DETAILED MAPPING OF FACULTY OF PHYSICAL SCIENCES

UNIVERSITY OF BENIN UGBOWO CAMPUS

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BENIN CITY, NIGERIA

P.M.B 1154

NOVEMBER 2025

DETAILED MAPPING OF FACULTY OF PHYSICAL SCIENCES

UNIVERSITY OF BENIN UGBOWO CAMPUS

A PROJECT SUBMITTED

BY

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ENV2006567

SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF A BACHELOR OF SCIENCES {BSCGEM - B.SC. GEOMATICS} DEGREE, IN THE FACULTY OF ENVIRONMENTAL SCIENCES, UNIVERSITY OF BENIN, BENIN CITY, EDO STATE, NIGERIA.

NOVEMBER 2025

CERTIFICATION

This is to certify that this project was carried out by SOROIBE, CHISOM CARRINGTON with Matriculation Number: **ENV2006567** of the Department of Geomatics, Faculty of Environmental Sciences, University of Benin, Edo State, Nigeria.

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EXTERNAL EXAMINER Date

DEDICATION

This project is dedicated with deep gratitude and love to the most important people in my life, whose unwavering support, encouragement, and belief in me have made this academic journey both meaningful and possible.

To my incredible parents, Mr. Soroibe J. Uche and Mrs. Soroibe O. Vivian thank you for being the foundation upon which my dreams stand. Your constant prayers, sacrifices, moral guidance, and tireless efforts have shaped me into the person I am today. You have taught me the value of hard work, discipline, faith, and perseverance, and I will forever be grateful.

To my sister, Soroibe Munachi, thank you for always being my source of joy and inspiration. Your cheerful presence, kind words, and sincere belief in my abilities lifted my spirits during the most challenging times. You remind me constantly that family is the most beautiful kind of support.

To Engr. Opara Kelvin C., I sincerely appreciate your mentorship, guidance, and the role you played in sharpening my focus toward this project. Your encouragement, professional advice, and genuine interest in my academic success gave me the clarity and confidence I needed to complete this work. Your impact has been both technical and motivational, and it will always be remembered.

This work is a reflection of the love, wisdom, and strength I’ve drawn from each of you. I dedicate this achievement to you all, with gratitude that words alone cannot fully express.

ACKNOWLEDGEMENT

First and foremost, I am profoundly grateful to God almighty, whose endless grace, mercy, and faithfulness have carried me through every stage of this academic journey. Without His strength and provision, none of this would have been possible.

I am especially thankful to my Head of Department, Dr. S.O. Oladosu, for his visionary leadership and for providing and enabling academic environment. My sincere appreciation also goes to my project supervisor, Engr. Mabel Alenkhe, whose invaluable guidance, patience, and support throughout this project have not only shaped my work but also enriched my academic growth. Your dedication to my success will never be forgotten.

To the incredible team of lecturers and staff in the Department of Geomatics, University of Benin, I extent my heartfelt thanks for creating a dynamic and inspiring learning atmosphere. I am particularly grateful to Prof. Raphael Irughe Ehigiator, Surv. Dr. Nwodo G.O., Surv. M.O. Ekun, Surv. Dr. Ojo P.E., Surv. Tijani, Mr. Chuks, Mr. Iyawe, Mrs. Omoh, Dr. Odumosu and all other dedicated faculty members who contributed in various ways to my development.

I owe deep gratitude to my parents, Mr. Soroibe Uche and Mrs. Soroibe Vivian, for their constant encouragement, sacrifices, and unwavering belief in me. Your Love and support have been the pillars of my resilience and motivation.

My sincere appreciation goes to Engr. Opara Kelvin C. Project Manager of Federal Ministry of Works Ikorodu road district, Surv. Ahmed O. Amos, Engr. Habeeb Ibrahim and Surv. Ibrahim Yakubu whose mentorship and practical insights significantly shaped my technical understanding and professional aspirations. Thank you for opening doors and investing in my growth.

To my wonderful friends and coursemates O.I. Chris, M.J. Gilbert, O.I. Anointed, B.U. Oghenefego, I.P. Edafe and S.M. Munachi, thank you for walking this journey with me. Your encouragement, collaboration, and companionship made this project less daunting and far more fulfilling.

Lastly, I would like to recognize all my colleagues in the Department of Geomatics for their collective spirit of learning, friendship, and support. You made these years unforgettable.

May God bless you all abundantly. Amen.

ABSTRACT

This project focuses on the detailed mapping of the Faculty of Physical Sciences, University of Benin, using modern geospatial technologies such as the Global Navigation Satellite System (GNSS), Geographic Information Systems (GIS), and AutoCAD. The study aims to produce an accurate, up-to-date, and comprehensive spatial representation of the Faculty, serving as a vital resource for future development, infrastructure planning, and facility management. The main objectives include generating a detailed and georeferenced map showing all key facilities and infrastructures, producing a perimeter plan that defines the Faculty's boundaries, and creating a Digital Elevation Model (DEM) and Triangulated Irregular Network (TIN) to represent the topography and terrain variations within the study area.

The methodology adopted involved office and field reconnaissance, data acquisition using Trimble GNSS receivers, data processing, and map generation through GIS and CAD platforms. The processed data provided valuable spatial insights into the Faculty's physical layout, infrastructure distribution, and elevation characteristics. The contour, TIN, and DEM maps generated will support engineering design, environmental management, and urban planning within the Faculty.

The study concludes that the integration of GNSS and GIS technologies enhances the efficiency, accuracy, and quality of mapping projects. It is recommended that regular geospatial updates be conducted to monitor infrastructural changes and to support continuous development and sustainable campus management at the University of Benin.

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ACRONYMS

GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GIS	Geographic Information System
CAD	Computer Aided Design
ASCE	American Society of Civil Physical sciences
LiDAR	Light Detection and Ranging
GLONASS	Global Navigation Satellite System
ESA	European Space Agency
DTM	Digital terrain Model
RTK	Real-Time Kinematic
PPK	Post-Processed Kinematic
SOP	Standard Operating Procedures
RDBMS	Relational Database Management System
API	Application Programming interface
SNR	Signal-to-Noise Ratio
TBC	Trimble Business Center
RINEX	Receiver Independent Exchange format
CORS	Continuously Operating Reference Station
PL	Polyline
TIN	Triangular Irregular Network
DEM	Digital Elevation Model

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

A detailed survey is a crucial form of land surveying used to determine and map the features and improvements present on a given parcel of land. These features may include both natural elements such as vegetation, elevation, and soil types, and man-made structures such as buildings, roads, utility lines, boundaries, landmarks, and drainage systems.

In recent years, the widespread adoption of Global Navigation Satellite Systems (GNSS) in detailed surveying has revolutionized the practice, significantly enhancing precision, speed, and data output (Kim, 2018). GNSS encompasses systems like the Global Positioning System (GPS), GLONASS, Galileo, and BeiDou, providing real-time, high-accuracy positional data. This has opened up new possibilities in the realm of surveying, enabling professionals to conduct tasks that were once time-consuming and resource-intensive more efficiently and effectively (Chen and Zhang, 2017).

As a modern geospatial technology, GNSS has been successfully integrated into various sectors of societal and economic development, with expanding applicability. It offers notable advantages over traditional surveying methods, including high accuracy, simplified field procedures, and reduced dependency on manual labour. Moreover, it is user friendly, requiring only a basic level of technical proficiency from field operators (Jiang and Zhao, 2023).

Within the Faculty of Physical sciences, University of Benin, GNSS is particularly advantageous. The faculty hosts numerous departmental buildings, laboratories, access roads, and underground and overhead utilities that require precise, up- to- date spatial documentation for effective facility management, infrastructure planning, and navigation.

Moreover, GNSS greatly lowers costs by minimizing manual fieldwork and auxiliary equipment (Shah and Chawla 2017). These benefits make GNSS an indispensable tool for mapping a complex environment such as the Faculty of Physical sciences, where timely, data- driven decisions underpin academic, research, and maintenance activities.

1.2 Statement of the Problem

Accurate spatial data is fundamental to effective environmental mapping, infrastructure planning, and facility management particularly in dynamic environments such as the Faculty of Physical sciences. Despite the continuous development of new laboratories, access roads, lecture halls, and service facilities, the faculty currently lacks an up-to-date detailed topographic map that captures the full range of its features.

Moreover, the undulating terrain elevations across the faculty compound poses significant challenges to drainage design, utility mapping and expansion works. Without a reliable geospatial database or contour model, planners and facility managers are limited in their ability to make informed decisions.

To address these issues, there is a pressing need for a comprehensive detailed survey and mapping project of the Faculty of Physical sciences using GNSS technology. This project will provide the spatial foundation necessary for future development, infrastructure maintenance, and effective administrative planning.

1.3 Aim and Objectives

The aim is to produce a comprehensive and accurate detailed map of the Faculty of Physical sciences.

Objectives includes to:

i. Generate a detailed and georeferenced map of the Faculty of Physical sciences, showing all key facilities, landmarks, and infrastructures.

ii. Produce a perimeter survey of the Faculty of Physical sciences, University of Benin.

iii. Create a TIN and DEM map of the terrain within the Faculty to support planning and development decisions.

1.4 Scope of the Study

The project involved a comprehensive reconnaissance survey, which included both field and office assessments of the spatial layout of the Faculty of Physical Sciences. This was followed by data acquisition through the collection of spatial data using GNSS devices. The raw data obtained were then subjected to data processing and analysis, where they were transformed into usable map outputs with the aid of GIS and CAD tools. Subsequently, the results were presented through clear visual representations such as maps showing contours, features, and site plans. Finally, a detailed report was compiled to document the methodology adopted, results obtained, key findings, and relevant recommendations.

1.5 Justification of the Study

A detailed survey of the Faculty of Physical sciences in the University of Benin offers critical value both to campus development and the field of geospatial science. The Faculty's diverse landscape, faces increasing pressure to manage its infrastructure and future development sustainably. Producing an up-to-date map will not only improve navigation for staff, students, and visitors but also enhance the management of utilities and infrastructure.

Access to a detailed geospatial database will allow planners and administrators to better understand facility distribution, detect planning inefficiencies, and identify areas vulnerable to flooding or poor accessibility. This contributes directly to improved service delivery and sustainable infrastructure development.

Academically, the project enriches the field of Geomatics by showcasing the application of GNSS in a real world setting, characterized by complex topography. The findings and outputs of the project serve as a model for similar studies in other institutions.

In conclusion, this survey is more than a mapping exercise; it is a foundational tool for efficient urban planning, resource optimization, and smart infrastructure development within the Faculty of Physical sciences. It stands as a contribution to both the university community and the broader field of geospatial technology.

CHAPTER TWO

LITERATURE REVIEW

2.1 General Overview

Geomatics, often used interchangeably with surveying, is traditionally defined as the field that integrates the scientific, technical, and creative aspects of identifying and analyzing the spatial relationships of points located above, on, or beneath the Earth's surface. This includes the establishment and measurement of these points to achieve precise positioning (Wolf *et al.*, 2012).

In its broader context, geomatics encompasses a wide-ranging discipline dedicated to the measurement, analysis, and interpretation of spatial data related to the Earth and its environment. It involves the collection of geospatial information and the production of various outputs and solutions that serve diverse professional and industrial needs.

Surveying, which forms the foundation of geomatics, has been an essential activity since ancient times. One of its earliest applications was the demarcation of property boundaries a function that continues to be vital today. As society's need for accurate spatial data and mapping has grown, the role of surveying has expanded significantly. The increasing complexity of development projects and the demand for precise control points, particularly in construction, have further amplified the importance of surveying (Wolf *et al*., 2012).

The primary aim of surveying is to provide accurate and dependable data about the dimensions, spatial location, and physical configuration of natural terrain and built features (Kavanagh, 2010). The resulting products such as maps, plans, and charts form the essential groundwork for the planning, design, execution, and management of infrastructure and Physical sciences projects (Schofield, 2007).

2.2 Types of Surveying

Surveying encompasses a variety of specialized branches, each tailored to specific applications and environments. Below are key types of surveying commonly employed in geospatial and Physical sciences practices:

i. Geodetic Surveying

   Geodetic surveying involves the execution of high-precision measurements over extensive areas. This method accounts for the Earth's curvature and variations in gravity, making it suitable for establishing geodetic control networks, mapping large regions, and determining accurate global coordinates (Leick, 2004).

ii. Topographic Surveying

   Topographic surveying focuses on the representation of both natural and artificial features within a defined area. It includes the measurement of terrain elevations, contour lines, vegetation, water bodies, and surface structures. This form of surveying is vital for land development, urban planning, and Physical sciences projects, as it offers a detailed understanding of the physical landscape (Wolf & Brinker, 2009).

iii. Cadastral Surveying

   Cadastral surveying is primarily concerned with identifying and documenting property boundaries and land parcels. It plays a critical role in the legal and administrative management of land by producing detailed land records, facilitating property ownership, and ensuring the accuracy of real estate transactions (Miguel, 2016).

iv. Construction Surveying

Construction surveying focuses on the precise positioning and layout of structures, utilities, roads, and other components during the construction process. Its main objective is to ensure that all construction activities strictly follow the design plans and technical specifications, thereby maintaining structural integrity and project alignment (Kavanagh, 2010).

v. Hydrographic Surveying

Hydrographic surveying pertains to the measurement and mapping of aquatic environments such as lakes, rivers, seas, and oceans. It involves collecting data on water depths, underwater terrain, and shoreline features, supporting marine navigation, coastal Physical sciences, and aquatic resource management (Church, 2012).

vi. Mining Surveying

Mining surveying serves the mining industry by providing spatial data for mapping mineral deposits, defining excavation boundaries, planning extraction methods, and monitoring site operations. It is essential for ensuring safe and efficient resource exploration and extraction (Borich, 2011).

vii. Detailed Surveying

Detailed surveying is focused on the accurate measurement and mapping of small scale physical features, including buildings, roads, drainage systems, and utility lines. It is commonly used in urban design, infrastructure development, architectural planning, and facility management due to its high level of detail and precision.(Uren and Price, 2010)

2.3 Detailed Survey

Detailed surveying is a specialized branch of geomatics that involves the accurate measurement and mapping of small scale physical features, including buildings, roads, utilities, and various man-made or natural structures (Kavanagh, 2010). This type of surveying is vital across multiple sectors, offering critical data for urban planning, civil Physical sciences, land development, and environmental management (Kavanagh, 2010).

The accuracy provided by detailed surveys is essential for the design, alignment, and upkeep of infrastructure and construction projects. As emphasized by the American Society of Civil Engineers (ASCE, 2018), detailed surveying serves as a foundational aspect of civil Physical sciences, playing a key role in the successful planning, design, and execution of diverse development initiatives.

In urban planning, detailed surveys are instrumental in collecting high-resolution spatial data about existing site conditions. This information helps planners understand current land use patterns and guides decisions about zoning, redevelopment, and infrastructure placement (Owen, 2017). Such surveys are indispensable for identifying areas that require intervention and for determining the best locations for new development.

Within the construction industry, precise surveying ensures that new structures are properly integrated into their surroundings. Accurate data about site topography, existing features, and boundary lines allows architects and engineers to produce designs that fit the context of the built environment, reducing construction errors, delays, and costly modifications (Carter, 2018).

In land development, detailed surveying supports site feasibility assessments by evaluating factors such as topography, access, and utility availability. It also helps delineate property boundaries, which is critical for land ownership documentation, legal transactions, and dispute resolution (Reid, 2019).

From an environmental perspective, detailed surveys provide essential data for managing and preserving natural resources. By accurately mapping water bodies, vegetation, and terrain features, environmental managers can implement sustainable resource utilization plans and conduct effective environmental impact assessments. This geospatial data supports informed decision-making on conservation and development policies (Reid, 2019).

2.2.1 Types of Detailed Survey

Detailed surveying entails the accurate measurement and representation of physical features on a localized or small scale. While "detailed surveying" is not a distinct category of its own, it incorporates a variety of specialized survey types and techniques aimed at capturing fine spatial details. Common forms of surveys that fall under this umbrella include:

i. Building Surveys:

   These surveys involve the comprehensive documentation of structural features, both internal and external. They include measurements of building dimensions, floor plans, elevations, and the identification of architectural or structural components. Building surveys are essential for renovation, property assessment, and facility management.

ii. Road Surveys:

   Road surveys are designed to collect precise information about roadway characteristics such as horizontal and vertical alignment, cross-sectional profiles, gradients, and pavement conditions. These data are critical for road design, maintenance, expansion, and safety evaluation.

iii. Land Surveys:

Land surveys provide accurate measurements of parcels of land, focusing on property boundaries, legal descriptions, topography, and surface features. They are essential for land registration, real estate development, zoning, and resolving land ownership disputes.

iv. Environmental Surveys:

These surveys focus on capturing spatial information about natural elements including vegetation cover, water bodies, wildlife habitats, and ecological zones. Environmental surveys support environmental impact assessments, conservation initiatives, and sustainable resource planning.

It is important to note that these categories represent general approaches to detailed surveying. The specific methods and instruments applied often vary depending on the project scope, terrain characteristics, and the intended application of the data.

2.2.2 Historical Background of Detailed Survey

The origins of detailed surveying date back to ancient civilizations, where the importance of accurate measurements and small-scale mapping was already well understood. Over the centuries, the discipline has advanced significantly, paralleling developments in technology and scientific knowledge.

One of the earliest known applications of surveying was in ancient Egypt, where surveyors played a critical role in the planning and construction of monumental structures such as the pyramids. The Egyptians employed rudimentary tools such as ropes, plumb bobs, and sighting devices to delineate boundaries, lay out building sites, and produce accurate maps of their environment (Turner, 2016; Shaw, 2010).

In ancient Greece, further strides were made in formalizing surveying practices. The mathematician Euclid outlined foundational principles of measurement and geometry in his seminal work *Elements* around 300 BCE. His contributions, which included techniques for measuring angles, distances, and areas, formed the basis of early geometric surveying (Greenway, 2010).

During the Roman Empire, surveying gained even greater prominence, particularly in the organization of land division and urban planning. The Romans introduced refined measurement methods and utilized tools like the groma, which enabled precise layout of straight lines and right angles (Sullivan, 2013). Many Roman cities and road networks still exhibit the geometric precision characteristic of their surveying methods.

The Renaissance period marked a turning point in surveying history, with the introduction of more advanced instruments such as the theodolite and the implementation of improved triangulation techniques. These innovations significantly increased measurement accuracy and enhanced the reliability of maps and plans (Crone, 2018).

The Industrial Revolution further propelled the field forward. Instruments like the total station enabled the integration of electronic distance measurement and angular calculations, streamlining the surveying process. The subsequent introduction of the Global Positioning System (GPS) revolutionized data collection by allowing real-time, high-accuracy positioning (Mikhail, 2001).

In contemporary times, detailed surveying has been transformed by cutting-edge technologies such as remote sensing, Light Detection and Ranging (LiDAR), and aerial photogrammetry. These tools have expanded the capacity of surveyors to collect precise, high-resolution data across diverse landscapes, reinforcing the importance of detailed surveying in modern geospatial and infrastructure projects.

2.3 Global Navigation Satellite Systems (GNSS)

Global Navigation Satellite Systems (GNSS) refer to networks of satellites that provide geospatial positioning, navigation, and timing services across the globe. These systems are crucial for determining precise locations on the Earth's surface. Currently, four major GNSS constellations are in use or under development: the United States' Global Positioning System (GPS), Russia's GLONASS, the European Union's Galileo, and China's BeiDou system (Liu *et al*., 2017).

The Global Positioning System (GPS), developed and maintained by the United States Department of Defense, consists of a constellation of satellites that orbit the Earth and transmit timing and location signals to receivers on the ground. These signals enable receivers to calculate the user's exact position, velocity, and time by triangulating data from multiple satellites. GPS is widely utilized in fields such as navigation, land surveying, cartography, aviation, transportation, and outdoor activities (Kaplan and Hegarty, 2006).

GLONASS, the Russian counterpart to GPS, operates in a similar manner. It provides global coverage and reliable positioning services by transmitting signals from its own satellite network. Like GPS, GLONASS enables users to determine their location with high accuracy. When GPS and GLONASS signals are combined, especially in areas with limited satellite visibility such as urban environments or dense forests, they can significantly improve positioning reliability and precision (Hofmann-Wellenhof *et al*., 2008).

Galileo, the European Union's GNSS initiative, is managed by the European Space Agency (ESA) and the European GNSS Agency (GSA). Designed to be independent yet compatible with other GNSS systems, Galileo aims to deliver highly accurate and dependable positioning services worldwide. It offers improved accuracy, integrity, and service availability, making it especially useful for applications requiring critical reliability (Giles and Rincon, 2019).

BeiDou, developed by China, initially served regional purposes but has since evolved into a fully operational global GNSS. Its satellite constellation now offers worldwide coverage, delivering positioning, navigation, and timing solutions. BeiDou emphasizes regional performance in the Asia-Pacific area while also supporting global transportation, emergency response, and economic development initiatives (Wu *et al*., 2018).

The integration and interoperability of these four GNSS systems significantly enhance the quality and reliability of positioning services. Utilizing signals from multiple constellations increases satellite visibility, reduces errors caused by signal blockage or atmospheric disturbances, and ensures consistent performance even in complex or obstructed environments (Kaplan and Hegarty, 2006). This synergy allows for greater precision and broader applicability in various geospatial, Physical sciences, and environmental disciplines.

2.3.1 GNSS Technology in Detailed Surveying

Global Navigation Satellite System (GNSS) technology operates by using signals transmitted from multiple satellites to determine precise geographic positions through a technique known as trilateration. Trilateration calculates the distance between a GNSS receiver and each satellite by measuring the time it takes for signals to travel from the satellites to the receiver. By analyzing these distances from several satellites simultaneously, the receiver can compute its exact coordinates on the Earth's surface (Kaplan and Hegarty, 2006). This method ensures that points captured during a detailed survey are accurately georeferenced.

The raw data collected from GNSS receivers during detailed surveys are often processed using advanced geospatial software. These specialized programs apply complex algorithms to refine positional accuracy, eliminate signal errors, and enhance the precision of the data (Hofmann-Wellenhof *et al*., 2008). Furthermore, such software supports the integration of complementary survey data from total stations, laser scanners, or photogrammetric sources allowing for the development of richer and more accurate datasets.

With this integrated approach, GNSS data can be used to generate detailed base maps, digital terrain models (DTMs), and three-dimensional (3D) representations of the surveyed area. These outputs are vital for numerous practical applications such as infrastructure design, city planning, environmental monitoring, and construction management. Maps generated from GNSS data offer clear and accurate illustrations of physical features like buildings, roads, and utility networks, providing a valuable foundation for decision-making in land use planning and Physical sciences design (Ginige *et al*., 2013). Additionally, DTMs provide critical topographic information such as elevation, slope gradients, and drainage flow that can be used for hydrological studies, road alignment, and terrain analysis.

The integration of GNSS technology with powerful software tools significantly improves the efficiency, accuracy, and productivity of detailed surveying. It allows surveyors to gather precise spatial data, analyze complex terrains, and present survey results in user-friendly formats that support informed planning and sustainable development.

2.3.2 Benefits of GNSS in Detailed Surveying

The use of Global Navigation Satellite Systems (GNSS) in detailed surveying offers numerous benefits, making it a vital component in modern geospatial data collection. Below are the key advantages of incorporating GNSS in detailed surveying:

i. Exceptional Accuracy:

   GNSS receivers are capable of delivering highly accurate positional data, which is essential for precise surveying tasks. With access to signals from multiple satellites and the application of sophisticated algorithms, GNSS devices can achieve sub-meter or even centimeter-level accuracy (Li *et al*., 2015). Such precision is critical for generating detailed maps, designing infrastructure, and ensuring accuracy in construction layouts.

ii. Worldwide Availability:

   One of the major strengths of GNSS including systems like GPS, GLONASS, Galileo, and BeiDou is its global accessibility. Regardless of location, GNSS provides consistent positioning and navigation support across the globe. This makes it especially useful for surveyors working across large geographical areas or in remote regions where traditional control points may not be available (El-Rabbany, 2019).

iii. Improved Efficiency:

Compared to conventional methods, GNSS greatly enhances field productivity. Surveyors can acquire positional data more rapidly and with fewer manual inputs. This reduction in time spent on data collection increases overall efficiency, allowing more ground to be covered in shorter periods and enabling quicker project delivery (Ginige *et al*., 2013).

iv. Enhanced Flexibility and Accessibility:

Modern GNSS receivers are compact and portable, enabling surveyors to navigate and work easily in challenging or inaccessible environments. This mobility allows for data collection in rugged, densely vegetated, or urbanized areas, expanding the range and applicability of detailed surveys (O'Keeffe, 2016).

v. Compatibility with Other Technologies:

GNSS systems can be effortlessly integrated with other advanced surveying tools, such as total stations, laser scanners, and Geographic Information Systems (GIS). This integration enhances the detail and accuracy of survey outputs by enabling surveyors to gather multidimensional data and produce rich, layered spatial models and maps (Ginige *et al*., 2013).

In summary, GNSS significantly improves the precision, speed, and versatility of detailed surveying. Its global functionality, ease of use, and ability to work alongside other geospatial technologies make it indispensable for applications such as construction, urban development, land planning, and environmental resource management.

2.3.3 Challenges and Limitations of GNSS in Detailed Surveying

While GNSS technology offers numerous advantages in detailed surveying, it also presents several challenges and limitations that may impact measurement accuracy and reliability. These issues must be carefully considered during field operations. Key challenges include:

i. Atmospheric Interference:

   GNSS signals are susceptible to atmospheric disturbances such as ionospheric delays, multipath effects, and signal weakening. These conditions, especially prevalent in areas with heavy vegetation, rugged terrain, or adverse weather, can distort signal transmission and reduce positioning accuracy (Kaplan and Hegarty, 2006). Surveyors must apply suitable atmospheric corrections to compensate for these influences.

ii. Satellite Visibility and Geometry:

   The accuracy of GNSS results depends heavily on the number and positioning (geometry) of satellites visible to the receiver. In environments like dense urban areas, forests, or valleys, satellite signals may be partially blocked, causing degraded accuracy or signal loss (El-Rabbany, 2019). Surveyors should monitor satellite availability and geometry to ensure optimal conditions for data collection.

iii. Physical Obstructions and Multipath Errors:

   Objects such as tall buildings, trees, or mountains can obstruct GNSS signals. In some cases, signals may reflect off surfaces before reaching the receiver, creating multipath errors false readings due to delayed signal reception (Hofmann-Wellenhof *et al*., 2008). To minimize such errors, surveyors must assess site conditions and, when necessary, reposition equipment or apply correction techniques.

iv. Equipment Quality and Maintenance:

The performance of GNSS largely depends on the quality and specifications of the receiver in use. High-precision instruments require routine calibration, technical knowledge, and proper handling to maintain accuracy (Li *et al*., 2015). Inadequate or poorly maintained equipment can lead to significant errors in survey outcomes.

v. Human Error and Technical Proficiency:

Human factors also influence the effectiveness of GNSS surveying. Mistakes in equipment setup, incorrect data logging, or improper processing can lead to inaccurate results. Surveyors must possess a sound understanding of GNSS operation, common sources of error, and proper data processing techniques to ensure reliable outcomes (Ginige *et al*., 2013).

To address these limitations, surveyors can adopt advanced strategies such as using multi-frequency GNSS receivers, employing Real-Time Kinematic (RTK) or Post-Processed Kinematic (PPK) techniques, applying differential corrections, and integrating GNSS with other surveying technologies like total stations. These methods help enhance accuracy and reduce errors, thereby improving the overall quality of detailed surveying results (El-Rabbany, 2019).

2.3.4 Detailed Surveying Procedures

To achieve high precision in detailed surveying using GNSS (Global Navigation Satellite System), surveyors must adopt best practices and follow systematic procedures. These measures help ensure the reliability and accuracy of collected data. The following are key considerations:

i. Equipment Selection:

Selecting appropriate GNSS equipment is fundamental to obtaining accurate results. Surveyors should assess the quality of the receiver, its ability to track signals effectively, and its compatibility with multiple frequency bands. High-end GNSS receivers with advanced features and strong signal tracking capabilities offer enhanced positional accuracy (O'Keeffe, 2016).

ii. Survey Planning and Design:

Thorough planning is essential to the success of a GNSS-based survey. This includes setting up well-distributed control points with known coordinates, which serve as references for the survey. Proper distribution ensures consistent georeferencing and data alignment across the survey area (Ginige *et al.*, 2013). Employing robust control networks and adjustment techniques helps reduce measurement errors.

iii. Calibration and Quality Assurance:

Regular calibration of GNSS instruments is crucial to maintain their accuracy. Surveyors should adhere to the manufacturer’s recommendations for calibration, particularly after significant environmental or hardware changes. Implementing quality control checks such as cross-verifying GNSS data with independent observations helps detect and eliminate errors (El-Rabbany, 2019).

iv. Data Post-Processing:

Processing GNSS data after field collection enhances measurement accuracy. Surveyors can apply differential correction techniques like Real-Time Kinematic (RTK) or Post-Processed Kinematic (PPK) to refine positioning results. Post-processing software utilizes advanced algorithms to minimize errors and improve positional precision (Li *et al.*, 2015).

v. Continuous Professional Development:

Keeping up with technological advancements in GNSS and modern survey methods is vital. Surveyors should participate in training, workshops, and professional courses to stay informed on emerging trends and best practices. Ongoing learning ensures that they can effectively apply the latest techniques and operate advanced GNSS tools with confidence (Ginige *et al*., 2013).

2.3.5 GNSS Equipment and Tools

Various types of GNSS equipment and tools are used in detailed surveying, allowing professionals to capture accurate geospatial data. The choice of equipment depends on the level of accuracy required, the field conditions, and project constraints. Common tools include:

i. Handheld GNSS Receivers:

These portable devices are ideal for real-time data collection in the field. They offer sub-meter to decimeter-level accuracy and are commonly used in asset inventory, forestry, and GIS applications where extremely high precision is not critical.

ii. Survey-Grade GNSS Receivers:

These are high-precision instruments designed for professional use in detailed surveying. Capable of delivering centimeter-level accuracy, they support multiple frequency bands, carrier-phase tracking, and internal data logging. These receivers are essential for tasks such as construction staking, boundary demarcation, and topographic mapping.

iii. GNSS Antennas:

Antennas are key components that receive satellite signals. Types include choke ring, geodetic, and survey-grade antennas. The selection of an antenna depends on the required precision, environmental factors, and receiver compatibility. High-quality antennas help reduce signal distortion and improve overall data accuracy.

iv. Data Loggers:

Data loggers record GNSS observations over time and are used in conjunction with receivers during static or kinematic surveys. They are essential for long-duration data collection where continuous and consistent logging is necessary.

v. Field Software:

Mobile software platforms, often installed on smartphones or tablets, facilitate real-time data acquisition and processing in the field. These applications provide user-friendly interfaces for capturing, validating, and managing GNSS data. Features may include waypoint navigation, live correction services, and data quality indicators.

When selecting GNSS tools, surveyors should prioritize accuracy requirements, compatibility with other instruments, durability, and ease of use. Using reliable, high-quality equipment ensures optimal performance and accurate results in detailed surveying operations.

2.3.6 Optimal Techniques for Effective Detailed Surveying

To ensure accurate and dependable results in detailed surveying using Global Navigation Satellite Systems (GNSS), surveyors must adopt a set of well established best practices. These methods enhance data quality, reduce errors, and improve overall survey efficiency. Key recommendations include:

i. Comprehensive Research and Survey Planning:

   Begin by conducting detailed research on the survey area. Identify any potential challenges, such as physical obstructions or signal interferences, that could affect GNSS performance. Carefully plan the survey design, establish well-distributed control points, and determine the most suitable equipment and techniques for the task (Ginige *et al*., 2013).

ii. Technical Training and Skill Development:

   Ensure that all personnel involved in the survey are well-trained in GNSS principles and operational techniques. Gain proficiency in data collection, processing, and troubleshooting. Staying up to date with advancements in GNSS technologies and industry practices through continuous professional development is crucial for achieving high accuracy (El-Rabbany, 2019).

iii. Regular Equipment Maintenance and Calibration:

   Maintain your GNSS equipment routinely to preserve its accuracy. Follow manufacturer recommendations for calibration and maintenance, and keep firmware and software updated. Proper storage and handling are also essential to prevent physical damage and maintain operational efficiency (Ginige *et al*., 2013).

iv. Implementation of Standard Operating Procedures (SOPs):

   Establish and adhere to clearly defined SOPs to maintain consistency across all surveying tasks. Standardize data collection methods, field operations, and quality assurance protocols. Documenting each procedure also enhances traceability and enables survey replication if needed (Li *et al*., 2015).

v. Quality Assurance and Validation:

   Conduct frequent quality checks to verify data integrity. Use redundant observations and compare collected data against established control points or benchmark datasets. Employ data validation techniques to detect and correct inconsistencies, ensuring that the final results are accurate and reliable (El-Rabbany, 2019).

2.4 Geographic Information Systems (GIS)

Geographic Information Systems (GIS) is an advanced technology that enables the collection, storage, analysis, and visualization of geospatial information. By integrating various types of data such as geographic, environmental, demographic, and socio-economic GIS offers a holistic approach to understanding spatial patterns, relationships, and trends. It is widely utilized across disciplines including urban planning, environmental management, public health, disaster response, and transportation systems.

2.4.1 Definition and Components of GIS

GIS is defined as a system that captures, stores, manipulates, analyzes, and presents data that is spatially referenced to the Earth. It consists of the following core components:

i. Hardware: This includes physical devices like computers, GPS receivers, scanners, and printers used for data collection, processing, and output.
ii. Software: GIS software facilitates spatial data management, analysis, and visualization. Common platforms include ArcGIS (by Esri), QGIS, and GRASS GIS.
iii. Data: Geospatial data serves as the backbone of GIS. It includes maps, satellite imagery, GPS data, aerial photographs, and survey measurements.

iv. People: Trained professionals such as GIS analysts, technicians, and spatial data scientists are essential to manage the system effectively and interpret the data for informed decision-making.

GIS plays a pivotal role in spatial analysis and decision support across multiple sectors by offering tools that combine data visualization with powerful analytical capabilities.

2.4.2 Data Capture and Sources

GIS relies heavily on the collection of accurate and reliable geospatial data from various sources. Key data acquisition methods include remote sensing, surveying, and the use of existing cartographic resources. Remote sensing involves capturing data through satellite imagery, aerial photography, and LiDAR technology, enabling the collection of spatial information from a distance. On-the-ground data can be gathered using modern surveying tools such as GPS receivers and total stations, providing highly precise spatial measurements. Additionally, existing maps, photographs, and legacy datasets can be digitized or scanned to convert them into usable digital formats. The quality, accuracy, and consistency of these data sources are critical in determining the effectiveness and credibility of GIS analyses (Borrough,P.A., and McDonnell, R.A. 2019).

2.4.3 Data Storage and Management

Efficient storage and management of geospatial data in GIS are facilitated through the use of structured databases. Data is typically organized into thematic layers or feature classes, each representing different geographic features such as roads, buildings, or land parcels. These datasets can be managed using relational database management systems (RDBMS) or file-based formats. Effective GIS data management includes key practices such as data validation, metadata documentation, and version control to ensure data accuracy, traceability, and accessibility. Common platforms used for GIS data storage include PostgreSQL with PostGIS extension, which supports spatial queries and large-scale geodata management (Longley, P.A., Goodchild, M.F., Maguire, D. J., and Rhind, D.W. 2015).

2.4.4 Spatial Analysis and Modeling

GIS empowers users to perform complex spatial analyses and geospatial modeling that reveal meaningful patterns, relationships, and trends. Analysis techniques include overlay analysis, buffering and proximity, network analysis, spatial interpolation, and spatial statistics. These tools enable users to evaluate how different geographic factors interact, supporting decisions in areas such as urban planning, infrastructure development, and environmental assessment. Furthermore, GIS-based modeling allows for the simulation of real-world phenomena, such as disease spread, flood risk prediction, or transport route optimization, enabling proactive planning and effective problem-solving (Borrough, P.A., & McDonnell, R.A., & Lloyd, C.D. 2015).

2.5 AutoCAD

AutoCAD, developed by Autodesk Inc., is a leading computer-aided design (CAD) software widely used across Physical sciences, architecture, manufacturing, and construction disciplines. Known for its powerful drawing capabilities and user-friendly environment, AutoCAD has become a foundational tool for producing accurate 2D drafts and complex 3D models in various technical fields.

2.5.1 Key Features of AutoCAD

i. 2D Drafting and Detailing:

AutoCAD excels in 2D drafting, offering a broad set of tools for creating technical drawings such as schematics, architectural floor plans, and Physical sciences diagrams. It is essential in producing precise layout documents for construction and design.

ii. 3D Modeling and Visualization:

The software supports advanced 3D modeling, enabling users to develop realistic structures and objects for presentation or simulation purposes. This feature is particularly useful in architectural visualization and product design.

iii. Customization Capabilities:

AutoCAD allows users to customize workflows through scripting languages like AutoLISP and offers support for plugins and APIs. This flexibility helps users tailor the platform to specific tasks or industry requirements.

iv. Parametric Design:

AutoCAD includes support for parametric constraints, enabling designers to set rules and relationships between drawing elements. This allows for dynamic updates and design consistency throughout the drafting process.

v. Collaboration and Cloud Integration:

With features such as real-time file sharing, cloud storage, and version control, AutoCAD enhances team collaboration and project management, especially for geographically dispersed teams.

vi. Industry-Specific Toolsets:

Autodesk provides specialized AutoCAD tool sets tailored for different industries, including AutoCAD Architecture, AutoCAD Electrical, and AutoCAD Mechanical, each offering libraries and features specific to the profession.

vii. Rendering and Presentation Tools:

AutoCAD includes built-in rendering features that allow users to produce photorealistic images and presentations of their models, making it a valuable tool for client presentations and design approvals.

2.5.2 Applications of AutoCAD

AutoCAD is widely applied in various sectors, including:

i. Architectural Design:

Used for drafting detailed building layouts, elevations, and 3D models, aiding architects in conceptualization and client communication.

ii. Physical sciences:

Engineers in mechanical, electrical, and civil fields use AutoCAD to create accurate technical drawings and component designs essential for fabrication and construction.

iii. Construction:

Facilitates the creation of site plans, structural layouts, and construction schematics, improving coordination between stakeholders.

iv. Manufacturing:

Supports product design and manufacturing process documentation, contributing to quality control and production efficiency.

v. Interior Design:

Interior designers employ AutoCAD for space planning, visual layouts, and 3D interior renderings, allowing clients to preview design concepts.

vi. Urban Planning:

Urban planners utilize AutoCAD for designing city layouts, zoning maps, and land use plans, promoting sustainable and functional development.

CHAPTER THREE

METHODOLOGY

3.1 Description of the Study Area

The study area for this project is the Faculty of Physical sciences, University of Benin, located within the Ugbowo Campus in Egor Local Government Area, Edo State, Nigeria. With boundary coordinate of 789047.43 m E, 707829.92 m N; 789274.46 m E, 708231.49 m N. The faculty comprises multiple departmental buildings, Physical sciences laboratories, roads, workshops, and utility networks that require accurate mapping for infrastructure planning and academic use.

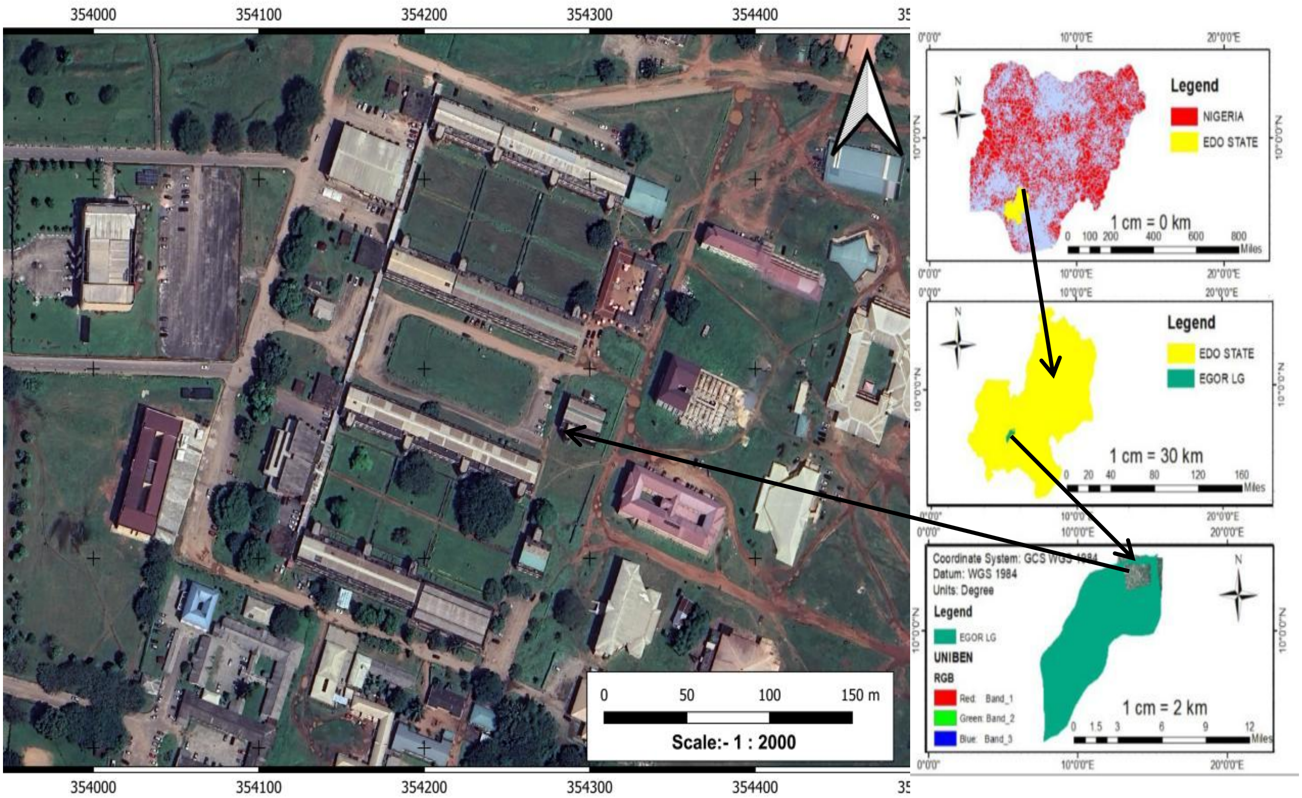


Figure 3.1: Study Area of Faculty of Physical Sciences

3.2 Office Planning and Field Reconnaissance

3.2.1 Office Planning (Desk Study)

Office planning, often referred to as desk study or preliminary reconnaissance, marks the foundational phase of any detailed surveying project. This stage involves the collection, analysis, and review of all available data, records, and background information relevant to the project site. The primary objective of office planning is to establish a comprehensive understanding of the site before any fieldwork is initiated.

During this phase, surveyors consult existing maps, satellite imagery, topographic sheets, previous survey records, Physical sciences drawings, utility layouts, cadastral plans, and geospatial databases relevant to the Faculty of Physical sciences to identify existing features and infrastructure within the project boundary. These may include roads, buildings, power lines, water pipelines, and other utilities. By analyzing this data, the survey team can determine potential challenges, identify suitable locations for control points, and prepare the necessary logistics and resources for efficient field operations (Kavanagh, B.F., and McKinlay, R. 2013).

Moreover, office planning aids in resource allocation, risk assessment, scheduling, and ensuring that the field crew is properly briefed on what to expect in the field. It is a critical step for minimizing field errors, avoiding redundancy, and ensuring that all necessary equipment and software are selected based on the project's unique demands.

3.2.2 Field Reconnaissance

Field reconnaissance is the physical inspection of the project area and follows the office planning stage. It involves visiting the site to validate information gathered during the desk study and to gain firsthand knowledge of the terrain, access routes, vegetation cover, man-made structures, and other features that may impact the survey.

This step ensures that the planning to be done at the office aligns with on-ground realities.

During field reconnaissance, surveyors check for obstructions such as tall buildings, thick vegetation, or uneven terrain that could affect GNSS signal reception. They also identify optimal locations for setting up base stations, control points, and equipment deployment. Photographic documentation, field sketches, and GPS waypoints are commonly recorded for further reference. Ultimately, field reconnaissance helps to refine the survey design and increases the efficiency and accuracy of the subsequent data collection phase.

3.3 Instrument and Software Selection

After the completion of both the office and field reconnaissance will be made, and reviewing the specific requirements of the project, appropriate instruments and software tools are selected to ensure the collection of accurate and reliable data. For this project, the following tools were chosen:

i. Trimble R8 GNSS Receiver and Accessories: Used for high-precision positioning and real-time data collection.
ii. Microsoft Excel: Employed for data sorting, processing, and tabulation.
iii. ArcGIS: Used for geospatial data analysis, mapping, and visualization.
iv. Google Earth: Utilized for base map reference and preliminary feature identification
v. Global Mapper: Applied for handling terrain data, coordinate transformations, and spatial analysis.

3.4 In-situ Check

The in-situ check, also known as the verification of control points, is a crucial step in confirming the accuracy and reliability of the control stations used during the survey. This process ensures that all subsequent data collected is accurately referenced to the national or project-specific geodetic framework.

For the project, the in-situ verification is planned to be conducted using GPS100, GPS101, and GPS102 stations, which have been identified as reference benchmarks for positional accuracy. The GNSS data from these stations were cross-checked to validate their coordinate integrity and confirm that any positional deviations remain within acceptable limits before commencing full-scale data acquisition.

3.5 Data Acquisition

The data acquisition phase is a critical step in detailed surveying, particularly when using high-precision GNSS technology like the Trimble R8. The following structured steps were followed to guarantee accurate data collection:

i. Equipment Setup

The Trimble GNSS receiver was properly assembled by attaching the antenna and securely mounting the unit on a tripod or surveying rod. All components were tested to ensure they function correctly. Proper setup ensures stability and optimal satellite signal reception.

ii. Establishment of Control Points

Before the spatial data is collected, control points were established throughout the survey area. These are fixed locations with known coordinates that provide a reference for all subsequent survey points. This helps ensure consistency and positional accuracy across the entire survey site.

iii. GNSS Data Collection

The GNSS data collection involved several sub-steps:

a) Initializing the receiver and waiting for satellite lock.
b) Selecting the appropriate surveying mode either Real-Time Kinematic (RTK), Post-Processing Kinematic (PPK), or static.
c) Configuring survey parameters like observation time and interval.
d) Recording data once sufficient satellite coverage and signal quality were established.

Each point was occupied long enough to obtain stable and accurate readings before logging the data.

iv. Data Quality Control

During the survey, real-time monitoring of satellite count, signal-to-noise ratio (SNR), and horizontal/vertical accuracy was conducted. Data that did not meet predefined quality thresholds was flagged for review or re-collection.

v. Post-Processing and Adjustment

Post-processing was conducted using Trimble Business Center (TBC) to refine the raw data. Correction files, such as RINEX or CORS data, were applied to improve accuracy and remove residual errors from atmospheric interference or satellite geometry.

vi. Data Integration and Analysis

Once post-processing was complete, the data was exported into compatible formats and integrated with GIS platforms like ArcGIS or Global Mapper for mapping, terrain analysis, and thematic representation.

vii. Quality Assurance and Quality Control (QA/QC)

Final checks were conducted to compare GNSS-derived coordinates with known control points. Discrepancies were evaluated and corrected as necessary to ensure the data will meet required accuracy standards.

3.6 Perimeter Mapping Using AutoCAD

Creating a perimeter map in AutoCAD involves a methodical approach to outline the project boundary accurately. Below are the steps followed:

Step 1: Initiating a New Drawing

i. Open AutoCAD and create a new drawing file.

ii. Set the drawing units (meters or feet), define the coordinate system, and configure the scale to align with the project's specifications.

Step 2: Importing Base Reference Data (Optional)

i. Insert existing DWG files, georeferenced images, or shapefiles if available.

ii. Scale and position them correctly within the drawing environment to provide a visual reference.

Step 3: Plotting the Perimeter Boundary

i. Use the Polyline (PL) or Line (L) command to draw the perimeter.

ii. Points can be manually plotted or entered using exact coordinates to maintain positional accuracy.

iii. The perimeter was completed and closed using the "Close" option in the command line.

Step 4: Annotation and Labeling

i. Labels such as “Perimeter Boundary” or point identifiers were added using the Text or MText tool.

ii. Text styles, heights, and positions were adjusted to ensure clarity.

Step 5: Saving and Backing Up

i. The drawing file was saved in the .DWG format and backed up on cloud or external storage for security.

Step 6: Exporting or Printing the Map

i. The final drawing was plotted using the Plot (PLOT) command.

ii. Print settings such as scale, paper size, and orientation were configured before producing a hardcopy or exporting to PDF.

Step 7: Final Review

i. A final inspection of the map was carried out to ensure all perimeter lines, labels, and spatial references is accurate and complete.

3.7 Steps in Creating a TIN and DEM Map

The creation of a Triangulated Irregular Network (TIN) and Digital Elevation Model (DEM) for the Faculty of Physical Sciences, University of Benin, involves a systematic workflow that integrates GNSS-based data acquisition, GIS processing, and terrain modeling techniques. These models provide a three-dimensional representation of the faculty’s terrain, which is vital for planning, infrastructure design, and environmental assessment.

Step 1: Data Acquisition

Accurate elevation and positional data form the foundation of both TIN and DEM generation. Using GNSS (Global Navigation Satellite System) receivers such as the Trimble R8, elevation points are captured across the Faculty of Physical Sciences. The following steps are taken:

i. Establish control points around the faculty to serve as spatial references.
ii. Conduct detailed GNSS observations to collect X, Y, and Z coordinates (Eastings, Northings, and Elevations) at regular intervals across the area.
iii. Ensure adequate coverage by collecting points at varying terrain elevations, including open fields, walkways, and building surroundings.

Step 2: Data Processing and Quality Control

The raw GNSS data are downloaded and processed using specialized software such as Trimble Business Center (TBC) or GNSS Solutions to correct for positional errors.

i. Apply differential correction to improve accuracy using base station data.
ii. Verify and filter out erroneous points or outliers to ensure uniform data quality.
iii. Export the processed data into a CSV or shapefile format compatible with GIS software (e.g., ArcGIS, Global Mapper, or QGIS).

Step 3: Importing Data into GIS Environment

After quality control, the processed GNSS data are imported into a GIS platform (e.g., ArcGIS Pro or QGIS) for visualization and terrain analysis.

i. Load the coordinate data as point features in the GIS workspace.
ii. Verify coordinate system consistency (e.g., UTM Zone 31N, WGS84 Datum).
iii. Symbolize the elevation points to visualize terrain variation across the faculty.

Step 4: Generating the TIN (Triangulated Irregular Network)

A TIN model is generated to represent the terrain surface using the elevation points.

i. Use the Create TIN or Delaunay Triangulation tool in GIS software to build a continuous network of triangles connecting the surveyed elevation points.
ii. The vertices of the triangles correspond to surveyed points, while the edges represent elevation gradients.
iii. Edit and refine the TIN by adding breaklines (e.g., roads, drainage lines, and building outlines) to improve surface definition.
iv. Validate the TIN for consistency and eliminate sharp anomalies or spikes.

The TIN model provides a detailed 3D representation of the faculty's surface, allowing visualization of slope, aspect, and elevation variation.

Step 5: Converting TIN to DEM

The Digital Elevation Model (DEM) is derived from the TIN to create a continuous raster surface.

i. Use the TIN to Raster or Raster Interpolation function (e.g., IDW, Kriging, or Spline) to convert the TIN into a gridded DEM.
ii. Set an appropriate cell size (resolution) depending on the area's scale (typically between 0.5m – 2m for campus-level mapping).
iii. The DEM provides uniform elevation data across the faculty area, suitable for further analysis.

Step 6: Visualization and Analysis

Once the DEM is created, additional terrain analysis can be performed to support planning and development:

i. Generate contour lines at specified intervals (e.g., 0.5m or 1m) to visualize elevation variation.
ii. Derive slope and aspect maps to identify drainage patterns, construction suitability, or erosion-prone zones.
iii. Combine the DEM with other GIS layers (e.g., building footprints, roads, and vegetation) for comprehensive spatial planning.

Step 7: Data Validation and Map Production

Finally, the generated TIN and DEM models are validated and used to produce cartographic outputs.

i. Cross-check elevations with control points or known benchmarks for accuracy verification.
ii. Design and label the final maps using ArcGIS Layout View or AutoCAD Map 3D.
iii. Export maps in suitable formats (PDF, JPEG, or GeoTIFF) for presentation and reporting.

CHAPTER FOUR

RESULT AND DISCUSSION

4.1 Detailed Map of the Faculty of Physical Sciences

The detailed map of the Faculty of Physical Sciences was produced using ArcGIS software, incorporating geospatial data collected during the field survey. The field data included three-dimensional coordinates (X, Y, and Z) representing easting, northing, and elevation, respectively. These coordinates were processed, georeferenced, and visualized to produce an accurate representation of the faculty's physical environment.

The resulting map provides a holistic view of the faculty's spatial organization, land use distribution, and physical infrastructure. The analysis of the generated map reveals the following notable features:

i. Academic and Administrative Buildings:

The map captures the distinct spatial arrangement of lecture halls, laboratories, departmental offices, and administrative blocks. These structures are well-organized, reflecting the faculty's planned academic layout and efficient land utilization.

ii. Internal Road Network:

The map clearly depicts a well-structured network of access roads and pedestrian walkways connecting different sections of the faculty. The connectivity between the various roads suggests careful infrastructural planning aimed at improving accessibility within the faculty premises.

iii. Green and Open Spaces:

Areas covered by vegetation and open grounds are distinctly represented on the map.

These green spaces enhance the faculty's environmental aesthetics and provide natural zones for air circulation and student recreation.

iv. Drainage and Natural Flow Paths:

The map also identifies existing drainage systems and natural flow paths that aid in the management of surface runoff during rainfall. This information is particularly vital for future infrastructural developments, ensuring that expansion projects consider existing drainage patterns to prevent erosion or flooding.

v. Utilities and Supporting Facilities:

The detailed survey also mapped essential utilities such as electrical poles, water pipelines, and parking areas. Their inclusion enhances the accuracy of the spatial database, making it a valuable tool for facility management and maintenance planning.

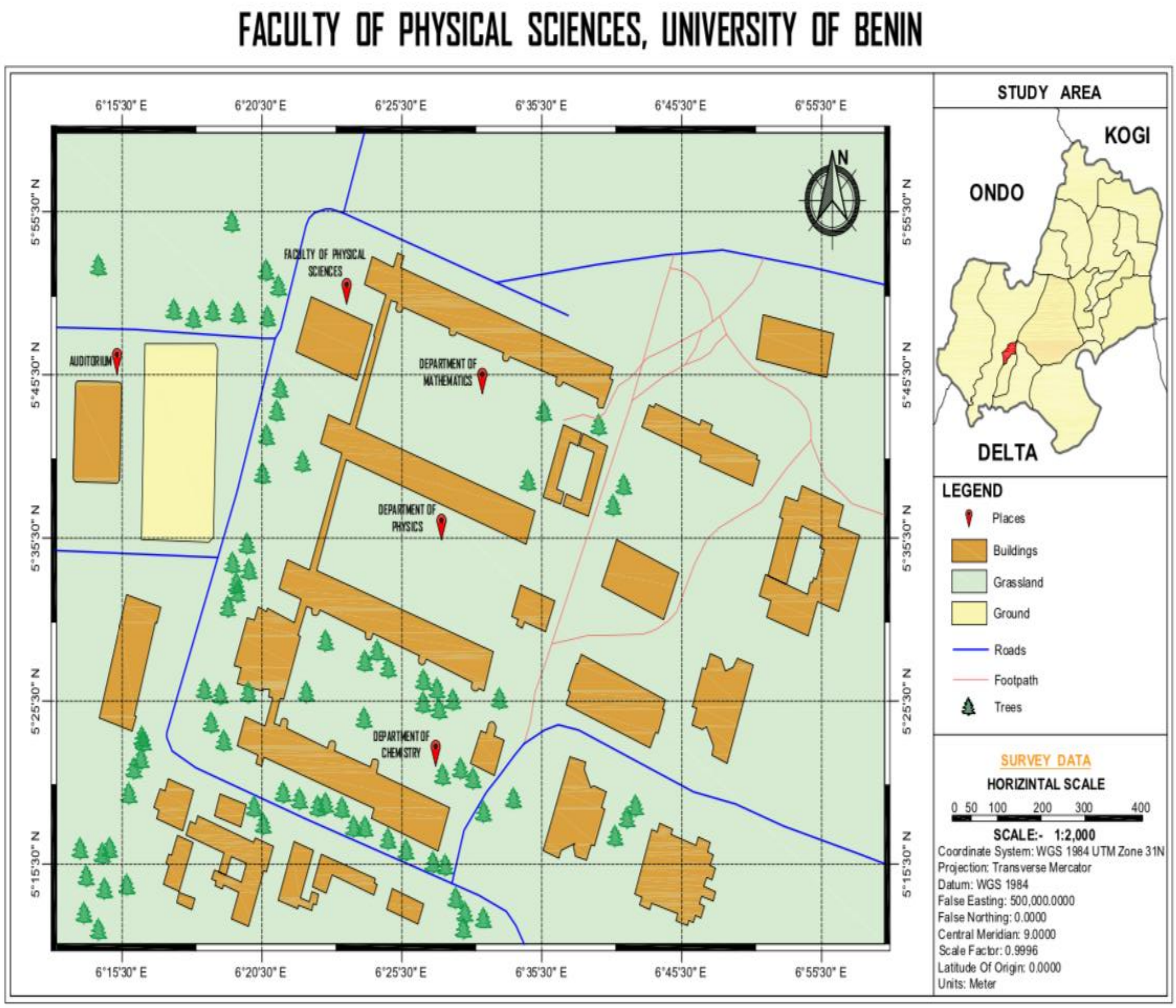


Figure 4.1. Digitized Map of The Faculty Of Physical Sciences, University of Benin.

4.2 Perimeter Map of the Faculty of Physical Sciences, University of Benin

The perimeter map of the Faculty of Physical Sciences, University of Benin, provides an accurate delineation of the faculty's boundary and spatial extent. This mapping exercise was carried out to establish well-defined boundary coordinates, which are essential for infrastructural planning, land management, and administrative purposes. Using GNSS-based field data and satellite imagery, the perimeter map was generated and analyzed to identify the key features within and around the faculty's boundary.

The analysis of the map and corresponding satellite imagery reveals the following:

i. Academic and Administrative Buildings:

The most prominent land cover within the Faculty of Physical Sciences consists of a variety of academic and administrative structures. These include lecture theatres, departmental offices, laboratories, and faculty buildings. Their well-organized layout reflects structured campus development and efficient land utilization for educational purposes.

ii. Vegetation and Open Spaces:

In addition to built-up areas, several vegetated zones are evident around the faculty complex. These areas include patches of trees, landscaped sections, and natural vegetation that contribute to the environmental balance of the faculty. The presence of green spaces also enhances the overall aesthetics of the environment and provides areas for relaxation and ecological sustainability.

iii. Roads and Access Paths:

The perimeter map clearly highlights a well-developed internal road network providing access to various departments and buildings within the faculty. These roads and walkways connect seamlessly with the main university roads, ensuring smooth vehicular and pedestrian movement. This connectivity facilitates easy navigation and efficient access to key locations within the faculty.

iv. Boundary Definition:

The perimeter survey also establishes a clear demarcation of the Faculty of Physical Sciences from adjoining faculties and facilities within the University of Benin. This defined boundary is essential for proper asset management, spatial planning, and future infrastructural expansion.

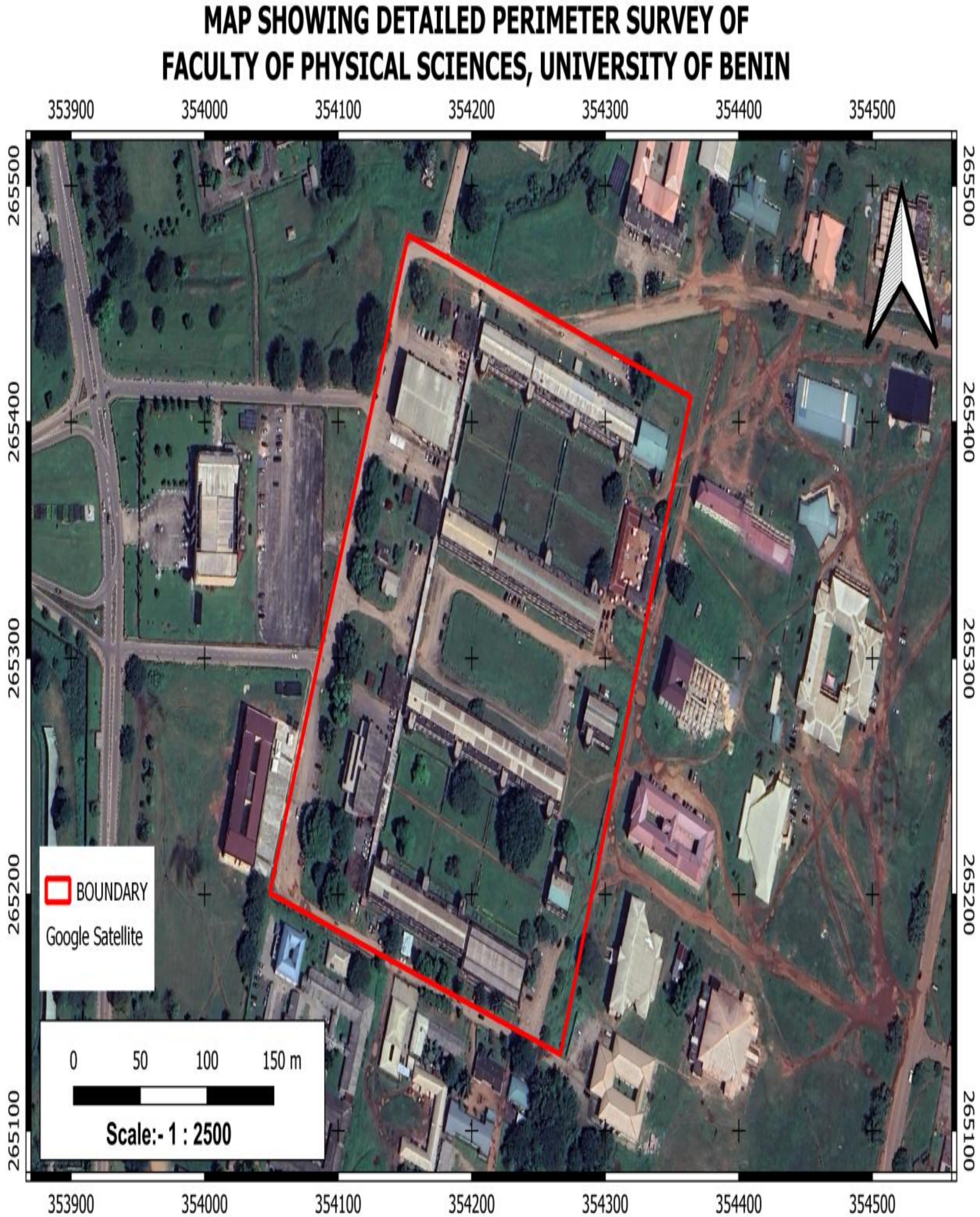


Figure 4.2. Detailed Perimeter Survey of The Faculty Of Physical Sciences.

Table 4.1. Perimeter Survey Coordinates of the Faculty of Physical Sciences

Eastings (m)	Northings (m)
354048	265200
354152	265478
354364	265410
354266	262135

Area = 66,640.863 square meters

4.3 Perimeter Plan of the Faculty of Physical Sciences, University of Benin

A perimeter survey, also referred to as a boundary survey, is a fundamental component of land surveying that focuses on accurately determining and mapping the legal and physical boundaries of a specific area of land. For the Faculty of Physical Sciences, University of Benin, this process was undertaken to define the exact extent of the faculty's land area and to establish reliable reference coordinates for future planning and development activities.

Through the use of Global Navigation Satellite System (GNSS) field data collection methods, the boundary coordinates of the Faculty of Physical Sciences were obtained with high precision. These coordinates served as the basis for generating the perimeter plan using AutoCAD software, ensuring geometric accuracy and professional presentation.

i. Developmental Planning:

A well-defined perimeter plan provides essential spatial information required for any future infrastructural development or construction projects within the faculty. By establishing precise boundary lines, planners and engineers can make informed decisions about land use, building placement, and potential expansion without encroaching on neighboring properties.

ii. Land and Facility Management:

The perimeter plan serves as a vital tool for effective land and facility management within the Faculty of Physical Sciences. It enables administrators to track land utilization, monitor encroachments, and manage resources within the designated boundary.

iii. Dispute Prevention and Resolution:

Clearly demarcated boundaries help to minimize or eliminate potential land disputes with adjacent faculties or external entities. The availability of an accurate perimeter plan provides verifiable evidence of ownership and spatial extent, which is crucial for institutional record keeping and legal referencing.

The perimeter plan analysis revealed that the total land area covered by the Faculty of Physical Sciences, University of Benin, is approximately 66,640.863 square meters. These measurements reflect the actual ground coverage derived from the processed GNSS field data.

In summary, the perimeter plan of the Faculty of Physical Sciences provides a foundational framework for spatial referencing, infrastructural planning, and effective land management. Its generation through AutoCAD software ensures accuracy, clarity, and professional visualization, making it a key output of this detailed mapping project.

4.4 Triangulated Irregular Network (TIN) Map of the Faculty of Physical Sciences, University of Benin

The Triangulated Irregular Network (TIN) map represents a three-dimensional digital model of the terrain surface of the Faculty of Physical Sciences, University of Benin. It was generated to depict the variation in elevation, surface slopes, and general topographic characteristics across the faculty premises. The TIN model plays a vital role in understanding the terrain configuration, which is crucial for engineering design, site planning, and effective drainage management.

4.4.1 TIN Data Development Process

The creation of the TIN model began with the acquisition of GNSS (Global Navigation Satellite System) field data, which provided precise three-dimensional coordinates (X, Y, and Z) of specific points within the Faculty of Physical Sciences. These points were carefully collected at evenly distributed intervals to ensure adequate coverage of the terrain and accurate representation of surface undulations.

After field data collection, the acquired coordinates were processed and imported into ArcGIS software, where the TIN model was generated. The ArcGIS 3D Analyst tool was used to construct the triangulated surface by connecting neighboring elevation points through a series of non-overlapping triangles. Each triangle vertex corresponds to a surveyed point with a defined elevation value. The algorithm used in creating the TIN model ensures that the resulting surface accurately reflects the real-world elevation profile of the faculty.

4.4.2 Analysis and Interpretation

The generated TIN map clearly illustrates the elevation variation within the Faculty of Physical Sciences. The visualization highlights gentle slopes, elevated areas, and slight depressions, all of which are important for construction planning and water flow management. The relatively stable topography within the faculty supports infrastructural expansion while also identifying areas that may require leveling or filling before construction activities.

The TIN model also assists in visualizing natural drainage patterns and slope directions, helping engineers and planners to design efficient storm water systems and avoid potential erosion-prone areas.

4.4.3 Significance of the TIN Map

The TIN map of the Faculty of Physical Sciences serves as a foundational dataset for multiple geospatial analyses and infrastructural applications, including:

i. Topographic Visualization: Provides a detailed three-dimensional representation of the land surface.

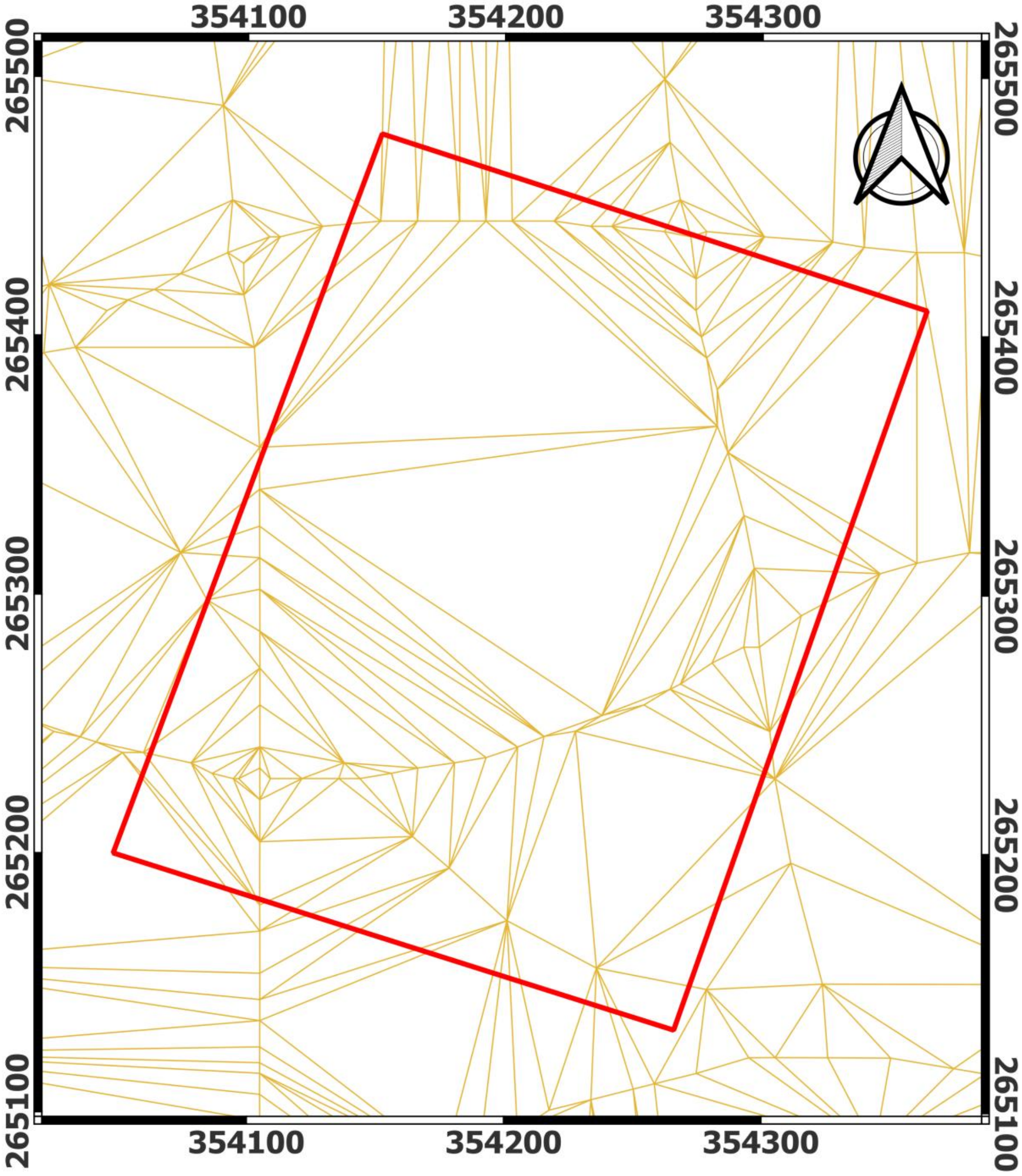
ii. Engineering Design Support: Assists in planning foundation levels, road alignments, and building placements.

iii. Hydrological Assessment: Helps identify water flow paths and runoff concentration zones.

iv. Urban Planning and Management: Facilitates effective decision-making in land allocation and construction prioritization.

The generated TIN map, shown in Figure 4.3, therefore provides a reliable digital representation of the faculty's terrain, serving as a critical tool for engineering and planning applications.

TRIANGULAR IRREGULAR NETWORK (TIN) OF FACULTY OF PHYSICAL SCIENCES, UNIVERSITY OF BENIN



Coordinate System: Nigeria West / Belt
Projection: Transverse Mercator
Datum: Minna
False Easting: 500,000.0000
False Northing: 0.0000
Central Meridian: 3.0000
Units: Meter

0 50 100 150 200 m

Scale:- 1 : 2,000

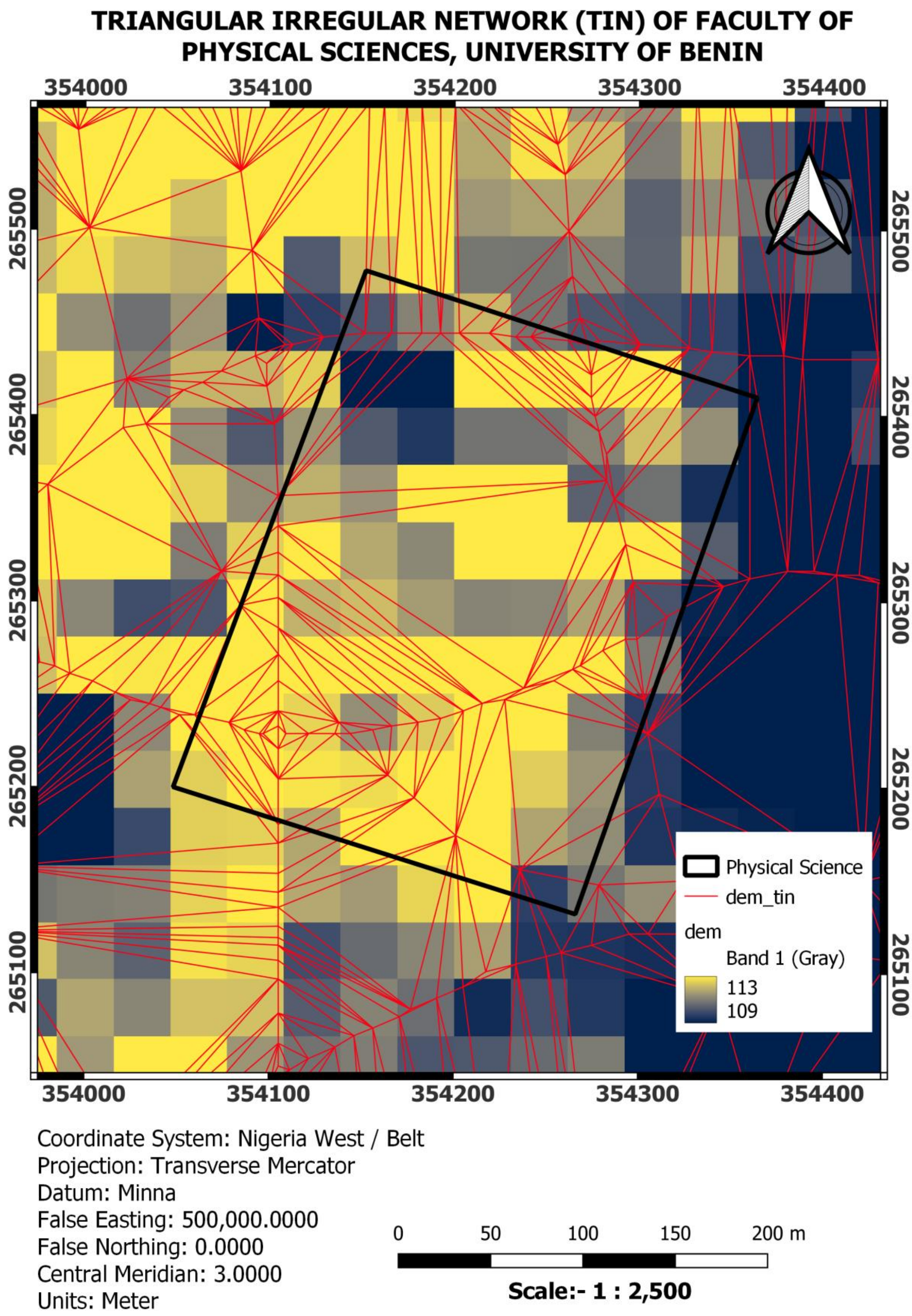


Figure 4.3. Triangular Irregular Network of Faculty of Physical Sciences

4.5 Digital Elevation Model (DEM) Map of the Faculty of Physical Sciences, University of Benin

The Digital Elevation Model (DEM) map is a raster-based representation of the terrain surface of the Faculty of Physical Sciences, University of Benin. It was developed from the TIN model to produce a continuous elevation grid where each cell contains an elevation value. The DEM provides a more generalized visualization of surface elevation, allowing for a wide range of spatial and environmental analyses.

4.5.1 DEM Generation Process

The DEM was generated by converting the previously created TIN model into a raster surface using the Spatial Analyst tool in ArcGIS software. The process involved interpolating elevation values between the known points of the TIN to produce a seamless and continuous elevation grid. The cell size and interpolation method were selected to balance accuracy and computational efficiency, ensuring a realistic and precise representation of the terrain.

The resulting DEM map provides a smooth visualization of elevation across the faculty, enabling a clearer understanding of elevation gradients, slope patterns, and drainage characteristics.

4.5.2 Analysis and Interpretation

The DEM map reveals subtle variations in elevation within the Faculty of Physical Sciences. Areas with higher elevation are displayed in lighter shades, while lower elevations appear darker, providing an easy-to-interpret gradient of the terrain. The analysis of the DEM indicates that the faculty lies on relatively gentle terrain, suitable for further structural expansion and infrastructural development.

Using the DEM, additional spatial analyses such as slope mapping, aspect analysis, and contour extraction can be performed. These analyses are essential for understanding terrain characteristics and making informed engineering and planning decisions.

4.5.3 Significance of the DEM Map

The DEM map offers several key benefits to geospatial, engineering, and environmental planning within the Faculty of Physical Sciences:

i. Hydrological Modeling: Enables the simulation of surface water flow and drainage pathways.
ii. Slope and Terrain Analysis: Provides data for identifying steep or low-lying areas critical for construction and drainage design.
iii. Infrastructure Development: Guides decisions regarding site grading, foundation design, and road construction.
iv. Environmental Management: Assists in assessing erosion risks, flood-prone zones, and vegetation planning.

The Digital Elevation Model, as shown in Figure 4.4, therefore serves as an invaluable spatial dataset that supports both academic research and practical decision-making related to environmental management, construction, and sustainable land use planning within the Faculty of Physical Sciences, University of Benin.

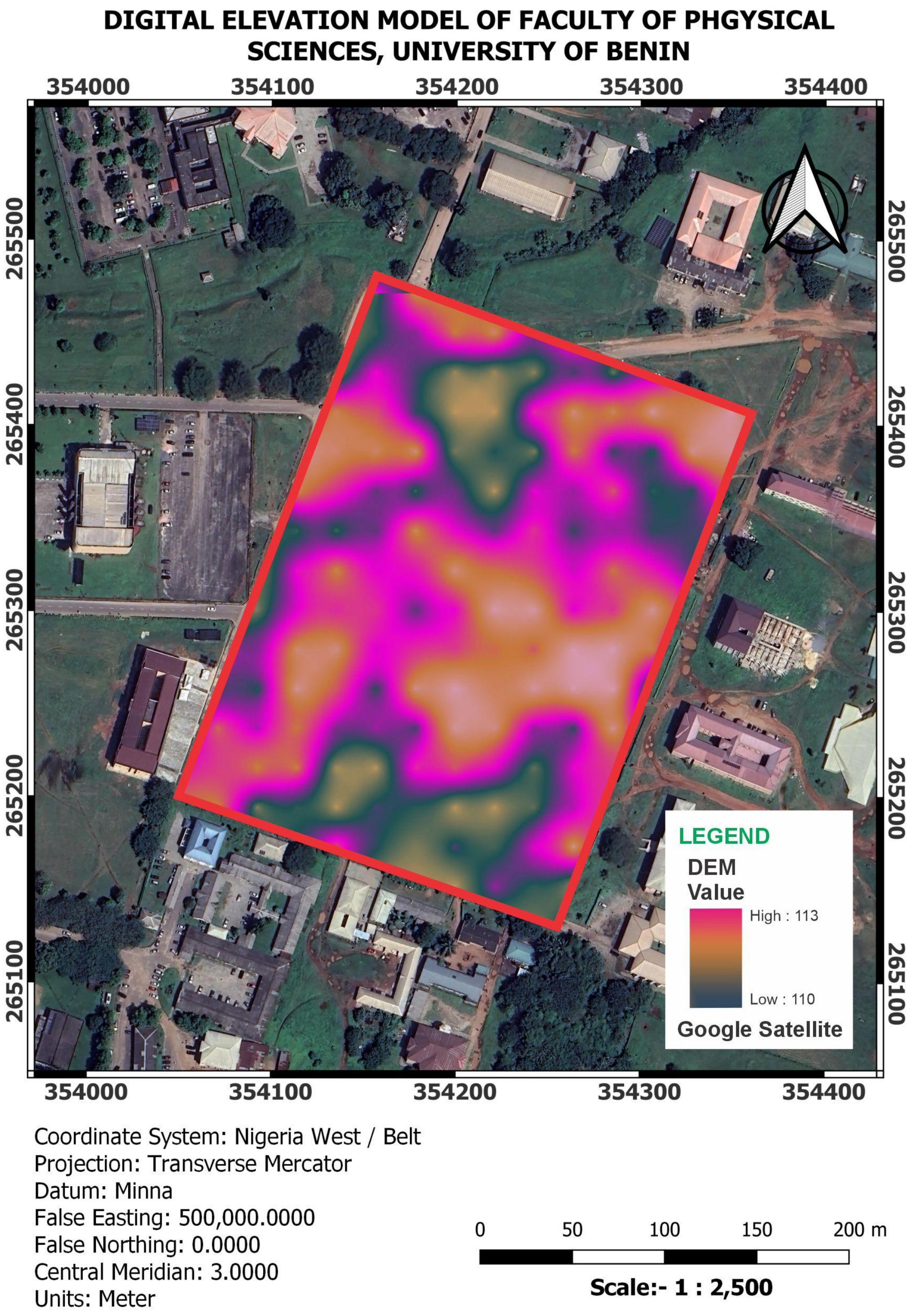


Figure 4.4. Digital Elevation Model of Faculty of Physical Sciences

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This project focused on the detailed mapping of the Faculty of Physical Sciences, University of Benin, with the objective of producing a comprehensive and accurate spatial representation of the faculty's features, boundaries, and terrain. The study successfully integrated modern surveying techniques and Geographic Information System (GIS) tools to generate three major outputs a detailed map, a perimeter plan, and terrain models (TIN and DEM maps).

The detailed map provided an up-to-date spatial representation of the faculty, highlighting key infrastructures such as buildings, road networks, vegetation zones, and open spaces. The perimeter plan accurately established the boundaries of the faculty, ensuring that spatial limits are clearly defined for future development and land management purposes. The TIN and DEM models offered critical insights into the topographical characteristics of the faculty, revealing variations in elevation that are essential for effective planning, design, and environmental management.

Through the use of GNSS technology, ArcGIS, and AutoCAD software, the study demonstrated the efficiency and reliability of geospatial tools in acquiring, processing, and analyzing spatial data. The integration of these technologies enhanced the precision, visualization, and interpretability of the resulting maps.

Overall, this project contributes meaningfully to both academic and practical domains. Academically, it serves as a case study in the application of geospatial technologies for institutional mapping. Practically, it provides the Faculty of Physical Sciences with an invaluable spatial database that can be utilized for campus planning, infrastructure maintenance, utility management, and future developmental projects.

The success of this mapping project underscores the significance of up-to-date geospatial information in sustainable infrastructure management and reinforces the vital role of Geomatics in supporting informed decision-making and resource optimization.

5.2 Recommendations

Based on the findings and experience gained during this study, the following recommendations are made to enhance the management and future development of the Faculty of Physical Sciences and the University of Benin as a whole:

1. **Regular Updating of Spatial Data:**

   The Faculty should institutionalize periodic updates of its geospatial data to ensure that new buildings, roads, and infrastructure developments are promptly captured. This will maintain the accuracy and relevance of the existing maps.

2. **Integration of GIS into Faculty Planning and Management:**

   The University should adopt GIS-based systems for facility management, infrastructure planning, and decision-making. This will allow for data-driven planning and improve resource allocation within the faculty.

3. **Expansion of Mapping Coverage:**

   Similar detailed mapping should be extended to other faculties and administrative units within the University of Benin to create a unified spatial database for the entire campus.

4. **Implementation of a Geospatial Data Repository:**

   Establishing a centralized GIS database will facilitate easy access, sharing, and management of spatial information among departments, researchers, and administrators.

5. **Environmental and Drainage Assessment:**

   The TIN and DEM outputs should be further analyzed for slope, contour, and watershed characteristics to aid in the design of effective drainage systems and flood mitigation measures within the faculty.

6. **Capacity Building and Training:**

   Continuous training should be provided for technical staff and students in the Department of Geomatics on the use of modern surveying and GIS technologies to enhance institutional mapping projects.

7. **Use of Drone Technology:**

   The university may consider integrating Unmanned Aerial Vehicles (UAVs) for future surveys to improve mapping resolution, speed, and coverage, particularly for larger or inaccessible area

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