

## **DEVELOPMENT OF A DIGITAL MAP FOR FEDERAL UNIVERSITY OF AGRICULTURE ABEOKUTA USING GEOGRAPHIC INFORMATION SYSTEM (GIS)**

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### **ABSTRACT**

Many cities encounter difficulties concerning navigation, resource distribution, and spatial organization as a result of the absence of a current, all-encompassing digital map. Our university campuses are similarly affected by these issues. This research presents the development and implementation of the Digital Map for the Federal University of Agriculture, Abeokuta (FUNAAB). The project addresses the challenges of navigating the university's large campus by creating a detailed digital map incorporating key features like buildings, roads, and landmarks. The platform offers search capabilities, real-time travel information, and accessibility options, aimed at improving the experience for students, staff, visitors, and prospective students. By utilizing Geographical Information System (GIS) technology, the map serves as a central resource for managing spatial data, aiding in better decision-making, resource management, and campus planning. The project seeks to solve the challenges faced by students in navigating the campus, especially the newly-admitted, visitors and investors alike. Utilizing a multi-faceted data collection approach incorporating high-resolution aerial photography, mobile Global Positioning System (GPS) mapping, and existing cartographic resources, the research developed an interactive web-based platform accessible via internet enabled devices. The system architecture integrates MongoDB for data management, Laravel for backend operations, and Flutter for mobile application development. The key components of the map include search, location selection, review places, view details and directions. It also outlines future improvements, such as ongoing data updates and additional features to support the university's sustainability efforts.

**Keywords:** Backend, MongoDB, spatial data, Mapping, FUNAAB, Campus Navigation.

### **INTRODUCTION**

In today's world, where data hold significant importance, the Geographic Information System (GIS) has become essential for analyzing and understanding spatial data, enabling informed decision-making across various fields (Roy *et al.*, 2024; Akindote *et al.*, 2023). These systems allow us to gather, store, analyze, and visualize geospatial information, which in turn supports decision-

making across various fields like urban planning and environmental conservation (Ali *et al.*, 2024). The GIS is a type of information system where the data is based on observations of spatial features, activities, or events that can be mapped as points, lines, or areas (Doumit, 2025). It helps us manipulate these data, making it easier to ask specific questions and get meaningful answers by storing and displaying both spatial and non-spatial

information. Integration of the Geographic Information Systems (GIS) in the development of digital maps has become a critical tool for spatial analysis and management in educational institutions. The process of mapping the Earth accurately was, until recently, the preserve of highly skilled, well equipped, and organized individuals and groups. 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 (Madhu *et al.*, 2023). The Federal University of Agriculture, Abeokuta (FUNAAB), serves as a prime example where GIS can enhance campus navigation, resource management, and facility planning. FUNAAB is well-known for its academic achievements and focus on agricultural development in Nigeria. However, with an expanding campus and diverse structures, the need for an effective mapping solution has become imperative. The FUNAAB digital map project was created to address this need by developing a tailored GIS platform that acts as a central hub for all the University's geospatial data. This platform is designed to be user-friendly, providing easy access to data, and offering powerful visualization and analysis tools.

With the help of the GIS technology, students, staff and visitors can gain valuable insights into the campus layout, including land use, infrastructure, and environmental features. This project is crucial for improving campus management, resource allocation, planning, development, and overall decision-making. The FUNAAB digital map will offer stakeholders the tools needed to make informed decisions and foster collaboration with external partners. This research is a significant step forward in using the GIS technology to enhance spatial data

management at FUNAAB. This innovative platform will not only help navigate the university campus more effectively but also contribute to sustainability efforts and regional growth and development. GIS is now providing new tools for advanced ecosystem management. The collection of remotely sensed data facilitates the synoptic analyses of Earth - system function, patterning, and change at local, regional and global scale over time. Such data also provide an important link between intensive, localized ecological research and regional, national and international conservation and management of biological diversity. GIS with the use of Remote Sensed data can provide a general extensive synoptic coverage of large areas than aerial photography (Ufoegbune and Fabiyi, 2016; Adekunle and Isaac, 2021).

The wide availability of high-quality location information has enabled mass-market mapping based on affordable GPS receivers, home computers, and the Internet. Although a range of products based on user-generated mapping have emerged, example of an existing product in this area of study is Map IT which was developed in MS Visual Basic (Kang *et al.*, 2024; Huang *et al.*, 2024). Its principal functions are: editing cartography, geo-referencing, coordinate conversion, database association, topological operations (topological clean-up, union, intersect, identity, clipping, erase, buffer), raster operations, construction of advanced and/or personal symbology, and import/export in the most common formats (shp, dwg, dxf, mif, mid, and the cadastral ntf).

Research indicates that GIS offers significant advantages in mapping and spatial analysis, particularly in educational settings. According to Wang *et al.* (2018), GIS provides a platform for integrating various data sources,

enabling comprehensive spatial analyses that enhance decision-making processes. Application of GIS in University settings has been documented to facilitate better resource allocation, emergency response planning, and infrastructure development. In the context of FUNAAB, developing a digital map using GIS could streamline campus navigation for students and visitors, ensuring a more efficient use of University resources.

Studies have illustrated the role of digital mapping in promoting user engagement and interaction with geographical data. As noted by Zerdoumi *et al.* (2022), interactive digital maps allow users to visualize spatial information dynamically, making it easier to locate facilities, services, and resources. At FUNAAB, implementing such a digital map could improve user experience by providing real-time information about campus events, academic resources, and administrative offices. This enhancement in user engagement is crucial for fostering a sense of community and belonging among students and staff. The technical aspects of developing a digital map using GIS involve several stages, including data collection, processing, and visualization. Research by Chandel *et al.* (2024) emphasized the importance of accurate data collection methods, such as GPS and remote sensing, to ensure the reliability of the digital map. In the case of FUNAAB, utilizing comprehensive data collection strategies would help create a detailed and accurate representation of the campus layout, including buildings, roads, and natural features. This attention to detail is vital for the map's effectiveness and usability.

Sustainability and maintenance of digital maps are also critical factors that influence their long-term success. As highlighted by

Franchi *et al.* (2023), ongoing updates and user feedback are essential for maintaining the relevance and accuracy of GIS-based maps.

Prior studies have demonstrated the efficacy of GIS in enhancing location mapping and management within various contexts. For instance, a study by Patrick *et al.* (2024) highlighted the successful implementation of GIS for urban planning in Malaysia, showcasing how digital mapping can facilitate better decision-making and resource management. Similarly, Xiao *et al.* (2024) explored the application of GIS in optimizing public transport routes in urban areas, underscoring the technology's potential to improve accessibility and efficiency. In the context of educational institutions, previous research has often focused on the creation of digital maps to enhance campus navigation. A study by Al-Rawashdeh *et al.* (2025) developed a GIS-based framework for mapping university facilities, which significantly improved navigation for students and staff. The findings indicated that such systems not only enhance user experience but also optimize the use of campus resources.

The current work builds on these foundations by offering a tailored GIS solution specifically for the Federal University of Agriculture, Abeokuta. Unlike previous studies, this project is designed to incorporate real-time data and user-generated feedback, providing a dynamic mapping solution that evolves with the campus. The current study emphasizes user engagement through an interactive platform, aligning with the findings of Maroneddze *et al.* (2024), who noted that user participation is crucial in the development of effective GIS applications. By fostering an environment where students and staff can contribute to the mapping process,

the project not only enhances the accuracy of the data but also promotes a sense of ownership and responsibility among users. For FUNAAB, establishing a framework for regular updates and incorporating user input will ensure that the digital map remains a valuable resource for the University community. This proactive approach to map management will contribute to the continuous improvement of campus navigation and planning processes.

The development of a digital map for the Federal University of Agriculture, Abeokuta, using Geographic Information System (GIS) technology aims to enhance spatial awareness and accessibility on campus. By creating a comprehensive and interactive digital map, the project seeks to represent key features of the university, including buildings, roads, facilities, and green spaces. This mapping initiative is expected to provide a valuable resource for students, faculty, and administrators, making it easier to navigate the campus and access essential information.

Utilizing GIS technology, the project will analyze and visualize spatial data to identify patterns and relationships within the campus layout. This analysis will inform planning and development strategies, allowing the University to address current challenges and anticipate future needs. By integrating various data layers, the digital map will serve as a tool for decision-making, helping stakeholders to utilize campus resources more effectively and improve overall operational efficiency. The development of a digital map for the Federal University of Agriculture, Abeokuta, using GIS presents a significant opportunity to enhance campus management and user experience. Through the integration of accurate data, interactive fea-

tures, and a commitment to ongoing maintenance, FUNAAB can leverage GIS technology to foster a more accessible and efficient educational environment.

The objectives of the project were:

To capture and organize spatial data of the Federal University of Agriculture, Abeokuta (FUNAAB) using Geographic Information System (GIS) tools.

To map and digitize key infrastructures such as lecture halls, hostels, administrative offices, laboratories, roads, and recreational facilities within the university campus.

To create an interactive and user-friendly digital map that will aid students, staff, and visitors in easy navigation around the campus.

To provide a reliable geospatial database that can support academic research, planning, and administrative decision-making within the university.

To establish a foundation for future smart-campus applications, including resource management, safety planning, and infrastructure development.

## MATERIALS AND METHODS

### Study Area

The Federal University of Agriculture, Abeokuta is located in Alabata Road, Ogun State with about 10,000 hectares in land size. The student population according to the pocket statistics for 2020/2021 is put at 20,233. Geographically, FUNAAB lies at a longitude of  $7.10^{\circ}$  N and a latitude of  $3.2392^{\circ}$  E (Ojoawo *et al.*, 2021).

### Data

The FUNAAB digital map project relied on various types of geospatial data to create a comprehensive and informative digital map of the University campus.

The key primary and secondary data used

were:

**Basemap Data:** This is high-resolution aerial and satellite photography providing a base layer for the map, allowing users to visualize the overall layout of the campus and surrounding areas.

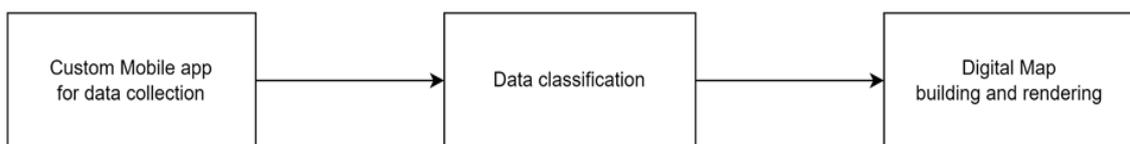
**Point-of-Interest (POI) Data:** The POI used for this research included: the locations and attributes of all buildings on campus, including academic buildings, administrative buildings, hostels and other facilities; spatial representation of academic Departments and programs within their respective building; locations of various campus facilities and amenities, such as libraries, laboratories, sports complexes, cafeterias, and healthcare centers; and information about roads, pathways, parking lots, and other transportation infrastructure within the campus.

**Additional Data Layers:** Data on the distribution of trees, shrubs, and other vegetation across the campus were used to advance the visual appeal of the map and to provide ecological insights. Information on accessible pathways, ramps, and other facili-

ties for people with disabilities was also incorporated into the map.

### Methods

A custom mobile app was built for designated officials to capture geospatial data, attribute information, and additional context (Figure 1). A high-resolution aerial photography that captured by a drone provided a comprehensive overview of the campus was taken. Existing data sources like campus maps were digitized to extract information about roads, buildings, and other infrastructure. To further enhance the map's representation, satellite imagery was classified into various land cover categories such as built-up areas, shrubs, forests, and water bodies. These data were integrated with the information collected through the mobile app, aerial photography, and digitization. The processed data were used to develop a user-friendly digital map accessible through a dedicated website (Figure 1). This multi-faceted approach ensured efficient data collection, accurate processing, and user-friendly map development, ultimately delivering a valuable resource for the FUNAAB community.



**Figure 1:** Three-pronged Approach for Data Collection and Map Development.

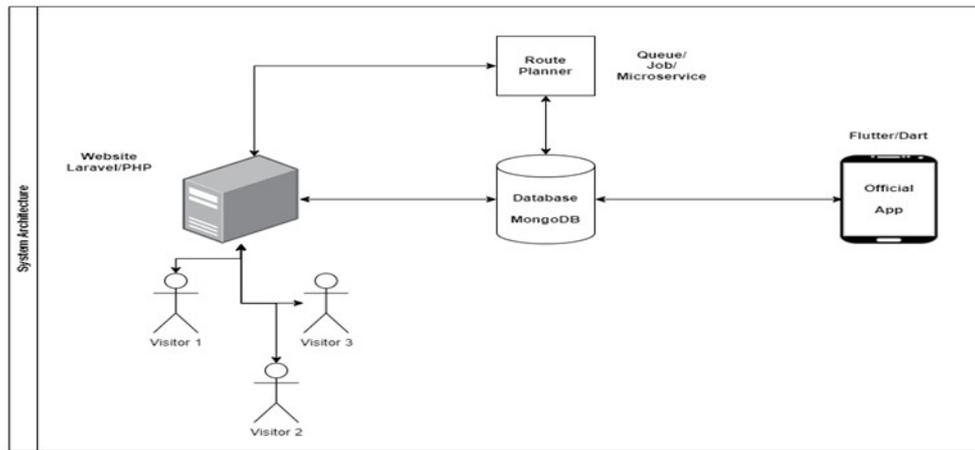
### Software development

The FUNAAB DIGITAL MAP project utilized a combination of Laravel, a Hypertext Preprocessor (PHP) framework, for the website. The backend and Flutter, a cross-platform development framework were used for the mobile application programme (Fig. 2). This hybrid approach leverages

Representational State Transfer (RESTful) Application Programming Interfaces (APIs) for efficient data exchange while enabling platform-specific functionalities. This offers various functionalities, including: cartographic editing, geospatial data management and advanced geospatial analysis. The mobile app integrated GPS capabilities, allowing users to

view their real-time location on the map, particularly valuable for navigating unfamiliar areas. This functionality is crucial for situations lacking readily available reference points. The software architecture of the digital mapping system comprised several key components that work together to provide a hiccup-free user experience. These components included a web server, a database, a mobile app for officials, and a route planner service. Visitors interact directly with the web server via their web browsers.

The web server, in turn, interacts with the MongoDB database through Transmission Control Protocol (TCP) to retrieve and store data. For routing requests, the web server communicates with the route planner service using Remote Procedure Call (RPC), which calculates the routes and returns the results. The route planner service and the mobile app for officials also interact with the database via TCP, ensuring that all components can read and write data as needed (Figure 2).



**Figure 2:** High-level software architecture of the FUNAAB digital map

### Database Design

The Geospatial data handling process contained a demand and supply processing of a phenomenon in the world, applying GPS technology to acquire survey data, creating a (relational) database via choice of a model at the conceptual level, and applying technology, (software & hardware) cum methodology on processing (analysis). The project utilized MongoDB, a robust NoSQL database management system, with Geojson extension for advanced geospatial functionalities. This database served as the central repository for all map-related information, including details about buildings, facilities, roads, points of interest, and other

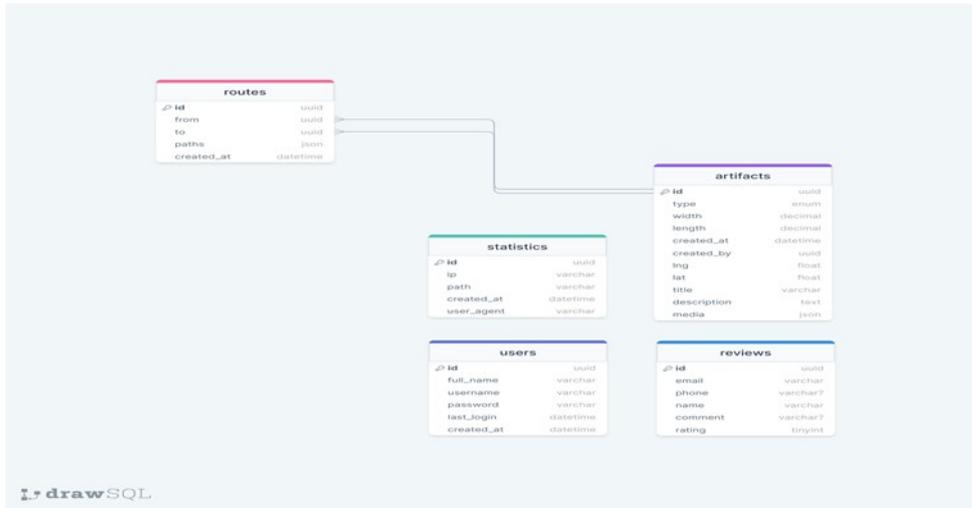
campus features. It also stores user information, access roles, and other relevant data. The Laravel backend interacts with the database to manage data retrieval, storage, and manipulation, ensuring seamless integration between the various components of the digital map system.

### Entity Relationship Diagram

An Entity-Relationship Diagram (ERD) is a pictorial representation of the entities within a system and the interrelations between these entities. It is a crucial component in database design, allowing for a clear and structured depiction of the data model. ERDs help in understanding the data requirements and the

interconnections between different data entities, facilitating efficient database schema creation. The primary benefits of using ERDs include improved communication between stakeholders, a clear blueprint for database design, and the ability to identify

potential issues early in the development process. By providing a detailed overview, ERDs help ensure data integrity and support effective data management strategies (Tao, 2023). The ERD for the software included five tables (Figure 3).



**Figure 3:** Entity Relationship Diagram for FUNAAB digital map.

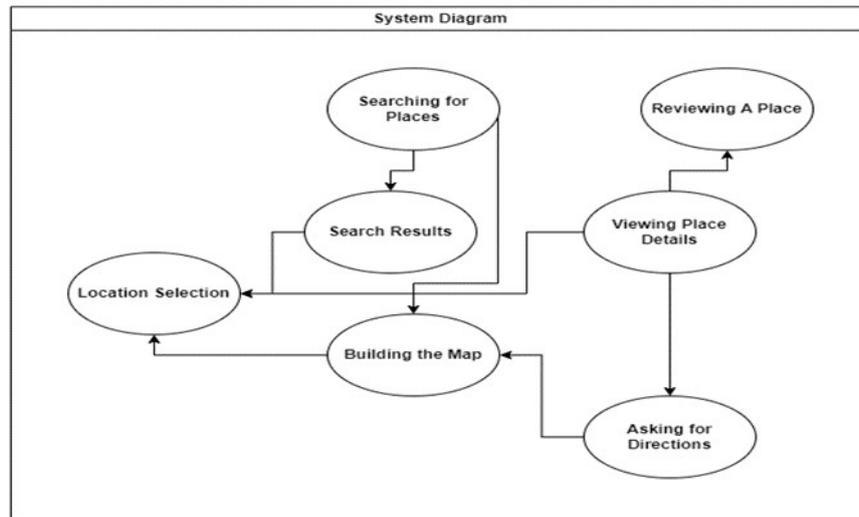
### System Design

The system design of the digital map application encompassed five key components and several crucial processes that collectively enabled the functionality of the platform. Each component and process played a significant role in ensuring the system is user-friendly, efficient, and effective in providing detailed and accurate mapping services (Figure 4).

### Key Components of the Map

The key components of the map were:

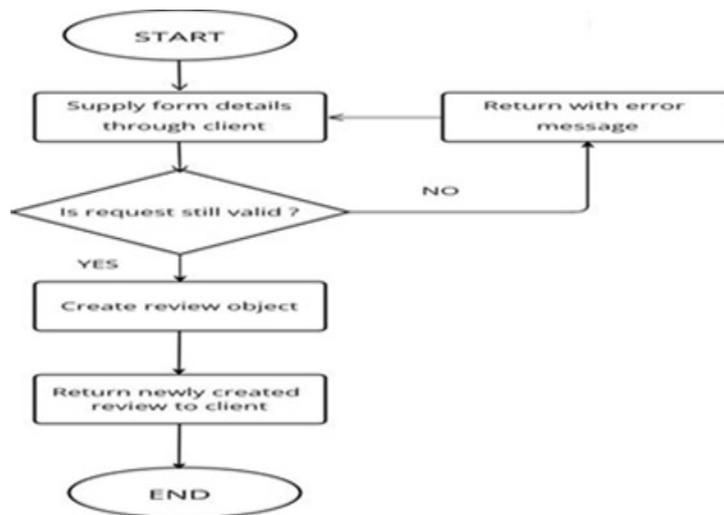
- Search - This component allows users to search for places using specific keywords.
- Location Selection - Users can select a particular location from the search results or directly from the map.
- Review Places - This feature enables users to view and add reviews for different places.
- Viewing Details - Users can view full details of a place, including media, descriptions, and names.
- Directions - This feature provides directions from one point to another.



**Figure 4: System Diagram**

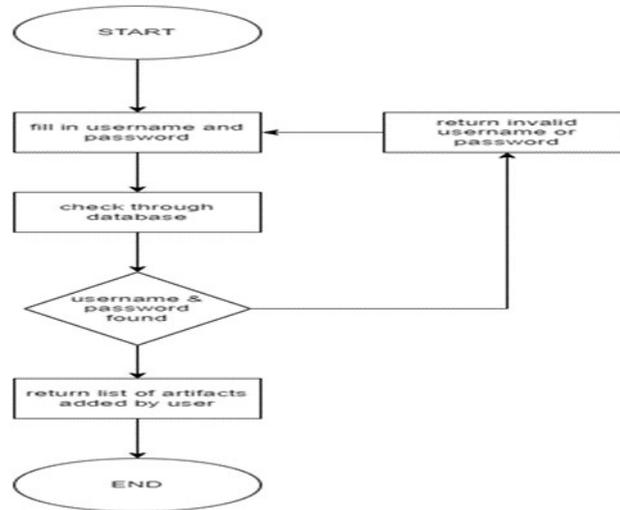
The flowchart outlines the process for handling a review submission from a client. It begins with the "START" node, where the client is prompted to supply the necessary form details (Figure 5). If the submitted request is found to be invalid, the system responds by returning an error message to the client. If the request is valid, the process

continues to create a review object. Once the review object is successfully created, it is returned to the client. The flowchart concludes with the "END" node, indicating the completion of the process. This structured approach ensures that only valid requests are processed, enhancing the overall user experience (Figure 5).



**Figure 5: Flowchart for the review process**

The Official Login Process includes: Filling of the username and password, these details will be checked in the database. If the username and password match, it will proceed; otherwise, an error message will be returned to the client (Figure 6).



**Figure 6: Flowchart for login process of the officials**

To obtain directions and render them on a map using Leaflet.js, the process begins by specifying the start and end locations (Figure 7). These inputs can be provided by the user through address inputs or by selecting points directly on the map, which are thereafter converted into geographic coordinates. Once the start and end points are established, the system checks if a corresponding route exists in the database's routes table. If a matching route is found, the stored path data is retrieved and set for display. In cases where no existing route is found, the system identifies the base location of the starting point; it then calculates a new route from this base to the destination using a routing service. The newly-computed route is saved into the database for future reference and set as the current path. To visualize the route, a polyline is drawn on the map using Leaflet.js, connecting the sequence of coordinates that define the path and is connected to the starting

and ending locations, providing a clear visual representation of the route on the map.

### Geo-referencing

The GPS generates universal transverse Mercator (UTM) coordinates, which will be used to geo-reference scanned images. This process links the scanned images to their actual ground representation by applying the point method, where identifiable ground points with GPS coordinates are matched to their corresponding locations on the map within the ILWIS environment.

### Data collection results

Comprehensive information were gathered from 80 buildings across the FUNAAB campus. Data collected included geographic locations, detailed descriptions of each building, internal structures such as the arrangement of offices and components, as well as high-resolution images and videos.



**Figure 7: Flowchart for getting directions**

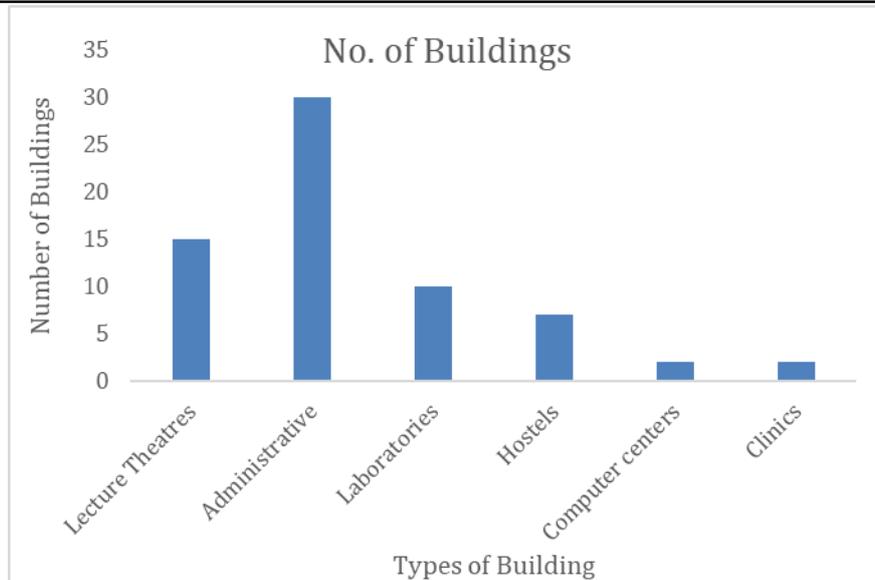
## RESULTS

To facilitate efficient searching and navigation on the digital map website, the build-

ings were grouped into six categories (Table 1); and building categories represented graphically using histogram (Figure 8).

**Table 1: Categories of Buildings Captured**

Building Type	No. of Buildings
Lecture Theatres	15
Administrative	30
Laboratories	10
Hostels	7
Computer centers	2
Clinics	2



**Figure 8: Histogram of buildings by category**

#### Data Collection Mobile App

The data collection process was enhanced by the custom mobile application developed using Flutter. The app was compiled in re-

lease mode and distributed to all members of the data collection team. It included a login page, an artifacts screen, and an add/edit artifact screen (Figure 9).



**Figure 9: Login page for data collection mobile application programme**

The artifacts screen, displays a list of all the buildings that have been added to the platform (Figure 10). These buildings are organized alphabetically, making it easy for team members to find and manage them. When a building tile is clicked, the app transitions to the edit screen, where users can update the

building's details. The add/edit screen, includes fields for entering the title, description, and type of the building, as well as options to add media files (images/videos) and a "Locate" button that utilizes GPS to pinpoint the building's location (Figure 11).



Figure 10. Artifacts list screen

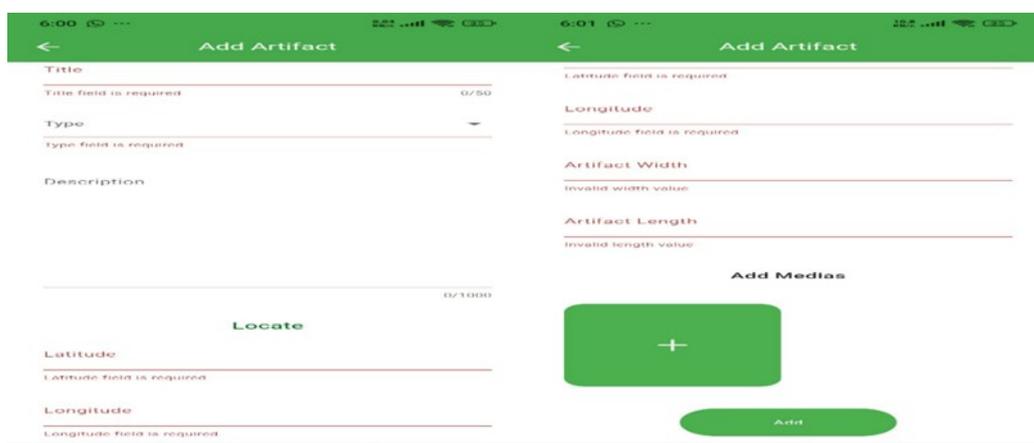


Figure 11: Add/Edit artifact screen

To ensure the data collected was well-structured and accessible, media files were uploaded to Cloudinary, and all building data were aggregated and formatted into GeoJSON before being uploaded to MongoDB. This approach streamlined the data management process and ensured that the information was consistently organized and readily available for integration into the digital map platform.

### Map Website

This component of this project serves as the digital interface that allows users to ac-

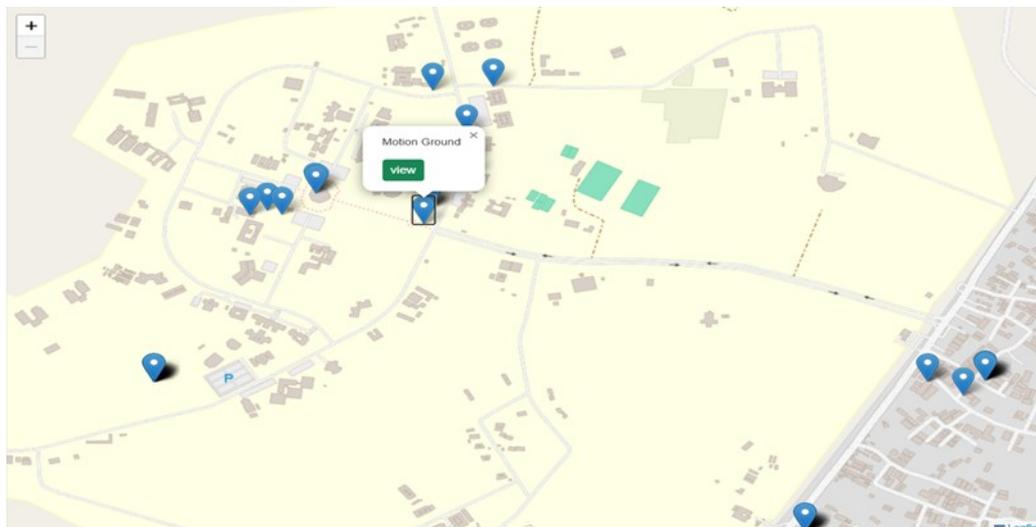
cess, explore, and interact with comprehensive mapping data for buildings and locations on the University campus. Built using Nuxt.js, the website incorporates several interactive features to facilitate navigation, location search, and data exploration in a user-friendly manner. The homepage displays a navigable map, designed to showcase various buildings and points of interest, each categorized based on structure type for easier access and usability. The website includes a responsive search feature, enabling users to find specific buildings or areas by typing keywords, as well as the ability to filter results by

building type, as specified in the data collection process. Users can also select individual map points to reveal detailed information, including descriptions, internal structures, and high-resolution images and videos stored on Cloudinary. Various views were obtainable from the map (Figures 12

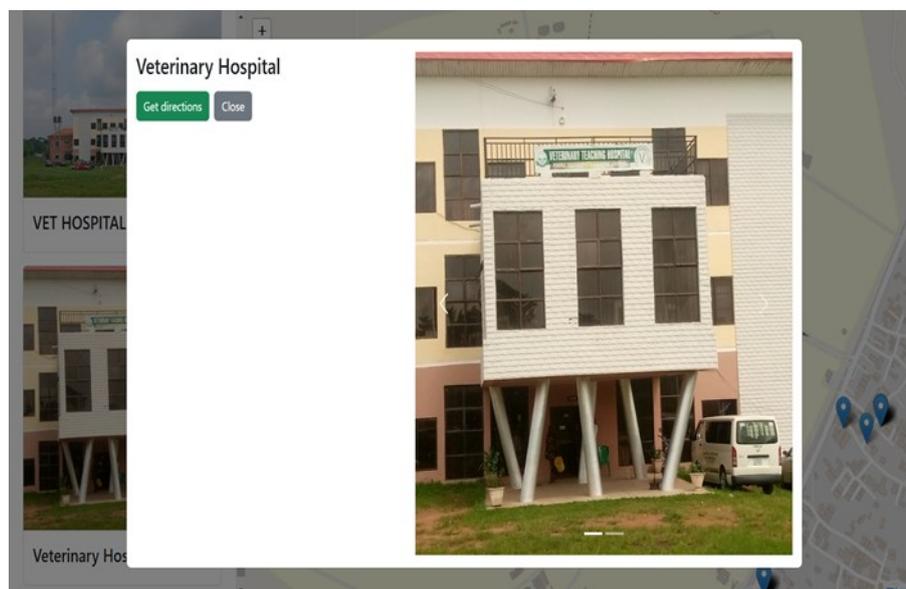
and 13). Once a building is selected, an information pane appears (Figure 14) and provides the user with a detailed breakdown, such as the building's specific coordinates, functions, and internal layout—data that had been formatted into GeoJSON and saved in MongoDB for easy retrieval.



**Figure 12: Homepage map of buildings and search functioning**



**Figure 13: Tooltip with information and view option for the selected map point**



**Figure 14: Building information pane with high resolution images**

The direction feature (Figure 15) allows users obtain paths from one building to another, utilizing route-planning algorithms that were preloaded in the system. This nav-

igational aspect is particularly valuable for first-time visitors to the campus or those unfamiliar with certain locations within the university.



**Figure 15: Direction feature on the map website: Works to Motion Ground by Cycling**

To enhance the visual experience, Leaflet.js and OpenStreetMap were integrated into the website to dynamically render map tiles and plot markers, with seamless zoom and pan functions for a more immersive experience.

## DISCUSSION

The development of a digital map for the Federal University of Agriculture, Abeokuta using Geographic Information System (GIS) technology represents a significant advance-

ment in campus management and navigation. This initiative addresses common challenges faced by educational institutions, such as ineffective resource allocation and insufficient spatial awareness among users. The importance of user experience in GIS applications cannot be overstated. Prior studies, such as those Gençtürk (2024), have emphasized that user-friendly interfaces and interactive features significantly boost user satisfaction and engagement. The digital map for the Federal University of Agriculture, Abeokuta incorporates intuitive navigation tools and easy access to information, which aligns with these findings. By allowing users to interact with the map through touch or voice commands, the system is designed to cater to a diverse user base, including students, staff, and visitors.

Another critical advancement in this project is the integration of real-time data. Previous works, like that of Dritsas and Trigka (2025), have illustrated the benefits of incorporating real-time updates in GIS applications, particularly in urban environments. For example, real-time traffic data can help users avoid congested areas, while live updates on facility availability can direct users to less crowded locations on campus. By implementing similar features, the digital map for the Federal University of Agriculture not only provides static information but also adapts to changing conditions, thereby enhancing its utility.

### CONCLUSION

The development of a digital map for the Federal University of Agriculture, Abeokuta, utilizing Geographic Information System (GIS) technology represents a transformative step in enhancing campus management and user engagement. This initiative not only addresses the immediate needs for effi-

cient navigation and resource allocation but also fosters a more interactive and accessible environment for students, staff, and visitors. The integration of accurate spatial data, combined with user-centric design, ensures that the digital map serves as a valuable tool for facilitating informed decision-making and improving the overall campus experience. The emphasis on regular updates and user feedback mechanisms will be crucial in maintaining the relevance and accuracy of the digital map over time. By establishing a sustainable framework for its management, FUNAAB can ensure that the map evolves in tandem with the University's growth and changing needs. This proactive approach will not only enhance operational efficiencies but also contribute to a sense of community and belonging among the university's stakeholders.

### RECOMMENDATION

Future research should focus on the implementation strategies for the digital map, exploring how best to engage users and integrate their feedback into ongoing developments. Investigations into the broader implications of GIS technology in educational institutions can also provide insights that extend beyond campus mapping, potentially influencing other areas such as emergency management, land use planning, and environmental sustainability. Ultimately, the successful deployment of a digital map at FUNAAB will serve as a model for other institutions seeking to harness the power of GIS to enhance their operational capabilities and enrich the educational experience.

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