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Section III: Urban Planning and Policy

Application of Geospatial Techniques in Revising and Updating Street Names in Bunkoro District, Cadastral Zone C18, F.C.T Abuja, Nigeria

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Abstract
Maps in Nigeria lack revision and update, making them obsolete. Maps produced some years ago lack details of recent developments; this contributes to the relatively low use of street maps in a developing country like Nigeria, compared to what is obtainable in developed countries. Adoption of recent advances in the map-making process would help solve the problem of a lack of accurate and up-to-date maps. Therefore, the study carried out a revision and updating of Google Maps and the production of a guide map of Bunkoro, Gwarinpa district, F.C.T, Abuja. The study applied the science of remote sensing and Geographical Information Systems (GIS) in base map acquisition (using drone aerial photographs) and extraction of street survey beacon points (using Arc GIS and AutoCAD), respectively, for accuracy. A comparison of the initial (past) street names was made with the revised (present) street names. The result was a generation of location-based information as regards current street names in the study area. The revised roads include 36 streets, which constitute 65% of the roads revised, 10 closes constituting 18%; 5 crescents constituting 9%; 2 sub-arterials constituting 4%; 1 arterial constituting 2%; and 1 highway constituting 2%. 22 roads were renamed, 21 were unchanged, 10 had no street sign (name), and 2 were recently assigned. The study demonstrates a way in which remote sensing and GIS could be used to tackle the issue of obsolete maps in Nigeria. The study recommends the adoption of regular revisions of maps in Nigeria and the implementation of the updates acquired.

Keywords: GIS; Remote Sensing; Street Guide; Transport; Map

1. Introduction

A map is a symbolic depiction of specific attributes of a location, typically rendered on a two-dimensional surface. Maps provide a straightforward and visual means of presenting information about the world. They educate us about the globe by displaying the sizes and shapes of nations and the positions of various features. Moreover, maps can demonstrate the spatial relationships and distances between various locations. They can also visually represent the distribution and organisation of different phenomena on Earth, including the patterns observed in human settlements. They can show the exact locations of houses and streets in a city neighbourhood (National Geographic Society, 2022). Maps are specially designed to serve several purposes and answer specific questions, such as street maps, utility maps, etc. (Idowu et al., 2016).

Until recently, individuals and groups possessing advanced skills, adequate resources, and strong organisational capabilities exclusively undertook the task of accurately mapping the Earth. For many years, it was usually the role of surveyors, cartographers, and geographers to map the world and transcribe it on paper or, since the 1960s, into the computer (Patrick & Haklay, 2008).

Maps have played vital roles in the world by aiding decision-making and policy formulation processes, as well as tourism and general navigation (Longley et al., 2007). A map, a spatial model of the earth's surface (Heywood et al., 2006) demonstrating the positions and relationships of physical features through the process of cartographic abstraction, is a powerful method of effectively communicating spatial information to individuals. Maps created in this manner serve as highly effective tools for conveying information about the arrangement of physical elements in a given space.

Ezra & Kantiok (2007) argued that street guides serve a dual purpose, being valuable not only for assisting with navigation within cities but also for aiding demographers in planning enumeration areas. These guides play a crucial role in helping individuals navigate urban environments, ensure efficient movement, and find specific locations. Additionally, street guides provide essential information for demographers, facilitating the process of planning and delineating enumeration areas for population studies and statistical analysis. A street guide can be defined as a graphical depiction or visual representation of a town or city, presenting comprehensive information about the positioning and nomenclature of streets, major and minor highways, roads, railways, and other significant landmarks. It serves as a specialised map that specifically emphasises the intricate network of roads and transport links within a specific geographical area. The primary purpose of a street guide is to facilitate navigation and provide users with a clear understanding of the spatial layout and connectivity of the road infrastructure in a given locality. Also, some of the uses of street maps are: for locating houses and streets; car navigation; planning transportation, trips, and driving directions; and for planning movement and provision of facilities, goods, and services (Udoh & Igbokwe, 2014).

Due to the everyday activities of man, the landscape changes rapidly, and based on this reason, maps produced some years ago soon lack details of recent developments; hence, map revision, the process of updating earlier maps, is therefore necessary to incorporate recent changes in the landscape (Musa & Tukur, 2006). The lack of proper addressing systems, especially functional street names, in most Nigerian cities is a deep-rooted problem in the absence of proper urban planning and design principles (Sulaiman et al., 2013). A street map stands as a basic datum that can also help researchers conduct good research, such as emergency response studies and proximity and accessibility studies (Idowu et al., 2016). The street map-making process can be daunting and challenging; however, advances made in computer hardware and software technology have tremendously improved both the speed and quality of street map-making (Nnam et al., 2012). It is necessary to apply methodologies for street map updating in a faster and more efficient fashion (Holland et al., 2004).

Modern remote sensing applications in mapping and related phenomena are simplifying and easing the exercises that would otherwise be executed through conventional methods, thus making the need for improved mapping inevitable (Bashir, 2001). Remote sensing is defined as the science of detecting or monitoring the biological, chemical, or physical properties of an object without being in physical contact with the object or target (Ndukwe et al., 2001). The importance of Remote Sensing and Geographic Information Systems (GIS) in the domain of map-making cannot be emphasised enough. These technologies can integrate spatial data (related to the physical location and attributes of features) with non-spatial data (such as attribute information and other descriptive data). By combining these datasets, remote sensing and GIS enable the creation of maps that effectively communicate information in a manner that is easily understandable by a wide range of individuals. This integration of data types enhances the overall quality and usability of maps, making them valuable tools for decision-making, analysis, and communication in various fields. Several works have taken advantage of the abilities of these technologies to produce street maps using high-resolution images (Idowu et al., 2016).

GIS, as a scientific tool, serves multiple functions in capturing, storing, creating interactive queries, analyzing, and managing spatial information. It enables users to edit spatial data and associated attributes effectively. By leveraging GIS technology, researchers and professionals can collect geographic data, store it in databases, and utilise it for various purposes. GIS also allows for the creation of interactive queries, which facilitate the anal[illegible] spatial information. Additionally, GIS [illegible] users to d[illegible]

...ationships. It provides a computer-implemented spatially oriented database for evaluating remote ...sing data in conjunction with other spatially formatted data and information acquired from ...ferent sources (Udoh & Igbokwe, 2014). As far back as 1986, it was pointed out that the digital ...proach to street map-making would play a vital role in developing countries (Taylor, 1986).

...summary, the utilisation of digital mapping has become imperative in tackling environmental ...allenges by offering precise and current spatial data. This technology enables efficient analysis ...d aids in making well-informed decisions regarding environmental management and ...stainability. The methods used for producing digital maps are many, depending on the level of ...ail required, the use to which the map will be put, and the source of data (Musa & Tukur, 2006)..

Study Area

...e study area is geographically located within the following coordinates: Longitude: 7º23'30" E ...7º25'30" E and Latitude: 9º05'00" N to 9º07'00" N. These coordinates define the approximate ...undaries of the study area in terms of longitude and latitude. The study area is located in the ...nkoro district of Gwarinpa. The study area covers an approximate area of 241 hectares and is ...rdered by the following districts and cadastral zones:

- To the North-East: Jahi district, cadastral zone B08
- To the South-East: Kado district, cadastral zone B09
- To the North-West: Wupa district, cadastral zone C15

...hese boundaries define the extent of the study area and its neighbouring districts and cadastral ...ones. The study area falls within the UTM (Universal Transverse Mercator) National Grid Zone ...2N. Bunkoro is predominantly a residential neighborhood, with some areas allocated for ...ommercial, institutional, recreational, and religious use; however, some parts of it have undergone ...ome forms of change (Wanogho, 2016). In addition, this cadastral zone has some reviewed street ...formation not available on our maps, with some streets without a label signpost on the ground ...nd some areas having label mismatches on Google Maps. Therefore, with the steadily growing ...ature of Bunkoro-Gwarinpa, accurate and frequently updated map information is necessary to ...acilitate logistics and other socio-economic activities. Figure 1 illustrates a vector representation ...f the study area. The vector representation visually depicts the boundaries and features of the study ...rea using geometric shapes and coordinates.

... Methodology

The data used consisted of:

- Abuja Geographical Information Systems (AGIS) obtained aerial imagery of the study area with a resolution of less than 0.5 meters.
- The Department of Survey and Mapping, Federal Capital Development Authority (FCDA), survey data layout for the study area.
- The Abuja Geographical Information Systems (AGIS) database information on old street names within the study area.

The process flow chart and dataset are summarized in Figure 2 and Table 1 respectively.

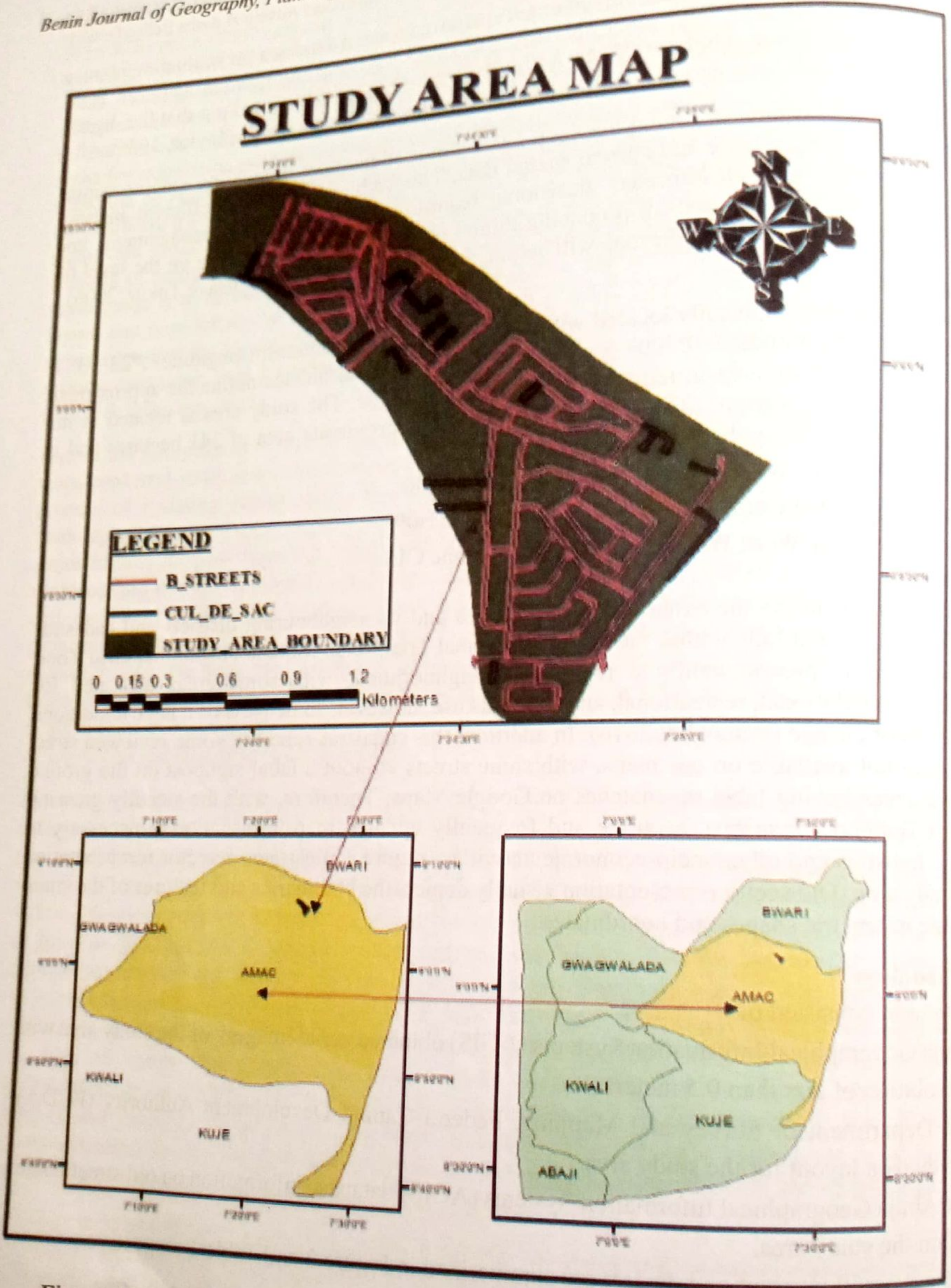


Figure 1: The Study Area

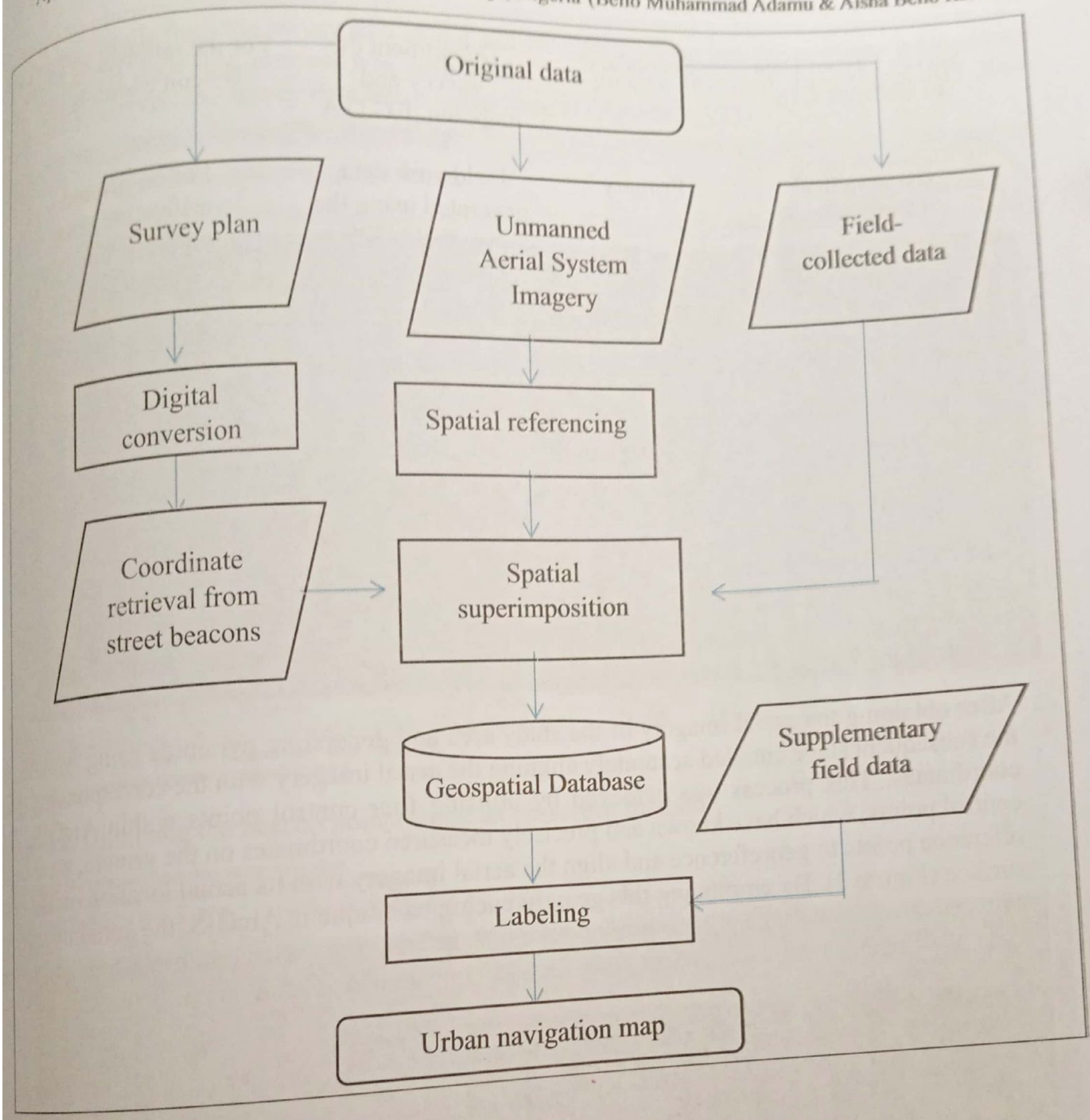


Figure 2. Process map (flowchart)

Table 1: **Methodological Table**

Dataset	Characteristics of the Data	Data Origin	Application
Aerial Imagery	Secondary	Abuja geographic information system (AGIS)	For the digital delineation of the study area's boundary and other essential features.
Attribute Database	Primary / Secondary	Primary from fieldwork and secondary from	For non-spatial data about the road network.

Survey Layout Data of Cadzone C18	Secondary	Department of survey and mapping, F.C.D.A	For the retrieval of street beacon coordinates.
Geographical Coordinates	Primary	Fieldwork data, generated using the handheld GPS device	For on-ground verification, map alignment, and data assessment.

The equipment consists of:

- HP (Hewlett-Packard) Laptop
- Garmin eTrex 10 handheld GPS device
- Hewlett Packard Jet 130 colored printer, scanner, and photocopier
- Camera

The software consists of:

- The AutoCAD 2007 version
- The ArcGIS 10.2 version
- Microsoft Office 2010 version packages

After obtaining the aerial imagery of the study area and generating pyramids using ArcGIS 10.2, the subsequent stage entailed accurately aligning the aerial imagery with the corresponding ground coordinates. This process was achieved by utilising four control points within ArcGIS. These control points, which have known and precisely measured coordinates on the ground, were used as reference points to georeference and align the aerial imagery with its actual location on the Earth's surface (Figure 3). By employing this georeferencing technique in ArcGIS, the aerial imagery was adjusted to align with the precise ground coordinates, ensuring their synchronisation and accuracy and ensuring accurate spatial positioning for subsequent analysis and mapping tasks.

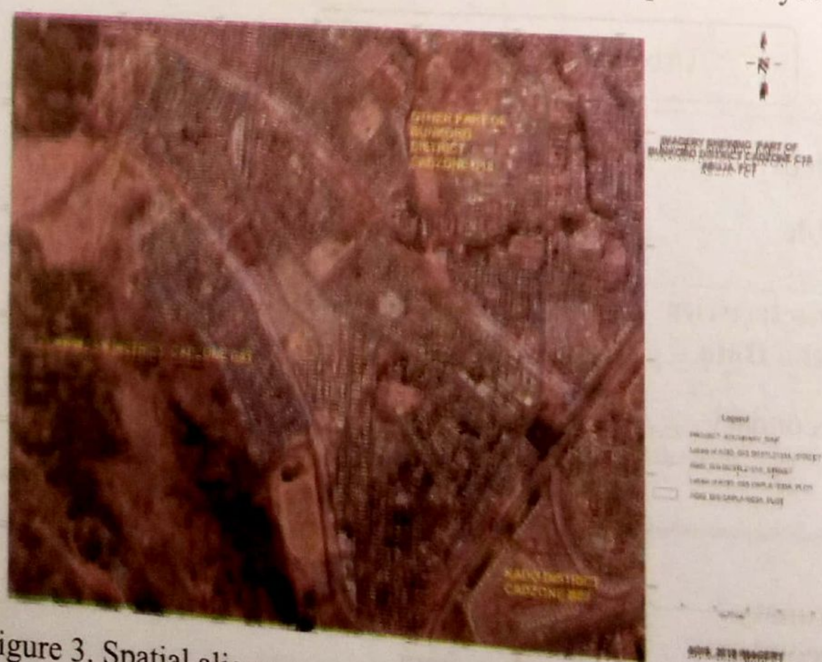


Figure 3. Spatial alignment of the aerial view for the study area

To extract details from the survey data layout and incorporate them into the new map information, the on-screen digitising process was employed. This process involved using AutoCAD 2007 software to convert the survey data into a vector format (Figures 4 – 7)

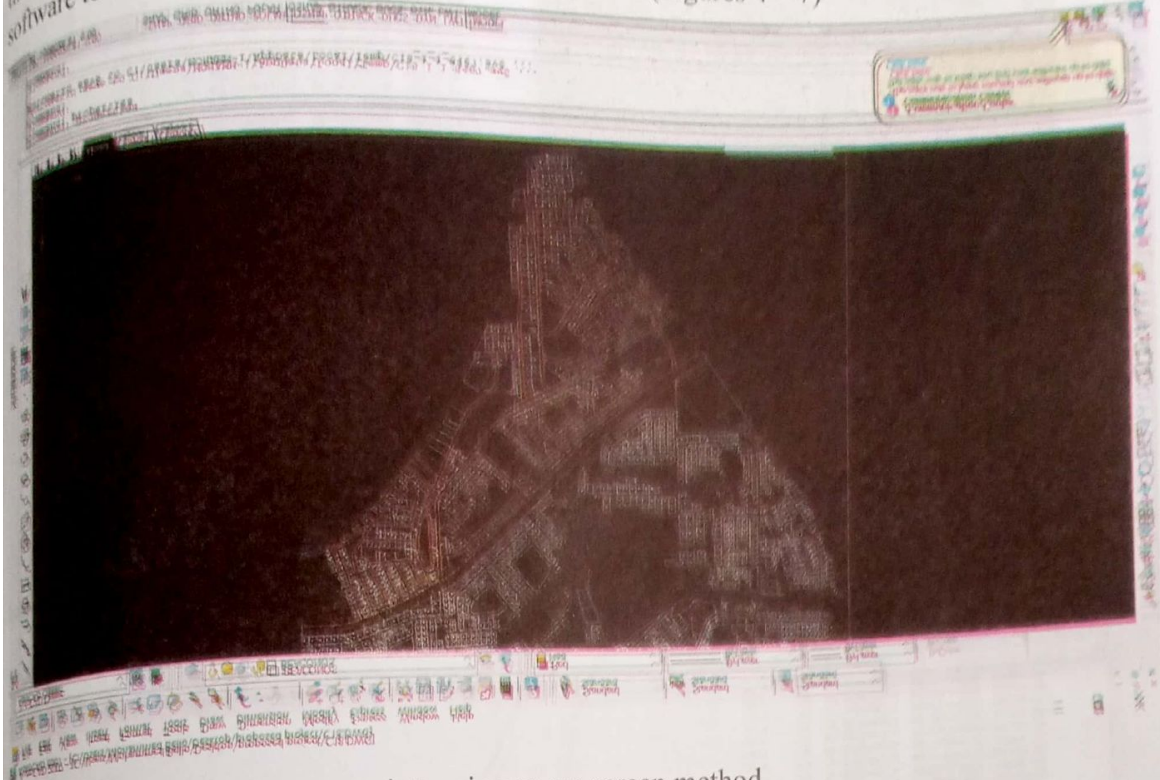


Figure 4. Digitizing the beacon points using an on-screen method

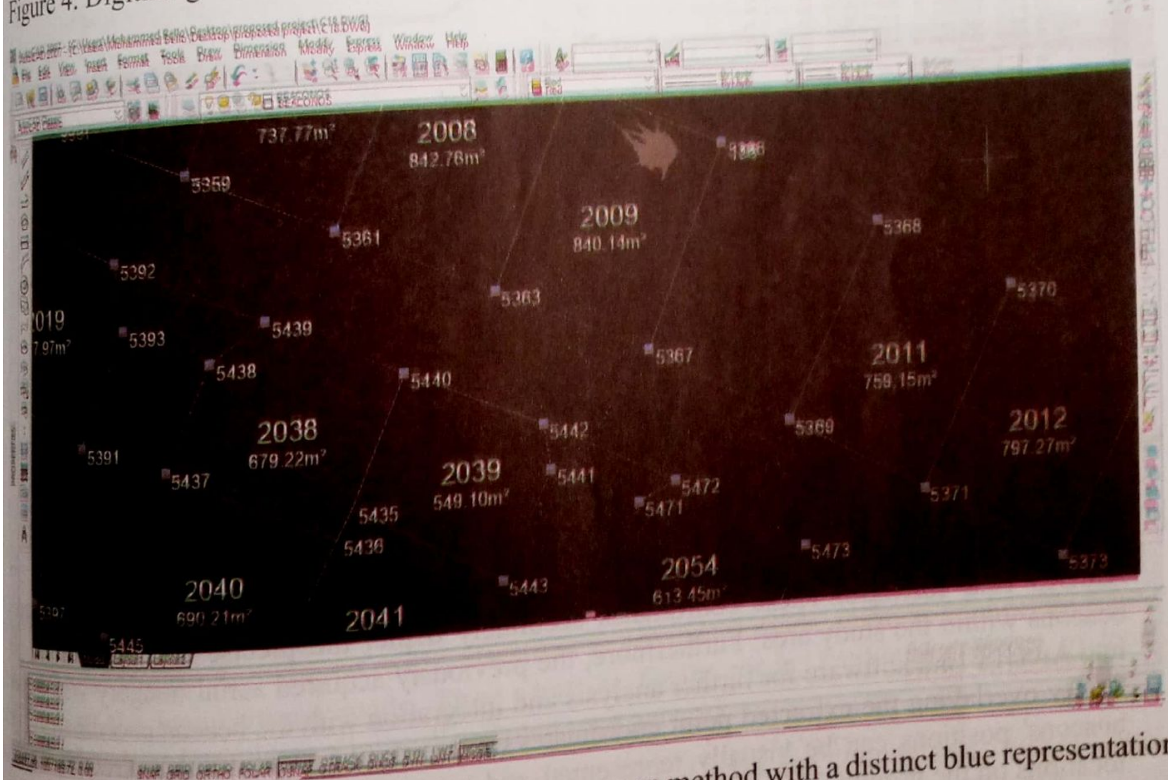


Figure 5. Digitizing the beacon points using an on-screen method with a distinct blue representation

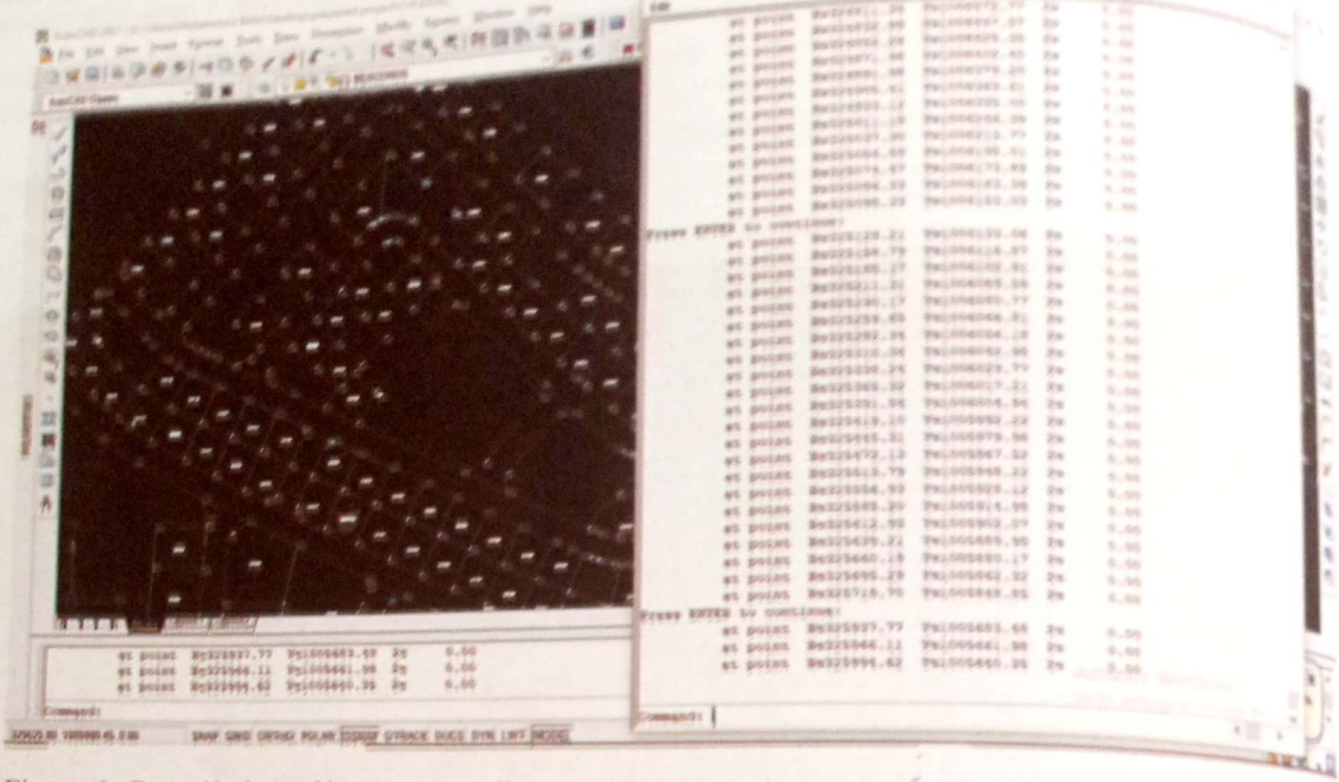


Figure 6. Compilation of beacon coordinates

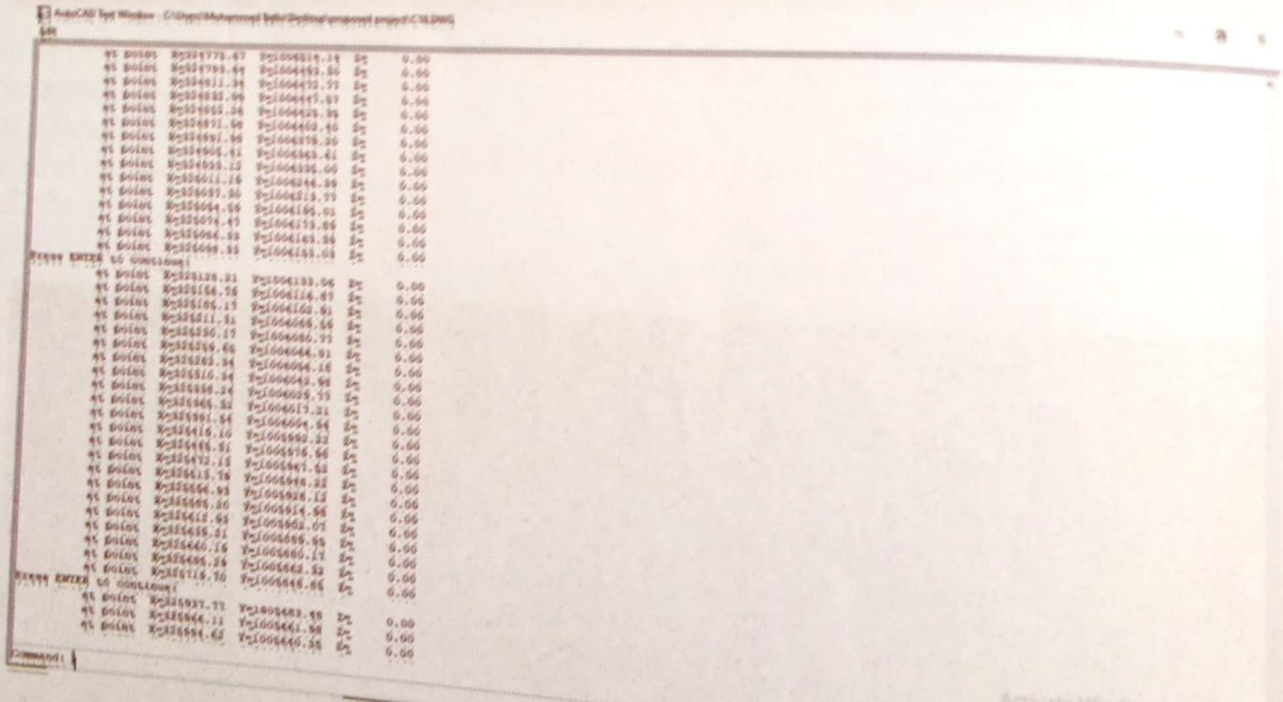
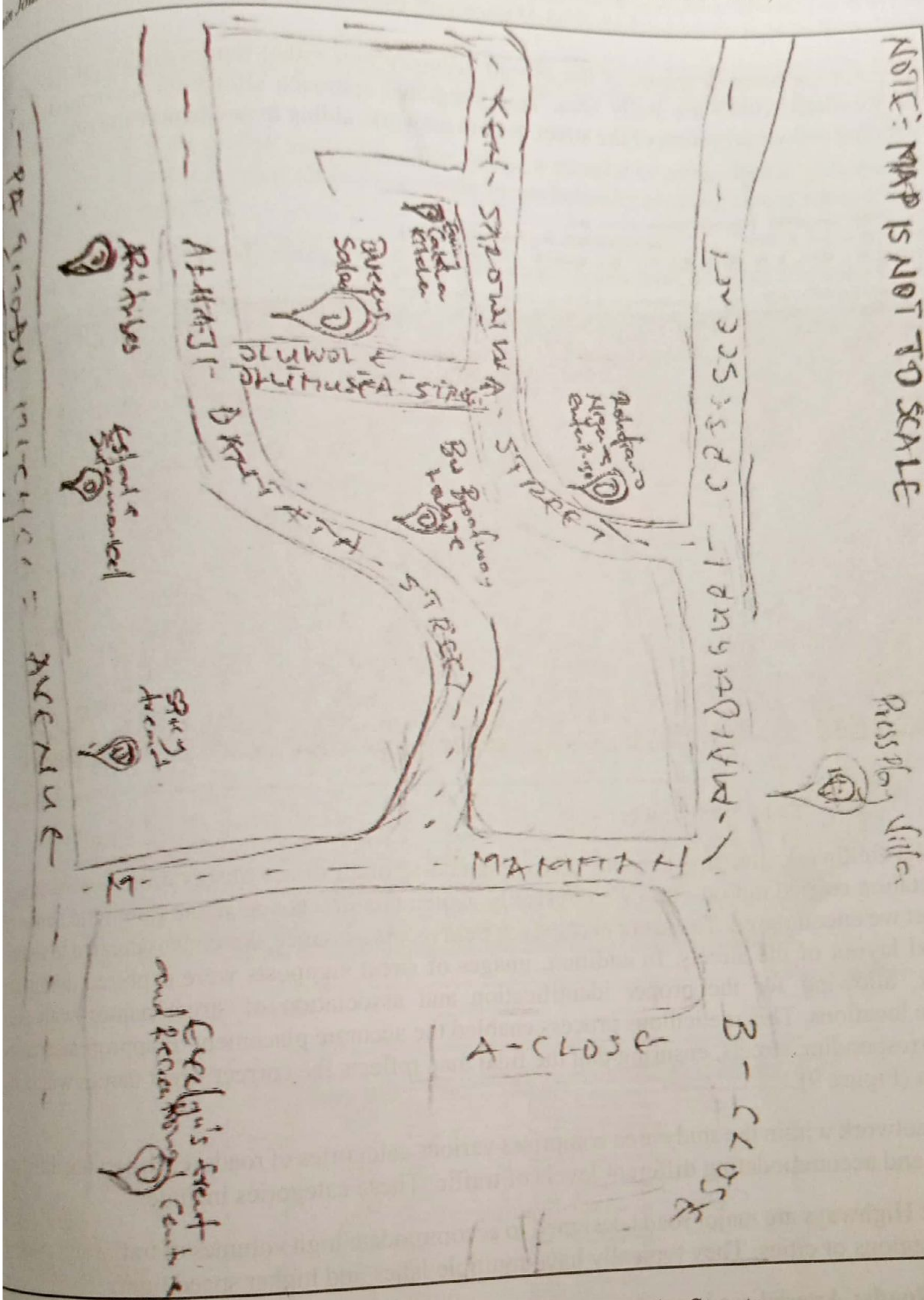


Figure 7: Listing of beacon coordinates

In the mapping process, the point coordinates of street beacons were extracted and imported into ArcGIS 10.2 software. These coordinates accurately depict the precise locations of the street beacons within the study area. Furthermore, the previously acquired aerial imagery was imported into ArcGIS 10.2 software for further analysis and integration with the beacon coordinates (Figure 8). By overlaying the extracted point coordinates on the aerial imagery within ArcGIS, the street beacons' positions can be visually represented and accurately aligned with their corresponding locations on the ground. This overlaying process provides a clear spatial reference and ensures the precise placement of the street beacons on the map. The combination of the aerial imagery and the



...ure 9: Field reconnaissance sketch for Revising and Renaming the Streets

...-Arterial Roads: Sub-arterial roads, classified as secondary roads, serve as connecting routes ...t link to the main arterial roads. They serve as feeder roads, facilitating access to local ...ghbourhoods and providing a more distributed road network.

...eets: Streets are the primary road type within residential areas and commercial districts. They ...pically have lower traffic volumes, are designed for local access, and have slower speeds.

overlaid point coordinates enhances the overall accuracy and visual representation of the street beacons' locations within the study area. This integrated approach allows for a comprehensive understanding and visualisation of the street beacon network, aiding in navigation and other related analyses.

Figure 8: Overlay of imported points

During the fieldwork, the street names were obtained through direct observations and thorough documentation carried out on-site. We physically visited the streets and wrote down the names of each street we encountered. To ensure accuracy, a field reconnaissance sketch was created to record the spatial layout of the streets. In addition, images of street signposts were captured during the fieldwork, allowing for the proper identification and association of street names with their respective locations. This meticulous process enabled the accurate placement of appropriate names on the corresponding streets, ensuring that the final map reflects the correct street names within the study area (Figure 9).

The road network within the study area comprises various categories of roads, each serving different functions and accommodating different levels of traffic. These categories include:

Highway: Highways are major roads designed to accommodate high volumes of traffic and connect different regions or cities. They typically have multiple lanes and higher speed limits.

Arterial Roads: Arterial roads are major thoroughfares that serve as the main routes within a city or region. They provide connectivity between different neighborhoods, commercial areas, and other key destinations.

Close (Cul-de-sac): Closes, also known as cul-de-sacs, are dead-end streets that typically have a circular or U-shaped design. They provide access to a limited number of properties and do not have through traffic.

Crescents: Crescents are curved roads that often follow a circular or semi-circular pattern. They are commonly found in residential areas and provide an aesthetically pleasing layout while offering access to multiple properties.

The inclusion of these different road categories in the study area's road network (Figure 10 - 12) allows for efficient traffic flow, proper land-use zoning, and convenient access to various destinations within the area.

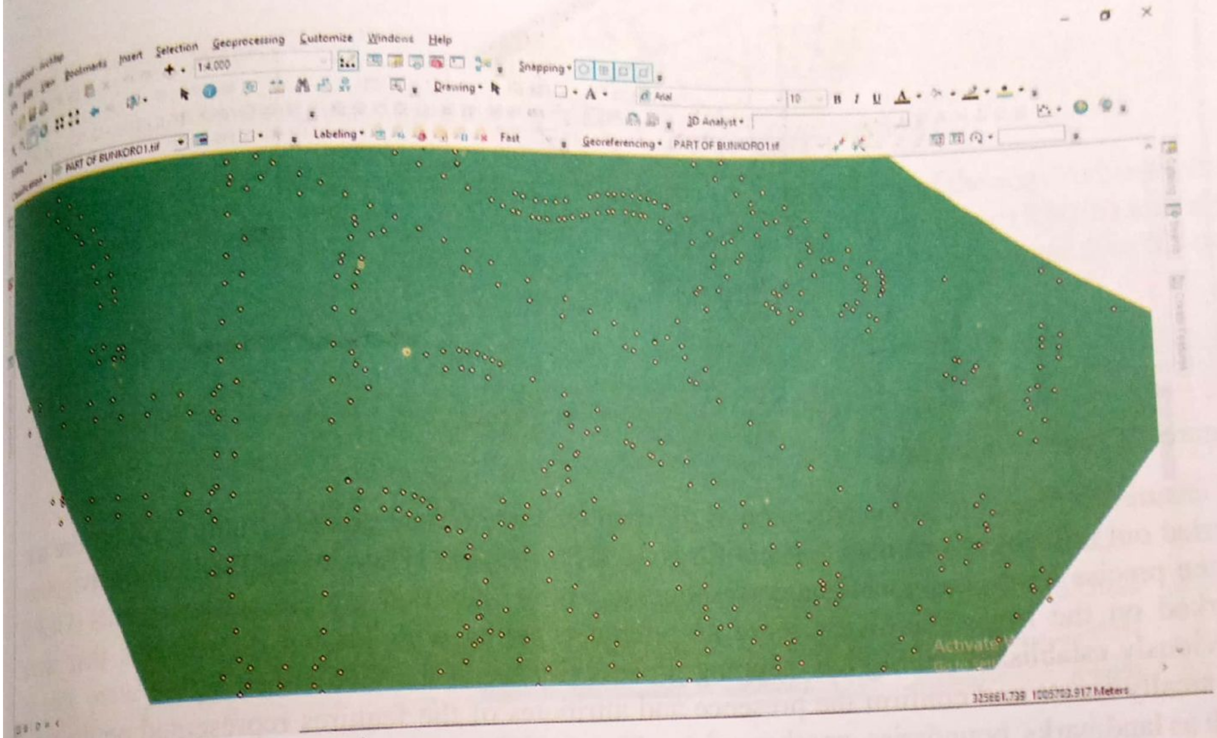


Figure 10. Imported Overlay points

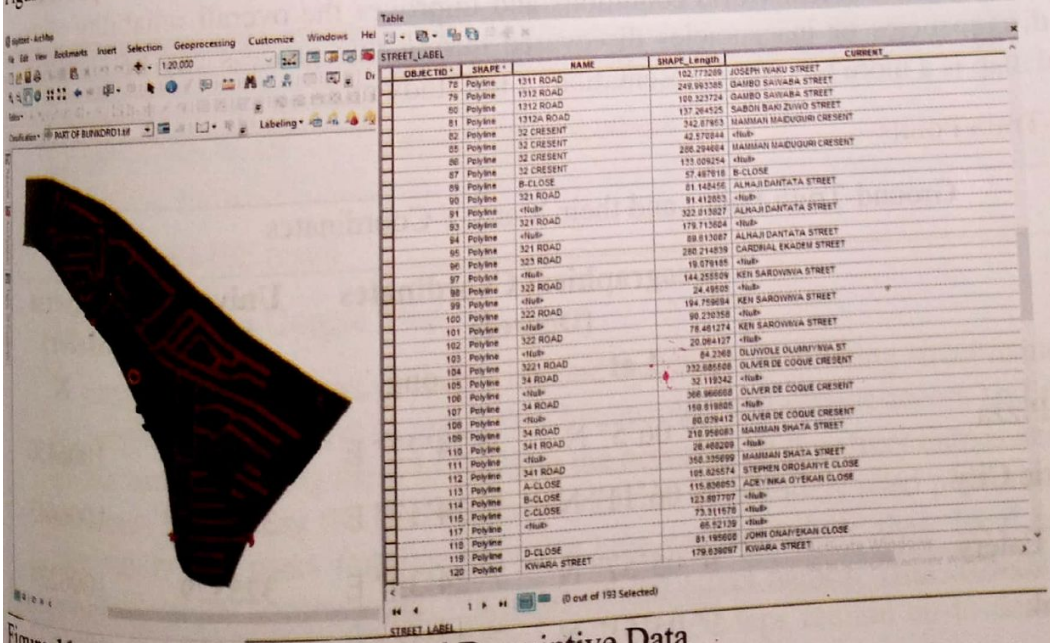
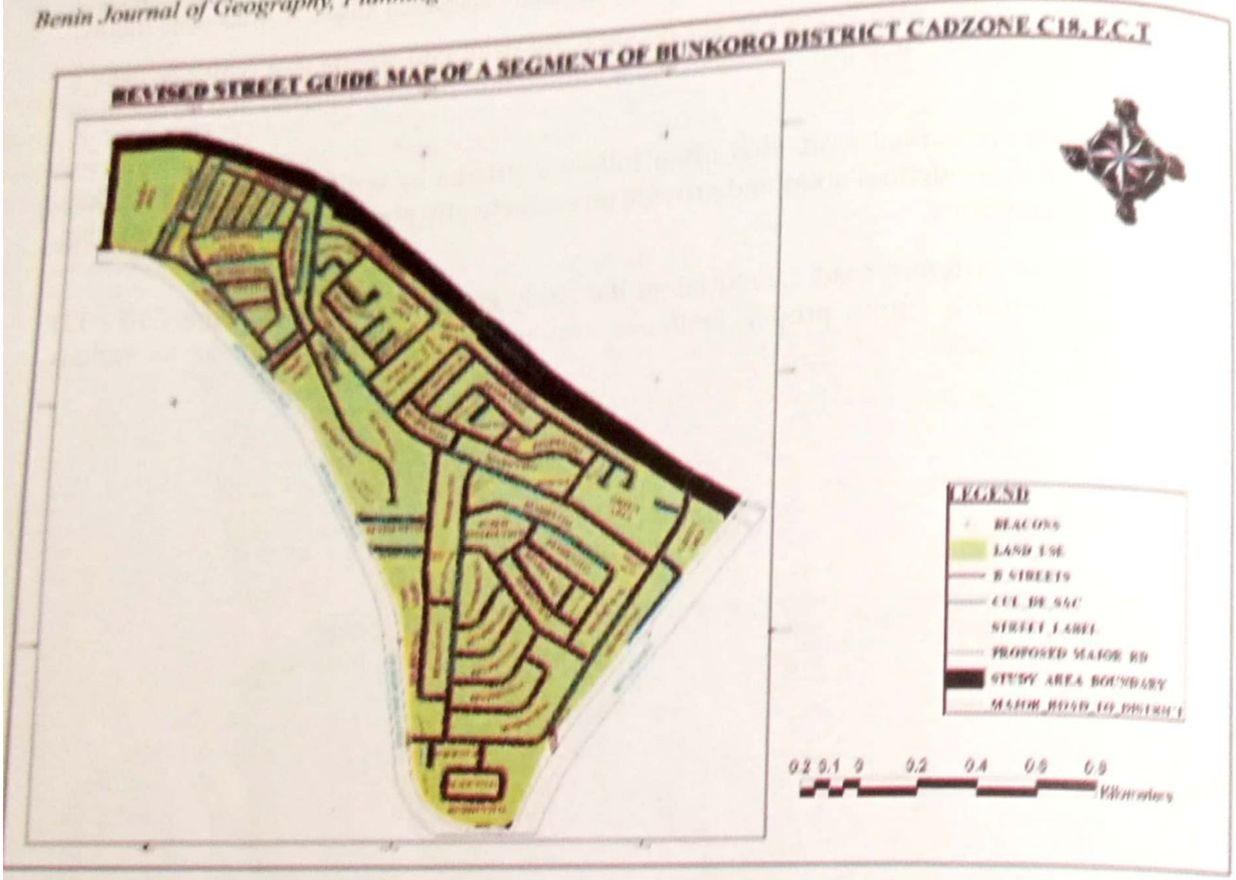


Figure 11. Combining Geographic and Descriptive Data



gure 12. Street Guide Map

ensure the precision and verification of the map features, a final ground-truthing procedure was ried out utilising a handheld Garmin Etrex 10 GPS receiver. This device facilitated navigation the precise on-ground locations corresponding to the identified ground control points (GCPs) rked on the map. The GCPs serve as reference points with known coordinates that were viously established during the mapping process. By using the GPS receiver, we were able to sically locate and confirm the presence and attributes of the features represented on the map, h as landmarks, boundaries, or other points of interest. This ground-truthing activity helps ensure the map accurately reflects real-world conditions and improves the overall reliability of the data. Any discrepancies or inaccuracies discovered during this process can be corrected, ring the final map is a more precise representation of the study area.

e 2: Ground-Truth Points

Ground-Truth Points and their X and Y Coordinates

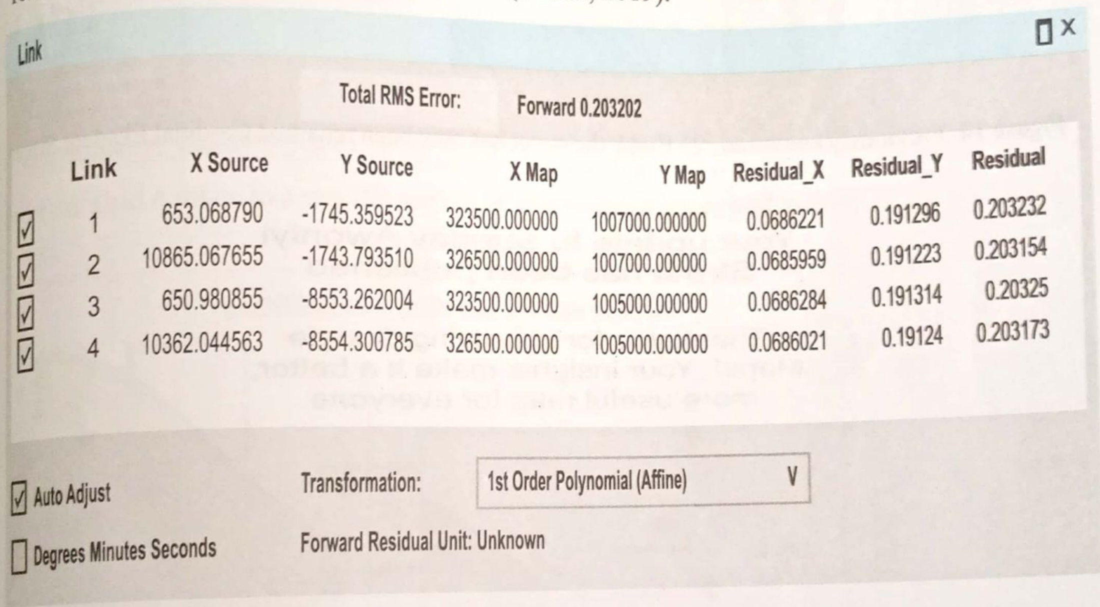
Name	Geographical Coordinates (Degree)		Universal Transverse Mercator (Meter)	
	Lat	Long	E	N
Domino's Pizza	9° 06'5" N	7° 24'22" E	324855	1006450
The Lingerie City	9° 06'11" N	7° 24'17" E	324696	1006643
Fowlchase Eatery	9° 05'57" N	7° 24'39" E	325379	1006224
Polaris Bank	9° 05'51" N	7° 24'36" E	325288	1006022

5	Zenith Bank	9° 05'34" N	7° 24'37" E	325307	1005495
6	Christiana Ajayi Okunuga Street	9° 05'34" N	7° 24'36" E	325285	1005503
7	E.C. Akinwumi Street	9° 05'33" N	7° 24'48" E	325651	1005468
8	Pa ImoduMicheal Avenue	9° 06'17" N	7° 24'16" E	324676	1006819
9	Joseph Waku Street	9° 05'32" N	7° 24'48" E	325653	1005454
10	Residential Building	9° 06'22" N	7° 24'14" E	324604	1006998

4. Results

4.1 Root Mean Square Error (RMSE) Of the Geo-Referencing

The residual Root Mean Square Error (RMSE) during georeferencing of the acquired aerial imagery is "0.2" (Figure 13). This indicates a very minimal Root Mean Square Error (RMSE) and is within the acceptable range value of Root Mean Square Error (RMSE) as values greater than 0.5 reflect a relatively poor accuracy of the data or model (Hanan, 2019).


Link

Total RMS Error: Forward 0.203202

	Link	X Source	Y Source	X Map	Y Map	Residual_X	Residual_Y	Residual
☑	1	653.068790	-1745.359523	323500.000000	1007000.000000	0.0686221	0.191296	0.203232
☑	2	10865.067655	-1743.793510	326500.000000	1007000.000000	0.0685959	0.191223	0.203154
☑	3	650.980855	-8553.262004	323500.000000	1005000.000000	0.0686284	0.191314	0.20325
☑	4	10362.044563	-8554.300785	326500.000000	1005000.000000	0.0686021	0.19124	0.203173

☑ Auto Adjust — Transformation: 1st Order Polynomial (Affine)

☐ Degrees Minutes Seconds — Forward Residual Unit: Unknown

Figure 13. RMSE result

4.2 Updating Google Map

To streamline the process of reviewing and updating the existing street names, they were uploaded to Google Maps (Figure 14 and 15). This enabled convenient access and promotes collaboration among users, allowing them to validate the accuracy of the street names and propose any required revisions. By making the street names available on a widely used platform like Google Maps, the community and users familiar with the area can contribute their local knowledge and provide feedback on the accuracy and relevance of the street names. This crowdsourcing approach helps ensure that the street names reflected on Google Maps remain up-to-date and reflect the current naming conventions and changes within the study area.

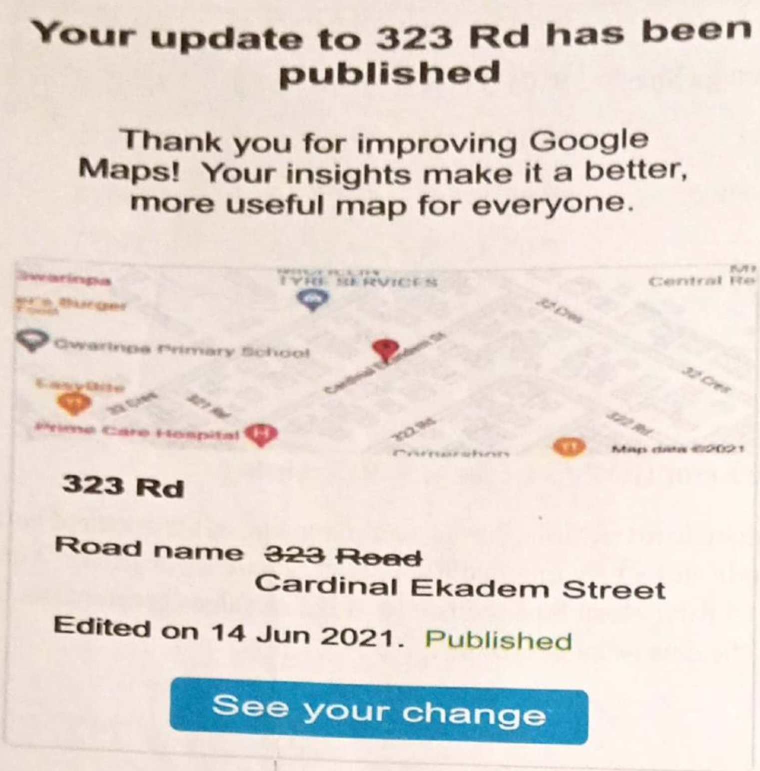


Figure 14: Previously known as 323 Road, the street has now been renamed Cardinal Ekadem Street

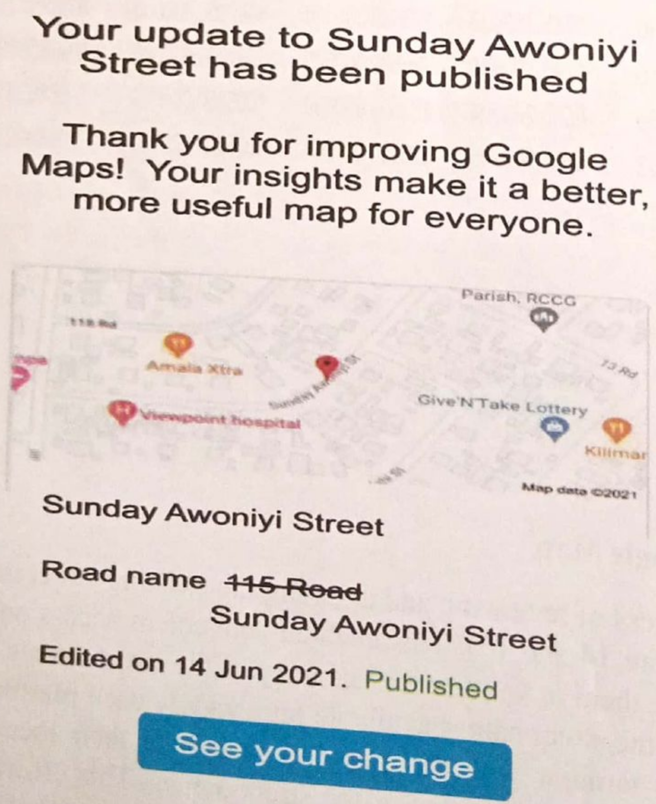


Figure 15. The street formerly known as 115 Road has been officially renamed to Sunday Awoniyi Street

4.3 Compiled Maps

The compiled maps are depicted in Figures 16 – 20.

Figure 16: Grid A refers to a specific section or area within a larger grid system

Figure 17: Grid B refers to another specific section or area within a larger grid system, distinct fr Grid A

Figure 18. Grid C refers to yet another specific section or area within a larger grid system, separate from Grid A and Grid B

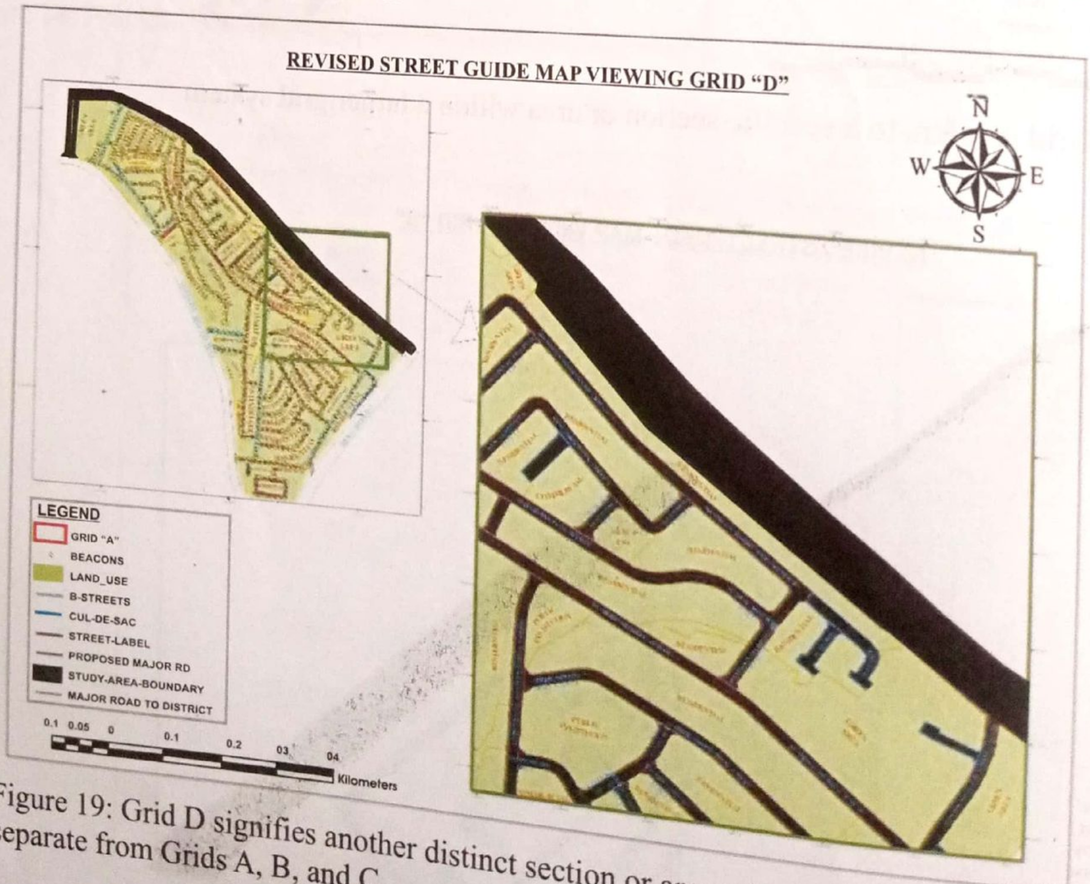
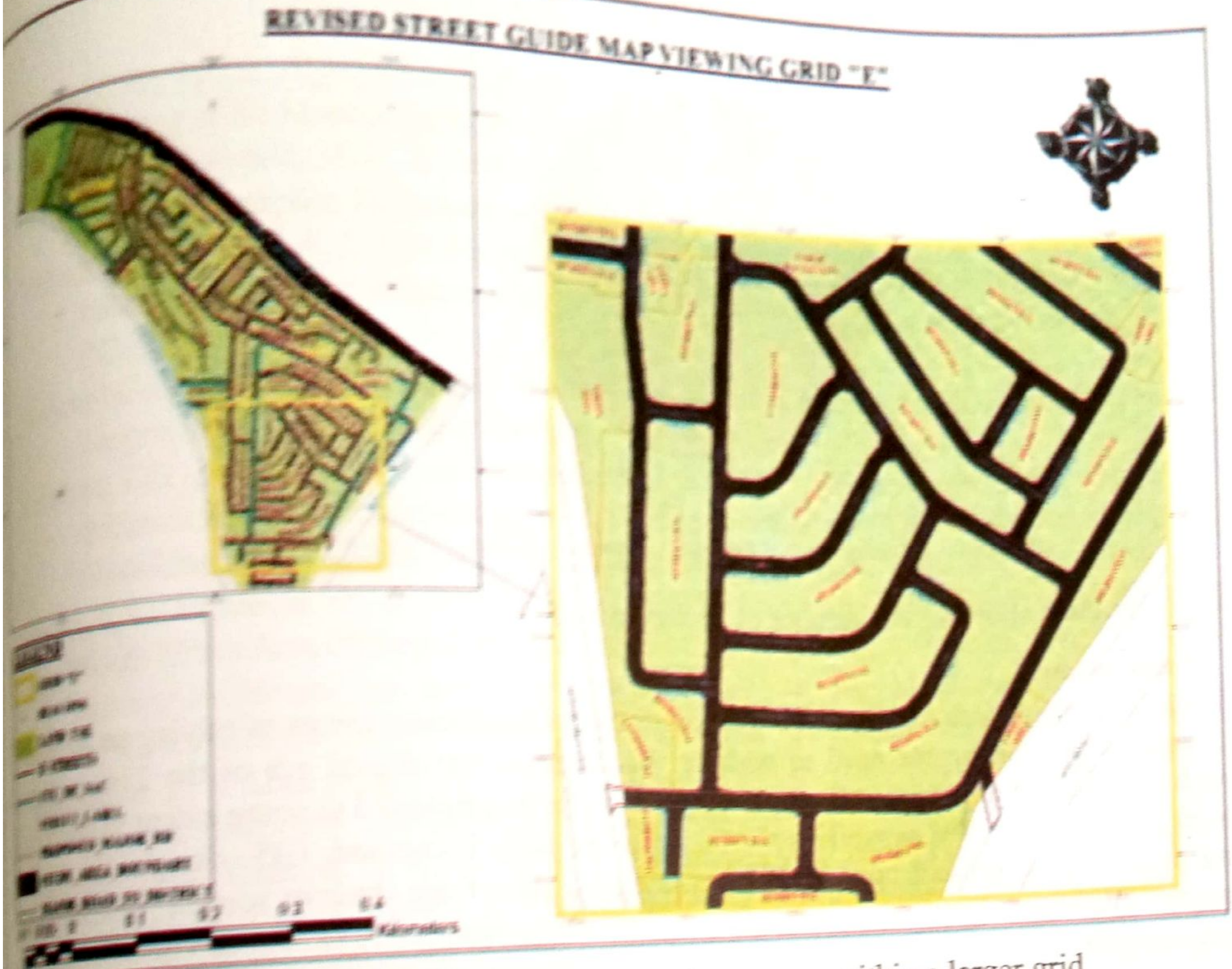


Figure 19: Grid D signifies another distinct section or area within a larger grid system, separate from Grids A, B, and C



...re 20. Grid E represents an additional distinct section or area within a larger grid ...em, independent of Grids A, B, C, and D

Discussion

...spatial science and technology play vital roles in presenting current and accurate maps for any ...a of interest worldwide. It enables the updating of maps as needed and enhances the convenience ...f map navigation, particularly in the southern axes of Bunkoro District that have been revised and ...dated. This, in turn, facilitates development across multiple sectors, such as infrastructure, ...rism, marketing, and overall regional progress. The production of a revised digital street guide ...ap for Bunkoro, Gwarimpa District Cadastral Zone C18, has resulted in a comprehensive and up-...date resource, including increasing the number of revised roads (Figure 21). This map provides ...extensive compilation of significant features in the area, accompanied by their respective ...ations and names. Moreover, the geo-referenced map produced as a result of this project can ...rve as a valuable street image map whenever necessary. The comprehensive compilation of streets ...d relevant feature attributes from this project serves as an invaluable database for future ...deavours concerning Bunkoro, Gwarimpa district, and the Federal Capital Territory (FCT) as a ...hole. It provides a rich resource that can be utilised for various purposes in the future. This ...tabase will contribute to the planning and execution of various projects, including infrastructure ...velopment, the equitable distribution of facilities, tourism initiatives, marketing strategies, and

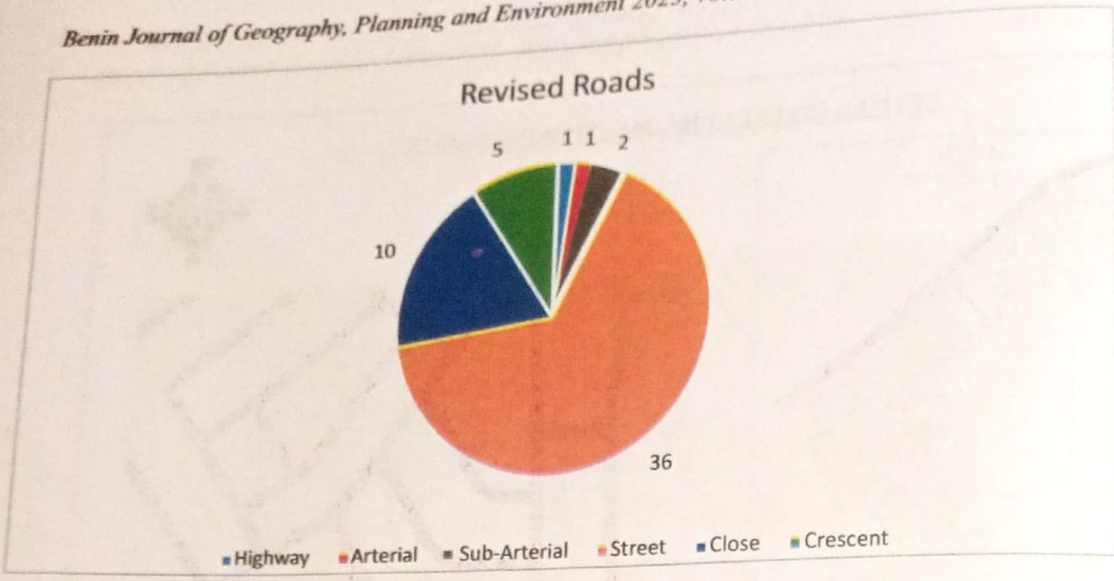


Figure 21. Pie chart showing the number of revised roads

6. Conclusion

Developing countries, such as Nigeria, are facing the adverse consequences of relying on outdated maps, emphasising the urgent need to address this issue in the digital era of the 21st century. Although Geographic Information Systems (GIS) have been employed to some extent in mapping efforts in Nigeria, their full capabilities have yet to be fully harnessed. GIS, along with remote sensing technologies, present opportunities to integrate data from diverse sources, enabling the overlaying of different layers onto a unified map. This integration offers enhanced visualisation and analysis capabilities for improved decision-making and resource management.

The conducted study successfully produced location-specific information regarding the present street names within select areas of the Federal Capital Territory (FCT) cadastral zone C18. This significant finding sheds light on the inadequate currency of our maps, primarily resulting from the absence of regular reviews and revisions after their initial development. The implementation of regular map review processes would yield improved navigational accuracy and foster wider adoption of maps for everyday navigation purposes. It is crucial for policymakers in Nigeria to promptly acknowledge and value the importance of GIS and remote sensing technology in addressing spatial challenges, including the regular review and implementation of maps. Creating awareness among policymakers will result in increased professional consultation to ensure the appropriateness and relevance of maps and facilitate the adoption of advanced technologies for sustainable development across Nigeria.

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