" (Simpson, 1976). Land includes all natural and cultural objects attached to the earth's surface (such as buildings and vegetation), rocks and minerals just below the surface, and areas covered by water such as the seas and lakes (Dale & McLaren, 1999). Land is considered a primary source of wealth, often becoming the basis for economic and power gains, and self-fulfilling interest (Burns & Dalrymple, 2008).

Land administration relates people to land and informs on the 'how,' the 'what,' the 'who,' the 'when,' and the 'where' of land tenure, land use, land value, and land development. Land administration systems are the basis for recording the complex range of rights, restrictions, and responsibilities related to people, politics, and

places (UN-GGIM, 2019). Land administration was described in the report prepared for the United Nations Commission for Europe (UNECE) as "the process of determining, recording and disseminating information about ownership, value and use of land when implementing land management policies" (Ukaejiofor, 2009). Land administration serves equitable access to land by stakeholders within the policy framework of a country (Nuhu & Salau, 2012).

Land registration requires cadastral maps that show the geometric values of land units. Cadastral surveys usually include a geometric description of land parcels linked to other records that describe the nature of the interests, the ownership or control of those interests, and often the value of the parcel and its improvements. The importance of cadastre cannot be overstated. It enables the identification and location of land parcels, facilitates land transactions, and ensures landowners have clear title to their property (Rajabifard et al., 2012). Cadastre also provides valuable information for land use planning, including the identification of land suitable for development, conservation, or other uses (McLaren, 2015). Cadastre is an essential component of a country's legal and administrative framework and is crucial for the effective management of land and property.

Traditionally, cadastral surveys are carried out through dependent or independent field measurements using survey instruments such as steel tapes, theodolites, total stations, and dual frequency GPS by qualified land surveyors to coordinate boundary points and produce an acceptable cadastral plan in accordance with cadastral survey regulations (Ibitoye, 2015). This method, when carried out with care, produces high-accuracy cadastral plans. The cadastre plays a central role in land registration as it is a large-scale map that shows the representation of the most detailed information on land and how people are connected to the land. This representation of the built environment and the logical understanding of land use patterns and other developments then form the fundamental land information sets that enable a country to deliver the benefits of land registration (Dale & McLaughlin, 1999). Positional accuracy is a critical aspect of remote sensing because it affects the usefulness of the imagery for various applications.

Ogundipe and Tade (2016) outlined the process of land registration in Nigeria to involve surveying the land, searching the title, applying for registration, examining the application, and finally, approval and registration. Kufoniyi (2015) elucidated the stands of land reform, stating that it should align with global thinking on land registration, international bodies like the World Bank, the International Federation of Surveyors (FIG), and other stakeholders. This is also in acknowledgment of the fact that countries that thrive in business are those with a proper land registration system. Efforts have been made in recent years to reform the land registration system in Nigeria, including the establishment of the Land Use Act in 1978, which sought to streamline the land registration process and provide greater security of tenure. However, these efforts have not always been successful, and more needs to be done to improve the system and address the challenges it faces (Oke, 2016).

Advances in remote sensing and photogrammetry offer improved measurement speed, reduced costs, higher image resolutions, and enhanced sampling granularity

(Rohan et al., 2020). The UAV describes a photogrammetry measurement platform, which operates remotely controlled, semi-autonomously, or autonomously, without a pilot sitting in the vehicle (Eisenbeiss, 2009). This method is currently contributing immensely to data capture for surveillance, mapping, and inspections (Nex & Remondino, 2014). However, rapid technological development has greatly impacted surveying, creating a serious gap to be addressed between the traditional method and the digital era in recent decades.

Nigeria has a very vast land mass of about 923,768 sq km (NBS, 2010). Despite being endowed with these enviable land resources, the potentials of such land as a veritable means of sustainable development have not been fully explored (Mabogunje, 2009; Oboli & Akoyoware, 2010; Ukaejiofor, 2011; Birner & Okumo, 2012; Shay, 2013). Ukaejiofor (2009) and Mabogunje (2010) argued that because more than 70% of lands are not registered in the State Ministries of Lands and Housing, and only about 3% of urban areas are mapped, there can be no proper land registration in the country. This problem underlines the inefficiency of the system that governs land titling and registration in the country. This research aims to carry out a comparative assessment of remotely sensed and conventional field datasets for Land Title Registration to help relevant agencies handling land registration offer their services more efficiently.

II. MATERIALS AND METHODS

2.1 Study Area

The area under study is Omowumi Estate in Asa Local Government Area of Kwara State, Nigeria. It is located on latitude 8°00‟ and 9°10‟ North of the Equator and longitude 2°45‟ and 4°15‟ East of the Greenwich Meridian (Figure 1). Asa Local Government Area has three (3) districts namely Afon, Owode and Onire. Asa LGA is one of the sixteen (16) LGAs of Kwara State. The headquarter of the Local Government is Afon that is about 27km away from Ilorin, the State capital. It is about 1,525sqkm in size and it stretches from the peri-urban fringes of the city of Ilorin by Oyo State (Ajibade, 2006). The population of the area as put forward by the National Population Commission is 126,435 comprising 64,982 males and 61,453 females (NPC, 2006). The population is projected to be 199,245 in 2023(Morenikeji et al, 2023). There is usually a short spell of harmattan between late December and mid-January (Odekunle,2004). The town has an annual rainfall of between 1000mm and 1500mm and Temperature ranges from 33°C to38°C, which is suitable for Agriculture. It has a relative humidity that ranges between 65% and 80% in the dry and rainy season respectively (Fawole, 2007). The vegetation belongs to the Tropical Savannah. The social-economic activities in the town include Farming of food crops with specialization on Sweet potato and Maize, Rearing of animals basically Goat, Cattle and sheep, Weaving, dyeing trade and Civil service. (Tunde, 2013).

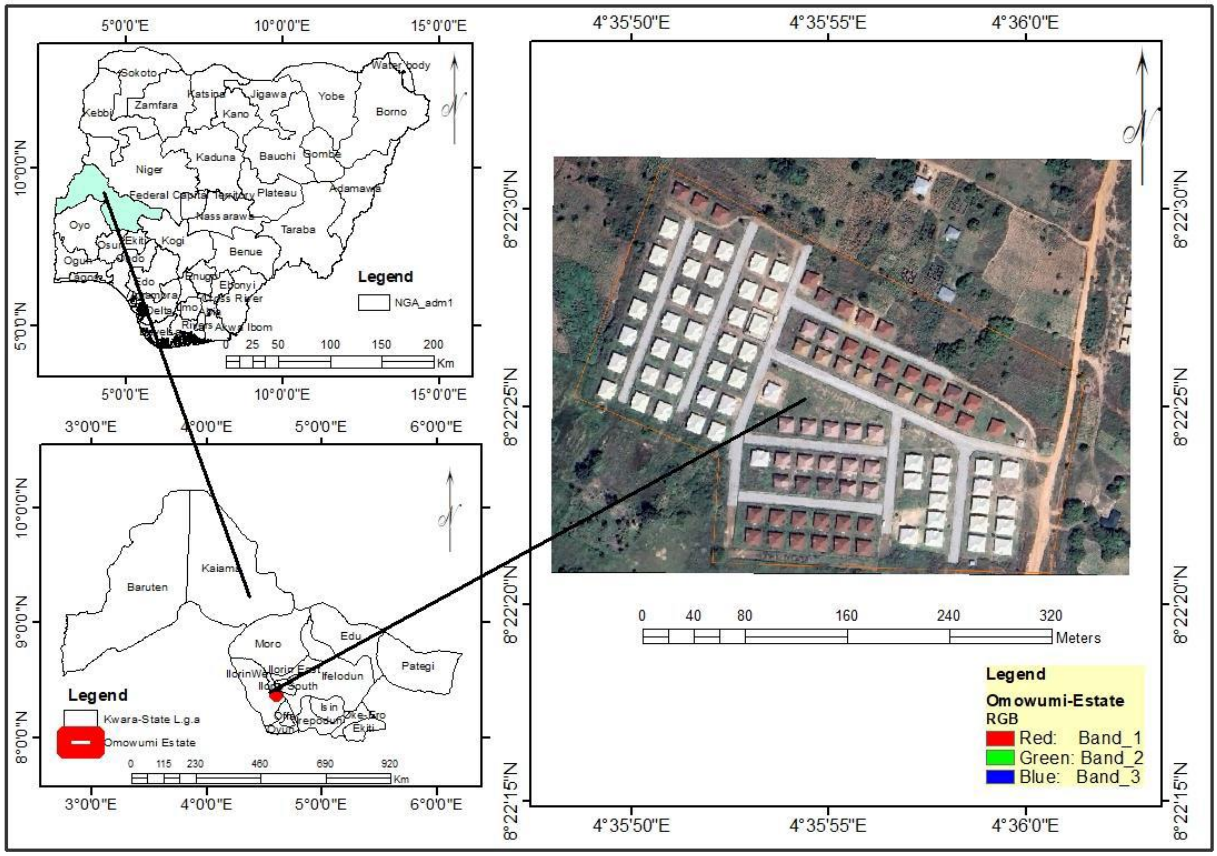


Figure 1: Showing Map of the Study Area

2.2 Materials

In this study, the data used were collected from two different sources namely; Primary and Secondary sources. The primary data used include, GPS coordinates of boundary points of the perimeter, Coordinates of each plot‟s boundary and other points of interest that can be identified using Total station and Mossaiced Ortophoto imagery of Unmanned Aerial Vehicle (UAV) while

secondary data include a Google Earth image of the study area acquired in May, 2023.

The instruments used in this research are listed below: 1 No Drone (Phantom 4 Pro), 3 Nos of CHC HuaceNav DGPS Receivers ,3 Nos Tripod stand ,3 Nos Tracking rod ,1 No of CST Berger Total station, 100m Steel tape,7.5m steel tape,10 Nos Ranging Poles, 2 Nos Cutlasses and 3 Nos Shovels. During the **reconnaissance,** the reference station points were provided which includes

PBL31210	676392.585mE	926245.104mN
PBL31211	676738.261mE	926144.566mN
PBL31219	676389.897mE	926064.640mN

2.3 Methods

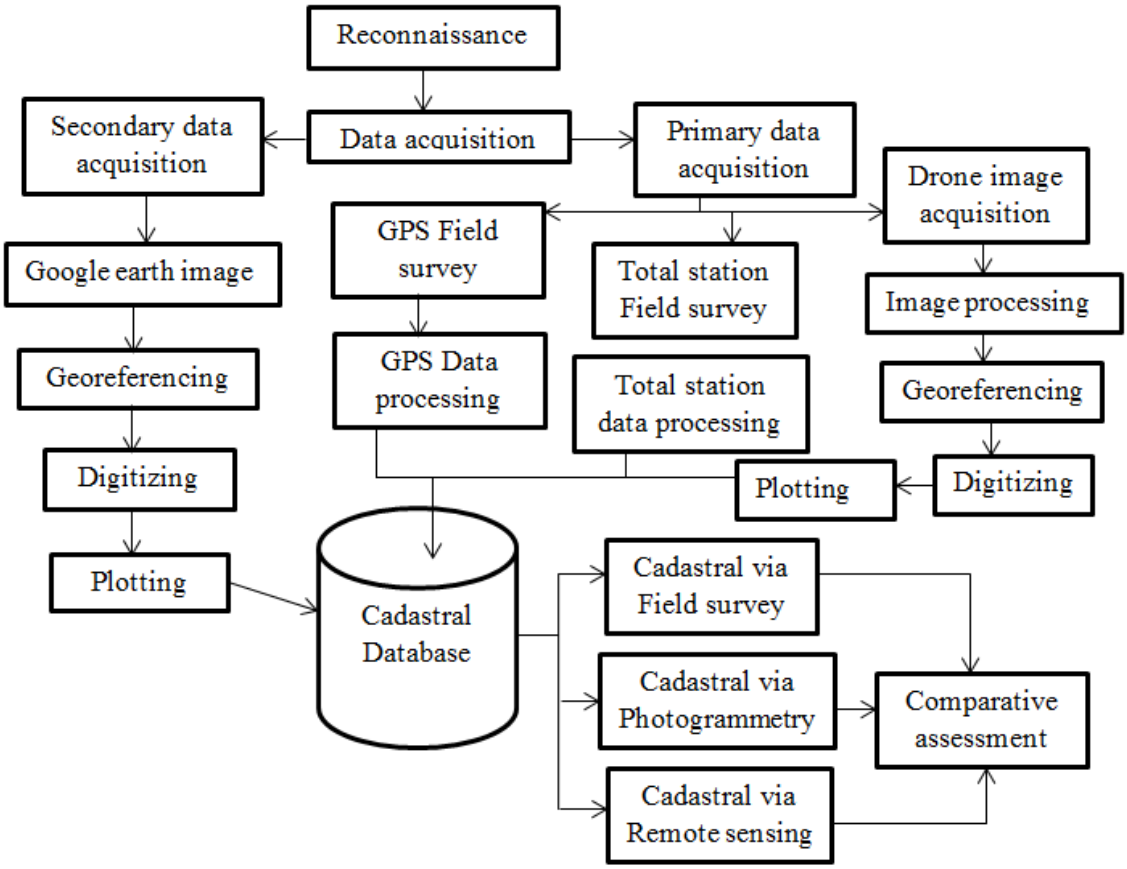


Figure 2: Flow Chart of the General Approach to the study

Source: The Author

2.4 Test of Instrument

In surveying, it is a requirement that all equipment to be use for Survey exercise must be subjected to test. These tests or investigation will ascertain the actual condition of the instruments as at the time of operation. The instrument tests were carried out to ascertain the measurements reliability of both the GPS and Total station on known points.

2.5 Data acquisition

Perimeters of various boundary were captured and **distribution of Ground Control Points for Georeferencing and Check Points were also obtained.** Ten (10) ground control points (GCPs) were acquired covering the study area mainly for georeferencing and check points for satellite images used for this study. The georeferencing was carried out using 1st Order Polynomials (Affine) into UTM Zone 31 (Minna Datum) – which is the coordinate system adopted for survey works in Nigeria. Five (5) control stations were selected for georeferencing while the remaining five (5)

were selected as check points for the computation of Root Mean Square of the georeferencing.

Table 1: showing the coordinates of the GCPs and their use for the research

S/N	Usage	East	North
GCP1	Georeferencing	675955.315	925840.652
GCP2	Check Point	676222.273	925807.173
GCP3	Georeferencing	676000.060	925990.652
GCP4	Georeferencing	676089.359	925957.206
GCP5	Check Point	676045.798	925773.129
GCP6	Check Point	676049.697	925819.489
GCP7	Georeferencing	676176.662	925832.672
GCP8	Check Point	676070.207	925878.901
GCP9	Check Point	679085.622	925919.814
GCP10	Georeferencing	676160.810	925755.447

2.6 Data Acquisition with Drone

The Drone was properly set and ready for operation, all necessary settings were carried out, and the area that the project covered was specified. The Phantom Pro4 drone was set up by attaching its fan blades, inserting the battery, and turning it on. The Drone Deploy software was used for data acquisition, where the flight mission was planned, including specifying the project area, flight strips, and laps. The software displayed the time required, battery levels, and the number of scenes, which depended on the drone's altitude. The drone was launched by pressing start, and its camera direction, altitude, and flight progress were monitored. After completing the mission, the drone landed precisely at its take-off point, showing proper calibration.

2.7 Delineation of boundaries of parcel of land with remotely sensed data

This process involves transforming imagery coordinates into the Ground Coordinate System using Ground Control Points (GCPs) obtained from Differential GPS (DGPS). The satellite image was imported into ArcGIS, and the coordinates (Easting and Northing) were assigned to each traverse station to performed georeferencing. For digitizing plots, plot layers were made editable in ArcGIS, and the boundary of interest was digitized by zooming in and placing markers on the points. Attributes for

each plot were then entered. Topology rules were applied to ensure that plot nodes were joined and adjacent plots shared nodes.

2.8 Comparison of data obtained from remotely sensed data and field survey

Positional accuracy is evaluated by comparing reference ground locations with their corresponding positions on an image. In this case, parcel data from drone imagery were analyzed in ArcGIS, while traditional land surveying data were collected using field equipment. This method has been employed by researchers such as Crommelinck et al. (2017), Eyor et al. (2019), and Manakwe (2022). Data from both remote sensing and land surveying methods were tabulated, and Pearson correlation was used to assess the agreement between the two. The results showed the correlation between conventional land survey data and remotely sensed data.

$$r = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum (x_i - \bar{x})^2 \sum (y_i - \bar{y})^2}}$$

Where,

r = Pearson Correlation Coefficient

x_i = x variable samples

y_i = y variable sample

$\bar{x}$ = mean of values in x variable

$\bar{y}$ =mean of values in y variable

Null Hypothesis (H01): remotely sensed data cannot be effectively used in determining cadastral boundaries, Alternative Hypothesis (H011): remotely sensed data can be effectively used in determining cadastral boundaries. The test hypothesis was done by comparing the coordinates of selected points in a T-distribution table.

$$t = \frac{\Sigma d}{\sqrt{\frac{n\left(\Sigma d^2\right)-\left(\Sigma d\right)^2}{n-1}}}$$

where d: difference per paired value

n: number of samples

III. RESULT AND DISCUSSION

3.1 Delineated boundaries from UAV Orthophoto

Figure 2 shows the orthophoto generated from the UAV observations. This is the process by which the location of each plot was plotted out based on the orthophoto generated from the observation with the drone. It was observed that both the perimeter and the layout plots are perfectly aligned. See Figure 3 for the outline of the delineated plots. All the components of the layout; the perimeter boundary, the road network, the blocks and the Plots appeared relative to their physical positions on the earth surface. The number of plots obtained is the same as the one hundred and fourteen that existed on the site.

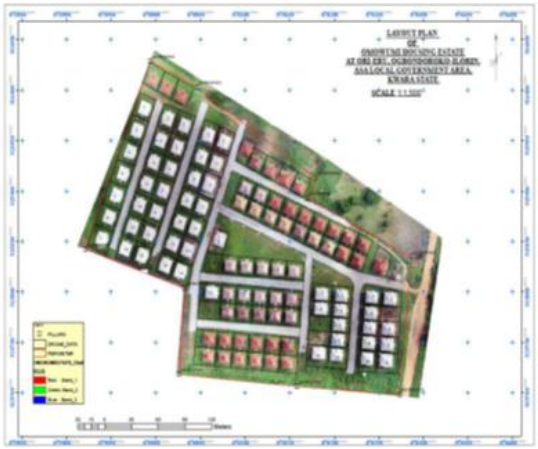


Figure 2. Showing the UAV orthophoto



Figure 3: Showing the outline of digitized plots from Drone image

3.2 Delineated boundaries from Google earth image

This is the determination of the boundaries of each plot and blocks as existed in the layout based on the Google earth image for the area. The figure above shows the Google earth imagery covering the project site with the red line showing the perimeter boundary of the layout. The delineated parcels are shown in Figure 4. A total number of One hundred and fourteen plots (114) grouped into eleven (11) layout blocks were digitized (electronically traced) from the imagery acquired. The shapes, the sizes of the plots and topological relationships are very similar to what was on ground.



Figure 4a: Showing the Google imagery of the layout



Figure 4b: Showing the outline of digitized plots from Google Earth image.

4.3 Delineation of parcels' boundaries through field survey

The Figure 5 shows the layout plotted as a results of field survey with the aid of Digital Land Surveying instruments (Differential GPS and Total station). A total of two hundred and twenty (220) boundary beacons were traversed and coordinated. The East and North coordinates obtained through this method serves as the standard upon which Photogrammetry and Remote sensing methods are compared. The Thick red line is the perimeter of the entire layout while the thin Red lines shows the actual locations of the plots within the layout. The black broken lines are the road network that give 37 access to each of the plots while the Purple lines show the Blocks in the layout and the available green areas.

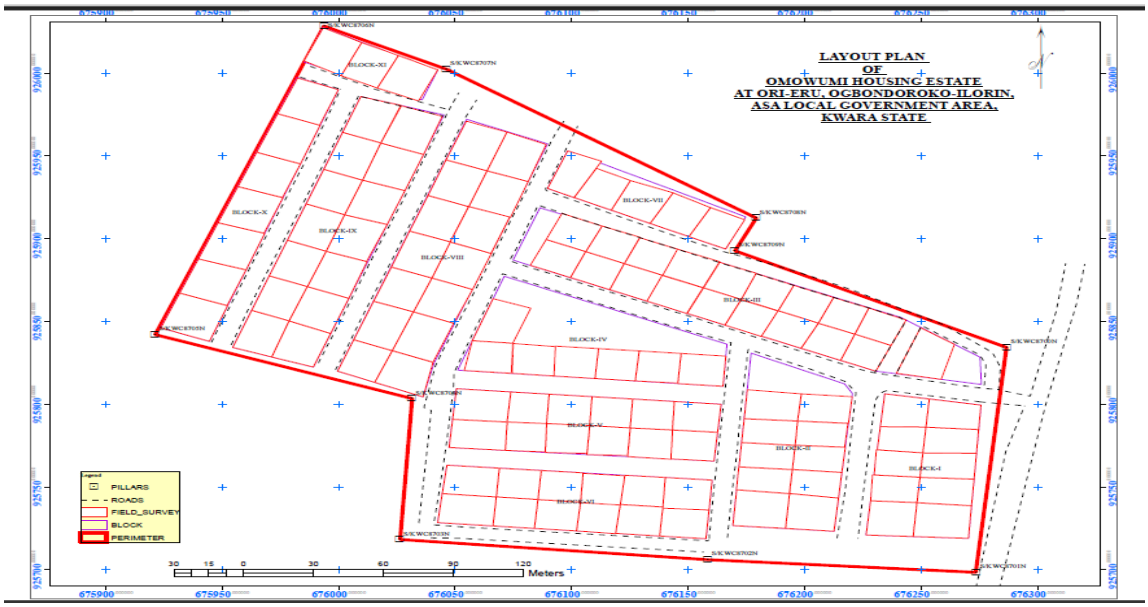


Figure 5: Showing the plot construction of Field survey data

4.4 Comparism of field survey and UAV data acquisition methods

Figure 6 shows an overlay of the parcels generated from the digital land surveying method (Field survey) and the one obtained from Unmanned Aerial Vehicle (UAV). The field survey method is in red while the drone data is in black which indicates that the two methods have a high degree of alignment.

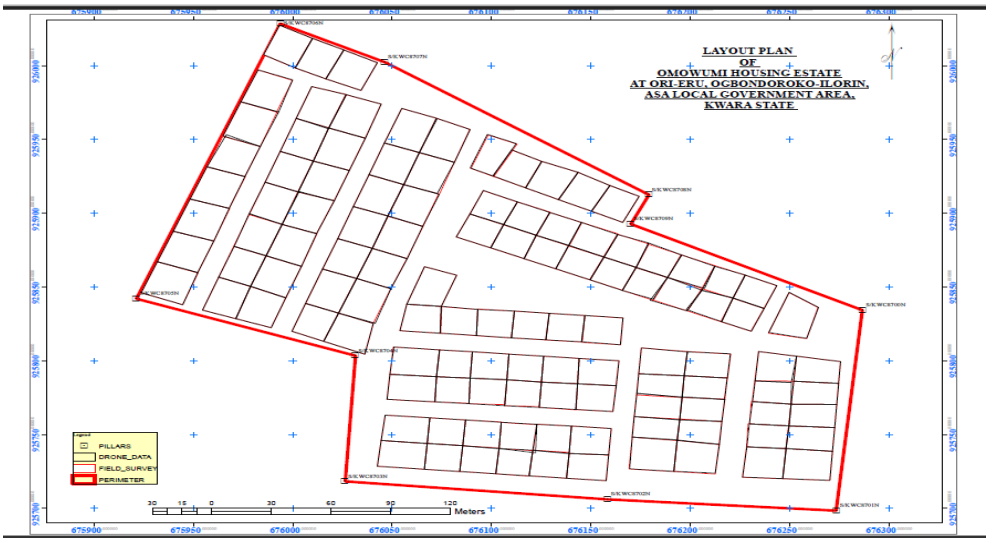


Figure 6: Showing field survey method overlayed on UAV data acquisition method

Comparism of Field survey and Remote sensing methods

Figure 7 shows overlay of the parcels generated from Digital land surveying method (Field survey) and the one obtained from Remote sensing method (Google earth). The field survey method is in red colour while the google earth is in black colour. There are little displacements in the positions obtained from Google earth compared to the positions obtained from Land surveying method. This indicates that the displacement is noticed which may be due to the imagery resolution, accuracy of georeferencing and date of acquisition.

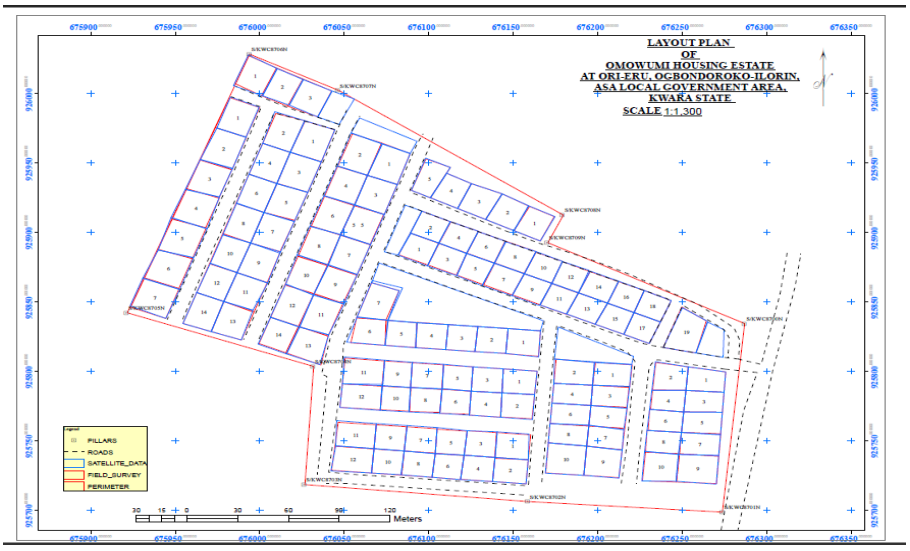


Figure 7: Showing field survey method overlayed on Remote sensing method

Composite of datasets obtained from Field survey, Remote sensing and UAV

Figure 8 shows the composite of plots constructed from the three methods under review; the Field survey, the Remote sensing and the Photogrammetry methods. Field survey method in colour red, the UAV in black and Google earth outline in blue colour. This shows the level of displacement of each methods from the Field survey that serves as standard method. It was discovered that the plot locations from the Photogrammetry method are more close to the field survey method than the Remote sensing method.

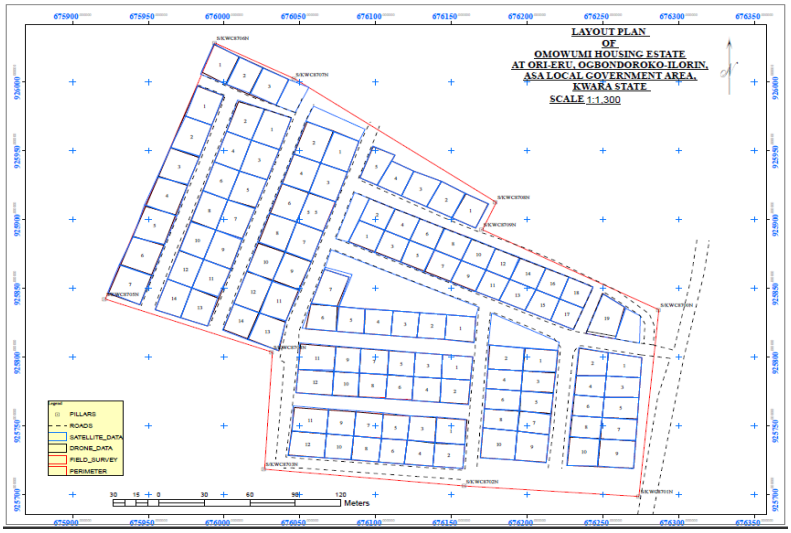


Figure 8: Showing composite of the three different methods

Conclusion

A total number of 114 plots were delineated from the study area using photogrammetry and remotely sensed datasets. Also, a total of 220 boundary points was determined through field survey to cover the whole site. These 220 boundary points were the true boundary points of plots identified from both Photogrammetry and remotely sensed data. The acquired field data was imported into ArcGIS 10.3 where boundary lines were created from the boundary points into the 114 plots, which corresponds to the 114 plots delineated via photogrammetry and remotely sensed dataset. Comparatively, the use of remotely sensed data and photogrammetry data to identify boundaries even when field surveys have not been carried out was clearly demonstrated as the plots constructed from the field survey method look very similar in visual analysis to the ones digitized except for very few exceptions where more than one point is used to indicate the boundary of properties on the ground. Digitized boundary lines were not totally aligned with the result of field survey but the boundaries digitized from the UAV image were more aligned than that of remote sensing. It was noted that the correlation of positional accuracy of the two methods showed a strong positive relationship of 0.95 and 0.98 respectively. This indicates

that the similarity of positions of parcel of land delineated from both UAV and Google earth imagery is high and positive at all time (i.e confidence level, $p < 0.001$), but increases with the resolution of the imagery used. The higher the resolution, the better the positional accuracy of the plots delineated. This means that if errors or dissimilarity were to be eliminated from determining cadastral boundaries from images, a higher resolution image will have to be always considered.

From results of this work, a larger percentage of 62% of the boundary points delineated from Google earth image have their displacement outside the expected displacement while only 5% of the one from UAV fall outside the expected displacement. More points were within the expected displacement 95% (208 points) for UAV when compared with the 38% (83 points) of Google earth. This confirms that majority of boundary points that may be extracted from cadastral points after careful georeferencing and digitizing may still be outside the expected range.

The significance test conducted on the coordinates obtained from the three methods of data acquisition has 0.341m for UAV and 2.334m for Google earth image. Standard deviation for 47. UAV is 0.536 while Google earth has standard deviation of 1.076m. The result of the T-test is significant for Google earth image which indicates that cadastral data acquired from remotely sensed data is significantly different from those obtained from field survey but the one obtained from photogrammetry is not significantly different. This implies that the UAV is suitable for cadastral survey and necessary chartings for land title registration.

While this research considers only digitizing as a method of extracting boundaries from images, further research should be conducted on the utilization of image segmentation for boundary delineation in Nigeria. Also, the placement of reflective targets or sensor at boundary points could be researched into so that radio wave remote sensing can be used to sense boundaries.

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