COMPARATIVE TERRAIN ANALYSIS USING TOTAL STATION AND GNSS DATA AT BLOCK OF FLAT UNIVERSITY OF BENIN, UGBOWO CAMPUS

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SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF SCIENCE (B.Sc.) DEGREE IN SURVEYING AND GEO-INFORMATICS,
FACULTY OF ENVIRONMENTAL SCIENCES UNIVERSITY OF BENIN
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CERTIFICATION

This is to certify that this project was conducted by OGBETA SAMUEL with the Matriculation number ENV2009683 of the Department of Surveying and Geo-Informatics, Faculty of Environmental Science, University of Benin, Edo State, Nigeria.

Surv.Dr. S.O. Oladosu **Date**

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Head of Department

External Examiner **Date**

DEDICATION

This Project is first and foremost dedicated to God Almighty, whose boundless mercies and affection have made it possible to carry out the work on this project, and my family and friends who have supported me all through my journey in University of Benin, with a special dedication to my Dad and Mum for their support.

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ABSTRACT

This study was conducted at the university of Benin block of flat to evaluate the accuracy, efficiency, and applicability of both surveying methods in terrain mapping. The research aimed to improve the reliability of topographic data acquisition and to recommend appropriate techniques for modern surveying practices. It focused on determining how both instruments perform under similar field conditions and how their outputs can be effectively compared and integrated.

Field data were acquired using both Total Station and Global Navigation Satellite System (GNSS) instruments. Four temporary benchmarks were established using GNSS, which served as reference points for Total Station observations. The collected data were processed using Autodesk Civil 3D**,** ArcGIS, and Surfer software to generate contour maps, Digital Elevation Models (DEMs), and 3D surface models representing the terrain. These outputs provided a clear visualization of the area's elevation pattern and slope behavior.

The results revealed that the elevation within the study area ranged from 85. meters to 93.5 meters, indicating a gently sloping terrain with drainage flowing from north to south. Both datasets showed consistent terrain patterns, with the Total Station producing more detailed elevation variations and the GNSS providing faster and broader coverage. The study concludes that while the Total Station offers higher precision for detailed surveys, the GNSS method enhances efficiency and ease of data collection. Integrating both techniques is therefore recommended for achieving optimal accuracy and productivity in modern surveying and mapping projects.

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND TO THE STUDY

Accurate terrain analysis is an essential aspect of surveying and geospatial data collection. It provides the fundamental information required for engineering design, land development, environmental monitoring, and infrastructure planning. Over the years, the advancement of technology in surveying instruments has introduced several methods for capturing terrain data with improved precision and efficiency. Among these, the use of Total Station and Global Navigation Satellite System (GNSS) equipment has become prominent in modern surveying practice. Each of these techniques offers distinct advantages in data acquisition, processing, and overall reliability, which makes it necessary to understand their comparative performance in different field conditions.

The Total Station is a conventional yet highly reliable instrument that integrates electronic distance measurement (EDM) and angular measurement to provide accurate horizontal and vertical positions. It is widely used in engineering and construction surveys where high precision is required. On the other hand, GNSS has revolutionized the field by enabling fast and real-time positioning over large areas without the need for direct line-of-sight observations. Its capability to provide georeferenced data has made it an essential tool for topographic mapping, cadastral surveys, and other geospatial applications. Despite these advancements, both methods exhibit certain limitations. Total Stations require intervisibility between points, while GNSS accuracy can be affected by satellite geometry, signal obstruction, and atmospheric conditions.

A comparative terrain analysis between these two technologies provides valuable insight into their relative accuracy, efficiency, and applicability under real field conditions. Such comparison is particularly important in determining the most suitable method for specific surveying tasks and terrain types. It also contributes to optimizing survey operations by balancing precision, time, and cost efficiency.

This study focuses on the University of Benin (UNIBEN) Block of flat, where both Total Station and GNSS data were collected to generate terrain information for comparative assessment. The objective is to evaluate the accuracy and efficiency of each method, identify their operational strengths and weaknesses, and recommend suitable applications for different surveying scenarios. The outcome of this research will contribute to improving surveying practices by guiding professionals and students in selecting appropriate techniques for terrain data acquisition, analysis, and mapping.

1.2 STATEMENT OF THE PROBLEM

Surveying and mapping activities require accurate, reliable, and efficient methods for obtaining terrain data. In many institutions and professional practices, the Total Station remains the most commonly used instrument for topographic and engineering surveys due to its high level of precision. However, its dependence on intervisibility between points, time-consuming setup, and limited coverage area often reduce efficiency in large or complex terrains.

Conversely, the Global Navigation Satellite System (GNSS) has introduced faster and more flexible methods of data acquisition, allowing surveyors to collect positions over wide areas without line-of-sight constraints. Despite these advantages, GNSS observations are prone to positional errors caused by satellite geometry, atmospheric interference, and signal obstruction, especially in built-up or forested environments. These limitations can compromise the accuracy of data if not properly controlled or corrected. Given these contrasting characteristics, there is a need to evaluate and compare the performanc d GNSS under similar field conditions to determine their relative accuracy, efficiency, and suitability for terrain analysis. The lack of localized studies on how these instruments perform within the University of Benin (UNIBEN) Block of flat environment creates a knowledge gap for surveyors and students who rely on these technologies for practical work. This study therefore seeks to address this gap by conducting a comparative terrain analysis using data obtained from both instruments, providing a clear understanding of their strengths, limitations, and potential for improving surveying methods.

1.3 AIM AND OBJECTIVES

The aim of this project is to carry out a detailed comparative analysis of Total Station and Global Navigation Satellite System (GNSS) in the context of terrain analysis. The study seeks to examine the performance, accuracy, and operational efficiency of both instruments when used for collecting spatial data in real-world survey environments

The Objectives are to:

1. conduct field surveys using both Total Station and GNSS.

2. generate Digital Terrain Models (DTMs), 3D Surface Model and contour map from both datasets.

3. assess the accuracy and limitations of each method and to recommend appropriate application

1.4 SCOPE OF THE STUDY

This study focuses on conducting a comparative terrain analysis using data obtained from Total Station and Global Navigation Satellite System (GNSS) instruments within the University of Benin (Block of flat). The research is limited to evaluating the accuracy, efficiency, and applicability of both surveying methods in producing reliable terrain information for mapping and analysis purposes.

The fieldwork covers a defined portion of the Block of flat area, where coordinate data and elevation readings were collected using both instruments under similar environmental conditions. The data processing, analysis, and comparison were carried out using standard surveying and geospatial software to ensure consistency and reliability of results.

The study does not extend to other surveying techniques such as aerial photogrammetry, LiDAR, or remote sensing-based terrain analysis. It is also limited by environmental factors such as weather conditions, instrument calibration, and signal reception that may influence the accuracy of the observations. Despite these limitations, the research provides a valid basis for understanding the performance of both Total Station and GNSS in typical field conditions within the study area.

1.5 JUSTIFICATION OF THE STUDY

In today's land development, surveying, civil engineering, and construction industries, the need for accurate and trustworthy three-dimensional surveying techniques is greater than ever. Both GNSS and total stations are now indispensable instruments in the field, each with their own advantages and disadvantages. Despite their extensive use, a lack of precise, comparable evaluations makes it difficult for many practitioners and students to decide which of these instruments is most appropriate for a given surveying assignment. In order to close that gap, this study provides a useful comparison of the two instruments based on how well they function in real world field settings.

CHAPTER TWO

LITERATURE REVIEW

2.1 BASIC CONCEPT OF THE STUDY

Terrain analysis involves the process of measuring, mapping, and interpreting the physical features of the earth's surface to understand variations in elevation, slope, and landform structure. It forms a crucial part of surveying and geospatial studies because accurate terrain data is essential for engineering design, construction, drainage planning, and environmental management (Smith and Clark, 2018). The quality of any terrain analysis largely depends on the precision of the instruments and methods used in data collection (Chang, 2016).

The Total Station is a modern surveying instrument that combines electronic distance measurement (EDM) with angular observations to determine the precise coordinates of points on the ground. It provides high accuracy and is widely used in engineering and topographic surveys, though it requires line-of-sight between the instrument and target points (Akindele and Olatunji, 2019). On the other hand, the Global Navigation Satellite System (GNSS) determines positions on the earth's surface by receiving signals from orbiting satellites. It enables faster data collection over wide areas and does not depend on intervisibility between points, making it suitable for large-scale and inaccessible terrains (Hofmann-Wellenhof *et al.*, 2008; Uren and Price, 2019). The comparison of these two technologies is important because each has unique advantages and limitations that affect its performance in the field. Understanding their differences in terms of accuracy, efficiency, and applicability helps surveyors choose the most suitable method for specific tasks and conditions. This study therefore applies both Total Station and GNSS techniques in a common terrain environment, UNIBEN Block of flat to evaluate their performance and demonstrate their potential for improving surveying methods and data quality. (Graham and Sunal, 2018).

2.2 TOTAL STATION

A Total Station is a contemporary electronic surveying tool used in mapping, engineering, construction, and surveying. Electronic distance measurement (EDM) equipment, data processing capabilities, and theodolite functionality are all combined into one integrated device (Uren and Price, 2019). For accurate measurements of angles and distances, as well as for data collection and mapping, total stations are frequently utilized (Wolf and Ghilani, 2012). The parts, functions, and uses of total stations will all be covered in this response.

A Total Station is a surveying instrument used to measure angles and distances with high precision. It combines an electronic theodolite and an electronic distance meter (EDM) in a single unit (Banach, 2020). Here's a breakdown of its core components:

Electronic Theodolite: This part is responsible for accurate angle measurements. It has a telescope with crosshairs for precise aiming at targets and an internal system of angle encoders to measure both horizontal and vertical angles. The theodolite ensures accurate alignment, and it usually includes a leveling system, often with a circular level vial, to guarantee the instrument is perfectly level. (Adewale and Balogun, 2019).

i. Electronic Distance Meter (EDM): This component measures the distance to a target point. It emits a signal, often an infrared light or a laser, and measures the time it takes for the signal to travel to the target and return. The EDM then calculates the distance using the speed of light. A prism reflector is typically used as the target to reflect the EDM signal back to the instrument, ensuring a strong return signal for accurate measurements.

ii. Microprocessor: The microprocessor acts as the central processing unit of the total station. It processes the raw data from the angle encoders and EDM to calculate horizontal distances, vertical distances, and coordinates. It controls the overall operations of the instrument, stores the measured data and calculated results, and provides the interface for the user to interact with the system.

iii. Keyboard/Display: This is the user interface for the total station. The keyboard (or touchscreen) allows the user to input data, such as target information and setup parameters. The display shows the measured angles, distances, and calculated coordinates, providing real-time feedback to the user.

iv. Data Collector and Storage System: This system is used to collect and store the measured data. Total stations have internal memory for data storage and can often transfer data to external devices such as USB drives or memory cards. This allows surveyors to store and transfer the data for further processing and analysis using specialized surveying software.

2.2.1 Operation of a Total Station:

The operation of a total station involves the following steps:

i. Setup and Leveling: The whole station is leveled using bubble levels and the built-in leveling mechanism after being placed on a tripod. To guarantee precise measurements, it must be leveled appropriately.

ii. Target Sighting: The target point is aimed at using the telescope on the total station. The target is in line with the telescope's crosshairs, also known as reticles.

iii. Angle and Distance Measurement: Using the internal angular measurement system, the total station calculates the target's horizontal and vertical angles after it has been sighted. At the same time, it measures the distance between the instrument and the target using the Electronic Distance Measurement (EDM).

iv. Data Collection: Angles, distances, and other measurable data can be stored by the total station. For every measurement point, it might also be able to store further data, like codes or descriptions.

v. Data Processing and Analysis: On-site data analysis, coordinate computations, and mapping are made possible by the software or data processing capabilities that total stations frequently have. Using the information gathered, they can produce reports, drawings, and maps.

2.2.2 Applications of Total Stations:

Total stations are widely used in various surveying, engineering, and construction applications, including:

i. Land Surveying: For boundary surveys, topographic mapping, cadastral surveys, and building layout, total stations are widely utilized in land surveying.

ii. Construction: For accurate building, road, utility, and other structural planning, total stations are utilized in construction projects. They guarantee precise alignment and placement of the building components.

iii. Engineering and Infrastructure Projects: Bridge building, tunneling, and dam monitoring are a few examples of engineering projects that use total stations. They support accurate deformation analysis, monitoring, and alignment.

iv. Monitoring: To track the movement, settlement, or deformation of buildings, bridges, and other infrastructure over time, total stations are used in structural monitoring.

v. Mining and quarrying: Accurate surveying, stockpile measurement, and slope monitoring are all made possible by total stations.

2.2.3 Features of Total Stations:

i. High accuracy and precision in measurements.

ii. Ability to measure angles, distances, and elevations.

iii. Automatic correction of measurement errors.

iv. Integration with GPS and other technologies.

v. Data recording and storage capabilities.
vi. Easy to use, with a user-friendly interface.

Selecting the best Total Station for your needs might be difficult because there are so many different brands and models on the market. To assist you in making an informed choice, the following reviews of well-known total stations are provided: The Leica Flexline TS07 Total Station is renowned for its precision and user-friendliness. It is appropriate for a variety of surveying applications and has a range of up to 1,000 meters (Leica Geosystems, 2020).

Topcon ES-105: This total station boasts cutting-edge technologies including Bluetooth connectivity and dual-axis correction. It is renowned for its robustness and long battery life (Topcon Positioning Systems, 2019).

The Sokkia CX-105 is a mid-range total station with excellent accuracy and dependability. It is appropriate for a variety of surveying applications and has a range of up to 500 meters (Sokkia Corporation, 2018).

2.2.4 Limitations of Total Station

While total stations are highly accurate and precise instruments, there are some limitations to their use. Some of the limitations include:

i. Line of sight between the instrument and the target is necessary for total stations, which might be difficult in particular settings.
ii. Accuracy may be impacted by atmospheric circumstances like fog or rain, which can impair total stations.
iii. To provide precise measurements, total stations need knowledgeable operators.
iv. In comparison to other surveying tools, total stations are somewhat pricey.

2.2.5 Accuracy of Total Station

With most sensors giving data to within a few millimeters, total stations offer great levels of accuracy and precision. A number of variables affect the total station's accuracy, such as the instrument's quality, the operator's proficiency, and the setting in which the measurements are made. (Chand *et al.*, 2018).

2.2.6 Advantages of Total Station

i. Compared to other surveying tools, total stations have the following benefits:
ii. High measurement accuracy and precision
iii. Capacity to measure heights, angles, and distances
iv. Integration with additional technologies, such laser scanning and GPS
v. Capabilities for data recording and storage
vi. User-friendly interface that makes it simple to use and operate

2.2.7 Disadvantages of the Total Station

The following are a few drawbacks of total stations:

i. Rather costly in comparison to other surveying tools
ii. Need knowledgeable operators to guarantee precise measurements
iii. Subject to atmospheric condition factors like rain or fog
iv. Needs a direct line of sight between the target and the instrument

2.3 GNSS SYSTEM

The Global Navigation Satellite Systems (GNSS) is a technology that enables users to determine their location, velocity, and time anywhere on Earth using satellite signals. The GNSS includes systems like the Global Positioning System (GPS) from the United States, GLONASS from Russia, Galileo from the European Union, and BeiDou from China. These systems use a constellation of satellites orbiting the Earth, transmitting signals that are received by GNSS receivers on the ground. By calculating the time, it takes for signals from multiple satellites to reach the receiver, the exact position of the receiver can be determined with high accuracy. GNSS is widely used in various applications such as navigation, surveying, mapping, transportation, agriculture, and military operations. It plays a crucial role in everyday technology, from smartphones to autonomous vehicles, and is essential for industries relying on precision timing, like telecommunications and financial services. (Langley,1998).

e of Total Station an

2.3.1 Table2.1 satellite constellation description parameters for the various systems that make up the GNSS is as given below;

S/No	GNSS system	No of satellites	Satellite altitude	Orbital planes	Orbital period	Inclination to the Equators
1	Global Positioning System (GPS)	31	20,200km (MEO)	6	12 hours	55°
2	GLONASS	24	19,100km	3		64.8°
3	BeiDou	27	21,500km (MEO)	3		
		5	(Geostationary)			
		3	nclined Geosynchronous			

2.3.2 Principle of GNSS

The principle of position determination in GNSS is based on trilateration, where a receiver calculates its position by measuring the time delay of signals from multiple satellites. Each satellite transmits its location and the time the signal was sent (Hofmann-Wellenhof *et al.*, 2008). The receiver uses the time delay to calculate its distance from each satellite. To determine a precise position, the receiver must obtain signals from at least four satellites, solving for the three spatial coordinates (latitude, longitude, and altitude) and correcting any clock error between the receiver and satellites). By combining these distances, the receiver pinpoints its exact location on Earth, making GNSS an accurate and reliable tool for global navigation and timing (Kaplan and Hegarty, 2017).

2.3.3 The typical GNSS unit comprises of three (3) segments which are;

1. Space Segment (Satellites): This includes the constellation of GNSS satellites that transmit signals to users on Earth. These satellites provide the necessary data for position determination.
2. Control Segment: Ground-based stations that monitor, control, and maintain the satellite constellation. They ensure accurate satellite positioning, health monitoring, and system synchronization.
3. User Segment: Consists of GNSS receivers (such as those in smartphones, vehicles, and specialized equipment) that collect signals from the satellites to determine the user's position, velocity, and time.

2.3.4 Procedures involved in GNSS positioning

The processes involved in GNSS positioning are;

i. Satellite Signal Transmission: GNSS satellites continuously transmit radio signals containing satellite position, time of transmission, and satellite health status. Global Navigation Satellite Systems (GNSS) rely on the transmission of radio signals between satellites and receivers on Earth to determine position. GNSS satellites broadcast signals containing timing information, which allows a receiver to calculate its distance from each satellite based on the time delay of the signal's arrival. The key principle governing GNSS positioning is time of flight the time it takes for a signal to travel from a satellite to the receiver.

(Hegarty and Kaplan 2017)

ii. Signal Reception by GNSS Receiver: The receiver on the ground captures signals from at least four satellites to determine position accurately. GNSS signal reception by a receiver unit involves acquiring and processing signals from multiple satellites to calculate the user’s precise position. The receiver’s antenna captures low-power radio frequency signals transmitted by GNSS satellites, which include data on satellite time and position (ephemeris and almanac). Once the signals are acquired, the receiver computes the pseudorange to each satellite by measuring the time difference between when the signal was transmitted and when it was received. These pseudoranges are then used in a process called trilateration to estimate the receiver's location on Earth. Since the receiver can experience timing errors, it must detect signals from at least four satellites to resolve both position (latitude, longitude, and altitude) and the clock bias. The receiver continuously updates its calculations as it moves or as satellite geometry changes. (Spilker and Parkinson 1996)

2.3.5 GNSS Data Post-processing.

GNSS data post-processing refers to the method of refining raw GNSS (Global Navigation Satellite System) data collected by receivers to improve accuracy and precision in position determination. This process is very important for applications requiring high accuracy, such as cadastral surveys, geodesy, and country mapping (Seeber, 2003). GNSS post-processing works by correcting the errors present in raw data due to factors like atmospheric interference, satellite clock inaccuracies, and multipath effects (Hofmann-Wellenhof *et al.*, 2008). The technique uses two or more GNSS receivers, where one is typically a base station at a known location and the other is a rover that moves to collect data. By comparing data from both receivers, corrections are applied to reduce errors in the rover's position estimates (Langley, 1998).

Post-processing can achieve centimeter-level accuracy, which is far superior to the accuracy provided by real-time GNSS alone, especially for high-precision tasks (Misra and Enge, 2012). There are various post-processing techniques, such as Differential GNSS (DGNSS), Static GNSS, Kinematic GNSS, and Precise Point Positioning (PPP). In DGNSS, correction data from a base station (with a known position) is used to adjust the rover's GNSS data (Teunissen and Montenbruck, 2017). Static GNSS post-processing involves the base and rover remaining stationary for long observation periods, providing highly precise results. Kinematic GNSS is used when the rover is in motion, applying similar corrections in dynamic environments. PPP relies on precise satellite orbit and clock data, requiring no base station but offers a standalone correction method. The choice of technique depends on the application, the required accuracy, and the available equipment. Post-processing is commonly performed using specialized software like Trimble Business Center, Leica Infinity, or open-source tools like RTKLIB, GAMIT, and GYPSY. (Zumberge *et al*., 1997)

2.3.6 Differential GNSS

Differential GNSS (DGNSS) is a technique used to enhance the accuracy of standard GNSS (Global Navigation Satellite System) positioning by employing a reference station, also called a base station, at a known location. The base station compares the GNSS signals it receives to its exact known position and calculates the errors in the satellite signals, which may result from atmospheric disturbances, satellite clock drift, or multipath effects (Langley, 1998). These error corrections are then transmitted to nearby rovers or mobile GNSS receivers in real-time or during post-processing, allowing them to adjust their positions accordingly (Leick *et al.*, 2015). DGNSS significantly improves positioning accuracy and reduces positioning error from several meters to within a few centimeters (Hofmann-Wellenhof *et al*., 2008).

There are two main types of DGNSS: Real-Time DGNSS (RTK) and Post-Processed DGNSS. In real-time DGNSS, the corrections calculated by the base station are broadcasted to the rover in real-time via radio, cellular networks, or satellite links. This approach is commonly used in applications such as precision agriculture, navigation, and construction, where real-time accurate positioning is required (Teunissen and Montenbruck, 2017). Post-processed DGNSS, on the other hand, involves collecting GNSS data at both the base station and rover and applying the corrections at a later time with the aid of a software. This is often the case in high-precision geodetic applications where real-time accuracy is not essential, but higher precision is required during data analysis and reporting (Misra and Enge, 2012). One of the key advantages of DGNSS is that it does not require highly specialized or expensive equipment; it can be used with standard GNSS receivers, with the addition of a base station or access to a network of base stations (Seeber, 2003). Most often than not, linking the rover to a network of Continuously Operating Reference Stations (CORS) which provide DGNSS corrections to users within the network's coverage area is the most common DGNSS method usually implemented (Rizos, 2007). The CORS networks enable users to access real-time or post-processed corrections without setting up their own base stations, making DGNSS more accessible and cost-effective (Soler and Snay 2008).

2.3.7 The Atmosphere and GNSS signals

The earth's atmosphere is composed of both the Troposphere and the Ionosphere

The troposphere: The troposphere is the lowest layer of Earth's atmosphere, extending from the surface up to about 8-15 km, depending on geographical location and weather conditions. It contains most of the atmosphere's water vapor, clouds, and weather systems. For GNSS (Global Navigation Satellite System) signals, the troposphere introduces delays as signals pass through this layer, caused by changes in temperature, pressure, and humidity. This is known as tropospheric delay and affects all satellite

signals regardless of their frequency. Tropospheric effects are particularly significant when satellites are closer to the horizon, as the signal travels a longer path through this dense atmospheric layer. However, unlike the ionosphere, these delays are non dispersive, meaning they do not vary with signal frequency. Tropospheric models and corrections, such as the Saastamoinen model, are used to mitigate these delays.(Davis and Herring 1985). Tropospheric error correction models include;

i. Hopefield model
ii. Goad and Goodman model

The Ionosphere: The ionosphere lies above the troposphere, extending from about 50 km to 1,000 km above the Earth's surface. It contains charged particles (ions and electrons), which affect GNSS signals through a phenomenon called ionospheric delay. This delay is dispersive, meaning it varies with the signal frequency. As GNSS signals pass through the ionosphere, their speed is reduced, and their path is bent (refraction), leading to errors in positioning accuracy. The severity of the ionospheric effect depends on the time of day, solar activity, and geographic location, with higher impacts seen during periods of solar storms or near the equator. To correct for ionospheric delays, dual-frequency GNSS receivers can compare signals on two frequencies (e.g., L1 and L2) to estimate and reduce the error. Additionally, models such as the Klobuchar model are applied for single-frequency receivers to mitigate ionospheric effects.(Klobuchar 1987)

Ionospheric error correction models include;

i. Klobucha model
ii. NeQuick model

2.3.8 GNSS Reflectometry

GNSS Reflectometry (GNSS-R) is a remote sensing technique that utilizes reflected GNSS signals from Earth's surfaces to measure environmental parameters. In GNSS-R, signals from GNSS satellites, initially intended for positioning, reflect off surfaces like water, ice, soil, or vegetation. Analysis of these reflected signals provides insights into various environmental conditions (Gleason and Gebre-Egziabher, 2009). For instance, water bodies reflect signals differently compared to soil, enabling the measurement of sea surface heights, soil moisture levels, and snow depth (Larson *et al.*, 2008). The variations in reflection characteristics, such as signal delay, phase, and strength, provide valuable data for monitoring climate change, studying ocean dynamics, and managing natural resources (Cardellach *et al.*, 2011).

Applications of GNSS-R are diverse, with significant use in environmental and Earth sciences. One primary application is in meteorology, where GNSS-R is used for tracking sea ice extent and changes in coastal waters, parameters fundamental in understanding polar region dynamics and predicting sea level changes (Ruffini *et al.*, 2004). Additionally, this technique is valuable in agriculture for monitoring soil moisture, aiding irrigation management, and enhancing crop yield predictions (Chew and Small, 2014). GNSS-R also supports disaster management by tracking flood-prone areas and providing timely data for rapid response (Zavorotny *et a*l., 2014). Its low cost, passive nature and global coverage make GNSS-R an effective tool for large-scale environmental monitoring (Katzberg *et al.*, 2006).

2.3.9 Reverse GNSS

Reverse GNSS is an emerging approach where GNSS receivers act as transmitters, enabling precise positioning of moving objects. Traditionally, GNSS satellites broadcast signals to receivers that calculate their positions. In Reverse GNSS, the roles are reversed: ground stations emit signals to be detected by GNSS satellites or other receivers, which then determine the location of these transmitters. This approach is particularly advantageous in environments where direct satellite receiver communication is challenging, such as dense urban areas, deep canyons, or indoors, where conventional GNSS signals are weak or obstructed. Reverse GNSS finds applications in critical areas like disaster management and search-and-rescue operations. In emergency situations, portable ground-based transmitters can be deployed to relay positioning data, helping locate individuals in remote or obstructed areas. Additionally, Reverse GNSS supports applications in autonomous vehicle navigation, where maintaining precise location is crucial, even in GPS-denied areas. Reverse GNSS can also play a role in aviation, aiding aircraft navigation when direct GNSS signals are unreliable. (Capdeville and Testud 2013).

2.3.10 GNSS Seismology

GNSS Seismology leverages Global Navigation Satellite System (GNSS) technology to monitor seismic activity by detecting ground displacements that occur during earthquakes. High-rate GNSS receivers, which provide data at frequencies of up to 10 Hz or more, record subtle movements in Earth's crust (Bock and Melgar, 2016). By continuously measuring the precise position of GNSS receivers placed in seismically active regions, scientists can track ground shifts in real time, providing critical data on earthquake dynamics (Blewitt *et al*., 2009). This method complements traditional seismology by providing direct measurements of crustal deformation before, during, and after seismic events, making it a powerful tool for earthquake monitoring and analysis (Larson, 2009).

Applications of GNSS Seismology are crucial in earthquake-prone regions for disaster management and geophysical research. The data from GNSS networks support early warning systems, enabling timely alerts that help reduce earthquake impacts on populations and infrastructure (Ruhl *et al*., 2017). Furthermore, GNSS Seismology plays an important role in studying tectonic plate movements, contributing to the identification of earthquake-prone zones and improving seismic hazard assessments (Kreemer *et al*., 2014). Additionally, GNSS data assist in modeling and analyzing the long-term effects of seismic events on landscapes, infrastructure, and ecosystems, offering a comprehensive understanding of post-seismic deformation processes (Melgar and Bock, 2015).

2.3.11 Trilateration in Relation to GNSS

Global Navigation Satellite Systems (GNSS), such as GPS, GLONASS, Galileo, and BeiDou, are satellite-based technologies used for determining precise positions on the

Earth's surface. The core mathematical method that allows a GNSS receiver to calculate its position is called trilateration.

Trilateration is a geometric method of determining the position of a point by measuring its distances from three or more known locations. Unlike triangulation, which uses angles, trilateration uses distances as the primary input. In GNSS, these distances are measured between the receiver and multiple satellites orbiting the Earth. (Leick., *et al* 4th edition)

2.4 COR STATION

Continuous Operating Reference Station is referred to as CORS. With GPS (Global Positioning System) or GNSS (Global Navigation Satellite System) receivers that continuously gather high-precision location data, a CORS is a permanently installed reference station. For a wide range of applications in surveying, mapping, geodesy, and related geospatial fields, CORS are essential sources of precise positioning data (Rizos, 2007). The basic idea behind a CORS is that it is designed to collect signals from multiple satellites within the GNSS or GPS constellation. These signals are processed using precise algorithms and correction models to determine highly accurate positions (Blewitt, 2015). To guarantee extensive coverage and consistent accuracy, CORS operate as part of a coordinated network of reference stations strategically distributed across regions. This network ensures reliable, continuous, and high-quality positioning information for users in both real-time and post-processing applications (Wanninger and Heßelbarth, 2020).

2.4.1 Principle of COR Station

Continuously Operating Reference Station (CORS) works on a simple yet powerful principle: it is a GNSS receiver installed at a precisely known, fixed location. Because the exact coordinates of this point are known, any difference between the position calculated by the receiver and the actual coordinates indicates the presence of errors in the satellite signals

(Blewitt, 2015). These errors could arise from atmospheric disturbances, satellite orbit irregularities, or timing issues (Rizos, 2007).

The CORS receiver continuously records these discrepancies and uses them to compute correction data. This correction information is then transmitted to nearby mobile GNSS receivers to enhance their positioning accuracy. By referencing the data from a stable, known point, users in the surrounding area can significantly reduce positional errors often from several meters to within a few centimeters (Wanninger and Heßelbarth, 2020). The system supports both real-time applications and post-processed surveys, making it invaluable in precision surveying, mapping, geodesy, and geospatial analysis (El-Mowafy, 2012).

2.4.2 Component OF COR Station

i. GNSS Antenna: This is the external device that receives signals from GNSS satellites (e.g., GPS, GLONASS, Galileo). It is mounted on a stable monument or structure to ensure it remains in a fixed position. The antenna must be of high quality to minimize signal distortion and multipath errors.

ii. GNSS Receiver: The receiver processes the signals collected by the antenna. It continuously records raw satellite data and computes position information. The receiver is responsible for logging data at high frequency (e.g., 1 Hz or higher) and must be capable of long-term, uninterrupted operation.

iii. Antenna Mount/Monument: This is the physical support or structure that holds the antenna in place. It is designed to be stable and resistant to movement caused by environmental factors like wind, temperature, or ground shifts. Common types include deep-driven pillars or concrete piers.

iv. Power Supply System: The power system ensures continuous operation. It can include mains electricity, solar panels, batteries, or a combination of these. A backup power system is often included to prevent data loss during outages.

v. Data Communication System: This system transfers data from the receiver to remote servers or end-users. It may use the internet, radio links, modems, or cellular networks. Real-time services like RTK (Real-Time Kinematic) depend on fast, reliable communication.

vi. Data Storage Unit: This is where the collected GNSS data is stored, either locally on the receiver or remotely on a server. Data is usually archived for later access, post-processing, or analysis.

2.4.3 Application of COR Station

i. Land Surveying: Surveyors use CORS correction data for boundary surveys, cadastral mapping, and topographic data collection with high precision.

ii. Construction and Civil Engineering: CORS supports machine control, site layout, road alignment, and infrastructure development by ensuring accurate positioning.

iii. Geodetic and Geophysical Studies: Researchers use CORS data to monitor crustal deformation, plate tectonics, and sea level changes.

iv. Mapping and GIS: Geographic Information Systems (GIS) benefit from improved positional accuracy for data collection and analysis.

v. Agriculture (Precision Farming): Farmers use GNSS-guided tractors and machinery corrected by CORS for tasks like planting, spraying, and harvesting with minimal overlap and waste.

vi. Agriculture (Precision Farming): Farmers use GNSS-guided tractors and machinery corrected by CORS for tasks like planting, spraying, and harvesting with minimal overlap and waste.

2.4.4 Benefits of COR Station

i. High Accuracy: CORS provides centimeter- to millimeter-level positioning accuracy when used with techniques like RTK (Real-Time Kinematic) and PPK (Post-Processed Kinematic). This is far superior to standard GNSS accuracy.

ii. Cost-Effective: Users can obtain correction data from existing CORS networks without needing to set up their own base stations, reducing equipment and labor costs.

iii. Time-Saving: Real-time corrections from CORS allow for instant accurate positioning, which reduces field time and speeds up survey and construction workflows.

iv. Reliable and Continuous Data: Since CORS stations operate 24/7, they provide a continuous and reliable stream of GNSS data that can be used at any time for both real-time and post-processing needs.

v. Improved Precision in Geospatial Monitoring: CORS networks help monitor tectonic movements, subsidence, and deformation with high precision over time.

2.5 REVIEWS ON RELATED LITERATURE

Transit and Theodolite Surveying: Transit and theodolite surveying use instruments to measure horizontal and vertical angles. Trigonometry is applied to calculate distances and positions. (James and Edward 2001).

Terrain analysis has become an important aspect of geospatial studies, particularly for understanding landform characteristics, slope variations, and elevation patterns. A study examined the use of GNSS data for generating accurate terrain models and evaluating surface characteristics. The research focused on collecting elevation data using GNSS receivers and processing the information to develop digital terrain representations. The results showed that GNSS-based observations can provide reliable elevation data for terrain modelling when proper correction techniques are applied. The study concluded that GNSS technology is suitable for large-scale terrain analysis due to its efficiency and wide spatial coverage. (Hofmann and Lichtenegger)

Another investigation focused on the application of total station instruments in terrain data collection and surface modelling. The research involved measuring ground points across a study area and using the observations to generate detailed terrain profiles. The results demonstrated that total stations provide very high accuracy in elevation and horizontal positioning, particularly for small project sites where detailed mapping is required. The study emphasized that total stations remain essential instruments in engineering surveying because of their precision in terrain data acquisition. (Uren *et al.*,2021)

Leveling: Leveling determines vertical differences or elevations using leveling instruments and rods. It is crucial for establishing accurate contours and height differences. (Barry and Kavanagh ,2017).

GPS/GNSS Surveying: GPS/GNSS surveying utilizes satellite signals to determine precise positions. It is widely used in mapping, geodesy, and navigation. (Pratap and Enge , 2011).

Total Station Surveying: Total station surveying combines electronic distance measurement with angular measurements. It enables accurate measurements of both angles and distances for precise positioning. (Kavanagh and Slattery, 2018).

Terrestrial Laser Scanning (TLS): TLS uses laser technology to create precise three-dimensional point clouds. It is commonly used in architecture, archaeology, and industrial applications. (Graham and Sunal , 2018).

A study examined the influence of measurement techniques on the quality of digital terrain models produced from survey data. The research involved collecting elevation points using different instruments and comparing the resulting terrain surfaces. The findings showed that the density and distribution of observation points significantly affect the accuracy of terrain models. The study recommended the use of systematic data collection strategies when conducting terrain surveys. (Mikhail and Bethel 2001).

Photogrammetry: Photogrammetry reconstructs three-dimensional information from overlapping images. It is used in mapping, aerial surveys, and cultural heritage documentation.(Karl and Sabry, 2016).

A study explored the integration of GNSS and total station observations for terrain analysis and digital surface modelling. The research compared the accuracy of both datasets when used individually and when combined for terrain modelling. Field observations were collected using both GNSS receivers and total stations, and the resulting datasets were processed using GIS software. The findings revealed that integrating both technologies improved the reliability and completeness of the terrain model. The study highlighted that combining GNSS and total station measurements provides better spatial representation of terrain features.(El-Rabbany 2012)

A related investigation assessed the performance of total stations in generating digital terrain models for engineering applications. The study involved detailed ground measurements and the creation of contour maps and terrain profiles from the collected data. The results indicated that total stations provide highly reliable elevation measurements, making them suitable for construction projects and engineering design. The research emphasized that despite the advancement of satellite-based technologies, total stations remain relevant for precise terrain analysis. (Wolf and ghilani 2013).

Another study investigated the accuracy of terrain models generated from GNSS data by comparing them with those derived from traditional surveying techniques. The research involved collecting elevation data from multiple observation points and processing the results to produce terrain surfaces. The findings showed that GNSS-derived terrain models were generally consistent with those obtained through conventional methods, although slight discrepancies were observed in areas with dense vegetation or poor satellite visibility. (Leick et al ., 2015)

CHAPTER THREE

METHODOLOGY

3.1 DESCRIPTION OF THE STUDY AREA

Block of flat is located in UNIBEN Benin City, which is in southern Nigeria, in the capital of Edo State. It is roughly located between longitudes 5°35′ East and 5°45′ East and latitudes 6°17′ North and 6°26′ North. The city, which occupies an area of around 1,204 square kilometers, serves as Edo State's political, cultural, and economic hub. Egor Local Government Area is located in Edo State, Nigeria, specifically within the South-South geopolitical zone. It's situated in the southern part of Edo State and is considered part of the Benin City metropolitan area. Its headquarters is in the town of Uselu.

The rainy season, which normally lasts from April to October, and the dry season, which lasts from November to March, are the two main seasons in Benin City, which is located in the tropical rainforest zone. The city receives between 1,500 and 2,000 mm of rainfall annually, and temperatures are high all year long, averaging about 27°C. The city's humid and lush environmental conditions are a result of normally high humidity levels, especially during the wet months.

Benin City's elevation ranges from roughly 50 to 150 meters above sea level, and the terrain is primarily flat with a few small undulating sections. Numerous rivers and streams, most notably the Ogba and Ikpoba rivers, provide good drainage for the region, affecting the hydrology and distribution of flora. Although fast urban expansion has resulted in significant destruction and change of the natural land cover, the original vegetation cover was primarily composed of dense tropical rainforest. As the former capital of the erstwhile Benin Kingdom, Benin City has significant cultural and political historical value. The city's fast urban expansion in recent years has been fueled by rising commercial activity, infrastructure improvements, and population growth. Complex land use patterns, geographical development, and a variety of other outcomes are the result of these dynamics.

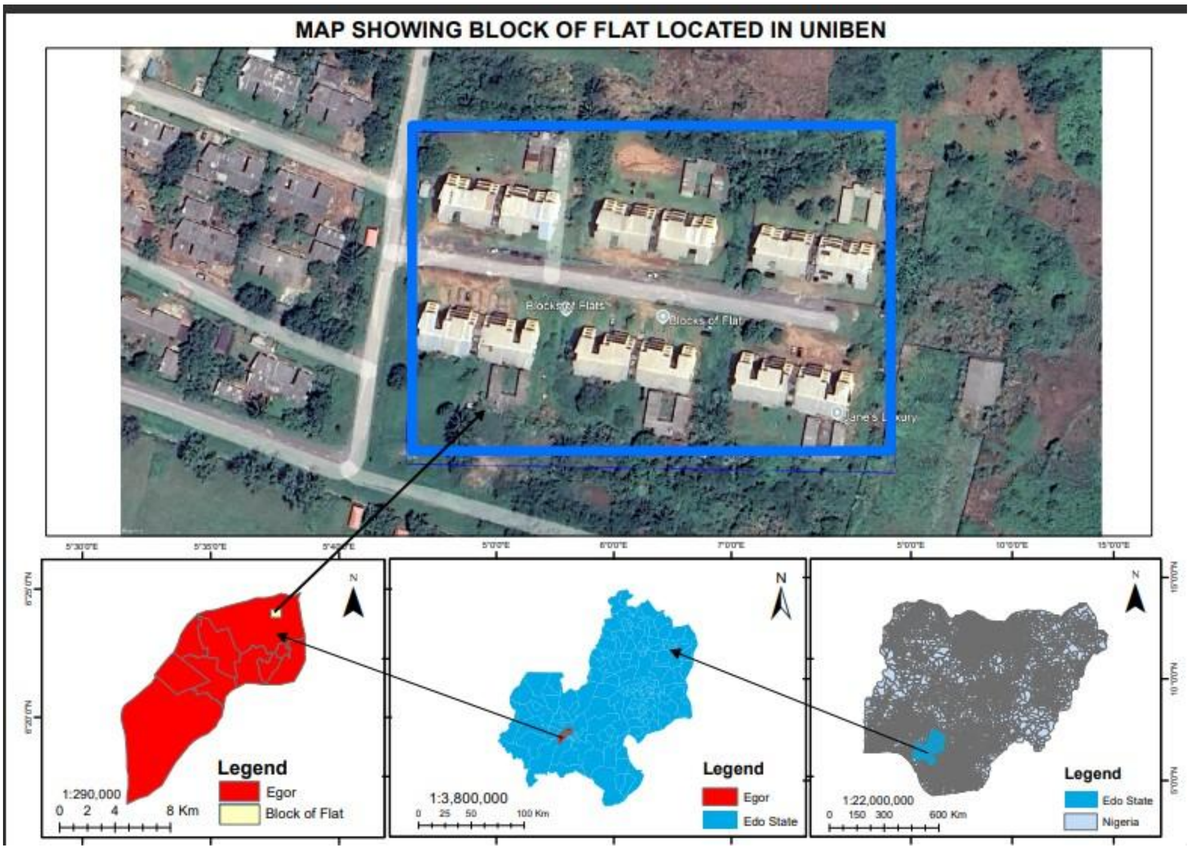

Figure 3.1 Study area map of block of flat and its environs

3.2 PLANNING

Prior to carrying out in-depth surveying operations, the survey region must be systematically inspected and examined as part of the crucial reconnaissance phase. Because it gives surveyors essential information that affects the design and execution of the survey, it is essential to the success and effectiveness of land surveying projects.

Surveyors visit the location during the reconnaissance phase to become acquainted with the topography, the surrounding environment, and any potential obstacles that could affect the survey.

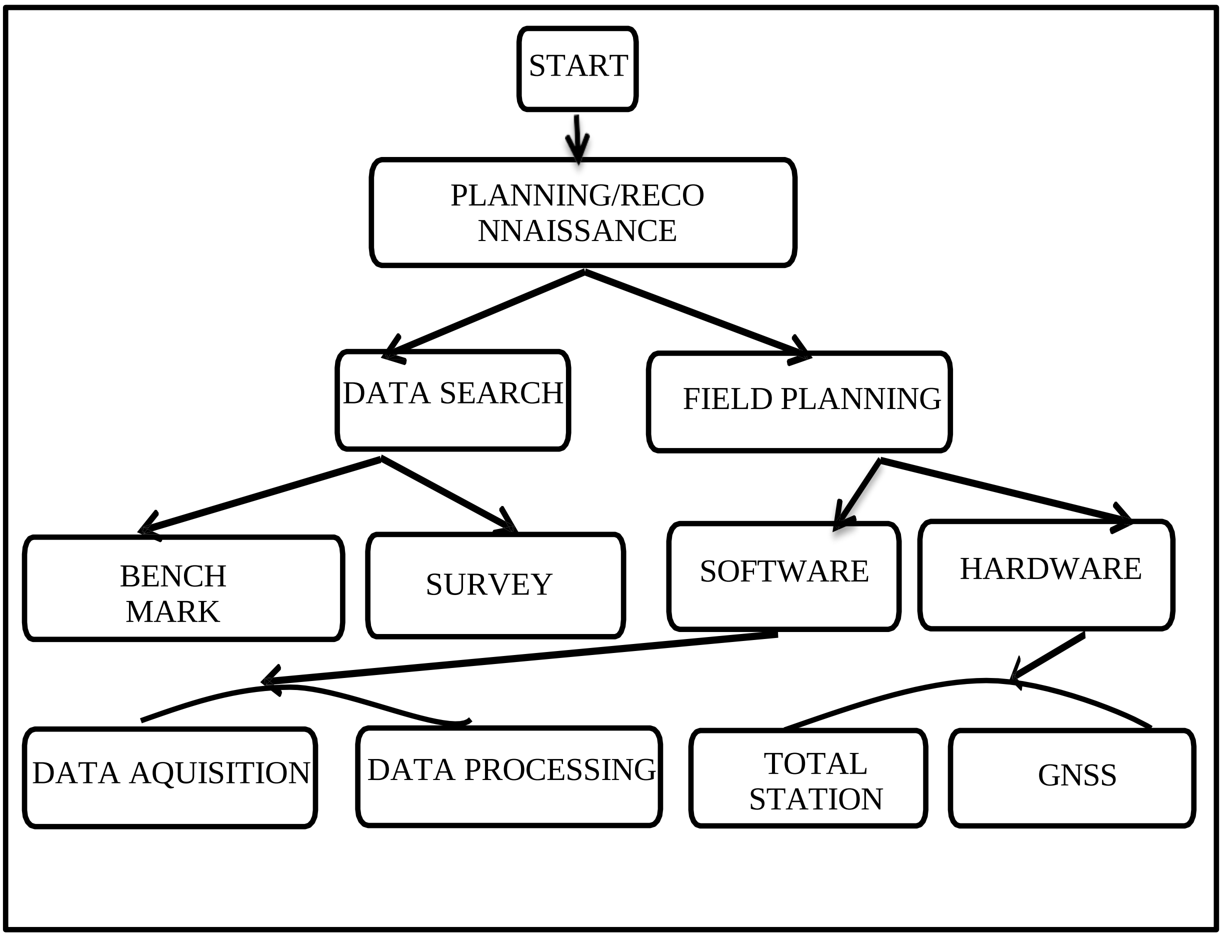

Figure 3.2 Stages followed

3.2.1 Planning/Reconnaissance

To evaluate the general characteristics of the research region and make plans for further fieldwork, a preliminary reconnaissance survey was carried out at Block of flat, University of Benin, Benin City. Finding appropriate sites for control point establishment and learning about the topography, accessibility, and environmental conditions were the goals. two bench mark were carefully establish and labeled to act as reference stations for the primary survey tasks. The establishment of these bench mark was based on factors such ground stability, intervisibility, and the lack of vegetation or building blockage. Crucial information from the reconnaissance survey influenced the primary data collecting phase's design and execution.

3.2.2 Bench Mark Establishment

A benchmark was established within the study area to serve as a temporary reference point for all subsequent survey operations. The benchmark was positioned using a Global Navigation Satellite System (GNSS) receiver to ensure accurate georeferencing and consistency in coordinate measurement. The site for the benchmark was carefully selected on stable ground, free from obstructions such as buildings, trees, or overhead cables, to allow clear satellite signal reception.

The GNSS receiver was set up directly over the selected point with the antenna height precisely measured and recorded. Observations were carried out using static mode, where satellite data were logged for a sufficient period to achieve high positional accuracy. The collected data were later processed using GNSS post-processing software to obtain the precise geographic coordinates and elevation values of the benchmark.

The computed coordinates were referenced to the WGS84 datum, and the point was permanently marked with a concrete pillar and metal identification tag for future reference. This benchmark served as the control point from which all other observations within the UNIBEN Block of flat study area were coordinated. Establishing the benchmark in this manner ensured uniformity, reliability, and precision throughout the data acquisition phase of the project.

3.3 SOFTWARE AND INSTRUMENT USED

The following instrument and software were chosen to achieve the desired result following study, proper project preparation, and review of the project specification. **Software used**

i. Civil 3D
ii. ArcGIS Pro
iii. Google Earth Pro
iv. Surfer
v. Microsoft Excel

Instrument used

i. GNSS
ii. Total station
iii. Tripod
iv. Reflector prism

3.4 DATA AQUISITION

After establishing the benchmark with GNSS, terrain data collection was carried out within the study area using a Total Station. The instrument was used to obtain precise horizontal and vertical measurements of various points across the UNIBEN Block of flat environment. The main purpose of this activity was to generate coordinate and elevation data that would be compared with those obtained from the GNSS observations for the same area. Before data collection commenced, the Total Station was properly set up and leveled over the established benchmark. Instrument calibration and atmospheric corrections (temperature and pressure) were applied to ensure measurement accuracy. The instrument height and target (prism) height were carefully measured and recorded for each setup. The benchmark served as the back-sight, while subsequent points within the area were observed as fore-sight stations.

Observations were taken systematically to cover the entire study area, including changes in elevation and terrain features. For each setup, the horizontal angle, vertical angle, and slope distance were measured automatically by the Total Station. These raw field readings were stored electronically in the instrument's internal memory for later transfer to a computer. Care was taken to maintain line-of-sight between the instrument and the prism to avoid errors in measurement.

Table 3.1 field data collected using Total station and GNSS

GNSS COORDINATES				TOTAL STATION COORDINATES		
utm_easting	utm_northing	altitude (m)		utm_easting	utm_northing	altitude (m)
791113.5	708624.6	85.7		791161.2	708630.6	85.1
791113.5	708577.4	93.8		790941.7	708583.4	93
791113.5	708548.4	88.8		791139.1	708554.4	88.2
790951.4	708657.1	93.4		790961.9	708663.1	92.6
790956.7	708655.3	93.5		790973.5	708661.3	92.9
790934.6	708653.2	93.8		790993.6	708659.2	93
791013.9	708650.2	93.9		791012.6	708656.1	93.3
791021.5	708648	94.5		791032.3	708654	93.7
791047.5	708645.2	93.6		791051.1	708651.2	93
791051.5	708643	93.2		791067	708649	92.6
790993.6	708641.2	93		791082.2	708647.2	92.2
791079.3	708639.7	92.3		791097.9	708645.7	91.7
791106.8	708637.2	91.2		791113.4	708643.2	90.4
791133.1	708636.5	87.5		791141.7	708642.5	87.3
790931.5	708642.3	92.4		790946	708648.2	92.2
790943.4	708642.9	92.8		790952	708648.9	92.6
790936	708633.3	92.4		790944.6	708639.3	92.2
790942.6	708633.9	92.8		790951.2	708639.9	92.6

790950.1	708631.6	93.2		790958.7	708637.6	93
790959.9	708629.5	93.8		790968.5	708635.5	93.6
790977.8	708628.8	93.6		790986.4	708634.8	93.4
790995.9	708627.2	93.1		791004.4	708633.2	92.9
791014.6	708624.6	92.6		791023.2	708630.6	92.4

At the end of the field exercise, the recorded data were downloaded using the instrument's data transfer software and processed to obtain northings, eastings, and elevation values of all observed points. The processed data were used to generate a Digital Terrain Model (DTM) and contour map of the study area. These results provided a basis for comparison with the terrain data derived from the GNSS observations, allowing for evaluation of the accuracy, efficiency, and applicability of both surveying methods.

3.4.1 Purpose of This Method

Using two known control points for orientation allows me to accurately align the instrument to true direction and minimize angular error ensuring that the new points collected during the traverse fit correctly into the existing control network established by GNSS.

3.4.2 Using GNSS to Pick the Same Points for Data Comparison

During the GNSS data acquisition, the receiver was connected to a Continuously Operating Reference Station (CORS) known as geosystem to improve the positional accuracy of the observations. The geosystem CORS provided real-time correction signals, allowing the receiver to operate in Real-Time Kinematic (RTK) mode.

In this setup, the CORS served as the base station, continuously transmitting correction data to the GNSS receiver (rover) in the field through an internet connection. Before beginning observations, the receiver was configured to connect to the geosystem network using its communication credentials, and the connection status was verified to ensure stable correction reception.

Once connected, the rover recorded precise coordinates and elevations for all observed points within the study area in real time. This approach minimized satellite and atmospheric errors and ensured centimeter-level accuracy without the need for long static observations. The corrected GNSS data obtained from the geosystem CORS were later saved and processed to generate accurate terrain information for comparison with the Total Station results.

3.5 DATA PROCESSING

The processed coordinate data obtained from both the Total Station and GNSS were imported into Autodesk Civil 3D for terrain modeling and map generation. The data, saved in CSV format containing northing, easting, and elevation values, were first added as point files within the Civil 3D workspace.

A surface was then created from these points using the Create Surface from Point Group command. Civil 3D automatically generated a Digital Terrain Model (DTM) representing the elevation variations across the study area. Afterward, contour lines were produced from the surface by setting suitable contour intervals to display terrain undulations clearly.

The generated DTM and contour map 3d surface map were reviewed, labeled, and adjusted for clarity. The final output provided a visual representation of the topography within UNIBEN Block of flat, which was later used for comparing the accuracy and quality of data obtained from the Total Station and GNSS surveys.

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 RESULTS AND DISCUSSION

The data collected from both the Total Station and GNSS within UNIBEN Block of flat were processed and analyzed using a combination of geospatial software to generate various terrain models. The coordinate and elevation data from each instrument were first processed and then imported into Autodesk Civil 3D**,** Surfer**,** and ArcGIS for visualization and analysis. From the processed datasets, two Digital Elevation Models (DEMs)**,** two 3D surface maps, and two contour maps were produced one set from the GNSS observations and another from the Total Station measurements.

The contour maps produced in Civil 3D provided a clear representation of the terrain pattern across the study area. Both the GNSS and Total Station contours showed a similar general slope and elevation distribution. However, the contours derived from the Total Station data appeared smoother and more continuous, indicating higher local accuracy. The GNSS contour map, though accurate overall, displayed minor elevation inconsistencies in a few spots, likely caused by signal obstruction and satellite geometry during data acquisition.

The Digital Elevation Models (DEMs) generated in ArcGIS showed consistent topographic variations within the site. Both DEMs revealed a gentle terrain with moderate elevation differences. The Total Station DEM provided a finer and more detailed surface definition, while the GNSS DEM offered a broader terrain representation that was still reliable for general mapping and analysis.

In Surfer**,** the 3D surface maps for both datasets gave a visual perspective of the elevation changes across the site. The Total Station 3D surface appeared smoother and more continuous due to its higher point density and precision. In contrast, the GNSS 3D surface map was slightly coarser but effectively represented the terrain structure and elevation trends within the area. In terms of operational performance, the GNSS method proved faster and more efficient for field data collection, as it allowed observations over a wider area without requiring line-of-sight between points. The Total Station, however, produced more precise elevation and coordinate data but required more setup time and intervisibility between the instrument and prism. These observations confirm that while GNSS offers speed and coverage, the Total Station provides accuracy and detail**.**

Overall, both methods successfully represented the terrain characteristics of UNIBEN Block of flat. The comparison indicates that GNSS is more suitable for large-scale mapping or reconnaissance surveys, while the Total Station is preferable for detailed engineering and construction work.

4.2 COORDINATE COMPARISON BETWEEN GNSS AND TOTAL STATION

During the course of the survey, four temporary benchmarks (TBMs) were established within the UNIBEN Block of flat using the GNSS receiver. These benchmarks served as control points for instrument orientation and referencing during the Total Station survey. The coordinates and elevations obtained from the GNSS observations were used as the initial reference values, while corresponding coordinates were later observed with the Total Station for the same points.

Table 4.2 data comparison

BENCHMARK	GNSS COORDINATES			TOTAL STATION COORDINATES			DIFFERENCES		
ID	EASTING	NORTHING	HEIGHT	EASTING	NORTHING	HEIGHT	ΔE	ΔN	ΔH
TBM1	791036.26	708586.96	91.95	791036.31	708587.11	91.82	-0.05	-0.15	0.13
TBM2	791054.56	708583.74	92.55	791054.60	708583.71	92.57	-0.04	0.03	-0.02
TBM3	791035.62	708560.21	93.25	791035.56	708560.22	93.10	0.06	-0.01	0.15
TBM4	791073.56	708577.81	92.45	791073.59	708577.76	92.41	-0.03	0.05	0.04

4.3 CONTOUR MAP OF THE STUDY AREA

The contour map of UNIBEN Block of flat was produced using Autodesk Civil 3D from the processed coordinate and elevation data obtained during the survey. The map illustrates the variation in elevation across the study area, providing a clear visualization of the terrain structure and slope pattern. The contour intervals were carefully selected to reflect the subtle elevation differences within the site. With a point scale of 0.25 and contour interval of 0.5m.

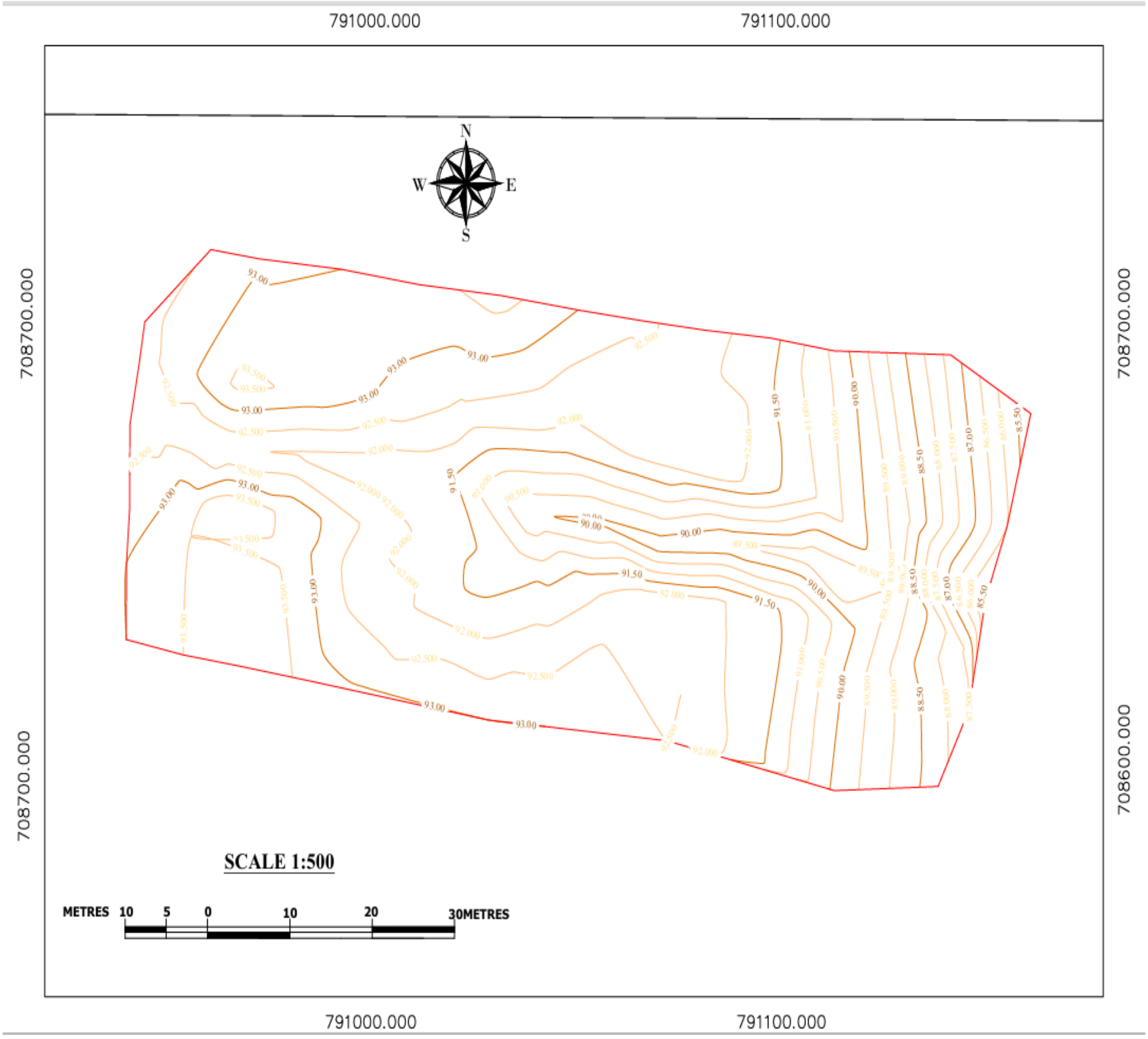

Figure 4.1 contour map of study area

As shown in Figure 4.1**,** the contour lines are closely spaced in certain portions of the area, indicating gentle slopes and slight variations in ground elevation. The overall pattern reveals that the study area has a generally uniform terrain with moderate undulations. This representation serves as the foundation for generating the Digital Elevation Model (DEM) and 3D surface map, as well as for comparing the outputs obtained from the Total Station and GNSS datasets.

The contour map of clearly illustrates the elevation variation across the study area, with the highest elevation recorded at 93.8 meters and the lowest elevation at 85.1 meters above mean sea level. This difference in height indicates a total relief of about 8.7 meters**,** which suggests that the terrain is generally gentle with moderate undulations.

The spatial distribution of the contour lines shows that the higher elevations are located toward the northern part of the area, while the lower elevations occur toward the southern and central portions. The contour lines are more widely spaced in most sections, confirming that the slope gradient is mild and suitable for various land uses, including construction, access roads, and agricultural activities.

In terms of drainage and water flow**,** the direction of runoff can be interpreted from the arrangement of the contour lines. Since water naturally flows from higher to lower elevations, surface runoff within the study area is expected to move downslope from the north (high ground) toward the south (low ground)**.** This implies that the southern section of the area may serve as a natural drainage path or accumulation zone, especially during heavy rainfall. Proper drainage design and erosion control measures would therefore be important in managing surface water flow and preventing localized flooding in the lower parts of the site.

The contour analysis thus provides essential insight into the topographic behavior and hydrological response of the area. It also supports the accuracy of the terrain models generated from both the Total Station and GNSS data, showing that the elevation patterns captured by both methods reflect the true physical condition of the ground.

4.4 DIGITAL ELEVATION MODEL (DEM) ANALYSIS

The Digital Elevation Models (DEMs) for the study area were generated separately from the GNSS and Total Station datasets to visualize and analyze the elevation pattern across block of flat. Both DEMs were produced using ArcGIS, which interpolated the field data points to create continuous elevation surfaces. The DEMs provide a clearer understanding of the topographic variations and serve as a basis for evaluating terrain characteristics.

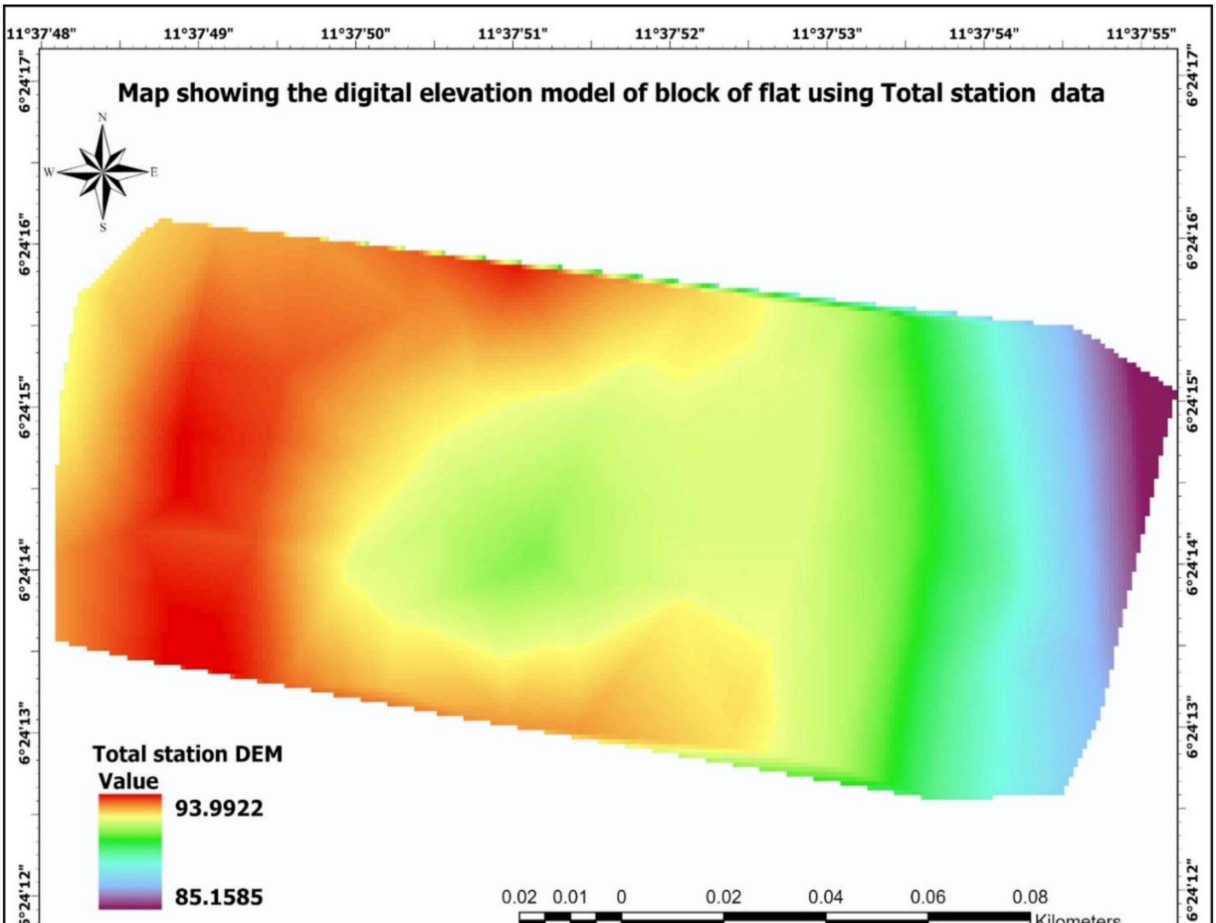

Figure 4.2 map shewing the digital elevation model of block of flat using Total station data

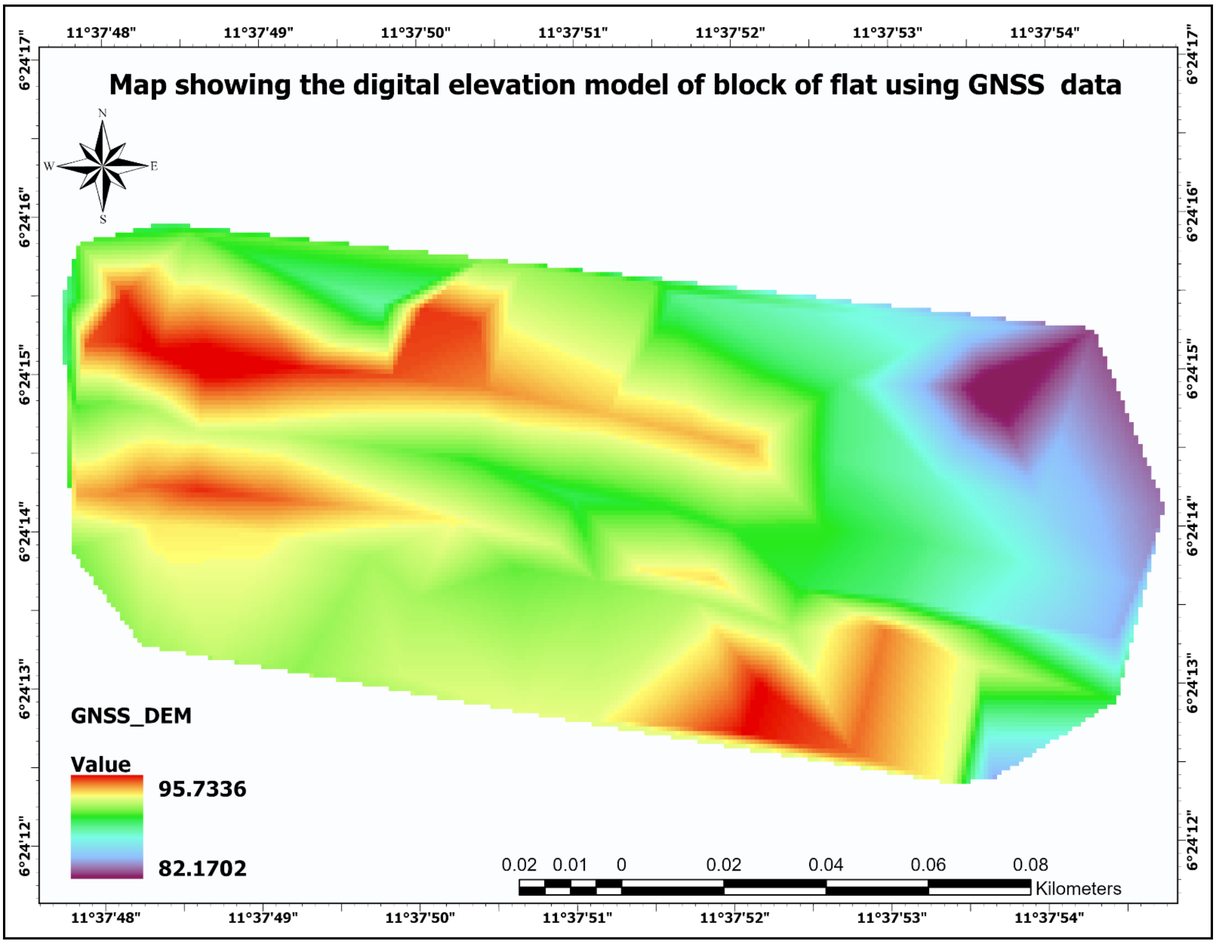

Figure 4.3 map shewing the digital elevation model of block of flat using GNSS data

As shown in Figure 4.2 and Figure 4.3**,** the two DEMs exhibit a similar general elevation trend, with the highest elevation reaching approximately 93.8 meters and the lowest around 85.1 meters above mean sea level. This corresponds with the contour analysis, confirming that the study area has a gently sloping terrain. The color gradient on both DEMs clearly illustrates the downward slope from the northern section toward the southern part of the site, indicating the natural direction of surface water flow.

Comparing the two DEMs, the Total Station DEM displays a smoother and more detailed surface representation, which reflects the instrument’s high precision in measuring short-range elevation differences. The GNSS DEM, while slightly less detailed, provides a broader and more generalized representation of the same terrain, accurately capturing the main elevation changes across the site. The slight differences between the two surfaces are attributed to the variation in point density, measurement precision, and environmental factors affecting each method.

4.5 3D SURFACE MODEL ANALYSIS

The 3D surface models of the study area were generated using the processed data from both the GNSS and Total Station surveys. The models were produced in Surfer software**,** which provided a realistic three dimensional visualization of the terrain at Block of flat. The 3D representation allows for better interpretation of the topographic relief, slope direction, and general landscape structure compared to conventional two dimensional maps.

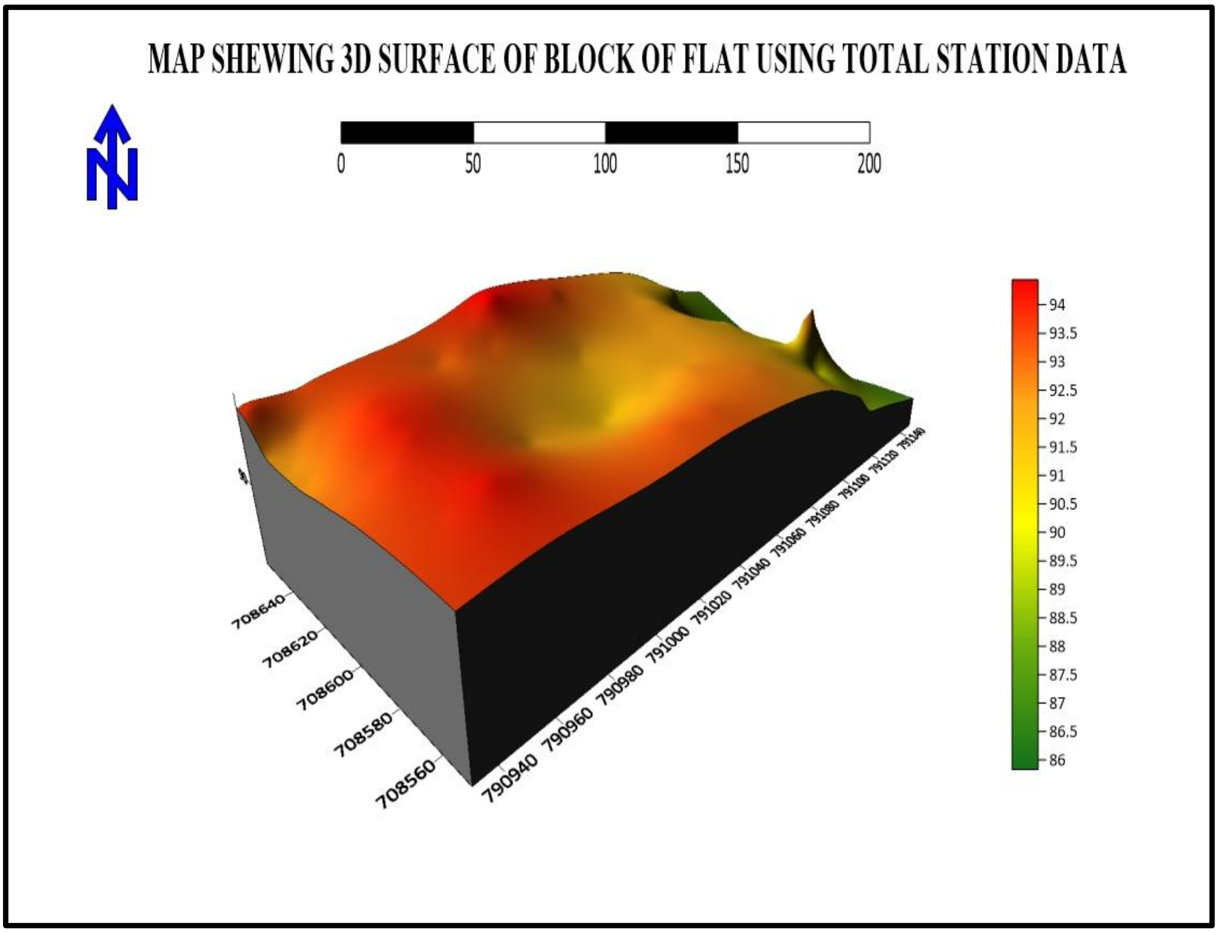

Figure 4.4 map shewing 3D surface of block of flat using total station data

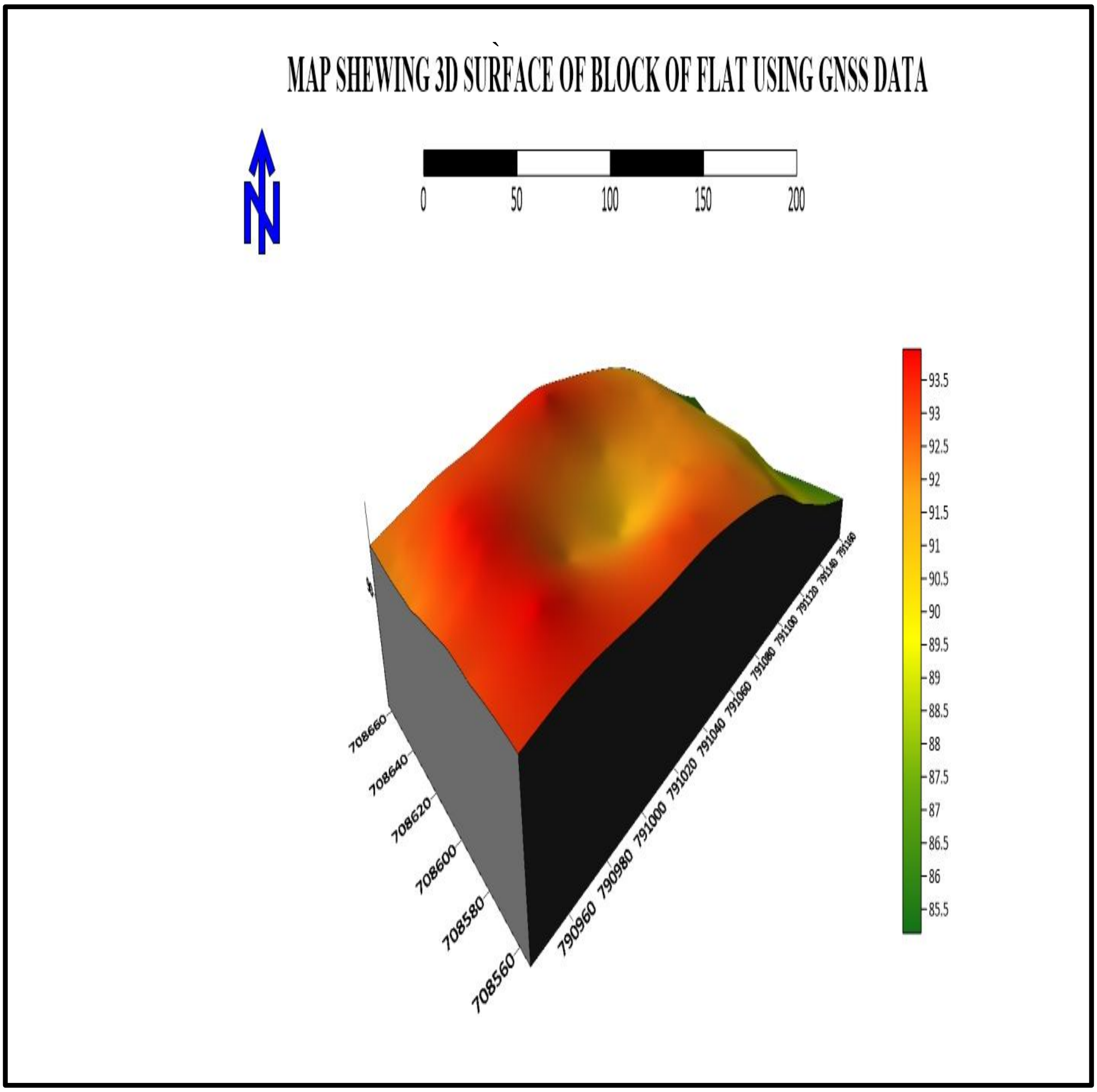

Figure 4.5 map shewing 3D surface of block of flat using total station data

As shown in Figures 4.4 and 4.5, both 3D surface models clearly depict the gentle undulating nature of the terrain, with elevations ranging from 85.1 meters at the lowest point to 93.8 meters at the highest**.** The high areas are predominantly located toward the northern portion of the site, while the southern section slopes gently downward. This configuration supports the results from the contour and DEM analyses, confirming that surface runoff and natural drainage tend to move from north to south.

A comparative assessment of the two models shows that the Total Station 3D surface provides a slightly more refined texture and sharper elevation transitions due to its higher spatial resolution and point accuracy. The GNSS 3D surface, on the other hand, presents a smoother terrain profile, reflecting the broader coverage and efficiency of GNSS data acquisition. Despite these differences, both models display a consistent terrain pattern, validating the reliability of both instruments for topographic modeling.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

This study on Comparative Terrain Analysis Using Total Station and GNSS Data was carried out within UNIBEN Block of flat to evaluate the efficiency, accuracy, and applicability of both surveying instruments for topographic mapping. The project involved conducting detailed field surveys using the Total Station and GNSS receiver, processing the acquired data, and generating terrain models, including contour maps, Digital Elevation Models (DEMs)**,** and 3D surface maps, to compare the outputs derived from each method.

The results from the contour and DEM analyses revealed that both instruments effectively captured the terrain characteristics of the study area, showing a consistent elevation range between 85.1 meters and 93.8 meters above mean sea level. The Total Station data produced slightly more detailed and refined terrain models due to its higher point density and line-of-sight precision. In contrast, the GNSS data provided a smoother but sufficiently accurate terrain representation, demonstrating its suitability for general topographic and engineering surveys.

The coordinate comparison between the two datasets showed only minor discrepancies in horizontal and vertical positions, which fall within acceptable survey limits. These variations can be attributed to instrumental precision, setup conditions, and environmental factors such as satellite geometry and signal interference. Despite these differences, both methods produced reliable and compatible spatial data for terrain modeling.

From the analyses, it can be concluded that Total Station surveying remains highly reliable for detailed, small-area projects that require centimeter level precision, such as construction layout and engineering design. On the other hand, GNSS surveying offers significant advantages in speed, ease of setup, and wider area coverage, making it ideal for reconnaissance, control establishment, and large-scale mapping.

5.2 RECOMMENDATIONS

Based on the results and findings from this study, it is recommended that both GNSS and Total Station methods be used complementarily in future surveying projects to maximize accuracy and efficiency. The GNSS should be employed primarily for the establishment of control points and benchmarks due to its speed and wider area coverage, while the Total Station should be used for detailed ground data acquisition where higher precision is required. This integrated approach will ensure that surveys are both time-efficient and technically reliable.

Proper calibration and maintenance of instruments before and during fieldwork are also essential to reduce systematic and human errors. Establishing permanent control points within the area will further enhance positional accuracy and serve as long-term references for future surveys or monitoring projects. In addition, environmental conditions such as satellite visibility, atmospheric interference, and line-of-sight obstructions should always be considered when planning and executing field measurements.

Surveyors and students should also be encouraged to acquire technical proficiency in both field and data processing software such as Civil 3D, Surfer, and ArcGIS, as these tools greatly improve data visualization and terrain modeling. The adoption of more advanced technologies like RTK GNSS and robotic Total Stations is equally encouraged to enhance productivity, reduce field time, and produce more accurate terrain representations. By applying these recommendations, future surveying and mapping operations can achieve higher standards of precision, reliability, and efficiency.

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