GEOSPATIAL MAPPING AND VISUALIZATION OF ABIA STATE POLYTECHNIC, ABA, NIGERIA: A TOTAL STATION-BASED DIGITAL TERRAIN MODEL APPROACH

Njike CHIGBU, Francis Richard OTIA (Nigeria)

KEYWORDS: Geospatial Mapping, Visualization, Total Station Survey, Digital Terrain Model (DTM), 3D Modeling, Interactive Web Map.

SUMMARY

This work presents a novel approach to geospatial mapping and visualization of Abia State Polytechnic Campus 1 in Aba, Nigeria, with a particular focus on creating a Digital Terrain Model (DTM) using data acquired from a Total Station survey. The study leverages open-source Geographic Information System (GIS) tools, primarily QGIS, and integrates them with surveying techniques to generate a detailed and accurate representation of the campus topography. This work encompasses the following key components: data acquisition through total station surveys, data processing using QGIS and GRASS tools, and the development of an interactive map using the QGIS2WEB plugin. The interactive map enhances accessibility for students, staff, and visitors, allowing them to navigate the campus efficiently and access information through pictures popup functions. The study also highlights the significant advantages of total station-based DTM creation for accurate elevation modeling and showcases the practicality of open-source GIS software for mapping educational institutions. Additionally, it demonstrates the value of GitHub for hosting and sharing the interactive map and accompanying user guide, ensuring widespread accessibility and usability. Thus, this work is seeking to contribute to the growing body of knowledge in the fields of geospatial technology and provides a valuable case study for institutions seeking to enhance campus mapping, navigation, and information dissemination.

1.0 INTROUDUCTION

1.1 BACKGROUND AND CONTEXT OF THE STUDY

The modern landscape of academic institutions is ever-evolving, with a constant demand for improved infrastructure, navigation, and information accessibility. Abia State Polytechnic, situated in Aba, Nigeria, is no exception. This institution, like many others, faces the challenge of ensuring that its sprawling campus is efficiently mapped, that its terrain is accurately represented, and that the campus community can access essential information seamlessly.

Geospatial technology, particularly Geographic Information Systems (GIS) and surveying, has emerged as a powerful solution to address these challenges. This research project delves

into a comprehensive approach to geospatial mapping and visualization of the Abia State Polytechnic campus. It emphasizes the creation of a Digital Terrain Model (DTM) as a pivotal component, achieved through meticulous data acquisition using total station surveys and innovative data processing using open-source GIS tools.

The significance of this project extends beyond the confines of the academic environment. It exemplifies the use of open-source software and demonstrates the valuable integration of surveying and GIS for educational institutions. The utilization of GitHub as a platform for hosting and sharing the interactive map and user guide underscores the project's commitment to accessibility and usability.

The primary objective of this research is to provide a detailed account of the methodologies, techniques, and tools employed in the mapping and visualization of Abia State Polytechnic's campus. By doing so, this study contributes to the growing body of knowledge in the fields of geospatial technology and surveying. Furthermore, it serves as a case study for other institutions seeking to enhance campus mapping, navigation, and information dissemination.

As the journey into the geospatial transformation of Abia State Polytechnic unfolds, it is crucial to recognize the potential benefits and challenges that such endeavors present. This research aims to provide a holistic understanding of the process, from data acquisition to interactive mapping, enabling other institutions and researchers to leverage the findings for their own campus mapping projects. It is a testament to the adaptability and practicality of geospatial technology, showcasing its effectiveness in enhancing the academic experience.

1.2 RESEARCH AIM

The primary aim of this research project is to advance the geospatial mapping and visualization of Abia State Polytechnic, Aba, with a focus on creating an accurate and detailed representation of the campus terrain

1.3 RESEARCH OBJECTIVES

i. **To Create an Accurate Digital Terrain Model (DTM):** The central goal of this project is to employ total station surveys and open-source GIS tools, particularly QGIS and GRASS, to generate a precise Digital Terrain Model of the Abia State Polytechnic campus. This DTM will provide a detailed representation of the campus topography, enabling improved understanding and management of its physical landscape.

ii. **To Develop an Interactive Campus Map:** Utilizing the QGIS2WEB plugin and the leaflet.js mapping library, we aim to create an interactive campus map that enhances accessibility for students, faculty, staff, and visitors. This map will facilitate efficient navigation within the campus, offering an intuitive platform to access vital information and services.

iii. **To Produce a User Guide**: As an integral component of the project, we will develop a comprehensive user guide that accompanies the interactive map. This

guide will serve as an educational resource, offering insights into the map's functionality and purpose. It will also address the significance of open-source GIS tools and the methods employed in this project.

1.4 SIGNIFICANCE OF THE RESEARCH

The significance of this research is multifaceted:

i. **Enhancing Campus Accessibility:** By creating an interactive map and DTM, this project aims to enhance the accessibility of the Abia State Polytechnic campus. It offers a practical solution to the common challenge of navigating a large and complex educational institution. Students, staff, and visitors will benefit from improved way finding, fostering a more conducive academic environment.

ii. **Utilizing Open-Source GIS Tools:** This research highlights the advantages of open-source GIS tools, particularly QGIS and GRASS, in the context of educational institutions. It demonstrates that advanced geospatial technology is accessible without the need for costly proprietary software, thereby reducing financial barriers to implementation.

iii. **Contributing to Academic Research:** The project contributes to the body of knowledge in the fields of geospatial technology and surveying. It showcases the practical application of surveying techniques and GIS tools in an educational setting, offering insights for researchers, practitioners, and institutions interested in similar projects.

iv. **Sharing Best Practices:** By hosting the interactive map and user guide on GitHub, this research project exemplifies the sharing of best practices and open access principles. It enables other educational institutions to benefit from the project's findings and replicate the mapping and visualization process.

1.5 OVERVIEW OF ABIA STATE POLYTECHNIC, ABA, NIGERIA

i. Abia State Polytechnic, located in Aba, Abia State, Nigeria, is an institution of higher learning renowned for its commitment to academic excellence, technical education, and skill development. Founded with a vision to provide quality education that meets the demands of a dynamic world, the polytechnic has grown to become a pivotal center for learning, research, and innovation in the region.

ii. **Historical Perspective:** Established in response to the growing need for specialized technical and vocational education, Abia State Polytechnic has a rich historical legacy dating back to 1992 (Year Founded). Since its inception, the institution has continually evolved, expanding its academic programs and facilities to cater to a diverse and growing student body.

iii. **Academic Departments and Programs:** Abia State Polytechnic offers a broad spectrum of academic disciplines and programs designed to equip students with the knowledge and skills required to thrive in today's competitive job market. These programs span various fields, including engineering, computer science, business management, and the environmental sciences. They include: Surveying and

Geoinformatics, Urban and Regional Planning, Statistics, Science Laboratory Technology, Office Technology and Management, Public Administration, Quantitative Analysis, Mechanical Engineering in Technology, Estate Management and Valuation, Food Technology, Electrical and Electronic Engineering, Computer Science, Computer Engineering, Business Administration and Management, Chemical Engineering, Banking and finance, Architectural technology, and Accounting.

iv. **Campus Facilities:** The polytechnic boasts a modern and well-equipped campus, featuring state-of-the-art classrooms, laboratories, libraries, and administrative offices. The campus is not only a center for academic pursuits but also a dynamic hub for extracurricular activities, fostering a holistic learning environment.

v. **Research and Innovation:** Abia State Polytechnic places a strong emphasis on research and innovation. Faculty members and students engage in research projects that contribute to the advancement of knowledge and the development of practical solutions to real-world challenges. The institution's commitment to research aligns with its vision of promoting technology-driven education.

vi. **Student Life:** The polytechnic prides itself on offering a vibrant and inclusive student life. Students have the opportunity to engage in various clubs, organizations, and social activities, enhancing their overall academic experience.

vii. **Vision and Mission:** At the core of Abia State Polytechnic's mission is the dedication to fostering a learning environment that empowers individuals to realize their potential and make a positive impact on society. The institution's vision is to be a leading center of academic excellence, research, and innovation in Nigeria and its slogan is "*Excellence in Technology*".

viii. **Role in the Region:** Abia State Polytechnic plays a pivotal role in the socio-economic development of Abia State and the surrounding regions. It serves as a training ground for a skilled workforce, contributing to local and national development initiatives.

ix. In summary, Abia State Polytechnic serves as the backdrop for this research project, symbolizing the importance of advancing the geospatial mapping and visualization of educational institutions. The polytechnic's commitment to academic excellence and innovation aligns with the goals of this study, which seeks to enhance accessibility, promote open-source GIS tools, and contribute to academic knowledge in the field of geospatial technology.

1.6 STUDY AREA

This project was carried out in Abia state Polytechnic Main Campus, Aba, Abia State. Geographically positioned at latitude 5 ° 7' 35.72" to 5 ° 7' 46.45", longitude 7 ° 21' 37.44" to 7 ° 21' 54.97" and 566889.431 to 567218.840 mN, 318254.865 to 318794.967 mE in UTM (Zone 32N) Coordinate System). The total area covered is 90151.698 Square Metres, 9.015 Hectares.

1.7 LOCATION MAPS

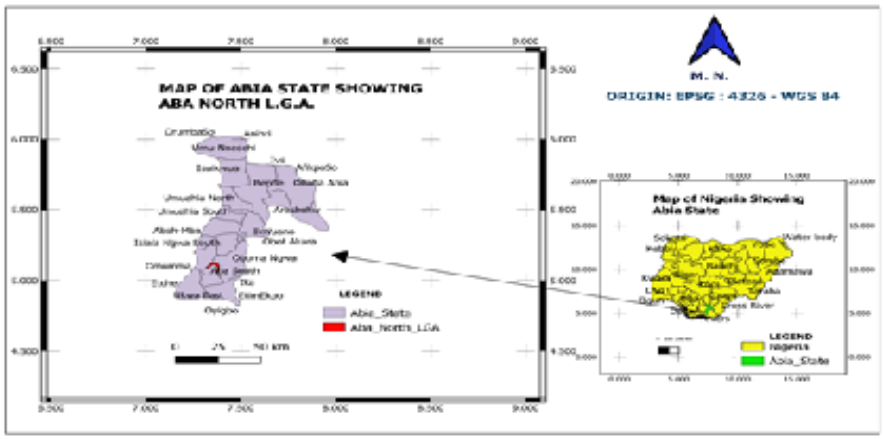

Figure 1.1: Map of Nigeria Showing Abia State with Map of Abia State Showing Aba North L.G.A. | Source: Authors 06/07/2023 | Link: https://github.com/fransylite/maps/

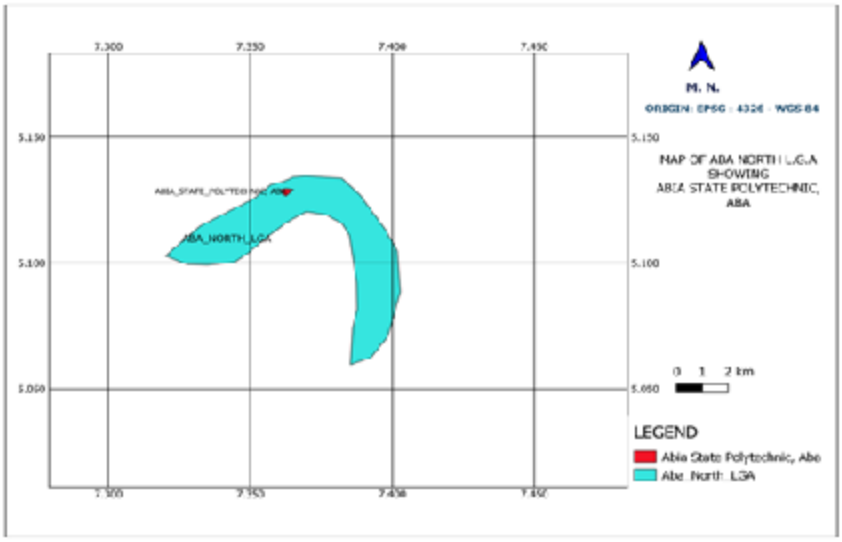

Figure 1.2: Map of Aba North L.G.A. Showing Abia State Polytechnic, Aba

Source: Authors (2023) | Link: https://github.com/fransylite/maps/

2.0 Literature Review

2.1 Total Station Surveying in Geospatial Mapping

Total Station surveying has emerged as a pivotal tool in modern geospatial mapping and land surveying. As emphasized by Lemmens and Zlatanova (2008), the Total Station integrates

electronic distance measurement (EDM) technology with precise angle measurement capabilities, enabling the acquisition of highly accurate spatial coordinates. This technology has been widely employed in various fields, including urban planning, infrastructure development, and environmental management.

2.2 Digital Terrain Models for Campus Mapping

Digital Terrain Models (DTMs) serve as fundamental representations of the Earth's surface, providing valuable insights into topographical features. In the context of campus mapping, DTMs offer a comprehensive view of the terrain, facilitating effective planning and visualization. Noteworthy contributions by Li and Zhu (2019) underscore the significance of DTMs in terrain analysis and 3D modeling, particularly in urban environments.

2.3 Integration of Total Station Data with GIS

The synergy between Total Station survey data and Geographic Information Systems (GIS) has revolutionized geospatial data processing. As outlined by Bolstad (2019), the integration of high-precision survey data with GIS platforms enables the creation of detailed spatial models. This integration empowers researchers and planners to conduct in-depth analyses, facilitating informed decision-making and visualization.

2.4 Web-based Cartography for Interactive Mapping

Web-based cartography has emerged as a powerful medium for disseminating geospatial information to a wider audience. Notable works by Peterson and Knapp (2017) emphasize the role of JavaScript libraries, such as Leaflet.js, in creating interactive and user-friendly web maps. This technology facilitates seamless navigation and exploration of spatial data, enhancing stakeholder engagement and decision support.

2.5 3D Modeling for Enhanced Visualization

The incorporation of building height data into geospatial models enhances the visualization of urban environments. Building on this concept, studies by Liang et al. (2019) highlight the benefits of 3D modeling in urban planning and architectural design. By integrating vertical data layers with horizontal terrain models, a comprehensive view of the campus environment can be achieved.

3.0 METHODOLOGY

3.1 DATA ACQUISITION

The first phase of the study involved the acquisition of spatial data through Total Station surveying techniques. This process entailed the systematic collection of precise coordinates across the entire Abia State Polytechnic campus. The survey data encompassed both horizontal

positions and vertical elevations, providing a comprehensive dataset for subsequent geospatial analyses.

3.2 TOTAL STATION SURVEYING

The Total Station instrument, renowned for its high-precision measurements, was employed in this study. The surveying process followed established protocols, ensuring accurate data capture. The instrument was systematically positioned at strategic locations across the campus, allowing for the collection of detailed spatial information.

3.3 DTM GENERATION

Following the acquisition of survey data, a Digital Terrain Model (DTM) was generated using QGIS in conjunction with the GRASS toolset. This process involved the conversion of raw survey data into a detailed representation of the campus terrain. Contour lines derived from the Total Station survey were utilized as the foundation for DTM creation.

3.4 INTEGRATION OF BUILDING HEIGHTS

To enhance the representation of the campus environment, building height data was integrated into the DTM. This step involved the assignment of uniform heights to specific building types, including bungalows, single-deck, double-deck, and triple-deck structures. The amalgamation of horizontal terrain data with vertical building information facilitated the development of a comprehensive 3D model.

3.5 WEB MAP DEVELOPMENT

Subsequently, an interactive web map was designed utilizing the Leaflet.js library. This platform served as an intuitive interface for accessing and exploring the geospatial data. The web map incorporated a user guide section to enhance usability though qgis2web plugin was the tool utilized to generate the HTML file for the interactive web map. Prior to this, picture popups were incorporated into the attribute form within QGIS. This allowed for the seamless integration of images, providing users with visual information within the web map interface.

3.6 CUSTOMIZATION WITH VISUAL STUDIO CODE

Visual Studio Code was employed to refine the aesthetics and functionality of both the web map and the DTM. Customized elements, including a user guide section and an H1 element displaying "INTERACTIVE WEB MAP OF ABIA STATE POLYTECHNIC, ABA, NIGERIA" were implemented to enhance the overall user experience.

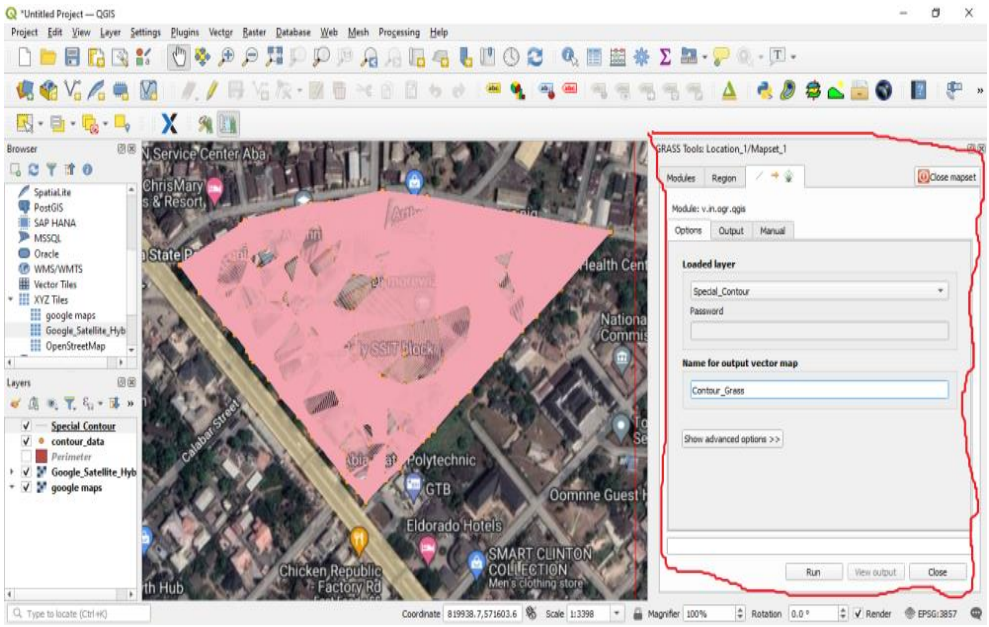

Figure 1: Screenshot showing how DTM is generated on GRASS | Source: Authors (2023)

3.7 SOFTWARE USED

i. QGIS 3.18.3 with GRASS 7.8.5

ii. Visual Studio Code

iii. Microsoft Excel

iv. Microsoft Word

3.8 HARDWARE USED

i. HP laptop

ii. Mouse

4.0 RESULTS

4.1 TOTAL STATION SURVEY DATA

The Total Station survey data yielded a comprehensive dataset of precise spatial coordinates across the Abia State Polytechnic campus. These coordinates provided the foundational information for subsequent geospatial analyses. Figure 1 displays a sample of the survey data points, showcasing the distribution across key campus locations.

id	Name	N (m)	E (m)	Z (m)	B (θ)	L (λ)	H (m)
1	B020504	567137	318675.8	80.1164	05:07:43.80748	07:21:51.11596	80.1164
2	pt1	567172.7	318792.7	79.306	05:07:44.97854	07:21:54.90936	79.3061
3	pt2	567115.2	318731.4	79.065	05:07:43.10133	07:21:52.92200	79.0651
4	pt3	567069.8	318682.5	79.3272	05:07:41.62020	07:21:51.33757	79.3273
5	pt4	567040.1	318650.4	78.856	05:07:40.65129	07:21:50.29814	78.8561
6	pt5	566994.3	318601.1	78.5103	05:07:39.15337	07:21:48.70255	78.5104
7	pt6	566954.8	318558.8	79.0281	05:07:37.86445	07:21:47.33099	79.0282
8	pt7	566914	318513.2	79.5125	05:07:36.53354	07:21:45.85299	79.5126
9	pt8	566890.9	318487.7	79.4745	05:07:35.77853	07:21:45.02808	79.4746
10	pt9	566902.1	318477.4	79.5962	05:07:36.14435	07:21:44.69391	79.5963

Figure 1: Sample of Total Station Survey Data | Source: Authors (2023)

4.2 DIGITAL TERRAIN MODEL (DTM)

The integration of survey data into QGIS, coupled with the application of GRASS tools, facilitated the generation of a highly detailed Digital Terrain Model. Figure 2 illustrates the resulting DTM, vividly representing the varied topographical features of the campus environment.

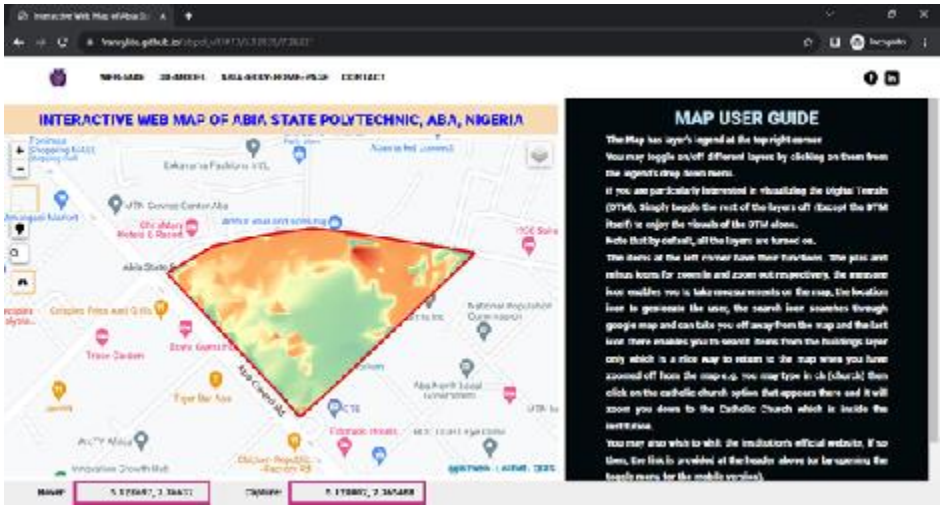

Figure 2: Digital Terrain Model of Abia State Polytechnic Campus | Source: Authors (2023)

4.3 3D MODEL INTEGRATION

Building height data integration further enhanced the representation of the campus. The uniform height assignment to distinct building types facilitated the development of a comprehensive 3D model. Figure 3 provides an overview of the 3D model, depicting the vertical dimension of the campus infrastructure.

Figure 3: 3D Model of Abia State Polytechnic Campus 1 | Source: Arthur (2023)

4.4 INTERACTIVE WEB MAP HOSTED ON GITHUB

The interactive web map, generated using the qgis2web plugin, was hosted on GitHub to ensure accessibility and seamless user experience. This platform enabled stakeholders to explore the geospatial data with ease. Figure 4 showcases the web map interface, highlighting the intuitive navigation and user-friendly features. The link to access the web map is: https://fransylite.github.io/abpol_v1/

Figure 4: Interactive Web Map of Abia State Polytechnic Campus (Hosted on GitHub) Source: Authors (2023)

4.5 PICTURE POPUPS ON ATTRIBUTE FORM

The attribute form within the web map, hosted on GitHub, incorporated picture popups, enhancing the user experience by providing visual information related to specific features on the map. Figure 5 exemplifies this functionality, demonstrating how images are seamlessly integrated within the interface.

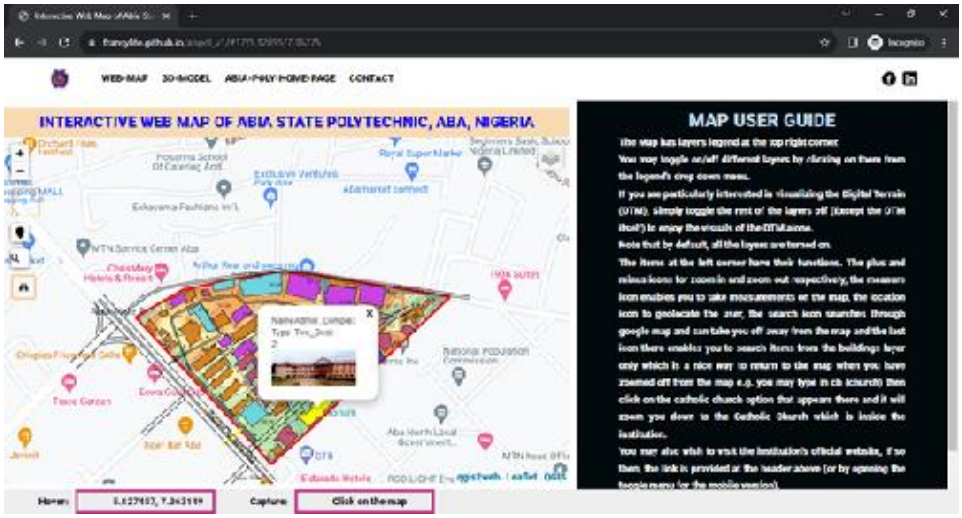

Figure 5: Example of Picture Popup on Attribute Form | Source: Authors (2023)

5.0 DISCUSSION

5.1 PRECISION AND ACCURACY OF TOTAL STATION SURVEY

The utilization of Total Station surveying techniques proved instrumental in acquiring high-precision spatial data for the Abia State Polytechnic campus. The precise coordinates obtained through this method serve as a reliable foundation for subsequent geospatial analyses. This level of accuracy is crucial for applications in urban planning, infrastructure development, and environmental management (Lemmens & Zlatanova, 2008). However, it's imperative to note that the accuracy of the survey data is contingent upon factors such as instrument calibration and field procedures.

5.2 VALIDITY OF THE DIGITAL TERRAIN MODEL (DTM)

The generated Digital Terrain Model (DTM) provides a detailed representation of the campus topography, offering valuable insights for terrain analysis and visualization (Li & Zhu, 2019). The integration of contour lines derived from Total Station survey data ensures that the DTM accurately reflects the ground surface. It's important to acknowledge that the validity of the DTM is subject to the quality and resolution of the survey data. Therefore, meticulous data collection and processing procedures are paramount.

5.3. 3D Visualization and Campus Planning

The integration of building height data into the DTM facilitates a comprehensive 3D representation of the campus environment. This not only enhances the visual portrayal but also opens avenues for informed decision-making in campus planning and infrastructure development (Bolstad, 2019). The 3D model provides stakeholders with a holistic view of the vertical dimension, enabling better assessment of building heights and their spatial relationships.

5.4 USER ENGAGEMENT THROUGH THE INTERACTIVE WEB MAP

The development of the interactive web map using the qgis2web plugin, hosted on GitHub, significantly enhances accessibility and user engagement. The platform allows stakeholders to explore the geospatial data intuitively and provides a dynamic interface for interacting with the campus environment. This aligns with the principles of effective cartography and user-centered design (Peterson & Knapp, 2017).

5.5 INTEGRATION OF VISUAL INFORMATION THROUGH PICTURE POPUPS

The inclusion of picture popups within the web map's attribute form further enriches the user experience. This feature provides visual context and enhances the understanding of specific features on the map. It's a valuable tool for conveying additional information, particularly for stakeholders who may not be familiar with the campus layout.

5.6 FUTURE DIRECTIONS AND ENHANCEMENTS

Moving forward, there are opportunities for further enhancements in data acquisition techniques and visualization methods. Exploring advanced surveying technologies and incorporating real-time data updates could contribute to even greater accuracy and timeliness in campus mapping. Additionally, the integration of augmented reality (AR) or virtual reality (VR) elements could revolutionize the user experience, allowing stakeholders to engage with the campus environment in immersive ways.

6.0 CONCLUSION

The integration of Total Station surveying techniques, Digital Terrain Model (DTM) generation, 3D modeling, and web-based cartography has culminated in a comprehensive geospatial mapping and visualization of Abia State Polytechnic, Aba. This research demonstrates the efficacy of advanced surveying technologies in capturing precise spatial data, forming the basis for detailed terrain modeling.

The generated DTM provides a nuanced representation of the campus topography, essential for informed decision-making in urban planning and infrastructure development. The seamless integration of building height data further enriches the 3D model, affording stakeholders a comprehensive view of the vertical dimension of the campus environment.

The development of an interactive web map, hosted on GitHub, enhances accessibility and user engagement. This platform serves as an intuitive interface for stakeholders to explore and interact with the geospatial data. The incorporation of picture popups within the attribute form adds a visual dimension, providing additional context and enhancing the overall user experience.

This research underscores the significance of integrating advanced surveying techniques with modern mapping technologies for effective campus planning and management. The outcomes

of this study contribute to the broader discourse on geospatial applications in educational institutions, emphasizing the potential for enhanced visualization and user interaction.

Moving forward, there exist opportunities for further innovation in data acquisition, visualization techniques, and user interface design. Exploring emerging technologies, such as augmented reality (AR) and virtual reality (VR), holds promise for revolutionizing the user experience in campus mapping and visualization.

In conclusion, this research exemplifies the potential of geospatial technologies in transforming the representation and analysis of educational institutions. By harnessing the capabilities of Total Station surveying, DTM generation, and interactive web mapping, we have presented a holistic framework for geospatial mapping and visualization that can be applied in diverse contexts.

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BIOGRAPHICAL NOTES

Surv. Dr. Njike Chigbu is a Registered Surveyor, Registered with the Surveyors Council of Nigeria (SURCON). He also doubles as the Deputy Rector (Admin) of Abia State Polytechnic, Aba and the Director of Physical planning. He is happily married with kids.

Mr. Francis Richard Otia holds a Higher National Diploma (HND) in the field of Surveying and Geoinformatics from Abia State Polytechnic Aba (2019). He is an indigene of Otuabula II Community in Ogbia Local Government Area of Bayelsa State, Nigeria. He loves learning so as to advance his skills in the Geospatial profession.

CONTACTS

Surv. Dr. Njike Chigbu
Abia State Polytechnic, Aba, Nigeria.
Aba

Nigeria
+234 803 342 3624
njikec@gmail.com

Mr. Francis Richard Otia
Abia State Polytechnic, Aba, Nigeria.
Aba
Nigeria
+234 816 196 5054
Francisotia1995@gmail.com