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Research Article

Geospatial Evaluation of Building Facility in Oyo State, Southwestern Nigeria

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Abstract

Geospatial image acquisitions through the Unmanned Aerial Vehicle (UAV) techniques has been used geospatially to assess the Infrastructural building roof facilities of Emmanuel Alayande College of Education Campus, Oyo State, Nigeria. Unmanned Aerial Vehicle (UAV) is an aircraft without a human pilot on board, it is a veritable tool to solve numerous problems socially, and spatially which serves as an effective means of search, detection and identifying objects and the subjects of interest, as well as the precise determination of their coordinates. Drone deploy flight planning software were also used during this study. This paper focused on the building roof assessment of Emmanuel Alayande College of education Oyo. To achieve this aim, a UAV (Drone) was filed at a height to acquire the image data, which was processed using Argisoft Photoscan Professional image processing software and a orthomosaic, was acquire. The orthomosaic was analyzed with ArcGIS 10.3 and a map of building assessment of Campus was obtained. The findings shows geospatially how important is the geospatial technology for mapping roofs of infrastructure in this citadel of knowledge.

Keywords: Keywords: Mapping, Orthomosaic, ArcGIS 10.3, Unmanned Aerial Vehicle, Geospatial, image

Introduction

Geoinformatics as a science has witnessed several developments in the recent years in the types of instrument used in acquiring data, both spatial and non-spatial data. It has drastically transformed from analog form into digital form. Previously ground based method were mostly applicable, which ranges from chain surveying to the use of theodolites and later to the world of refined instrument such as Total Station, Scan Station, Smart Station, Differential Global Navigation System (DGNSS) and recently the Unmanned Aerial Systems (UAS), also called Unmanned Aerial Vehicle (UAV). An Unmanned Aerial Vehicle or Remotely Operated Aircrafts (ROAs) commonly known as drone is an aircraft without a human pilot on board. UAVs are a component of an unmanned aircraft system (UAS) which include a UAV, a ground based controller and a system of communications between the two. The flights of UAVs may operate with various degree of autonomy: either by a human operator or autonomously by onboard computers. Unmanned aerial vehicle offer less stressful environment, it is used for better decision making, it present safer environment (Anna, 2017).

Many fields of study including building facility assessment have adopted the Unmanned Aerial Systems (UAS) as a very useful tool. As Anna, 2017 puts it, in

recent years research has developed following the use of digital images acquired through Unmanned Aerial Vehicles (UAVs), to monitor the technical condition of real estate and inventories of technical infrastructure (Bayirhan and Gazioğlu, 2020). The use of UAV can significantly improve the collection of geometric and structural data in such areas. Digital Surface Models (DSMs), Orthophotos and three-dimensional (3D) models derived from processed UAV images allow accurate mapping of joint geometries and their degree of uncertainty. The latest drone hardware and software developments allow their application in several fields of science, including the study of structure instability (Rau et al. 2011; Niethammer et al., 2012; Danzi et al., 2013; Salvini et al., 2014; Francioniet al., 2015; Giordan et al., 2015; Turner et al. 2015 as cited in Hellerann and Morgenthal 2013; Gazioğlu et al., 2017; Erenoğlu and Erenoğlu, 2018; İncekara and Şeker, 2021). Digital Surface Models (DSMs), orthophotos and three-dimensional (3D) models derived from processed UAV images allow accurate mapping of buildings joint geometries and their degree of uncertainty. Zhang, (2008) confirms that recently, commercial remote sensing technologies have been introduced for pavement assessment (road assessment). UAV data can also be used both for calculation of yield (in terms of commercial value) and deterministic analysis of stability and the study of stress distribution within structures (in terms of safety)

(Gönültaş et al., 2020). Expectedly, the continuous increase of the spatial resolution of space borne image. This paper aimed at evaluating the building facility of Emmanuel Alayande College of education campus, Oyo state, Nigeria using Geospatial Norms. Emmanuel Alayande College of Education is geographical located in Oyo Town, Oyo State embedded within a built-up area as

seen in Figure 1 below. It lies between 7° 52' 24"N, 7° 53' 04"N and 3° 53' 50"E, 3° 54' 38"E with an approximate height of 277m to 295m. It is a higher institution surrounded by the Erelu dam and comprises of a campus, which consist of academic and administrative units, as well as service centers.

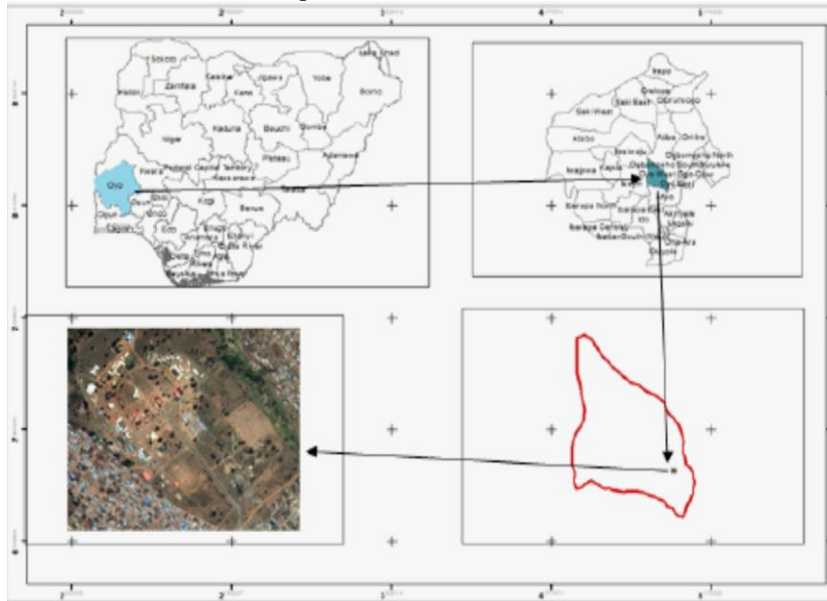


Fig.1: Map showing the study area

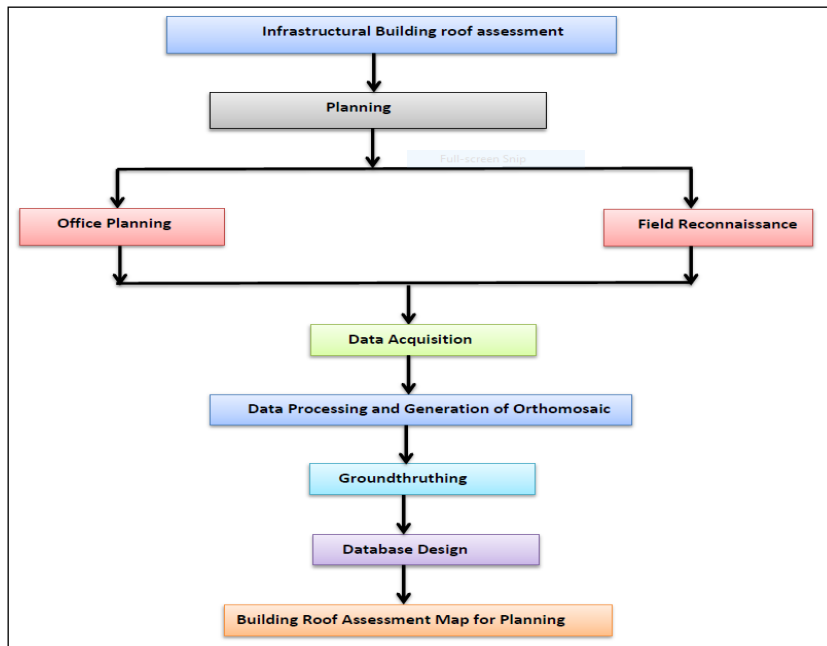


Fig.2: The Flow chart of process used in the assessment

Methodology

The Methodology deployed for this paper involved a reconnaissance survey, fixing of ground control points and check points (GCPs & CPs), flight planning and execution, images processing to obtain orthomosaic, vectorization of Orthophotos map, ground truthing, database creation and query design, analysis and presentation of information in mosaic maps, charts and tables. A diagrammatic representation of the procedure deployed for this study is shown in Figure 2.

The flight campaign was conducted on 7th September 2019 when the weather was clear enough with a repeated flight due to the detection of a gross error in the first data on the 7th October 2019, but this time the weather was a bit accommodating. The materials used for this study involved various datasets. These datasets includes Orthophotos acquired through an UAS flown at 80m above ground level (AGL), at a side overlap of 65% and forward overlap of 75%. Ground Control Points were also established in the study area for accuracy check.

Establishment of Ground Control Points were done with nine (9) Ground Control Points (GCPs) regularly placed apart which were targeted by CHCx20 DGNSS, (GPS and GLONASS). The Ground Control Points (GCPs) horizontal and vertical accuracy was 15-20mm as seen in

Figure 3. The GCPs on ground and the control check were assumed to be the same with the GCPs is shown in Figure 3 below, 3D models of the buildings and roads were acquired from the imagery as seen in figure 6 and the Ground control points values are shown in Table 1.



Fig.3: Ground Control Points used in the study area.



Fig 4: Field reconnaissance of the study area

However, field Reconnaissance survey were done as seen in Figure 4 by visiting and inspection of the site in order to have first-hand information about the study area and to determine various movement about the area in terms of equipment/instrument, personnel required, and ground control network.

Image Data Acquisition

The DJI Phantom 4 pro Drone as seen in Figure 5 was used in the image data acquisition. It is a lightweight quadcopter flying platform (with the following specifications: weight: 1388g, vertical GPS accuracy: $\pm 0.1\text{m}$ (with vision positioning), $\pm 0.5\text{m}$ (with GPS positioning) and horizontal GPS accuracy: $\pm 0.3\text{m}$ (with vision positioning), 1.5m (with GPS positioning). Max ascent speed; S-mode: 6 m/s, P-mode: 5 m/s. Max descent speed: S-mode 4m/s, P-mode: 3 m/s. Max speed; S-mode: 45mph, (72 kph), A-mode: 36 mph (58 kph), P-mode: 31 mph (50 kph). Max tilt angle; S-mode; 42°, A-mode: 35°,P-mode: 25°. Max angular speed; S-mode: 250°/s, A-mode: 150°/s. Max flight height: 6000m Above Sea Level

(ASL). Max wind speed resistance: 10 m / s, max flight time: 30 minutes, operating temperature: 32° to 140°F (0° to 40°C), diagonal size: 350mm (propellers excluded) robust carbon aluminum frame.



Fig.5: A DJI Phantom 4 Pro Drone used for image data acquisition.

It is stabilized by inertial measurement units (IMU); including gyroscopes, acceleration sensors, altimeter and

compass. This unit is attached to a GPS (satellite positioning systems by GPS/GLONASS) unit with standard less than 2 m precision. Flight endurance with 5870 mAh Lipo 4S batteries having voltage level of 15.2 V, lasts up to 30 minutes. A compact mirror-less 1” CMOS sensor camera with 20m effective pixel and FOV 84° 8.8mm/24mm (35mm format equivalent), f/2.8—f/11 auto focus at 1m-∞ lens, was used for image acquisition, and ISO sensitivity, zoom and aperture were set at fixed values with exposure time between 8-1/800s. The system also has a vision component, which houses the obstacle sensory range and velocity range.

Table 1: Ground control points values.

CGP S/N	Latitude	Longitude	Elevation(m)
1	600552.3	870338.7	273.708
2	600466.3	870284.5	277.399
3	600171.8	870491.8	271.041
4	599877.4	870740.0	261.765
5	599838.8	871300.5	251.986
6	600016.7	871120.0	257.195
7	600430.8	871043.3	248.076
8	600228.9	870772.2	264.762
9	600567.0	870419.0	271.128



Fig.6: 3D model of buildings and road network.

Image Data Processing

A Total of 1,545 in number of UAV images were processed in the Agisoft Photoscan pro software processed to obtain a Orthomosaic image. The Orthophoto mosaic was then produced and exported. It is then vectorized for analysis on ArcGIS 10.3. The Agisoft Photoscan pro software uses Structural process from Motion algorithm (SfM) to reconstruct the actual surface from a large number of overlapping photos. The software locates matching features on each image and uses iterative bundle block adjustment to estimate image orientation, exterior orientation parameters and building model geometry. The GCPs were entered to aero triangulation, which enables precise calculation of the exterior orientation parameters and improves spatial georeferencing accuracy. The final step generates the

Digital Surface Model (DSM) by building the model texture and exporting a 2D model (mesh) or orthomosaic.

Results and Discussion

Data base query were done which involve Single-Criterion Query and Multiple-Criteria Query accordingly as seen in Fig 7 to Fig.15 respectively. A model analysis was also performed as seen in Fig.16 to Fig.23 respectively. Spatial analyses were performed on the database created which is the vital important aspect of GIS. Virtually, all the important queries were done but only few were shown in this paper due to data security.

Query: Return All Buildings with Corrugated Roof
 Syntax=Roof Type= Corrugated.

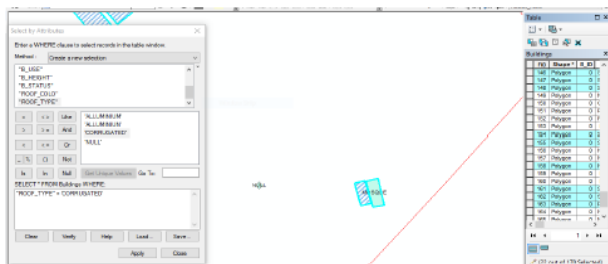


Fig 7: Query showing building roof that is corrugated
 Query: Return Buildings with Aluminum Roof (Type) base on their state of condition (Status) Syntax = “ROOF_TYPE” = ‘Aluminum’ AND “ROOF_STATU” = ‘GOOD’



Fig 8: Query Showing building roof type and status Aluminum Roof in Good Condition
 Syntax= “ROOF_TYPE” = ‘Aluminum’ AND “BRF_STATU” = ‘GOOD’

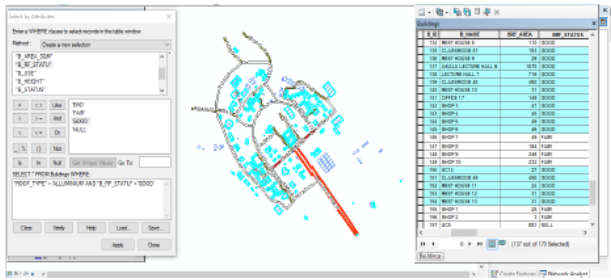


Fig 9: Query Showing Buildings with Aluminum Roof in Good Condition.
Aluminum Roof in Fair Condition
Syntax= “ROOF_TYPE” = ‘Aluminum’ AND “BRF_STATUS” = ‘FAIR’

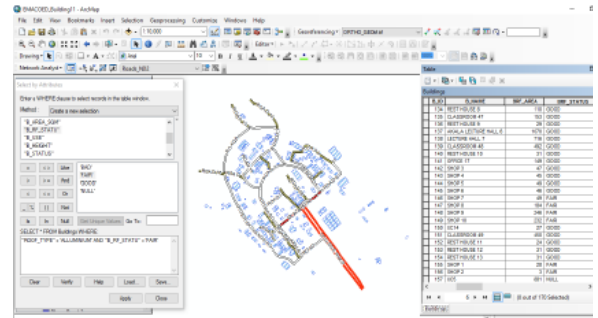


Fig 10: Query showing all buildings with Aluminum Roof of fair status
Aluminum Roof in Bad Condition
Syntax= “ROOF_TYPE” = ‘Aluminum’ AND “BRF_STATUS” = ‘BAD’

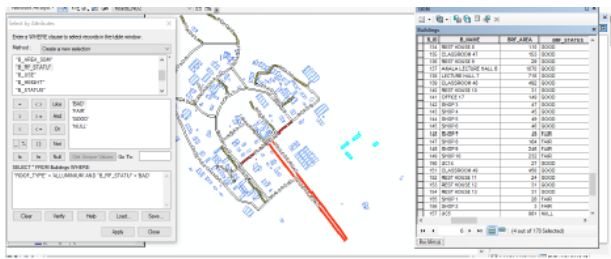


Fig 11: Query Showing Buildings with Aluminum Roof in Bad status.

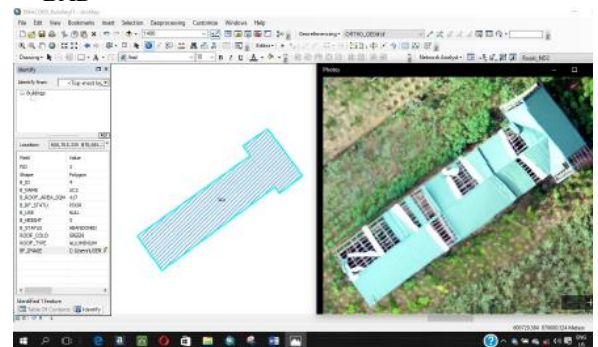


Fig 12: Query Showing hyperlink of Image of a Building with Aluminum Roof having Blue colour and of Bad Status
Corrugated Roof in Good Condition
Syntax=“ROOF_TYPE” = ‘CORRUGATED’ AND “BRF STATUS” = ‘GOOD’

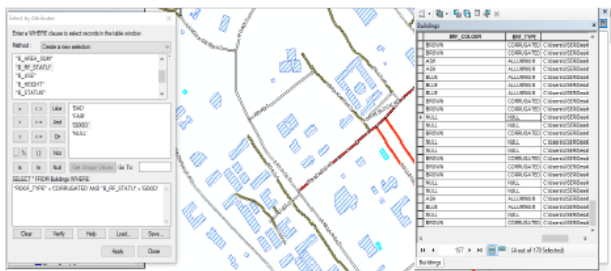


Fig 13: Query Showing Buildings with Corrugated Roofs in Good Condition
Corrugated Roof in Fair Condition
Syntax=“ROOF_TYPE”=‘CORRUGATED’AND“BRF_STATUS” =‘FAIR’



Fig 14: Query Showing Buildings with Corrugated Roofs in Fair Condition
Corrugated Roof in Bad Condition
Syntax=“ROOF_TYPE” = ‘CORRUGATED’ AND “BRF_STATUS” = ‘BAD’

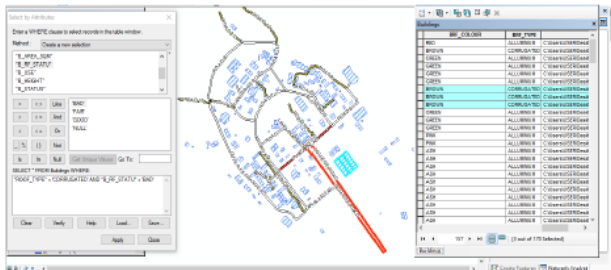


Fig 15: Query Showing Building with Corrugated Roofs in Bad Condition
All Buildings
Syntax=B_ID >= 1

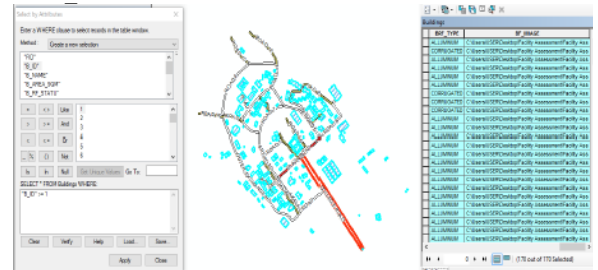


Fig 16: Query showing all Buildings in the Study Area

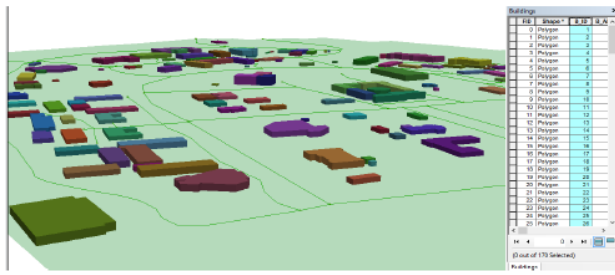


Fig 17: Query showing the 3D view of buildings in the study area Buildings with Aluminum Roof Syntax="ROOF_TYPE" = 'Aluminum'

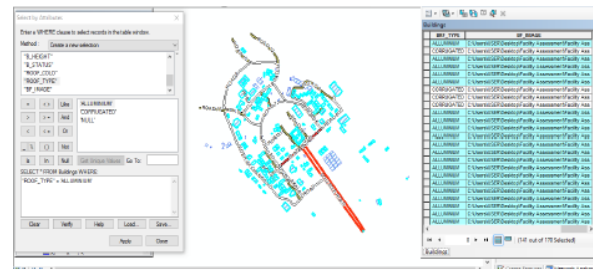


Fig 18: Query showing all Buildings with Aluminum Roof

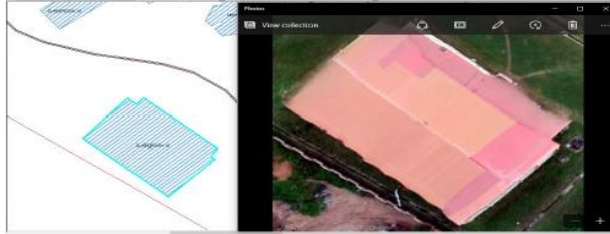


Fig. 19: Query Showing hyperlink of Image of a Building with Aluminum Roof Buildings with Corrugated Roof Syntax="ROOF_TYPE" = 'Corrugated'

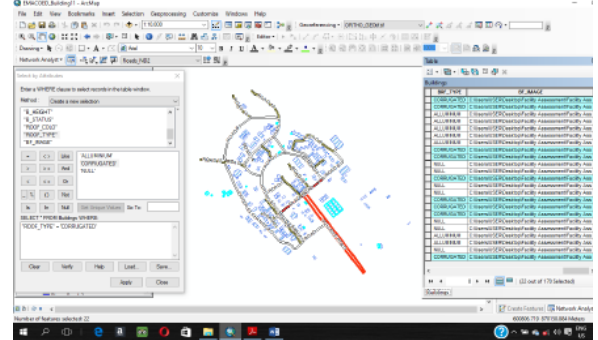


Fig.20: Query showing all Buildings with Corrugated Roof

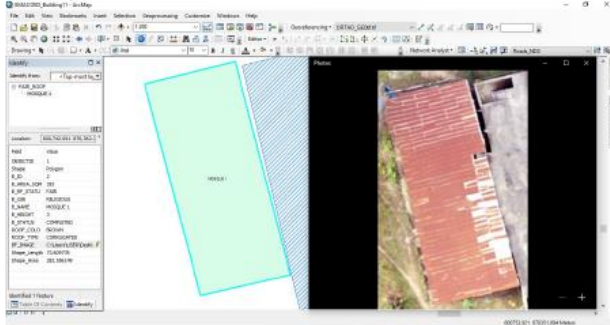


Fig.21: Query Showing hyperlink of Image of a Building with Corrugated Roof Buildings without Roof Syntax: "ROOF_TYPE" = 'NULL'

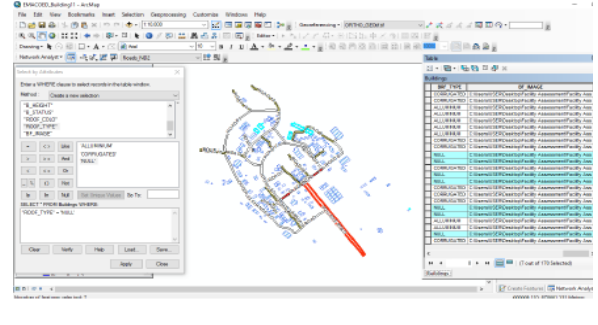


Fig.22: Query showing all the Buildings without Roof

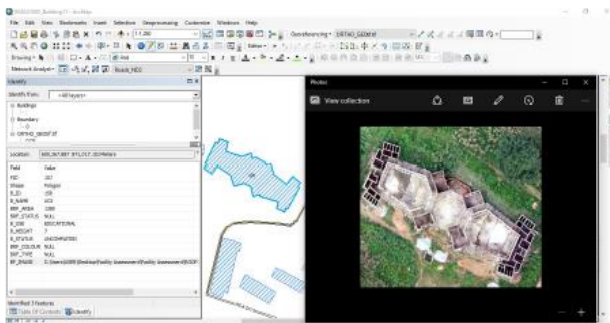


Fig.23: Query Showing hyperlink of Image of a Building without Roof

Conclusion

From the result obtained from this study, it is vividly deduced that, there are numerous ways of solving geospatial problems and supporting decision-making. The building roof assessment and mapping of Emmanuel Alayande College of Education was carried through remote sensing and GIS techniques involving UAV and

terrestrial data acquisition, processing, spatial analysis and map production. The project was executed by establishing ground control points, acquiring image data, processing image data, georeferencing and vectorization, as well as producing the desirables. The orthomosaic was digitized to generate features of interest. More so, ground trothing, updating, linking of attribute data with geometric data, spatial analysis and map production were done. The

database creation and management was done using ArcGIS 10.3. This study has shown that archived information and detection of infrastructural faults on the building can really paved a way geospatially in solving problem relating to building.

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