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Map revision of Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria

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Abstract

Day-to-day changes in physical environment due to both natural events and human activities require regular documentation in form of map for planning an optimum allocation of limited resources. This study acquired and digitized the orthophoto and satellite imagery of Obafemi Awolowo University; updated the existing map based on the identified features on the satellite imagery and ground survey method; created a GIS database and analyzed the various changes found in the study area. Primary and secondary data were used for the study. Global Positioning System (GPS) Receiver was used to capture newly constructed buildings that were not found on the satellite imagery. The secondary data used were data derived from existing orthophoto, base map of the study area and satellite imagery. A conceptual model for map revision was developed and implemented. The source maps were digitized, layers such as road, river and buildings were created and analysis was performed by overlaying these layers. New features were added, features that no longer exist were deleted and changed features were amended to reflect the new situation. GIS database, comprising both geometric and attribute data, was created. The study revealed that percentages of the newly constructed buildings between the year 2012 and 2021 and that of the demolished buildings were calculated to be 17.34% and 11.27% respectively. Analysis also showed that there was tremendous infrastructural development in the study area in terms of road and building construction. The up-dated Obafemi Awolowo University map was produced at the same scale as that of the source map, 1:25000. It is concluded that high-resolution satellite imagery and Differential Global Positioning System (DGPS) observation are effective and efficient methods of updating map. The results of this study will facilitate rapid decision making and enhance planning of facilities in future development of Obafemi Awolowo University, Ile- Ife.

Keywords: Geographic Information System (GIS); Mapping; Map Revision; Remote Sensing

Introduction

A map is a symbolized representation of geographic reality, representing selected features or characteristics, resulting from the creative effort of its author's execution of choices, and is designed for use when spatial relationships are of primary relevance (ICA, 2003). Map revision is the process of identifying and surveying all changing features on the map (as soon as they occur) and making the information available to the map user. Naturally, it includes both deletions from and additions to the existing map (Walker, 1984).

The concept of revision is to keep all published maps up-to-date with complete and accurate records of natural and artificial changes that have taken place in the environment; thus, making maps preserve their usefulness. The task of map revision can be quite immense notably in areas where changes are likely to be extensive and rapid, majorly in urban and highly developed areas. Up-to-date map is a necessary requirement for informed decision in a dynamic environment. Geospatial data play an important role in an estimated 80% of our daily decisions (Heipke *et al.,* 2008) and in various urban planning activities.

Map revision and update were traditionally done by conventional surveying method using analogue equipment (Egbu, 2018) and it takes time considering the period spent on the data collection, processing and production. This conventional method is slow and cumbersome and it is very costly to the extent that continuous national mapping remains far beyond the realms of affordability for countries (Sadeghi *et al.,* 2007).

Regular updating of printed products is not always practicable because of the cost and time involved however, digital maps are so easily modified that they can be revised as frequently as one wishes (Msemakweli and Lyimo, 2000). The computer technology has brought a lot of improvement to the traditional approach of acquiring, processing and presentation of map.

Egbu (2018) noted that computer technology has brought a revolution into digital conversion (revision and updating of maps) through the application of Geographic Information System. Digital maps have opened up a whole new range of possibilities and the manner of utilization of maps has changed over time. Because features are stored as layers in computer files, changes to the content and extent of a map can be made more easily. The entire map-making process is now more automated and interactive.

The available existing map of Obafemi Awolowo University, Ile-Ife, was updated with SPOT-XS image in 2002. Based on the reconnaissance and ground truthing exercise carried out at the study area, it was discovered that significant physical developments have occurred between the year the map was last updated and the present moment. The map does not reflect present environmental development; therefore, no new information can readily be retrieved from it. This prevailing situation often result into unjustifiable selection of project sites and inappropriate distribution of meagre resources within the university estate. The effect is worse when there are misleading base data or non-available data to guide experts during planning and construction of developmental projects. Moreover, because the available map is static and cannot be viewed in real time, the Physical Planning and Development Unit (PPDU) of the OAU, saddled with the responsibility of planning of the University projects is hampered by the lack of up-to-date map, hence the map revision of Obafemi Awolowo University (OAU) Ile-Ife examined in this work.

There are three prominent approaches to map revision viz Photogrammetric, Satellite techniques and Ground survey methods. Digital photogrammetry is the most adopted technique for city maps production. But if there is no photo flight plane available in the country, aerial photogrammetry becomes time consuming and expensive (Yasser, 2012).

Satellite remote sensing technique has comparative advantages in terms of costs, repetitive coverage of the area of interest and accessibility to the terrain features (Sadeghi *et al.,* 2007). Ground survey method is more useful and economical for revision of large-scale maps but it is impractical for small-scale maps. The method has the advantage of enabling the observation of information directly from the ground measurements instead of an image, but has the disadvantage of being time consuming and costly in term of manpower required to capture the data (Msemakweli and Lyimo, 2000).

Technological intervention has brought a great improvement to the process of map preparation and revision of both small- and large-scale maps. In addition, the advancement in technology ushered in the era of big data where volume of earth data has to be acquired, analysed and decision taken in real time. With this development, the traditional approach to map making no longer posed any threat as regards time, cost and manpower requirements. Furthermore, integrated approach that facilitates the combination of remote sensing data and traditional survey method, enables the production of hybrid map (Tuladhar, 2005; Ali *et al.*, 2012; Parida *et al.,* 2014).

Though there are maps produced purely from satellite remote sensing data, the hybrid map provides optimal combination of the multisource dataset in an efficient manner serving as an effective tool for revision of map. Parida *et al.,* (2014) demonstrated the efficacy of a hybrid methodology for cadastral resurvey and updating on a very small parcel of land in Pitambarpur Sasana village in India. They discovered that 79 % of plots derived by high-tech survey method show acceptable level of accuracy despite the fact that the mode of area measurement by ground and automated method has significant variability. They proposed that the methodology can be extended to larger areas for updating and cadastral resurvey. This research advances the work of Parida et al (2014) and integrates both traditional and modern method of data acquisition in a GIS environment to manage the rapid growth and changes in the environments.

High resolution images from satellites such as IKONOS and QuickBird have been deployed in the mapping and surveillance of extremely inaccessible areas, for instance areas of military conflict, such as Afghanistan and Iraq (Holland and Marshall, 2004). Such images have also been used to update maps, or generate completely new maps, in many areas of the world, including Saudi Arabia, Indonesia and Alaska where tradition mapping technique is not effective (Mandeville, 2001; Alrajhi, *et a.l,* 2016).

Dansena *et al.,* (2022) carried out an assessment of the capabilities of increasing spatial resolutions of satellite imagery and hybrid survey systems for the updating and resurvey of land information, such as land parcel size and their real earth position. The study compared chain and tape surveying, traditional survey methods with High Resolution Satellite Image (HRSI)-based surveying. They assessed the accuracy of three different methods for comparing land information viz: old traditional method of land surveying, conversion of hard copies of cadastral maps into digitized maps using computer-aided technique and improvised ortho-HRSI-based geospatial technology. In this research, no comparison was made rather both traditional and modern method of data acquisition, that is, conversion of hard copies of cadastral maps into digitized maps using computer-aided technique and improvised ortho-HRSI-based geospatial technology, in a GIS environment to manage the rapid growth and changes in the environments were integrated.

Geoinformation methodology is based on integration of global positioning system (GPS), remote sensing (RS), and digital photography including existing maps or document for spatial data acquisition (Tuladhar, 2005). Nearly similar integrated approach was adopted in both rural and urban regions of Pakistan. Ali *et al.,* (2012) integrated global positioning system (GPS) data, remote sensing (RS) imagery, and existing cadastral maps. The panchromatic image with 0.6 m spatial resolution and the corresponding multi-spectral image with 2.4 m spatial resolution and 3 spectral bands from QuickBird satellite were ortho-rectified and fused together. The approach was found to be efficient in updating cadastral data with less time and cost.

Some other potential uses of satellite imagery as demonstrated by various researchers are highlighted below. Mozgovoy *et al.,* (2018) carried out map updating using an automated approach to monitor anthropogenic changes in waterbodies and vegetation of sub-meter spatial resolution of the visible and infrared bands. The approach was tested in Mentougou – the suburb of Beijing, one of the largest and dynamically developing megacities of China. Vegetation and water bodies were identified on satellite images by automation. By processing multispectral images from the satellite SuperView-1A, vector layers of the identified objects were produced. Their research suggested that map of large cities with high spatial resolution can be updated by automation while reducing financial costs. While their work focused on vegetation and water bodies, this research focuses mainly on built-up areas within a university campus.

Zhang *et al* (2019) mapped changes in Whuan, China using deep learning-based methods on very high resolution (VHR) remote sensing images. By using an existing GIS map, their research was able to avoid the subjective and data-dependent setting of thresholds, which had always been a problem in change detection approaches. Classification and extraction of features from VHR images were done using full Atrous convolutional neural network (FACNN). Both polygon-based and object-based change detection accuracy were investigated. The results showed that object-based change detection produce better result than a pixel-based method and provide accurate change maps for urban land cover updating. In this research object-based change detection was also employed to validate the assertion.

Geospatial database is an important component in the process of map revision. Databases need to be designed with great care, and to be structured and indexed to provide efficient query and transaction performance. Geospatial database is a structured spatial dataset based on vector, tessellation or object-oriented data model and implemented by relational, network, hierarchic, object-oriented or object-relational data structure. It is the heart of GIS (Kufoniyi, 2010).

Database design follows three (3) levels of real-world entities and their relationships. These are Conceptual, Logical and Physical Design phases. Conceptual Design presents human conceptualization of reality in a simplified manner to meet the information requirement of the application (Kufoniyi, 1998). At this level, the basic entities, the spatial relationships among the entities and the attribute of each entity that support the database is designed. Logical Design aspect of the database translates the conceptual data model to the chosen generic logical model to obtain a data structure (Kufoniyi, 1998) . Physical Design translates the real-world entities into the computer compatible form of the chosen structuring model such as relational, geo-relational, network, and hierarchical. In this work, relational structuring method was used due to its easy implementation and management. All geospatial and non-spatial (attribute) data were structured to form a database in a format acceptable by the implementing software and hardware.

Database creation has successfully been employed in criminal investigation (Krimsky and Simoncelli, 2010), tenement rating (Oluwadare & Olatoye, 2014), street map revision (Udoh and Igbokwe, 2014), hazard vulnerability and flood risk mapping (FEMA, 2019) among others. In this research, database creation was employed majorly to revise and update the existing map of the study area.

Accurate analysis of map elements provides a good basis for decision making and policy formulation. Kufoniyi (1998) noted that geographic analysis gives the opportunity to study and understand real world processes by developing and applying manipulation, analysis criteria and models and to carryout integrated modeling. GIS enhances this process by providing tools, which can be combined in meaningful sequence to reveal new or previously unidentified relationships within or between data sets, thus increasing better understanding of the real world.

The effectiveness of a map and its database is subject to a number of spatial queries and network analyses. Planning of future development through GIS mapping and spatial analysis of ecological phenomena and land use was demonstrated by Bauer (2006). In another dimension, Elfadaly & Lasaponara (2019) carried out optimized hotspot analysis for calculating the pattern of spatial distribution to point out that the changes in the urban areas between 1998 and 2018 were more random and unplanned in the case of Alexandria than in the Baia study area. They carried out cluster and outlier analysis to capture clusterization and randomness of the observed urban distribution. Rhyma *et al.,* (2016) carried out map analysis to extract as much information as possible from the images and to provide accurate information to facilitate conservation planning and policy-making. In this research, spatial queries on the uses, location, extent of existing and existed features are easily determined as captured in the database.

The Study Area

This work covers the main campus of Obafemi Awolowo University (OAU) Ile-Ife. The choice of the university for the study was occasioned by the rate at which developmental

projects are being executed at the campus. In addition, the strategic position occupied by the university in terms of longevity and vastness justifies the choice for investigation. OAU is one of the first-generation universities in Nigeria the result obtained through the study can be replicated in other universities in the country with similar characteristics. Features within the university estate (such as buildings, fields, water bodies and roads) were captured with their attributes that is, name, class, type, size and position of points.
A map of 1:25,000 scale was produced. This paper took into consideration both the artificial and natural changes in the old map.

Methodology
The framework for methodology includes reconnaissance survey, data acquisition, data conversion, database creation, data analysis and data presentation.
The changes recognized on the satellite imagery were saved as Keyhole Markup Language (KML) and were imported into ArcMap Software by converting the KML to Layer. The layers were thereafter converted into shapefiles.
Likewise, the resulting positions acquired from DGPS observation were added as a table in comma-separated values (csv) format. The table was imported into the ArcMap Software as a layer. Minna Datum was the adopted reference system for the GPS observation. This was projected to World Geodetic System 1984 (WGS 84) and the layer was thereafter converted into shapefile. A thorough check was conducted to ensure that all the features in the study area are correctly classified.
Figure 1 shows the vector conceptual model whereby settlements and car parks were represented as point object, roads, streams as linear (line) features while boundary, buildings, waterbody and fields were represented as polygon. In designing the database, entity relationship (E-R) model was used. An entity-relationship (ER) model is a specialized graphic that illustrates the relationships between entities in a database (Watt and Eng, 2014).

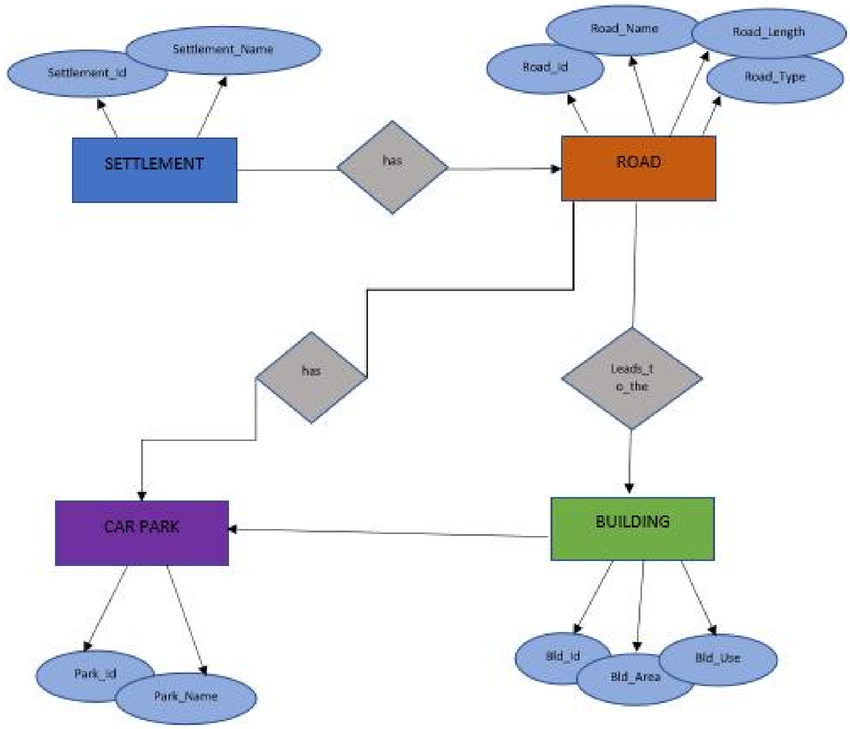

Figure 1: Conceptual database design (Source: Salimon, 2021)

Figure 2 shows the Entity Relational diagram comprising five entities – Country, District, Block, Parcel and Building. Relationships between two entities are linked by arrows, indicating that an entity has or is in another entity. For example, the arrow from Parcel pointing to Building shows that the Parcel has Building. The attributes of entities are represented by the diamonds and are shown linked to the entities by arrows. For example, attributes of parcel, like status and use, are represented with diamonds and are linked to the parcel entity by arrows pointing to the entity itself.

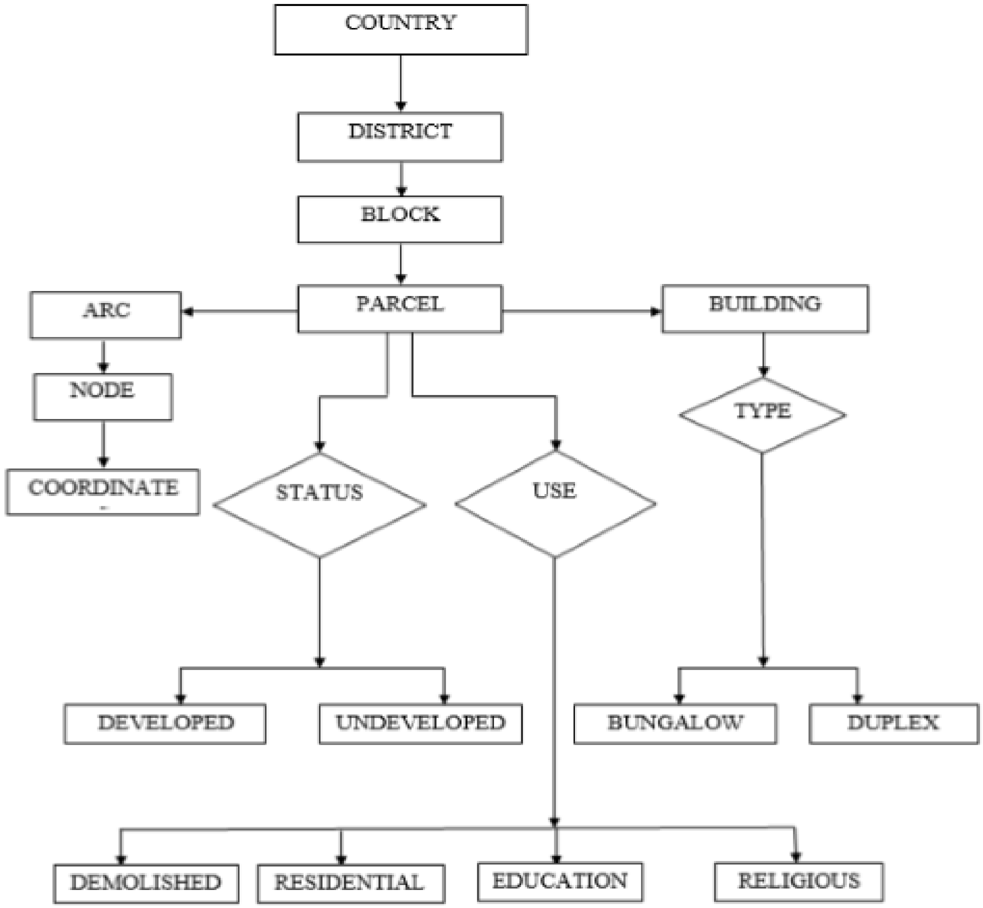

Figure 2: Entity relational diagram of a parcel-based information system. (Source: Adapted from Emengini *et al.,* (2017)

Data Requirements

The data used for this work were principally the existing map of Obafemi Awolowo University (Appendix A) and the orthophoto of Obafemi Awolowo University (Appendix B), showing the features available as at the time they were produced. Other necessary data were obtained from the space imagery and field observation.

Both primary and secondary data were used for this study.

Primary Data and Sources

The primary data used for the project were the coordinates of the existing features on OAU campus obtained with the aid of Geographic Positioning System (GPS) Receiver.

Secondary Data and Sources

Secondary data were the coordinates derived from already existing map and imagery of the study area. These secondary data sources included Orthophoto and Google earth imagery. The Orthophoto was used for reconnaissance, while Google Earth Imagery downloaded from the website of the Google Earth Explorer provided missing details in the existing map.

Table 1: Data Requirements (Source: Salimon, 2021)

Type of data required	**Data source**	**Reference system/ Datum**	**Purpose**	**Scale/ Resolution**	**Date**
Existing map	Physical Planning and Development Unit (PPDU) and Geography Department of Obafemi Awolowo University, Ile-Ife.	WGS 84	Reference	1:25000	2002
Orthophoto	Office of the Surveyor-General, Osun State	WGS 84	Feature extraction		2012
Google earth imagery	Google earth	WGS 84	To update the study area	15cm	2020
DGPS Coordinates	GPS observation	WGS 84	To determine position of points.		2021

Both hardware and software were used for spatial data collection and processing of data. The hardware used for the study are: Differential Global Positioning System (DGPS); computer and scanner. Software used for the study are: ArcGIS 10.3; Microsoft Excel 2016 and Google earth.

Results and Discussion

Information Extraction

The orthophoto used as the existing data was acquired in 2012 and the satellite imagery used for the map was captured in 2020. Features like roads, water courses, buildings,

settlements and car parks were extracted and digitized from orthophoto and the satellite imagery of the study area using GIS tools. The digitized features from the orthophoto were overlaid on satellite image and this enabled the identification of demolished and newly constructed structures. The orthophoto enabled a sharp contrast between the existing features and the new features during overlay using GIS software. The overlay made the extraction of features easier (Figure 3).
Due to non-static nature of physical development, some structures which were constructed after satellite imagery, acquired in December 2020, were captured using ground survey method.

Observation of Building Positions by GPS Observation
Differential Global Positioning System (DGPS) was adopted to capture the recently erected structures. GPS observation was carried out using Promark 3 in stop-and-go mode using 15secs at every selected building corner. The adopted reference system was Minna datum and the observed data were later converted to World Geodetic System 1984 (WGS 84). Since the three combined methods were in the same coordinate system, it was easy to plot the positions of the newly constructed structures on the existing map.
The coordinates were processed and adjusted using GNSS solution software. The average mean deviation of position of building was ±0.30m in the horizontal plane, while that of the vertical plane was ±0.46m. Little attention was placed on the deviation in vertical position because height was not used in the final compilation of the map. The average mean position of ±0.30m is sufficient for the 3rd order requirement of this map revision.

Ground Truthing
To ensure a high fidelity of details content of the map, extensive field completion and verification were carried out. This was done using physical field inspection in making use of the printed copy of the orthophoto. The field completion carried out was to obtain the names of all settlements on the map, classify the road networks, obtain names of rivers and carry out the addition or deletion of natural, cultural and infrastructural details as enumerated above. Three classes of settlements were found (hostels, academic arena and the staff quarters) within the study area. In the same vein, roads were classified into two (paved and unpaved). The major river detected in the study area was Opa river that flows into Opa Dam, which is the major source of water supply for the University community.

Change Intelligence
Although the main duty of a mapping agency is to update geospatial data, such data cannot be updated unless it is known where topographic change has taken place. Therefore, change intelligence forms a very important part of the map revision process (Holland and Marshall, 2004). Local observation by surveyors in the field is one of the ways to identify changes. Imagery and physical inspection play an important role in direct observation and

notification of change.
The main types of change identified in the study area are building demolition; erection of new buildings; newly constructed car parks and footpaths alterations. Other changes are building boundary changes, building renovation, which sometimes affects shape, size and use. For instance, the old dental ward originally occupied by the Department of Dentistry had been converted for another purpose, due to relocation of the Department to their permanent site at the Teaching Hospital Complex.

Overlay Result
The result of the overlay of all the data is as shown in Figure 3. The structures in yellow represent the buildings identified on the orthophoto, the structures in black represent demolished buildings, the structures depicted in blue represent the buildings identified on the satellite imagery and the red-coloured structures represent the buildings captured during DGPS observation.

Figure 3: Orthophoto of part of the study area showing the overlay result (Source: Salimon, 2021)

Evaluation of the Change Detection
Several changes took place within the period of acquisition of orthophoto of the study area and 2021. Amongst the changes are the demolition of buildings and construction of new ones.
Out of the total changes that occurred between 2012 and 2021, demolished buildings accounted for 11.27% while the percentage of the newly constructed buildings was 17.34%. There is clear indication from the evaluation above that the rate at which newer buildings

are constructed is more than that of demolition due to development taking over and majorly to create a more conducive environment. Demolition of structures in Obafemi Awolowo University was low despite the fact that most of the buildings were constructed over six decades and this could be attributed to the quality of materials used and the integrity of builders at the period of construction. The major demolition that occurred between the period was at the old bukateria and the shops between Angola and Mozambique Hostels. This is necessary because the buildings at the old bukateria were temporary in nature (mainly sheds) and were constructed on a rocky and hilly terrain that neither enhance commercial activities nor promote the beauty of the landscape. They were therefore moved to a more suitable location. The higher percentage of newly constructed buildings could be as a result of the Tertiary trust fund (Tetfund) intervention that supported the university in the construction of new structures and completion of abandoned structures. Details of the updated map of the study area are presented in Appendix C.

The Old Bukateria was relocated to a more conducive and befitting environment while the Department of Music, Admin Extension and ICAN lecture theatre were constructed to replace the demolished Old Bukateria. Topography of the site for Old Bukateria and limited accessibility as a result of bad road could be responsible for the relocation to a fairly levelled terrain with good road and large space which could easily accommodate commercial activities. The Music Department now occupies a more serene environment where there is little or no interference from other activities on campus. In addition, the activities of the Music Department will not constitute sound pollution to others in academic arena.

Summary of Findings

The combination of Remote Sensing, GIS and ground survey methods was demonstrated in this study as an effective tool for revision of map. Identification, detection and extraction of polygon features (old and newly constructed buildings) was easy due to the combination of high-resolution satellite imagery and orthophoto in GIS environment. Abdelwahed *et al.,* (2011) attested to it that satellite imagery provides access to any location on the Earth's surface through the journeys it makes around the globe. Linear features such as roads and streams were also extracted easily, except in some places where the contrast was relatively low. However, the point features such as car parks were generalized on the image.

Ground survey method was employed based on the fact that the satellite imagery used for the update of the study area was last captured in December 2020, and since the development that took place from that time to when the map was made was countable. The method was found more useful and economical for revision of part of the study area. The data acquired from the ground survey were added to the existing digital mapping data. Both the planimetric and vertical accuracy obtained were good enough for revision of study area. This shows that field survey is also useful in digital map revision for large scales. For small areas, field methods are fast enough and relatively low cost. However, in addition to the

limitation of large-scale maps, the use of the method in remotely inaccessible areas will be a problem.
The analysis carried out in the study area revealed that the majority of newly constructed buildings were found at the central part, that is the academic area, of the university and this extended westward towards the student village where construction of hostels is in progress. Major part comprising the north eastern and western parts have vast land yet to be developed, except few settlements randomly and sparsely sited within these undeveloped areas (see Appendix C).

Conclusion

In this study, satellite imagery and DGPS observation were used to update the study area successfully. Updating of either digital or paper map can be achieved with the use of a high-resolution satellite imagery, ground survey method, photogrammetric method or the combination of the three.
This study produced a revised map of Obafemi Awolowo University, Ile-Ife Osun State. The simplicity, accuracy, versatility and the convenience associated with digital mapping, especially when addressing problems associated with map revisions, will charm all those associated with maps and map making.
From the results and analysis obtained from this study, it is shown that the percentage of the newly constructed buildings from 2012 to 2021 is greater than the percentage of the demolished buildings. It is concluded that hybrid approach of combining high-resolution satellite imagery and Differential Global Positioning System (DGPS) observation is apt for cost and time efficiency map updating.
The major problem that affects the use of satellite images for map revision lies in the huge size of satellite images, which makes the processing and storage of the data difficult, thereby reducing the information content of the resulting revision maps. The acceptable images should provide information content required for revision of maps.
Thus, the relevant stakeholders should adopt the use of remotely sensed data for map revision exercises; government should subsidize the cost of acquisition of high-resolution satellite imageries to facilitate regular map updating and provide adequate hardware and software for data acquisition, processing, storage and retrieval of remote sensing and GIS-compatible data.

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