ARDHI UNIVERSITY

ASSESSMENT OF SENTINEL 2 IMAGERY AND NASADEM FOR TOPOGRAPHIC MAPPING

A Case Study of Jordan University College Morogoro, Tanzania.

MBONDE JABIRI J

BSc Geomatics

Dissertation

Ardhi University, Dar es Salaam

August 2023

ASSESSMENT OF SENTINEL 2 IMAGERY AND NASADEM FOR TOPOGRAPHIC MAPPING.

A Case Study of Jordan University College Morogoro, Tanzania**.**

JABIRI MBONDE J

A Dissertation Submitted to the Department of Geospatial Sciences and Technology in Partially Fulfillment of the Requirements for the Award of Science in Geomatics (BSc.GM) of Ardhi University.

CERTIFICATION

The undersigned certify that they have read and hereby recommend for acceptance by the Ardhi University dissertation titled **"Assessment of sentinel-2 imagery and NASADEM for topographic mapping, a Case Study of Jordan university college"** in partial fulfillment of the requirements for the award of degree of Bachelor of Science in Geomatics at Ardhi University.

………………………………… ……………………………..

Dr Zakaria Ngereja **Mr Bakari Mchila**

(Main Supervisor) (Second Supervisor)

Date ……………………… Date ………………………

DECLARATION AND COPYRIGHT

I, MBONDE JABIRI J hereby declare that, the contents of this dissertation are the results of my own findings through my study and investigation, and to the best of my knowledge they have not been presented anywhere else as a dissertation for diploma, degree or any similar academic award in any institution of higher learning.

………………………………..

MBONDE JABIRI J

22789/T.2019

(Candidate)

ACKNOWLEDGEMENT

The completion of this undertaking could not have been possible without the participation and assistance of many people whose names may not all be enumerated. Their contribution is sincerely appreciated and gratefully acknowledged. First of all, I am grateful to Allah for enabling me to successfully complete this research. I would like to extend my earnest gratitude to my supervisor, Dr. Zakaria Ngereja and Mr Bakari Mchila for their support, valuable advice, inspiration, motivation, and guidance during my dissertation. It was a very good professional experience to do my dissertation under their supervision. Sincere thanks to my fellow students Benedict Mramba, Abdallah Machemba and Jons Kamwenda who's in one way or another have contributed to the accomplishment of this research, also another grateful thanks goes staff members of School of Earth Science, Real Estates, Business and Informatics of Ardhi University for their contributions during my entire studies which helped me to shape and successfully complete this research. Last but not least, I would like to thank my classmates, fourth year students 202 in Department of Geospatial Science and Technology (DGST) for their help and cooperation during my entire studies at Ardhi University

DEDICATION

I am thankful to my family, friends and the university staff for encouraging me throughout my journey of this work. Thereby I dedicate this dissertation work to my beloved Mother, Fatuma Shabani who has been my great support in all ways.

ABSTRACT

A topographic map is a type of map characterized by large-scale detail and quantitative representation of relief, usually using contour lines in modern mapping, by using variety methods. Accuracies of Topographic maps vary depending upon the different application and type of instrument to acquire topographic data.

In this study, the main aim was to assess the performance of sentinel-2 imagary and NASADEM in topographic mapping a case study of Jordan University college in Morogoro region Tanzania. Sentinel-2 optical imagery was used for the feature extraction and NASADEM was used in extraction of contours for assessing vertical position. Topographic map was generated after combining features from the image and contour lines from NASADEM in AutoCAD. Based on the accuracies of the image and digital elevation model, standard deviation obtained from position of features was negative in value that indicate data from RTK-GPS method are not correlated with data from the image.

Results indicate that satellite image with NASADEM data and RTK-GPS data sets have not good enough in large scale mapping of a scale large than 1:50000 but it can be useful in small scale mapping of a scale small than or equal to 1:50000 example in production of topographic sheet connection with a range of difference around + 13m up to 18m horizontal and 19m up to 23m vertical. Pearson correlation coefficient of Satellite image with NASADEM values in the connection with RTK-GPS in topographic mapping data sets indicates a strong negative correlation and least positive correlation -0.15928,0.24153 respectively. Therefore, Satellite image and NASADEM are not good enough in topographic mapping.

Keywords: Global Navigation System (GPS), Sentinel-2 image NASADEM

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATION

UAVs	Unmanned Aerial Vehicles
SRTM	Shuttle Radar Topography Mission
GPS	Global Positioning System
GNSS	Global Navigation Satellite System
RTK	Real Time Kinematics
NASA	National Aeronautics and Space Administration
DEM	Digital elevation model
USGS	United States Geological Survey
GDEM	Global digital elevation model

CHAPTER ONE

INTRODUCTION

1.1 Background

Topographic maps are detailed, accurate graphic representations of features that appear on the earth's surface using contour lines. These features include roads, buildings, urban development, railways, airports, names of places and geographic features, administrative boundaries, state and international borders, reserves, lakes, rivers, streams, swamps, coastal flats. (Charles & Worf, 2015)

Map is described as documents showing a structure on the world or another celestial body, which is made with abstract characteristics, with a particular scale on a flat surface in a graphical and photogrammetric way. These strategic information sources have usually been preserved in palaces and military bases because of the value of the information they contain. Maps are one of the oldest written information resources. Maps are usually seen as being used in military operations and wars. For this reason, when the map is named, firstly wars come to mind. However, maps are used in many fields except this field and they can be prepared differently according to these fields. This shows that it is necessary to control the maps, produce them according to particular rules and apply different rules in access and organization of them. Cartography, which is known as mapping or surveying map, had not seen as a science and application field at first. Considering the historical process, it is known that the first maps were drawn in the shape of plans and included narrower lands. These map drawings have been seen in Mesopotamia, where the civilization occurred, for the first time. However, the first remnant resembling a map (in fact a city plan) was found in the excavations of Çatalhöyük and this is dated 6200 B.C. This plan is in the Museum of Anatolian Civilizations in Ankara (Bagrow, 1964:2-3; Brock, 2001). Another important map is the first world map drawn on a clay tablet by the Babylonians (Bagrow, 1964:31; Bricker, 1968:11; Brown, 1949:33, 37). (Bashir G Adam et al., 2022, pp. 350-362)

Ground data collection is well known as a conventional method of data collection for mapping in the land survey field. This method has been shown to produce a highly accurate set of data collection results. This explains why this method has been practiced and accepted worldwide for many centuries. However, there are a lot of obstacles to practicing this conventional method like

Acquiring data in remote areas under environmental conditions such as low sun angle, shimmering, darkness, and cloudy skies, dangerous animals, bad topography led to problems in time consuming, death from dangerous animals, cost and etc.

Advancement of technology lead to generate different kind of methods of acquiring geospatial information for carrying out topographic mapping such as conventional survey method, Satellite imagery, Digital elevation model, Unmanned Aerial Vehicle (UAVs). (Azmi et al., 2014)

This advancement of instruments and technologies in surveying is a signal that the survey industry must keep up with the modern technologies of their society. NASA introduced the first digital elevation model, SRTM, in the early twenty-first century. For different purposes, such as the creation of a relief map, mass movement, extracting terrain parameters, the geographic information system, base mapping, and surface analysis. (Ballaney & Nair, 2002)

1.2 Statement of the problem

Traditional surveying methods have been the primary techniques for surveying measurement with high achievable accuracy (Nkeki & Asikhia, 2014). However, the method of acquiring data in remote areas under environmental conditions such as low sun angle, shimmering, darkness, and cloudy conditions is time-consuming, tedious, and difficult. New technology such as satellite images and digital elevation models, can collect data covering a large area in less time than traditional methods. Satellite images with digital elevation models are used in topographic mapping in the same way that traditional surveying methods.Till this moment no study has been conducted to examine the suitable of satellite image with digital elevation model in topographic map. It is important to conduct the study as it will greatly help updating maps using short period of time while achieving required accuracy

1.3 Research Objectives

1.3.1 Main objective

To investigate the performance of satellite image coupled with digital elevation model for Topographic mapping.

1.3.2 Specific objectives

i. To carry out comparative analysis of topographic map derived from satellite image with NASADEM digital elevation model and RTK-GPS method.

ii. To assess the quality of the data acquired with satellite image, digital elevation model against insitu GNSS-RTK data.

1.4 Research Question

i. How closely can satellite image and digital elevation model in Topographic mapping match those derived from in situ measurements or field surveying?

ii. How well does satellite image and digital elevation model represent real world dimensions in both horizontal plan as well as the vertical?

1.5 Significance of the research

i. This study will help users such as consultants, engineers and surveyors to select appropriate methods in topographic mapping depending on the accuracy.

ii. To bring knowledge about remote sensing and application especially on the satellite images.

1.6 Beneficiaries

Beneficiaries of this research surveyors, engineers and other researchers based on this research.

1.7 Scope of the study

The research will utilize sentinel 2 optical image that undergone geometric and radiometric correction, but unfortunately, there is no available ground truth information. A specific case study has been chosen in a remote area that cannot be accessed using traditional methods.

CHAPTER TWO

LITERATURE REVIEW

2.1 Background

This section describes some of what others have done in related work in order to give brief idea about the overall concept of precision and accuracy of GPS and remote sensing technique (satellite image and digital elevation model) in topographic mapping. The methods and concepts discussed below come from literature having to do, in some capacity, with remote sensing techniques in topographic mapping.

2.2 Topographic Mapping

Topographic map is a type of map characterized by large scale detail and quantitative representation of relief features usually using contour lines but historically using variety of methods. Traditional definitions require a topographic map to show both natural and artificial features. One of the most widely used of all maps is the topographic map. Topography comprises of two English words, namely 'topo' that deals with earth surface and 'grapho' that represents information. (Moustafa et al., 2012)

A map is a model of part of the earth surface showing the shape and position of different countries, political borders, natural features such as rivers and mountains and artificial features such as roads 6 and buildings. A map can also give a particular type of information about a certain area on the surface of the earth. A topographic map is a two dimensional representation of a three dimensional land surface. Topographic maps are differentiated from other maps in that they show both the horizontal and vertical positions of the terrain and a major distinction from the other maps is the presence of contour lines which depicts the elevation of points on the earth's surface (Costa & Diambra, 2005)

The creation of digital topographic maps provided by the two major factors: i) completeness of the feature contents and attributive information; ii) accuracy of the feature metrics description. Geometric potential, scale, information contents and image resolution are very important for mapping. It is important for how many details shall be included in the map based on the area. (Azmi et al., 2014).

Indeed, the wide range of information provided by topographic maps makes them extremely useful to both professional and recreational map users. They also contain valuable reference information for surveyors and cartographers including benchmarks, baseline, meridians and magnetic declinations. Topographic maps are used by civil engineers, environmental managers as well as urban planners; they are used as basic tools for planning and executing projects, emergency services agencies and historians well as by outdoor enthusiasts. They are of prime importance in planning settlements, airports, highways, dams, pipelines, transmission lines and countless other types of construction. They are an essential part of ecological studies and environmental control, geodetic research, studies of the quantity and quality of water, projects for flood control, soil conservation and reforestation. Intelligent and efficient development of our natural resources depends on the availability of adequate topographic maps. Topographic maps are also utilized by 7 outdoor enthusiasts, including hunters and hikers to show the relief features, wooded areas and watercourses. (Azmi et al., 2014)

2.3 Global Navigation Satellite System

A GNSS/GPS receiver measure the incoming phase of the satellite signals to millimeter precision (Schofield, 2007). However, as the satellite signals propagate from satellite to receiver they pass and are affected by the atmosphere. The atmosphere that influence the incoming satellite signals consists of the ionosphere and troposphere effect. Disturbance in the atmosphere cause degradation in the accuracy of the observation (GPS 500 user manual)

2.4 Real time kinematics (RTK)

RTK provide real time position to be determined instantaneously as the roving receiver occupies a position. The system requires two receivers with only one positioned over a known point. A static period of initialization will be required before work can commence. The base station transmits code and carrier phase data to rover. On-board data processing resolves the ambiguities and solve for a change in coordinate differences between roving and reference receivers (E, 2012). As presented in figure 1 below

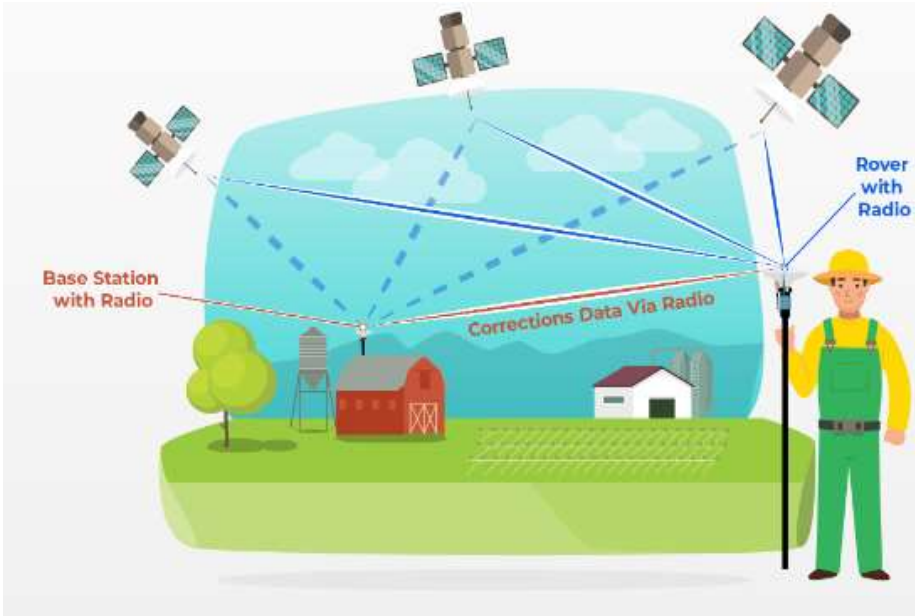

Figure 2-1: Base station transmits signal to the rover to determine a new position of a point *(Costa & Diambra, 2005)*

2.5 Use of Satellite Imagery

The Copernicus Sentinel-2 mission comprises a constellation of two polar orbiting satellites placed in the same sun synchronous orbit, phased at 180 degrees to each other. It aims at monitoring variability in land surface conditions, and its wide swath width and high revisit time will support monitoring of the Earth's surface changes. This Sentinel-2 Mission guide provides a high level description of the mission objectives, satellite description and ground segment. It also addresses the related heritage missions, thematic areas and Copernicus services, orbit characteristics and 13 coverage, instrument payload and data products.

Also Copernicus Sentinel-2 mission is based on a constellation of two identical satellites in the same orbit. Each satellite carries an innovative wide swath high resolution multispectral imager with 13 spectral bands for a new perspective of our land and vegetation. (Javorovic, 2005) The mission guide categories are Overview, this section provides a brief description of the mission and the main thematic areas and services such as land monitoring and climate change. Mission Objectives, describes primary and secondary objectives of the Copernicus Sentinel-2 mission. Satellite description, describes the satellite platform and the communication links, the main instrument of the Sentinel-2 mission, the multispectral instrument as well the orbit characteristics of the mission. Ground segment, describes the flight operations segment and the payload data ground segment of the mission. The use of high resolution satellite images become more useful and convenient for mapping than using aerial images. Moreover, it has opened a new field of applications and has created a competition to the use of large scale aerial images (Azmi et al., 2014).

Nowadays, due to improvements in satellite technology, remote sensing data is used for mapping at different scales. In Iran, there is a necessity to utilize satellite imagery as a complementary data source to aerial photographs. One of the main reasons for this, aside from the usual advantages of this technology, is the ability to map and revise border areas having aerial access limitations due to security reasons (Moustafa et al., 2012).

Dynamism of satellite images of linear array leads to complexity of execution of one accurate algorithm for real time positioning which needs information of satellite orbits. In other hand vendors of high resolution satellite images have no aptitude to issue information of their sensors. Then to relate the object space and image space we should use the approximate models to satisfy the accuracy without need to orbital information of satellite. However, the real possibility of using satellite images for cartography depends on several factors such as; the possibility of providing planimetric and altimetric accuracy as well as information content with respect to detection and identification of features (Samadzadegan et al., 2004).

Under usual conditions the geometric accuracy is not the limiting factor. The main factor is the information content which depends upon various factors such as; spatial and radiometric resolutions. This is in addition to spatial scale of the features to be imaged, radiometric contrast between different target types and the final 14 application for which the image has been acquired (Sadeghi et al., 2004). The use of satellite images in updating maps depends mainly on the accuracy of the geometric correction for the image as well as for their information content. So it is important to evaluate the capabilities of any satellite images to fully understand its potential of application possibility. The main criteria for the comparison of image information content of different sensors is the ground sampling distance (GSD), the distance of neighbored pixel centers projected to object space (Mostafa & Abdelhafiz, 2012).

2.6 National Aeronautics and Space Administration Digital Elevation Model (NASADEM)

The NASADEM is a void-free, near-global 1-arcsec elevation model that is generated by reprocessing of SRTM data. The main objective of the product is to eliminate voids and other limitations present in the SRTM by using datasets that are unavailable during the original processing. The improvements involve void reduction through improved phase unwrapping and better vertical control by referring to ICESat/GLAS elevations using a height error correction algorithm. Remnant voids are filled primarily by ASTER GDEM3 after merging the elevation data (Buckley, S. M., P. S. Agram, J. E. Belz, R. E. Crippen, E. M. Gurrola, S. Hensley, M. Kobrick, et al, 2020). The NASADEM is supposed to be the successor of SRTM DEM, and expected to be more accurate and robust than the SRTM data (Crippen et al., 2016). The products are provided by 1° × 1° tiles with WGS84 geographic coordinates, and are relative to the Earth Gravitational Model of 1996 (EGM96).

NASADEM is a modernization of the Digital Elevation Model (DEM) and associated products generated from the Shuttle Radar Topography Mission (SRTM) data. NASA reprocessed the original SRTM raw signal radar data using improved algorithms and incorporating data primarily derived from the Ice, Cloud, and Land Elevation Satellite (ICESat) Geoscience Laser Altimeter System (GLAS) and Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) instruments. These lidar and DEM data were unavailable during the original SRTM processing. The NASADEM products are freely available through the Land Processes Distributed Active Archive Center (LP DAAC) at one-arcsecond spacing. The most significant processing improvements involve void reduction through improved phase unwrapping and using ICESat GLAS data for control. The updated processing strategy now includes an alternative phase unwrapper for data processing patches where the unwrapped coverage from the original unwrapper falls below a coverage threshold. Patch boundary voids are mitigated by reprocessing with different along-track starting locations in the data and merging the unwrapping results.

NASA also updated a low-resolution elevation database to aid with phase unwrapping bootstrapping, retaining isolated component of unwrapped phase, and assessing the quality of the strip DEMs. We introduced a height error correction algorithm to reduce artifacts in the strip elevation data.

These height ripples are a few meters in size and have along-track spatial scales of tens of kilometers. The source of the problem is uncompensated mast motion from the original data collection and is most pronounced after Shuttle roll angle adjustment maneuvers. Our along-track filtering approach utilizes differences between the SRTM heights and ICESat GLAS elevation data to correct the SRTM strip DEMs. After merging and regrinding the strip DEMs into 1x1-degree tiles, remaining voids are primarily filled with the ASTER-derived Global DEM (GDEM). NASA use a delta surface fill method to rubber-sheet the fill data across the void for a seamless merger. Finally, a new post-processing module creates DEM-derived products from the void-free elevation data. The slope, aspect, plan curvature, and profile curvature are found by fitting a local surface at each DEM posting and computing metrics from the fit coefficients. This document is organized as follows: NASA provide a summary of the SRTM mission and NASADEM products. NASA then provide technical details and example results from the NASADEM SRTM radar processing improvements. They also describe the finishing processes of void filling and slope and curvature generation. Ancillary and auxiliary input datasets and their conditioning for use in the NASADEM processing are also described in the processing improvements and finishing sections (Buckley et al., 2020)

2.7 Previous studies

Recent studies and reports such as (Gahlot et al., 2018)) conduct a research on DEM and ortho-imageries are building blocks for topographic mapping and satellite imageries are prime source of data for inaccessible terrain. When the required mapping scale is of the order 10k or higher, the accuracy needed is also of higher order. It becomes imperative to evaluate the accuracy of available high resolution DEMs and corresponding imageries to provide quality products for mapping. The present study is encouraged by the fact that not every place of our earth is accessible, so an assessment of satellite data products is required for precise mapping. Here, the accuracy assessment has been carried out in terms of RMSE, SD, CE90 and LE90 of various products viz. Carosat-1, Cartosat-2E, Worldview-2 (WV), Vricon, Pleiades, ALOS-World-3D (AW3D) ASTER, SRTM with Yahoo image. GCPs acquired by DGPS field survey were used to evaluate the products. The results have demonstrated that Vricon 0.5m ortho-image provides the best RMSE (3.42) and CE90 (4.65); however, WV and Vricon DEM turns out to be best with RMSE of 2.20m and 2.90m respectively. Both products are suitable for large scale topographic mapping. The data can be used for inaccessible terrain where GCPs are not available. However, Cartosat-1 and Cartosat-2E can be used where good GCPs are available. The outcome of study can be used for planning of data suitability for scale variant mapping and inaccessible terrain mapping.

Also other studies have shown that high resolution satellite images are still used in large scale mapping due to the need to produce fast products. High resolution stereoscopic satellite images present good enough 3d products that include the benefits of large-scale coverage and low-cost products. A stereo pair of IKONOS satellite is used in this research that covers a part of North Sudan country. The study handles the 3d mapping accuracy of using stereoscopic satellite images. The study gives a spotlight on the accuracy in X, Y, Z and the space vector R. Another view of this study the N, E and elevation is indicated. The research environment is mainly ENVI software due to its capabilities of topographic processing module. Some distributed set of ground points (control and tie) was determined on the images and then observed using GPS surveying. Several experiments have been performed to evaluate the resulted mapping product. Conclude that the accuracy of the mapping product using stereo satellite images can reach to 1.5 of ground pixel size so the user of this type of products can take this information in his consideration. Using the standard deviation in this study gives another way to understand the accuracy limits of mapping process from stereo satellite images. One can conclude that 0.5 standard deviation of the ground pixel size is the accuracy limits for this type of products. In general, one can conclude that it is good to make mapping using stereoscopic satellite images in geodetic and topographic mapping products but it is not convenient to use it in cadastral mapping products (El-Semary, 2017).

Also other studies have shown that ASTER Global Digital Elevation Model V002 with 30 m resolution was used to extract information on terrain surface and drainage network at the micro-catchment level. ASTER data was compared with 39 reference points from integrated Global Positioning System (GPS) and topographic maps. However, there was a gap between ASTER dataset and reference points; thus, a readjustment process of ASTER dataset was required. The results indicate that Global Positioning System (GPS) and topographic maps data sets have good connection with a range of difference around ± 32.7 m. Pearson correlation coefficient of ASTER Pixel values in the connection with GPS and topographic maps data sets indicates a strong positive correlation 0.8, 0.827 respectively. Therefore, a Multiple Linear Regression (MLR) model was used to readjust ASTER data based on topographic maps, and ground points. The ‘best’ fit of MLR model for ASTER was chosen and used to interpolate a multiscale temporal and spatial distribution. The research applied two interpolation techniques: The Inverse Distance Weighting (IDW) and Kriging to better understand the spatial distribution. The results show that there is a slight difference between ASTER data and the other two types of elevation models. (Alatawi & Abushand, 2015)

2.8 Accuracy of the result

Accuracy is the degree of conformity of a measurement to its true value, (Anil, 2005). Accuracy relates to quality of the result. Small magnitude errors of individual measurement may affect the quality of the final result by considerable large amount. Therefore, the final result may depend on the accuracy and precision from each individual measurement.

CHAPTER THREE

METHODOLOGY

3.1 Background

This chapter includes the methodological options available to be used and the reasoning behind choosing the best approach for this research, description of the site area, field study, procedures and research data analysis that will be used and to achieve specific objectives.

3.2 Description of the study area

The central geographical location of the college is 6º48’20” S latitude and 37º40’9” E longitude. These site containing numbers of man-made and nature features like structures, tree and etc.

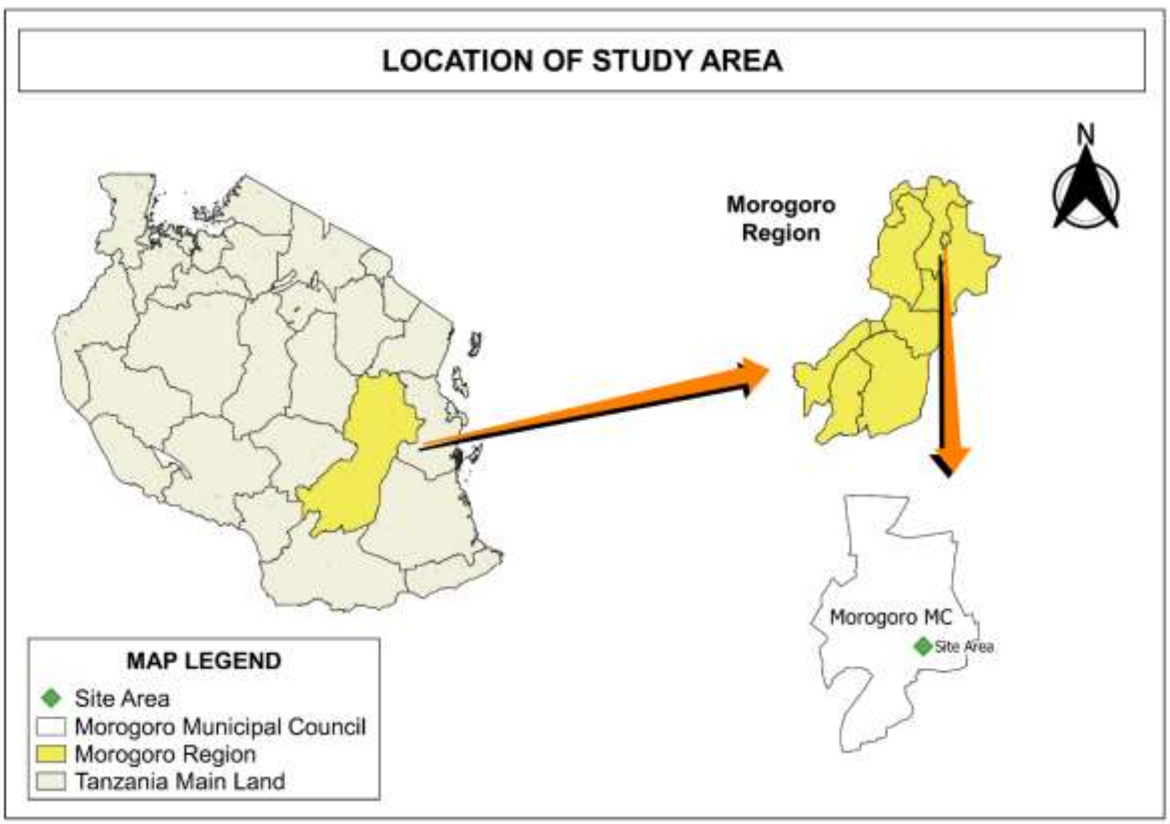

Figure 3-1: Location of study area

3.3 Field Reconnaissance

Reconnaissance was an essential stage in this study. Involves going to the project site to determine extent of the project site, also to consider the number of GCPs necessary to cover the area of interest and all information about control point and benchmark near the area of interest

3.4 Data and instruments

All materials and instrument utilized in this study were chosen because of their ability to aid in the accomplishment of this research. These data and instrument are sentinel -2 image, NASADEM and GPS

3.5 Data collection

This dealt with various methods and techniques employed in the collection of data for the purpose of map production.

Data used in this research were satellite imagery which were Sentinel 2 with 10m spatial resolution and National Aeronautics and Space Administration Digital Elevation Model which shown the contours where by its resolution was 30m resolution. Since in preparation of the topographic map required to determine the 3D positions of the man-made and natural features this also enable to show the nature of terrain of an area of interest.

3.6 Data processing

The data processing stage was the stage where all the acquired data processed. The NASADEM of Jordan University college were preprocessed, and then the image was projected to Geographic coordinate system (WGS 84). Vector data were preprocessed by extracting only the required features through selecting features by attributes in Arc Map. The following stages involved during the data processing stage; Geo-referencing, creating of shape files (feature class), vectorising, adding and masking the NASADEM, contour generation from the NASADEM, satellite imagery mosaicking.

3.6.1 Satellite imagery

After download image there are process followed in processing satellite image includes;

(i) Layer stacking

Image downloaded are in form of band. This the process bringing together different images(Band) of the downloaded satellite imagery to form a single imagery. This done using QGIS software.

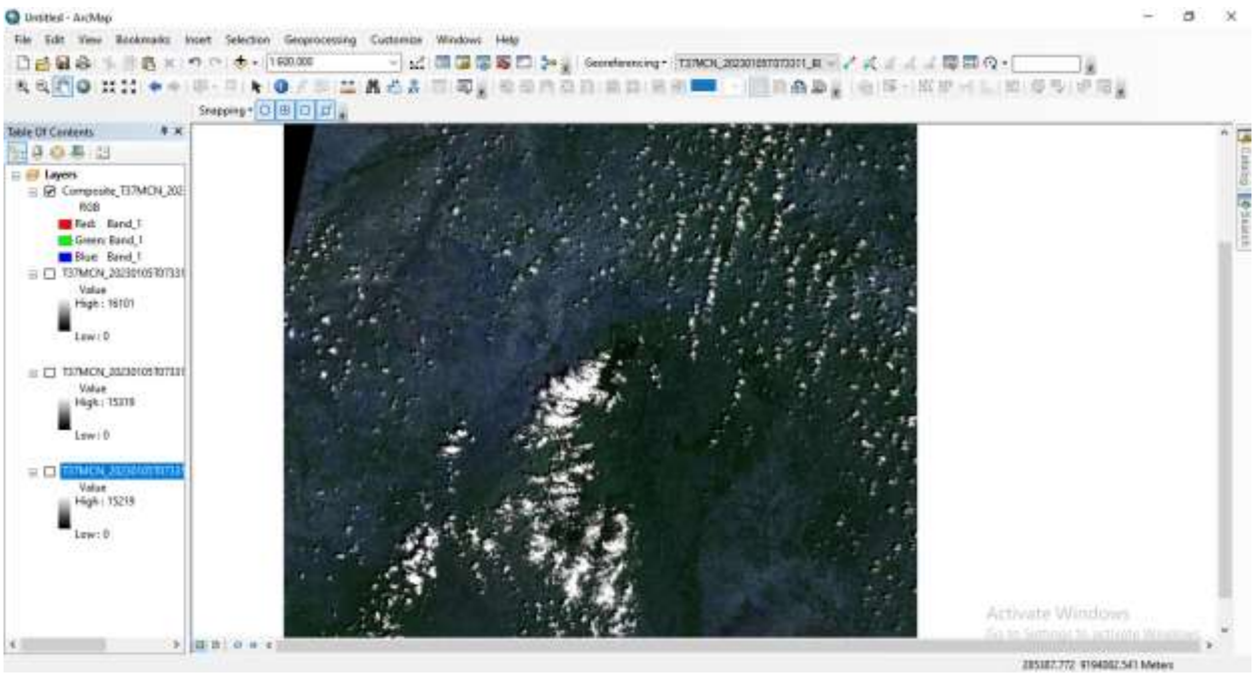

Figure 2-2: Layer staking

(ii) Digitization of satellite image

At this point layers (shape files) created that was used in vectorising the satellite image. Shape files point, line, polygon features are created from the image.

3.6.2 Downloading of the NASADEM

Digital elevation model is downloaded in form of tiles (GeoTIFF) with resolution of 1arcsec (30m). The following below are process followed in processing DEM

(a) Mosaic of the NASADEM

Merging of the downloaded tiles in global mapper by exporting those data into elevation grid format (Surfer Grid).

(b) Masking of the NASADEM

The area covered by the NASADEM was too large therefore there was need to mask out the study area from the entire tiles.

(c) Contour extraction

National Aeronautics and Space Administration Digital Elevation Model was used to generate contours after masking it with the administrative boundaries layer of Morogoro city. The clipped vector layer and contour layer generated were then overlaid to get Topographic map

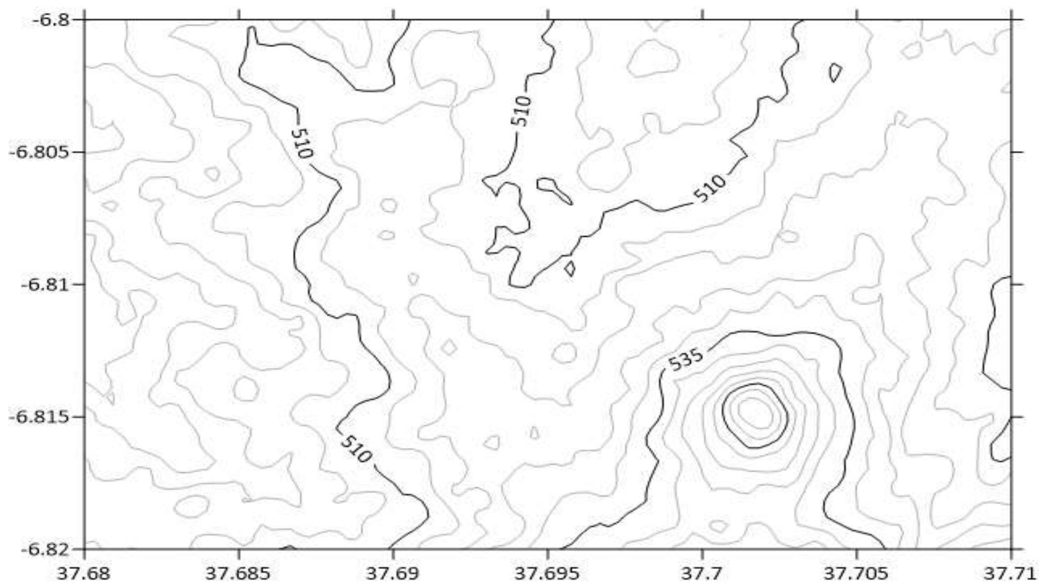

Figure 3-3: Contour creation

3.5.3 Details picking using RTK-GPS

This method is more accurate compared to other methods. Here the detail such as Spot height(SH), Trees and Road (RD) were picked by using CHC X12 GPS, which comprised with one GPS receiver, one GPS antenna and Controller.

When you start a GPS survey from an autonomous base position, you need to solve a localization to adjust GPS measurements into local coordinates. Localizations is done so as to relate your arbitrary GPS start point into your non-geodetic local system. The purpose of the localization is to tie the ellipsoid and planar datum together with a "best fit". This is particularly true for vertical where the geoid model will likely not have enough resolution to give high accuracy for vertical measurements.

One-point localization was used to create new coordinate system for use with the GPS kit. A single point defines the coordinate system, this point was surveyed with the GPS kit and its Eastings, Northings and Orthometric Height were known. This was the point assigned into new Coordinate system can also be downloaded (with the job) to Navistar Geo Office and used there.

After done with localization with one point, its where then the GPS rover start to measure the features and point which were also observed in satellite image.

Here, the raw data were downloaded from GPS controller with the software known as Navistar Geo office and exported into MS Excel file. And followed by importing point into AUTOCAD Civil 3D 2018.After importing the coordinate into AUTOCAD Civil 3D 2018, the procedures undertaken include;

(a) Creating layers

In AutoCAD, a layer is a named, logical grouping of objects. Layers are used to organize and manage the objects drawing. Each layer can have a unique set of properties such as color, line type, line weight, and transparency, which can be assigned to objects on that layer. This allows you to control the appearance of objects in your drawing and make changes to specific groups of objects easily.

Creating layers in AutoCAD can help us to;

- organize your drawing; You can group similar objects on the same layer, making it easier to find and edit them
- Control object properties; You can assign different properties to each layer, such as color, line weight, and line type.
- Control object visibility; You can turn layer on and off to control which objects are visible in the drawing.
- Control object printing; You can control which layersa are printed or not printed, and adjust their appearance when they are printed.

(b) Creating surface

In AutoCAD, a surface is a 3D object that represent a continuous geometric shape or form, such as a terrain, a building foundation or a road. Surface creation in AutoCAD involves creating a 3D model that represent the shape and contours of particular object or terrain.

Surface creation in AutoCAD is a powerful tool for creating 3Dmodels of objects and terrains, and can be used in wind range of industries, including agriculture, engineering, and construction.

(c) Creating and managing contours

Once you have created the surface, you can generate contour lines based on the elevation data. Use the "Contour" command in AutoCAD to specify the desired contour interval and other parameters. AutoCAD will automatically generate the contour lines based on the surface data.

AutoCAD provides tools to edit and manage contours. You can modify the contour lines by adding or removing vertices, adjusting elevation values, or smoothing the contours. Use commands like "Edit Contours" or "Modify" to make the necessary changes. To provide additional information, you can annotate and label the contour lines. AutoCAD offers tools for adding elevation labels or text associated with the contour lines. Finally, you can customize the display of the contours to visualize and present them effectively. AutoCAD provides various options to control the appearance of contour lines, such as line styles, colors, and line weights.

CHAPTER FOUR

RESULTS AND ANALYSIS

4.1 Result of the study

4.1.1. Topographic map resulted from RTK-GPS data

Data collected were used to prepare the drawn Topographic map below using AutoCAD civil 3D 2018.

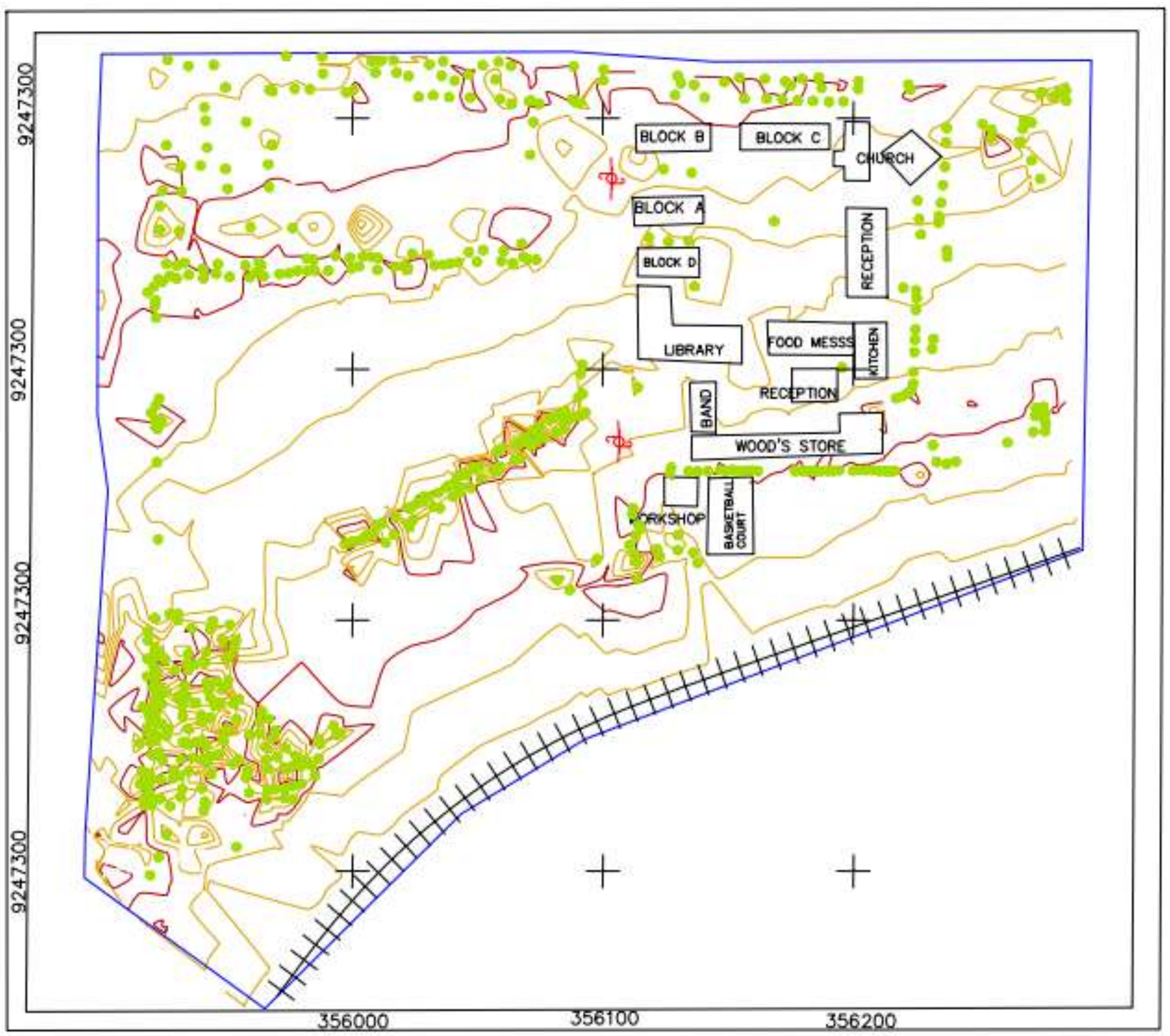

Figure 4-1: Topographic map derived from RTK-GPS data

For more visualization see APPENDIX-A

4.1.1. Topographic map resulted from NASADEM and Sentinel-2 image.

After processing of digital elevation model and image, it followed by drawn of topographic map by using AutoCAD civil 3D 2018.

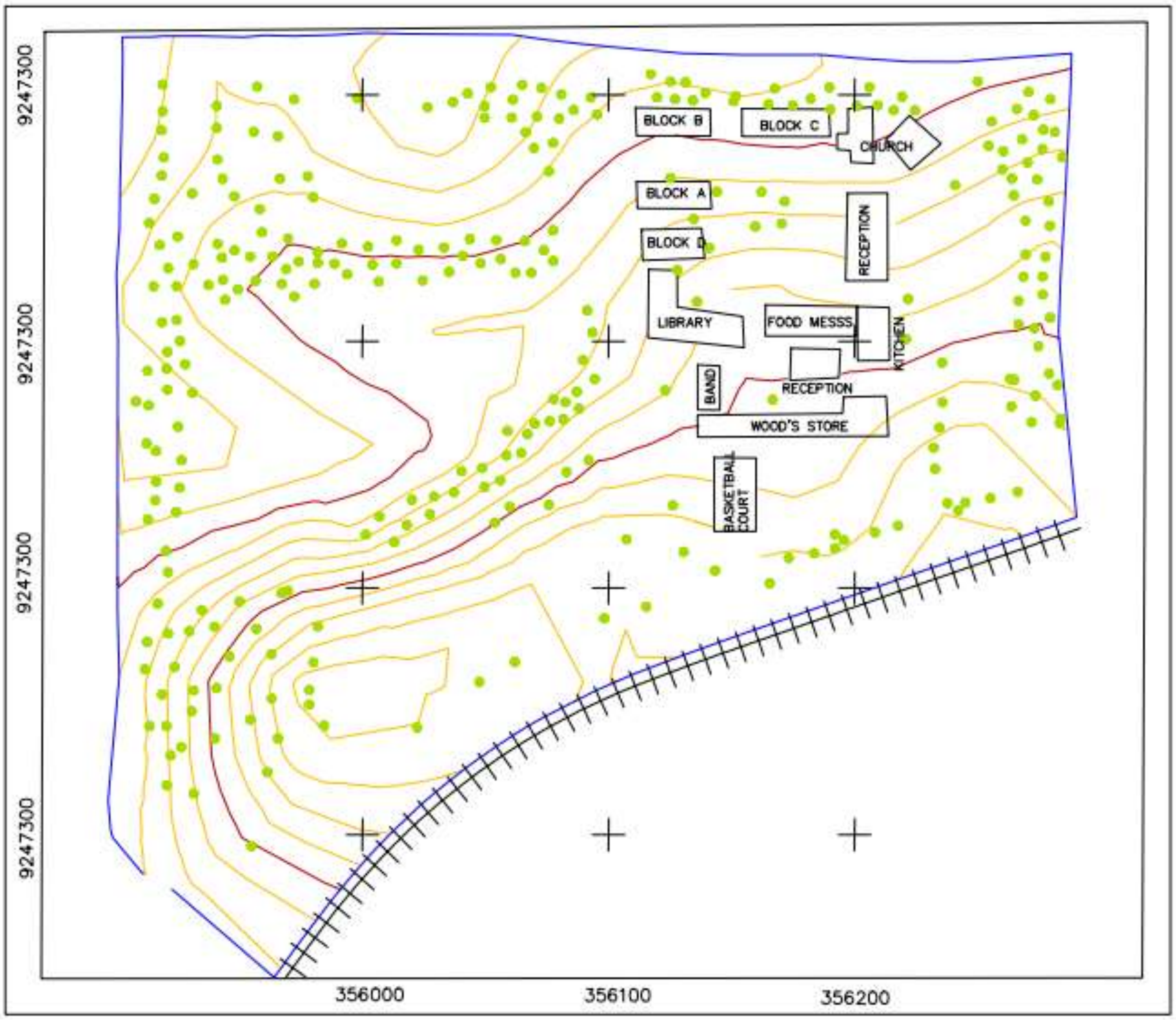

Figure 4-2: Topographic map derived from image and DEM

For more visualization see APPENDIX-B

4.2 Analysis of the result

4.2.1 Assessment of the topographic surveying done by RTK-GPS and topographic map done by NASADEM and Sentinel-2 image

(a) Horizontal positional accuracy measure

The differences between the coordinate resulted from RTK-GPS and the coordinate of features from image, were used to calculate the distance of deviation. Look for identifiable landmarks or features that are present on both maps. These could be cities, roads, buildings, rivers, or any other distinctive geographical elements. By Select multiple reference points that are clearly visible on both maps. The more reference points you have, the more accurate your analysis will be. That deviation shows the distance a part between two point which appears of the same position on different map

$$Distance, d_{xy} = \sqrt{\left[\Delta_x^2 + \Delta_y^2\right]}$$ (Schofield, 2007)

Where

d_{xy} = Distance between point of similar feature

Δ_x = Change in Eastings

Δ_y= Change in Northings

Table 4-1:Horizontal deviation

RTK-GPS DATA			IMAGE DATA			DIFFERENCE		
POINT	Eastings,X	Northings,Y	POINT	Eastings,X	Northings,Y	Δ_x	Δ_y	d_{xy}
P1	356113.2142	9247597.651	P1	356113.1427	9247583.978	-0.0715	-13.673	13.67319
P2	356113.475	9247586.71	P2	356113.4955	9247572.594	0.0205	-14.1161	14.11611
P3	356143.2125	9247597.99	P3	356143.4481	9247583.474	0.2356	-14.5157	14.51761
P4	356143.201	9247587.275	P4	356143.5844	9247572.568	0.3834	-14.7069	14.7119
P5	356155.031	9247598.244	P5	356156.2206	9247583.669	1.1896	-14.5753	14.62377
P6	356154.888	9247587.548	P6	356156.3046	9247572.335	1.4166	-15.213	15.27881
P7	356190.6522	9247597.993	P7	356191.6546	9247583.39	1.0024	-14.6027	14.63706
P8	356190.6522	9247587.752	P8	356192.2189	9247572.271	1.5667	-15.481	15.56007
P9	356113.891	9247533.507	P9	356118.4574	9247518.39	4.5664	-15.1166	15.79125
P10	356127.017	9247533.215	P10	356130.0021	9247518.101	2.9851	-15.1143	15.40626
P11	356114.235	9247504.276	P11	356118.1045	9247490.696	3.8695	-13.5798	14.12034
P12	356127.8999	9247517.849	P12	356130.0424	9247503.132	2.1425	-14.7177	14.87283
P13	356155.632	9247517.461	P13	356156.5606	9247499.354	0.9286	-18.1073	18.1311
P14	356155.6027	9247502.388	P14	356157.2359	9247486.739	1.6332	-15.649	15.73399

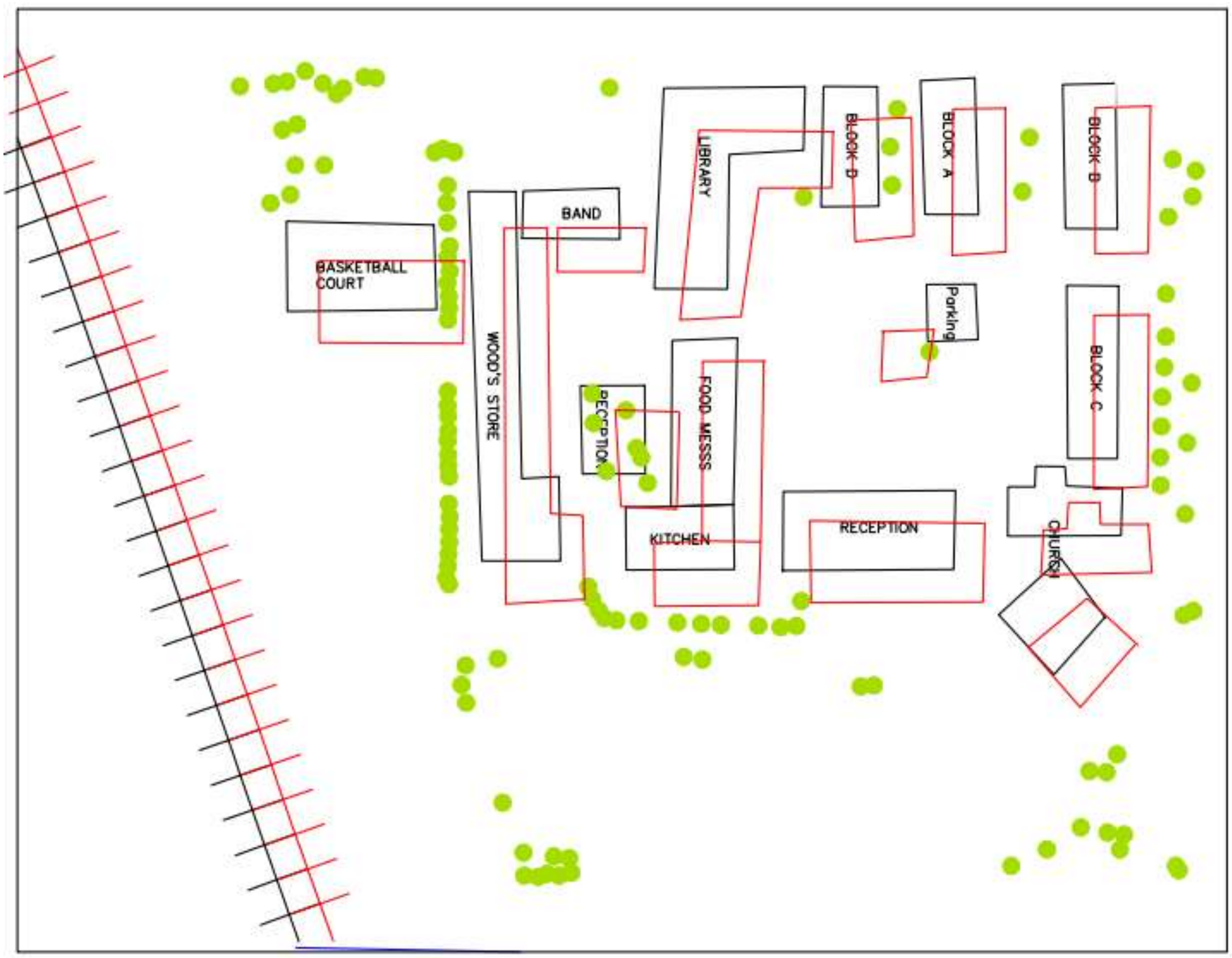

Figure 4-3: Overlaying features

From the table 4-1 above it can be shown that horizontal deviation between topographic map derived from RTK-GPS data and topographic map derived from satellite image with DEM is very large. It can be analyzed that common causes of big deviation of horizontal position are incorrect digitized features. For the accurate result, when digitized features care was taken to make sure that crosshairs of the digitizer puck are centered on a feature.

Also the above figure it can be shown that positional accuracy of the features was tested by overlaying some feature from field measurement e.g. boundaries, buildings, roads etc. With the plot of the same features obtained from satellite image with DEM. When overlaying topographic map from the image data on the topographic map derived from RTK-GPS data, discrepancies are seen as open spaces between the features on the high accurate map (derived from RTK-GPS data).

Pearson's correlation coefficient is the test statistics that measures the statistical relationship, or association, between two continuous variables. It shows frequency of correlation between two observables. Are used to measure how strong a relationship is between two variables. Range between -1 and 1. 1 indicate a strong positive relationship, -1 indicate a strong negative relationship and 0 indicate no relationship at all.

$$\delta_{xy} = \sqrt{\sum_1^n \Big((\overline{\Delta_x} - \Delta_{xi})(\overline{\Delta_y} - \Delta_{yi}) \Big)} / (n-1)$$ (Costa & Diambra, 2005)

where

$$\delta_{xy} = correlation\ coefficient$$

$$\overline{\Delta_x} = Mean\ of\ change\ in\ Eastings$$

$$\overline{\Delta_y} = Mean\ of\ change\ in\ Northings$$

$$\Delta_{xi} = Change\ in\ Eastings\ in\ i^{th} term$$

$$\Delta_{yi} = Change\ in\ Northings\ in\ i^{th}$$

N= number of values

Table 2 : Correlation coefficient

Δ_x	Δ_y	δ_{xy}
-0.0715	-13.673	-0.15928
0.0205	-14.1161	-0.09777
0.2356	-14.5157	-0.04335
0.3834	-14.7069	-0.02119
1.1896	-14.5753	-0.01047
1.4166	-15.213	0.170202
1.0024	-14.6027	-0.01455
1.5667	-15.481	-0.00019
4.5664	-15.1166	-0.04067
2.9851	-15.1143	-0.01901
3.8695	-13.5798	0.241538
2.1425	-14.7177	0.009953
0.9286	-18.1073	0.154302
1.6332	-15.649	-0.00388

From the table above show correlation between position of the similar features have small value that indicate inadequate relationship between image data from RTK-GPS data

(b) Vertical accuracy measure

The vertical deviation between two topographic maps can be determined by elevations of the common feature. The differences between the elevations resulted from RTK-GPS and the elevation of features from image, were used to calculate the deviation of elevation. Look for identifiable landmarks or features that are present on both maps. These could be cities, roads, buildings, rivers, or any other distinctive geographical elements. By Select multiple reference points that are clearly visible on both maps. The more reference points you have, the more accurate your analysis will be

Vertical deviation, hi = Elevation of map A – Elevation of map B

Table 4-3:Vertical deviation

POINTS	DEM elevation (m)	RTK-GPS elevation (m)	Difference (m)
P1	523.141	500.22	22.921
P2	523.141	500.201	22.940
P3	523.098	500.184	22.914
P4	522.988	500.15	22.838
P5	522.787	500.172	22.615
P6	522.609	500.13	22.479
P7	522.387	500.163	22.224
P8	522.083	500.16	21.923
P9	521.580	500.092	21.488
P10	520.859	500.131	20.728
P11	520.342	500.075	20.267
P12	519.583	500.162	19.421

From the table above show big difference in elevation caused by the accuracy of the DEM is very small compared to the elevation of data captured by GPS-RTK.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

According to the results introduced in chapter four, some remarks can be concluded;

Results indicate that satellite image with NASADEM data and RTK-GPS data sets have not good enough in large scale mapping of a scale large than 1:50000 but it can be useful in small scale mapping of a scale small than or equal to 1:50000 example in production of topographic sheet connection with a range of difference around + 13m up to 18m horizontal and 19m up to 23m vertical. Pearson correlation coefficient of Satellite image with NASADEM values in the connection with RTK-GPS in topographic mapping data sets indicates a strong negative correlation and least positive correlation -0.15928,0.24153 respectively. Therefore, Satellite image and NASADEM are not good enough in topographic mapping.

5.2 Recommendations

Based on the conclusion that Sentinel-2 imagery and NASADEM are not good enough for topographic mapping especially in large scale mapping of a scale large than 1:50000 but it can be useful in small scale mapping of a scale small than or equal to 1:50000 example in production of topographic sheet. In case of large scale mapping there are some reason that cause to NASADEM and sentinel-2 image to be insufficient due to inadequate plan metric and vertical accuracies, here are some recommendations for the future researchers to consider:

I. To use other satellite imagery sources that may provide higher resolution or more accurate topographic information. For example, consider using high-resolution optical sensors such as WorldView-3 or Pleiades satellites, which offer improved spatial resolution compared to Sentinel 2.

II. To assess other digital elevation model (DEM) datasets apart from NASA's DEM. There are various sources available, such as commercial providers, national mapping agencies, and local government organizations. These alternative DEMs may offer better vertical accuracy for topographic mapping.

III. Also geometrical correction was done with no any ground truth, so other researchers should be correct all geometrical error by ground truth.

REFERENCE

Alatawi and Abushand. (2015). Evaluation of ASTER Satellite Imagery in Comparison with Topographic . *Earth Science & Climatic Change*, 2157-7617.

Anil, M. c. (2005). *Poblem solving with theory and objective type question.* Newdelhi: New Age International (P) Ltd.

Azmi, S. M., Ahmad, B., & Ahmad, A. (2014). Accuracy assessment of topographic mapping . *Earth and Environmental Science*, (pp. 1755-1315).

Azmi, S., Ahmad, B., & Ahmad,A. (2014). *Accuracy assessement of topographic mapping using UAV image integrated with satellite image.* Egypt : IOP Conference Series, Earth and Environment Science.

Ballaney, S., & Nair, B. (2002). Application of Satellite Imagery and GIS in the the preparation of Development Plans. *Environmental planning Collaborative Trupati Region*, 245-253.

Bashir G Adam, Abdul Malik, Gidado Bakar, & Mohammed. (2022). Preparation of topographic map using. *International Journal of Advances in Engineering and Management (IJAEM)*, pp: 350-362.

Buckley, S. M., P. S. Agram, J. E. Belz, R. E. Crippen, E. M. Gurrola, S. Hensley, M. Kobrick, et al. (2020). *NASADEM: User Guide.* NASA.

Charles, D. G., & Worf, R. P. (2015). *Elementary Surveying an introduction to Geomatics 14th edition.* upper saddle River, New Jersey: Pearson Education Inc.

Costa, F., & Diambra, L. (2005). *Topographical maps as complex networks.* Sao paulo: Institute of Physics at Sao Carlos, University of Sao Paulo.

Crippen, R., S. Buckley, P. Agram, E. Belz, E. Gurrola, S. Hensley, M. Kobrick, et al. (2016). *NASADEM Global Elevation Model: Methods and Progress.* International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences.

E.M, A. (2012). Performance Analysis of the RTK Technique in an Urban Environment. 47-54.

El-Semary, H. H. (2017). Evaluation of Mapping Accuracy of High-Resolution . *American Scientific Research Journal for Engineering, Technology, and Sciences*, 2313-4402.

F.,Sadeghi Naeeni A, A. A., & B, A. E. R. (2004). *Evaluation of the potential of spot 5 hrg, high resolution satellite imageries FOR 1:25000 scale maps revision.* Center of Iran: Photogrammetry Dept. of National Cartographic .

F.samadzadegan, A. Milanlak, & M.GH.Majdabadi. (2004). *Geometrical Correction Of Satellite Image By Generic Models.* University of Tehran: Depertment of Surveying and Geomatics Engineering, Faculty of Engineering.

Gahlot,N., Dhara, M., and Prusty, G. (2018). ACCURACY EVALUATION OF VARIOUS SATELLITE IMAGERY PRODUCTS FOR LARGE SCALE TOPOGRAPHIC MAPPING. *Int. Arch Photogramm Remote Sens. Spatial*, 105-110.

Javorovic, I. (2005). *Research on Topographic Map Updating.* University of Zagreb: Faculty of geodesy.

Mostafa, Y. G., & Abdelhafiz, A. (2012). *The Potentials of Satellite Images for Map Updating* . Sohag : Civil Eng Dept. Faculty of Engineering, Sohag .

Moustafa, Y. G., Farrag, F. A., & Ahmed, A. (2012). *Updating with emphasizes on Egypt SAT-1* . . Mining and Metallurgy Eng. Dpt. Faculty of Engineering.

Nkeki, N. F., & Asikhia, M.O. (2014). *Mapping and Geovisualizing Topographical Data Using Geographic Information System (GIS).* Nigeria: University of Benin CIty.

S. M. Buckley, P. S. Agram, J. E. Belz, R. E. Crippen, E. M. Gurrola, S. . (2020). *NASADEM_user_guide* . California: Jet Propulsion Laboratory.

Schofield, W. (2007). *engineering survey sixth edition.* Oxford : Elsevier Ltd.

APPENDICES

1. APPENDIX A: Topographic map derived from RTK-GPS data
2. APPENDIX B: Topographic map derived from image and DEM

APPENDIX A: Topographic map derived from RTK-GPS data

APPENDIX B: Topographic map derived from image and DEM