Sudan University of Science &Technology

College of Graduate Studies

COMPUTATION OF OIL WELLS ELEVATION POINTS USING DIGITAL ELEVATION MODELS

حساب ارتفاعات نقاط ابار النفط باستخدام نماذج الارتفاعات الرقمية

A thesis Submitted for the Partial Fulfillment Degree of Master of Science in Geodesy and GIS

Prepared by:

Mohamed Ajeeb Suliman Omer

Supervisor:

Dr.MohamedElamein Ahmed

October 2017

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أَفَلَا يَنْظُرُونَ إِلَى الْإِبِلِ كَيْفَ خُلِقَتْ (١٧) وَإِلَى السَّمَاءِ كَيْفَ رُفِعَتْ (١٨)
وَإِلَى الْجِبَالِ كَيْفَ نُصِبَتْ (١٩) وَإِلَى الْأَرْضِ كَيْفَ سُطِحَتْ (٢٠)

صدق الله العظيم

سورةالغاشية الايه (١٧-٢٠)

Dedication

Every challenging work needs self-efforts as well as guidance of elders especially those who were very close to our heart.

My humble effort I dedicate to my sweet and loving

Father &mother

& my wife

Whose affection, love, encouragement and pray of day and night make me able to get such success an honor,

Along with all hard working and respected

Teachers

The main objective of this research is to use three methods in the process of generating digital elevation models DEM. The first method is to use the observed data for points by the GPS device using Real time Kinematic (RTK). The second method is to extract the data from the Google Earth program, whereas method three that is downloading the digital elevation model resolution 30 meters from the website. Then comparing the DEM which obtained from the three methods.

The objectives of the research also the use of these models in finding the height of the test points (oil wells) by interpolation , the elevations represent one of the most important elements of the site of oil wells and show their importance in determining the depth and following the drilling process and making sure that the required depth was reached.

GIS program was used in generating DEM for each method, to insert test points into each model by means of one of the interpolation methods (IDW) and obtain points heights and then to comparing the actual Height values with the height values obtained from each method.

It was found that the DEM which created from the GPS data (RTK) gave the best results for the height values and close to the true values. Then, the Google Earth data model, and finally the DEM which downloaded from website.

الهدف الاساسى من هذا البحث هو استخدام ثلاثة طرق فى عملية انشاء نمازج الارتفاعات الرقمية الطريقة الاولى هى استخام البيانات المرصودة لنقاط بواسطة جهاز الجى بى اس(الرصد الحظى المتحرك) ,ام الطريقة الثانية هى االستخراج البيانات من بنامج القوقل ايرث والطريقة الثالثة تحميل نموزج ارتفاع رقمى بدقة وضوح 30 متر من الويب سايد.ومن ثم مقارنه نمازج الارتفاعات الرقمية المتحصل عليها من الطرق الثلاثة.

ومن اهداف البحث ايضا استخدام هذه النمازج فى ايجاد ارتفاعات نقاط الاختبار (ابار نفط)عن طريق الاستكمال, تمثل الارتفاعات واحدة من اهم العناصر المكونه لموقع الابار النفطية وتظهر اهميتها فى تحديد العمق ومتابعة عملية الحفر والتاكد من انه تم الوصول الى العمق المطلوب.

تم استخدام برنامج الجى اى اس فى انشاء نمازج الارتفاعات الرقمية لكل طريقة على حده ,وادخال نقاط الاختبار فى كل نموزج عن طريق واحدة من طرق الاستكمال والحصول على ارتفاعات النقاط ومن ثم مقارنة القيم الحقيقة مع القيم المتحصل عليها من كل طريقة مقارنتها.

وجد ان نموزج الارتفاعات الذى تم انشاءه من بيانات الجى بى اس (الرصد اللحظى السريع) اعطى افضل نتائج لقيم الارتفاعات وقريبة للقيم الحقيقية .وبعده تاتى نموزج بيانات القوقل ايرث وفى النهاية نموزج الارتفاع الرقمى من الويب سايد.

I would like to express my special thanks of gratitude to my Dr. (Mohamed Alameen Ahmed) who gave me the golden opportunity to do this wonderful project on the topic (Write the topic name), which also helped me in doing my research and I came to know about so many new things I am really thankful to him .

Secondly I would also like to thank my parents, my wife and friends who helped me a lot in finalizing this project within the limited time frame.

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Dedication

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Abstract

The elevations of points considered as one of the most important element of the site of oil wells. The importance of knowing the elevations of points appear in determination of depth during drilling of wells to ensure the required depth.

The main objective of this research is a comparison between methods of generating digital elevation models (DEM) which are used to determine the elevation of oil wells. Three methods had been used ,in the first method the observed data of points using the GPS device using Real time Kinematic (RTK). Extraction of the data from the Google Earth program, were used in the second method. Method three is downloading the digital elevation model resolution 30 meters from the website. A comparison between generated DEMs was done, and the elevation of the test points (oil wells) was computed using an interpolation method.

Arc map program was used in generating DEM for each method, to insert test points into each model by means of one of the interpolation method inverse distance method (IDW) and obtain points elevation and then to comparing the actual elevation values with the elevation values obtained from each method.

The results show that a DEM which created from the GPS data (RTK) giveresults for the elevation valuesclose to the true values which best than the other two methods.The Google Earth data model give result better than Shuttle Radar Topography Mission SRTM method.

التجريده

تعتبر ارتفاعات النقاط واحده من اهم العناصر فى تحديد مواقع ابار النفط وتظهر هذه الاهمية فى تحديد الاعماق فى عملية الحفر وذالك للتاكد من انه تم الوصل الى العمق المطلوب.

الهدف الاساسى من هذا البحث هوالمقارنه بين عدة طرق لانشاء نمازج الارتفاعات الرقمية التى تستخدم فى تحديد مناسيب ابار النفط,ثلاثة طرق تم استخدامها ,اولها استخدام البيانات المرصودة لنقاط بواسطة جهاز الجى بى اس باستحدام (الرصد اللحظى المتحرك) ,ام الطريقة الثانية هي استخراج البيانات من برنامج القوقل ايرث والطريقة الثالثة تحميل نموزج ارتفاع رقمى بدقة وضوح 30 متر من الويب سايت.ومن ثم مقارنه نمازج الارتفاعات الرقمية المتحصل عليها من الطرق الثلاثة,ارتفاعات نقاط الاختبار (ابار النفط) تم حسابها عن طريقة الاستكمال.

تم استخدام برنامج ارك ماب فى انشاء نمازج الارتفاعات الرقمية لكل طريقة على حده ,وادخال نقاط الاختبار فى كل نموزج عن طريق واحدة من طرق الاستكمال والحصول على ارتفاعات النقاط ومن ثم مقارنة القيم الحقيقة مع القيم المتحصل عليها من كل طريقة مقارنتها.

النتائج تظهر ان نموزج الارتفاعات الذى تم انشاءه من بيانات الجى بى اس (الرصد اللحظى المتحرك) اعطى افضل نتائج لقيم المناسيب وقريبة للقيم الحقيقية,وان نموزج بيانات القوقل ايرث اعطى نتائج افضل من نموزج الارتفاع الرقمى الماخوذة من الويب سايت.

Acknowledgement

I would like to express my special thanks of gratitude to Dr. (Mohamed ElameinAhmed) who gave me the golden opportunity to do this wonderful thesis on the topic (Computation of Oil Wells Elevation Points Using Digital Elevation Models), which also helped me in doing my research and I came to know about so many new things I am really thankful to him.

I would also like to thank my parents, my wife and friends who helped me a lot in finalizing this project within the limited time frame.

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Abbreviations

DEM Digital Elevation Model

DTM Digital Terrain Model

DSM Digital Surface Model

GPS Global Position System

GISGeographic information systems

RTK Real Time Kinematic

SRTM Shuttle Radar Topography Mission

INSAR Interferometric Synthetic Aperture Radar

ALS Airborne Laser Scanning

LIDRLight Detection and Ranging

ASTERAdvanced Space borne Thermal Emission and Reflection Radiometer

NEDNational Elevation Dataset

SONARSound Navigation and Ranging

IDW Inverse Distance Weighted

KML Keyhole Markup Language

CHAPTER ONE

INTROUDUCTOIN

The oil sector isconsidered as one of the most important sectors of the economy, which States depends on. Where the surveying engineering is one of the most important section in this sector.In thisresearch, different methods used in generating digital elevation model (DEM) were studied, these DEMs were used to calculate elevation of new oil wells in Sufyan oil field in block 6 East Darfur State.

1.1 Research Problems

The problem of this research includes:

1- Use a number of methods in generation digital elevation model and compare the resultsfor these methods.
2- Determine elevation for new oil wells (interpolation) after generation and evaluates DEM for the three methods.

1.2 Aims and Objectives

The main objective of this study is to investigate the methods of establishment of the new oil well from generated DEM, the other objectives are:

1- Analysis byusing elevation values obtained for new oil wells (sample points) in the three methods.
2- Determine the best method to be using.

1.3 Previous studies

There are a variety of studies which were done to investigate different methods used to generate DEM.

Generated DEM from RTK-GPS technique along the Rayong beach, Thailand, were studied by Amornchai Prakobyaetl(2014).The study has been attempted to utilize RTK-GPS for DEM generation along theRayongcoast of Thailand. The primary result showed that this technique has been efficient applied for getting DEM based on the limitation of cost and time.

Rusli and majid (2012),were studied Google Earth's derived digital elevation model: A comparative assessment with Aster and SRTM data.The result of this study is in flat area, quality of Google Earth's elevation data is similar to SRTM90which is approximately produce 90 meter resolution of data. However, as Google Earth data was tested in Higher (from hilly to mountainous) area, its quality become better and almost similar to quality ofASTER data, better than SRTM90.

Also Evaluation of Multiresolution Digital Elevation Model (DEM) from Real-Time Kinematic GPS and Ancillary Data for Reservoir Storage Capacity Estimation, were studied by Luca Brocca(2017), fromDepartment of Civil and Structural Engineering, Moi University, Kenya.

This study presents that the estimation of reservoir storage capacity using multiresolution Real-Time Kinematic Global Positioning System (RTK-GPS) DEM, in comparison with ASTER and contour-derived DEM. Through RMSE comparisons of the elevation point uncertainty and error analysis, the results shows that the RTK-GPS DEM gave the best results for the reservoir capacity-area power curve estimation.

1.4Structure of the thesis:

Thesis is structured into five chapters from the introduction to the thesis in chapter one discussion of the concepts of DEM, Research problem and the aim and objectives were explained in details.

In chapter two, methods of DEM generation and application were presented in details.

Chapter three outlines the location of study area in addition to data and sources.Methodology used in this study also investigated in this chapter, includingDEM generation using RTK data,DEM from Google earth data and Shuttle Radar Topography Mission (SRTM) raster data, sample points data. Also include software and hardware.

Chapter four contains result and table of comparison and analysis of result in chart form.

Chapter five includes conclusion and recommendation.

CHAPTER TWO

Digital Elevation Model Production and Applications

2.1 Introduction

The term "digital elevation model" (DEM) is used generically to mean the digital Cartographic representation of the elevation of the earth surface in any form. It is sometimes also referred to as a "digital terrain model" (DTM). The (horizontal) spacing is specified in arc-seconds, with smaller horizontal spacing usually implying a better resolution in height - though the height accuracy is actually a function of the production methods (Greve and American Society for Photogrammetry & Remote Sensing., 1996; Mikhail et al., 2001).

Currently the majority of DEMs are generated by photogrammetric methods. DEMs can be represented in various formats such as grid, lattices and triangulated irregular network (TIN) model. The formats of grid and lattices have uniform point spacing so that the same density of elevation points is applied to the entire area; while TIN uses data points more closely spaced in complex terrain and more sparsely distributed over other 'flatter' areas.

Besides the conventional photogrammetric and field surveying techniques, the new technologies of radar interferometry, or so-called interferometric synthetic aperture radar (InSAR), and airborne laser scanning (ALS) can also be used to generate high quality DEMs. The traditional applications of DEMs include a wide range of civil urban planning and military uses. Nowadays, flood estimation (Blomgren, 1999; Sugumaran et al., 2000), landslide detection and surface morphology mapping (McKean &Roering, 2004), and underground mining subsidence monitoring (Fischer&Spreckels, 1999; Spreckels, 2000) can also be done with the aid of high resolution DEMs.

The main objective of this research is to compare the height accuracy of several DEMs derived using the technologies of Google Earth,STRM and field survey data, Real-Time Kinematic Global Positioning System (RTK GPS) is used to collect the field survey data against true elevation for sample point. A comparison of the elevation profiles derived from the DEMs against true elevation of sample point is then given with the aid of Microsoft excel worksheet.

2.2 Description of Digital Elevation Models

Geographic Information Systems (GIS) provide users from a variety of backgrounds and professions both utility and convenience in the analysis of spatial Information. GIS spatial information is available in a variety of data models. Digital Elevation models (DEMs) are one such spatial data model. A DEM gives a representation of the earth’s surface. DEMs offer both a valuable and versatile tool for application in many disciplines which utilize GIS. These disciplines include flood modeling, resource Management, shoreline delineation, hydrologic delineation, transportation and utility Applications, seismic monitoring and geologic applications (Bolstad, 2002).

2.3 Digital Elevation Model Data Types

Digital elevation data are available in variety of data formats. These include Digital Surface Models (DSM), Digital Terrain Models (DTM) and Triangulated Irregular networks (TIN). DSMs and DTMs are available in raster format which consists of a set of square or rectangular cells, gridded regularly, each representing a particular elevation Value. The difference between a DSM and a DTM is that a DTM represents ground Elevations whereas a DSM represents the first elevation return of the highest object at a given location, such as a tree or building (Maune, 2007). Advanced Space borne Thermal Emission and Reflection Radiometer(ASTER), National Elevation Dataset(NED) and SRTM DEMs are in raster DTM format. Vector data can also be used to represent elevation. Vector data consists of point, line or polygon data. Vector data is often used to represent Localized objects such as a point identifying a home address, a line representing a street, Or a polygon representing the boundary of a county. A vector data model is constructed with the use of either of these types of data or a combination of point, line or polygon Data. Contours break lines and point elevations are examples of vector elevation data. Though DEMs provide a representation of a 3-dimensional surface, DEMs are referred to as 2.5-dimensional due to the limitations of algorithms in providing representation more Than a single elevation value for a given resolution area (Pfeifer, 2005). A TIN is a separate data model type that consists of polygon data, representing slope and aspect of surfaces, and point data, representing known elevation values (Maune, 2007). Raster data offers a valuable resource in that it offers continuous spatial coverage of an area. A raster can be color formatted in a multi-spectral array to effectively illustrate Variation between cells. This variation is often used to provide a “third dimension” to 2- Dimensional planar surface. Examples of commonly used raster datasets that illustrate variation are a temperature map, precipitation map, a digital photograph or the previously discussed DEM.

2.4 Digital Elevation Model Generation

Means and techniques used to produce DEM data are varied. Active refinement of the methods and means used to acquire DEM data continues. Methods for generating DEM data can be broken into two categories. These categories are ground surveyed elevation data and remotely sensed elevation data.

2.4.1 Ground Survey Digital Elevation Models

Ground survey data includes the use of traditional mechanical survey tools and the Global Positioning System (GPS). The contour digitization technique involves the use of topographic line contours. To generate a raster grid, the area between contour lines is interpolated statistically with known elevation values being the contour lines. The Weakness with contour digitization methods is that there is no data between contours Intervals. Therefore, the interpolation results between those unknown areas may not provide an accurate portrayal of the topography. This phenomenon is particularly apparent when distance between contours is large due to either a large elevation interval between contours or in low relief terrain where a greater horizontal distance is covered between contour intervals (Maune, et. al, 2007).

The availability of the GPS has greatly influenced the science of earth surface data collection (Scherzinger et. al, 2007). The GPS, which includes multiple satellites and the use of a ground receiver, can be used to collect surface location data with precise accuracy (Lee et. al, 2005). This data is collected as point values which includes 3-Dimensional position coordinates. With multiple positional point data values, a DEM Raster can be interpolated with areas between points statistically estimated. The accuracy of the statistical estimations dependent upon the precision and accuracy of the point data, the distance between points and the statistical model used in performing DEM raster or TIN interpolation.

2.4.2 Remotely Sensed Digital Elevation Models

The second category of DEM creation involves the use of remotely sensed elevation data. Photogrammetry, Light Detection and Ranging (LiDAR) and Radar are widely used to collect elevation data (Garcia, 2004).

Photogrammetry involves the use of stereo images. With the use of either analog

(Hard copy photographs) or digital imagery, estimations of elevation can be generated.

Photogrammetry typically involves the use of remote sensing data collected from passive sensors onboard an airplane or satellite (e.g. ASTER or Landsat 5 TM). Passive systems measure energy from the Earth using naturally occurring incoming energy (from the sun).

Analog stereoscopy involves the use of two parallel images taken along separate flight paths with at least 60% overlap perpendicular to the flight path. When theimages are over lappedand aligned at an angle perpendicular to the flight path and viewed through a stereo scope, a condition known as hyperstereoscopy is achieved where each eye assumes the view at the separate observation point, regardless of the distancebetween the two observation points. When this condition is achieved, 3-dimensional properties are recognized. With this additional vertical dimension or parallax, the height of objects viewed at these different angles can be estimated or calculated through triangulation (Jenson, 2000).

Digital photogrammetry, in a fashion similar to analog stereoscopy, involves the use of a variety of imagery collected via airborne or satellite methods. An image or Images are acquired simultaneously from the vehicle at an angle directly below or vertical to the ground surface (nadir) and at an oblique (off-nadir) angle. The center of the image is the nadir; the edges of the image are off-nadir. As images are overlapped the perspective of objects or surfaces is viewed at different angles resulting in the parallax. The parallax can then be electronically processed or triangulated to calculate feature heights.

Active methods of acquiring elevation data require the measurement of the energy return of a synthetically emitted energy source. Commonly used synthetic return methods include the use of light detection and ranging (LiDAR) and interferometric synthetic aperture radar (InSAR or IfSAR) systems.

LiDAR is effectively laser range-finding. Through simulated emission, a syntheticLight source is used to measure the distance between an object and the light source (Fowler, et. al, 2007). By measuring the round trip travel time and the speed of light, Distances can be effectively measured. InSAR works through the use of airborne or Space borne radar. The equipment emits a microwave radar pulse and then measures the rate and timing of the return at nadir and off-nadir angles. Similar to other stereoscopic methods this return data can be used to triangulate the elevation of a surface (Rabus et. al, 2003). The shuttle radar topography mission (SRTM) is perhaps the most widely used InSAR dataset.

Sound Navigation and Ranging (SONAR) is also an active distance measurement system. SONAR is used in a similar method to other active return systems which triangulate nadir and off-nadir responses; however, SONAR uses sound waves to measure distance. SONAR is particularly effective in measuring distances in deep water due to the effectiveness of sound reverberating through liquids where light, heat and microwave energy are absorbed at a higher rate in liquids as compared to terrestrial Applications (Huff and Noll, 2007).

2.5 APPLICATIONS OF DEM

Geographical information technology and digital image processing has become a rapidly expanding field in recent years with particular significance in the treatment of geo- and image information for scientific, commercial and operational applications. For most applications in these three domains, digital elevation models (DEMs) are an important, integral part. In the following sections the various applications and application areas of DEMs is described in more detail. It is decided to consider these as a selection of representative activities in the domains of:

• Scientific applications.

• Commercial applications.

• Industrial applications.

• Operational applications.

• Military applications.

Where DEMs play a significant role in the improvement of analysis result, product development and decision making. Thus DEMs are an asset in a variety of both commercial and public business and management fields within telecommunications, navigation, energy, disaster management, transportation, weather forecast, remote sensing, geodesy, land cover classification, civil engineering and many more. The wide range of different applications in which DEMs will be useful reflect the overall importance of the availability of global, consistent, high quality digital elevation models (Satheesh et.al, 2008).

2.5.1 SCIENTIFIC APPLICATIONS

Exact information about the Earth's surface is of fundamental importance in all geosciences. The topography exaggerate control over range of Earth surface processes (evaporation, water flow, mass movement, forest fires) important for the energy exchange between the physical climate system in the atmosphere and the biogeochemical cycles at the Earth surface. Ecology investigates the dependencies between all life forms and their environment such as soil, water, climate and Landscape. Hydrology needs the knowledge about the relief to model the movement of water, glaciers and ice. Geomorphology describes the relief recognizing form-building processes. Climatology investigates fluxes of temperature, moisture, air particles all influenced by topography.

In weather forecast and climate modeling, models of conversion processes between the ground and the atmosphere as well as of movements in the lower atmospheric strata also rely on uniform and global DEMs, Relationship between the topography and the shape of the land surface with a variety of state variables of geo-processes like evaporation, runoff, soil moisture, influencing the climate in local and global scale.

Another area of application is a global land cover classification. Precise mapping and classification of the Earth's surface at a global scale is the most important prerequisite for large-scale modeling of geo-processes. In numerous studies, it was demonstrated that radar images are suitable for documentation and classification of natural vegetation and agricultural areas. In remote sensing DEMs are used together with GIS to correct images or retrieve thematic information with respect to sensor geometry and local relief to produce geocoded products. Thus, for the synergic use of different sensor systems (and GIS), digital elevation model are a prerequisite for geocoding satellite images and correcting terrain effects in radar scenes(Satheesh et.al, 2008).

To summarize, the science community, for example, employs DEMs for researchon

- Climate impact studies
- Water and wildlife management
- Geological and hydrological modeling
- Geographic information technology
- Geomorphology and landscape analysis
- Mapping purposes and
- Educational programs

2.5.2COMMERCIAL APPLICATIONS

Commercial applications are more marked and business oriented applications related to sale and distribution of DEM and DEM products. From this point of view, two main market sectors are interested in digital terrain models. One sector employs basic DEM products where data are preprocessed and geocoded but have no application associated with them. The other sector encompasses the value-adding services, which couple DEMs with a specific application. The following overview for both sectors addresses questions like.

Is there a market for digital elevation models?

Do the users know the available products?

Are there any competitors on the market?

Commercial providers offer DEMs or DEM –associated products, which are of interests for issues in:

- Telecommunication.
- Air traffic routing and navigation
- Planning and construction.
- Geological exploration.
- Hydrological and meteorological services.
- Geocoding of remote sensing.
- Market of multimedia applications and computer games.

2.5.2.1 Basic DEM Products

New opportunities for generating digital elevation models are given by new technology in remote sensing to measure elevation at the Earth surface at increasing resolution for larger areas. An example is the X-SAR/STRM Shuttle Radar Topography Mission that gives a digital elevation data at 30m resolution covering 80% of the Earth surface. Several studies where carried out for the European Union, for the European Space Agency and by the Euro image Consortium. All studies confirm that there is not only a significant marked which is served with remotely sensed DEMs from airborne and space borne sensors, they even forecast a boost in the DEM offers induced several radar and high-resolution optical sensors. The studies demonstrated a currently strong need for DEMs of a variety of sources with accuracies ranging from 1m to 100m. DEMs covering areas of tens of millions km^2 with annual production rates of several million km^2 are in the archives.

A large amount of topographic data is available. In many cases however, the coverage is incomplete or the products are not accessible for civilian. Also technology is needed to effectively manage and distribute the large amount of elevation data collected to an increasing number of disparate users.

For many years, companies and agencies have offered digital elevation data from different countries. The cost varies from country to country. The largest distributor of DEMs worldwide is the French company ISTAR, followed by Atlantis Scientific Inc., USA. The main data source used by ISTAR is the SPOT system, complemented by ERS and RADARSAT and recently by airborne SAR DEMs.

In Norway the leading distributor is The Norwegian Mapping Authority. They deliver a digital elevation model (DEM level 1) for the whole of Norway at 100m resolution. Digital elevation data as contour lines however is available at larger scale. Other Norwegian providers of digital elevation models are BLOMASA and Fotonor, offering high-resolution DEMs by e.g. using laser interferometry and digital photogrammetry. Customer are only willing to invest in DEMs if the data product is according to their specific needs, e.g. delivered in a specific data model (TIN,GRID), covering the entire study area homogeneously at accurate resolution(J. R. Sulebak , 2000).

2.5.2.2 Value added DEM Products

In the long run, the sales of basic digital elevation models only cover the operational costs of a company. The real market opportunity lies in the value-adding process during which the basic products are tailored to the requirement of an end user. Value-adding cover a variety of processes ranging from transforming the reference coordinate system into a user specific grid to applications in the fields of e.g.

- Planning and construction.

- Hydrological and meteorological services, including risk assessment.
- Geocoding of remote sensing data.

In all the above market segments digital elevation models are required. The marked dynamics are vivid. Some of the end-users buy DEM data others license them. Some offers DEMs for resale. Presumably, the value-adding enterprise will show the most rapid growth rate for DEM use within the next decade.

2.5.2.2.1 Planning and Construction

Desktop planning and construction based on high resolution digital elevation models is a market for both, the small value-adding businesses as well as the large construction companies. Linear constructions like roads, railway tracks, oil and gas pipelines, bridges and electric power lines may be planned without having to send surveyors onsite. For example digital topographic data sets facilitate urban planning and enable engineers to model new roads within an existing landscape context.

2.5.2.2.2 Hydrology and Meteorological Services Including Risk Assessment

For hydrological modeling of watersheds, it is necessary to have very precise and homogenous DEMs. Only through the combination of topographic data, land use information, precipitation, water storage etc. is a forecast on river flooding possible. Apart from such extreme events, an ongoing analysis of hydrological situation is important for the agricultural activities like irrigation management and for power companies when estimating the market of electricity. Small and medium-sized value-adding companies in cooperation with local and central water management authorities can carry out this work.

It should be possible to provide services of hydrological parameter extraction form interferometric SAR data and the development of flood forecast models based on remote sensing and digital elevation data. Examples of such parameters are flow paths and slope that may serve as input into a rainfall-runoff model for flood forecast and flood prediction. Insurance companies are very interested customers of this kind of manipulated DEM data for a client oriented assessment of flood risks (J. R. Sulebak , 2000).

2.5.2.2.3 Geocoding of Remote Sensing Data

A variety of applications require the combination of imagery of different sensors, seasons, resolutions or frequencies. For these purposes, the remotely sensed data sets need to be geocoded, meaning that each pixel in an image will be transformed from its sensor dependent relative grid system position to its absolute geographic coordinates. If this is not or rather insufficiently performed, any quantitative interpretation of remote sensing data will render erroneous results. In the case of side looking sensors, the transformation from slant to ground range is extremely important ,especially of terrain with large relief.Neglecting the influence of image geometry distortions caused by topographical effects will results in a great loss of detailed information or in the worst case in incorrect analysis results. The providers of satellite data usually carry out this kind of value-adding. However, in many cases, where DEMs of sufficient accuracy does not exist for geocoding purposes, this process has to be subcontracted. SRTM DEMs for example may prove beneficial for geocoding ERS or Envisat products in cases where no other digital elevation models are available for the area under study (J. R. Sulebak , 2000).

2.6 INDUSTRIAL APPLICATIONS

For industrial applications digital elevation models are used for development of market oriented product technology, improved services and to increase the economic outcome of the industrial production. Such applications are found within e.g. the Telecom, Telematics, Avionics, Mining, Mineral exploration, Tourism and Engineering industry(Satheesh et.al, 2008).

2.6.1 Telecom Industry

The telecommunication sector encompasses manufacturers, wireless service providers and operators. About 60% of all DEM sales in Europe are to the telecommunication industry (GIS Europe 1996). Topographic data are used for:

• Macro cell planning (area grid cells ranging from 3-5km with elevated base transceiver Stations).

• Micro cell planning (mainly applied in central parts of large cities).

• Clutter data (land use information in the telecommunication industry).

Typically the databases of 100m grid elevation data are used for macro cell planning while detailed 5-10 m elevation data are used for micro cell planning. Tools are developed for modeling multi transmitter communication networks and for aid in positioning of radio towers. Such tools strongly rely on the availability of recent DEMs and land use information supplied by value adding companies.

Actual digital elevation models are required for determining optimal locations for transmitting masts for all forms of terrestrial radio signal propagation. Based on e.g. the SAR data of the SRTM, DEMs will be calculated that have the advantage of showing the existing situation "as is", with all human-made and natural objects that might impede radio wave transmission.

2.6.2 Avionics Industry

By combining land use data and terrain height information with airport databases, value-adding software companies are able to provide avionics industry with an important tool for collision avoidance systems, ground proximity warning and flight management systems. Flight simulators for crew training will have a realistic background and together with real-time in-flight GPS positioning information air traffic will become safer.

2.6.3 Telematics Industry

The reliability of Global Positioning System (GPS) navigation applications, e.g., for automobiles and aircraft, depends on actual and precise data, too. The topographic data of SRTM are captured and processed in order to maintain compatibility with the global co-ordinate system defined for GPS. Hence, clear improvements in GPS navigation applications are expected to progress current development. Terrestrial data acquisition often depends on political decisions, in many cases resulting in abrupt resolution changes in areas where state borders meet. The resolution of SRTM DEMs will remain constant on a global scale.

Great commercial expectations are associated with the expanding market of car navigation systems and digital road map. Here the most important information for the user remains the horizontal plane; nonetheless, terrain height is used by the mapping industry to estimate elevation values to road segments. New updated road data however are registered with an elevation value by using GPS in moving vehicles.

Updated basic data can considerably enhance the efficiency of transportation network planning. Computer-based scenarios ease analyses of necessary excavations and bridges, which are primary cost factors in the construction of transportation infrastructure. A realistic simulation of air corridors to airports with actual data is another DEM application.

2.6.4 Mining and Oil Industry

Exploration experts are possibly the most experienced users of remote sensing data and digital elevation models. By analyzing optical radar images they determine promising regions of potential mineral deposits around the world. More and more, a combination of remote sensing data, especially DEMs, with gravity maps the identification of oil spills on satellite imagery and other phenomena and combinations leads the prospecting companies to successful explorations. In addition to exploration activities digital elevation models are also used for monitoring the exploration consequences. The problems of "subsidence in mining regions", for example, are addressed by Atlantis Scientific Inc. in cooperation with Shell Oil.

2.6.5 Tourism Industry

With the widespread availability of personal computers in private households, the value adding sector increasingly turns to expanding private market. A great potential exists in the areas of tourist and leisure maps, digital color coded satellite maps and digital elevation models. An example is the CD rom "Opplev Norge" provided by the Norwegian Mapping Authority. Although still only using 2D maps. It should be combined with a digital elevation model combined with fly-through software that enables the user to virtually cruise over the terrain surface of Norway. Other applications and companies can be found in the tourist section. Portier System combines 2D map data, satellite images and orthophotos with digital elevation models with tourist information to yield a tourist information system for Norway or any specific region. Further, the users are able to inform themselves interactively about their potential vacation destination. The user can extract 3D visualizations and 3D fly-through animations of scenic viewpoints and specific scenic regions of Norwegian nature. They can also extract information oninfrastructure, accommodations, leisure activities, opening hours of restaurants and more.

2.7 OPERATIONAL APPLICATIONS

Geoformation is a substantial part of the need of modern society for communication and information technologies. This data is increasingly used throughout all levels in administration, management and planning. Geoformation is the basis for regional planning and its availability the prerequisite for decision making processes in order to locate infrastructure development and investment. Operational applications include applications where DEM is used to improve management and planning of natural resources and within areas of regional planning, environmental protection, hazard reduction, military and other security-relevant applications, insurance issues, health services, agriculture, forestry, and soil conservation. Operational applications are mostly related to state and governmental services and management operations. DEMs may ultimately replace printed maps as the standard means of portraying Landforms. Finally, operational users need DEMs for (Satheesh et.al, 2008).

• generating and updating geoformation for governmental issues
• administering assistance in areas inflicted by disasters.
• Airline operation safety.
• Security relevant activities (risk and hazard).

Below follows some examples of operational applications.

2.7.1 Reconnaissance for Mineral and Water Resources

A successful reconnaissance for mineral and water resources is often dependent on the opportunities of a synoptic view of many geospatial information sources. Geophysical and geological prospecting has to be done in several steps by increasing degrees of intensity mapping and prospecting. Remote sensing information and digital elevation models deliver basic information on geologic structures. These information sources are especially important in remote areas where coverage by topographic maps is limited.

An example is finding ground water resources in Africa where drinking water resources are scarce. German Remotes Sensing Center aims at extracting ground water relevant information from radar images. Information on hydrologicalpatterns, lineaments, morphological structures, tectonic and sedimentological anomalies are to be extracted and to be merged with optical satellite data and available topographic and geological maps.Remote sensing techniques are being utilized to search for promising bearing grounds and to designatelocations of wells.High resolution digital elevation models would deliver much needed additional information for the interpretation of the ground water relevant structures and catchment areas, e.g. for wadis .

2.7.2 Aircraft Guidance Systems – Flight Simulations

Current investigations in the field of aircraft guidance systems focus on the improvements of operational safety and quality. Today aircraft crews have to handle increasingly complex situations. The simulated topography renders additional information and ascertains safety, particular in critical situation like in darkness and under adverse weather conditions. The detailed simulation of landscape based on accurate digital elevation model is important for training purposes but, more so, guiding the aircraft when approaching an unsupported airstrip, be it times of military actions or when attempting to reach an undeveloped area affected by natural hazards or Other catastrophic events. Only if the integrated terrain data are reliable can they be introduced safely to such critical applications. Consequently, high accuracy and high resolution are of great importance.

2.7.3 Forest Planning and Management

Resent years there has been an increasing focus on a sustainable management of natural resources like forest. Tools have been developed e.g. at SINTEF applied mathematics to create plans for a sustainable management of forest during a longer time span. By introducing digital terrain models different criteria concerning the topography of the forest area can be considered in the planning process. Examples are calculation of slope gradient and its influence on erosion process due to clear cutting of hill slopes; aspect computation and the effect of solar in solution on forest growth and derivation of surface curvature related to soil moisture conditions.

2.7.4 Planning of Breakwater Constructions

Breakwaters are important to protect harbors for damages caused by large ocean waves e.g. along the Norwegian coastline. Exact location of the breakwaters is important to give maximum protection due to e.g. prevailing wind directions.

Digital models of the seafloor bottom and the coastal zone can be used to produce realistic computer simulations of the optimal location of breakwaters before construction. It is well known that seafloor topography and coast morphology have significant effects on the direction and size of ocean waves at shallow water.

2.7.5 Mass Movement and Hazard Prediction

Rock fall and avalanches is responsible for large costs due to reparation of infrastructure and buildings in addition to the loss of life for more catastrophic events. An important task for the public community is to predict and prevent such hazardous events. Digital terrain models combined with geological, vegetation and soil information is important to detect risk areas in order to prevent building constructions and where to start specific protection actions. Such information is also of interest for insurance companies in determination of high-risk areas with larger potential for damages and thus exposed for higher insurance fees.

2.7.6 Hydrology Flooding Risk Assessment

The modeling of river catchment areas necessitates high-precision DEMs that are homogeneous and not confined to areas of the respective water authorities. Only the combination of exact topographic data, situational information, data on precipitation, water retention and storage capacities enables precise statements as to the duration and extent of floods caused by rivers.

Aside from such extreme situations, a continuous Monitoring of hydrological phenomena is useful in agriculture, for example, in helping making decisions on the need for irrigation. In coastal zones, DEMs can be used to assess in advance the dangers in areas exposed to potential inundation, and help governments in their task of maintaining open shipping routes.

Disaster management (prevention, relief, assessment) Disaster management is often impeded by lacking, incorrect or simply imprecise information about the situation on the ground. Up-to-date and precise data are imperative in assessing potential Risks (posed by floods, for example), in employing relief personnel effectively, in disaster aid (e.g., locating adequate spots for dropping of relief supplies) and in analyzing damages and changes.

CHAPTER THREE

Methodology

3.1 Introduction

Digital elevation model (DEM) measures the height of terrain above a reference datum. DEM as a term is in widespread use and generally refers to the creation of a regular array of elevations, normally squares or hexagon pattern, over the terrain (El–Sheimy, 1999).

Nowadays DEMs can be generated with several methods such as ground survey, photogrammetry (e.g., analytic photogrammetry and digital photogrammetry), InSARtechnique and Airborne Laser Scanning (ALS).

The ground survey (GPS positioning, levelling, etc.) provide height information to a high degree of accuracy, but are time-consuming, laborious and costly, andprovide information on point basis only, the point information on height may not be sufficient for conducting an engineering study on regional basis that requires dense spatial information. The spatial extent of height can be obtained from DEM.

Recently Shuttle Radar Topography Mission (SRTM) obtained elevation data on a near-global scale to generatethe most complete high-resolution digital topographic database of the Earth. SRTM consisted of a specially modified radar system that flew onboard the Space Shuttle Endeavor during an 11-day mission in February of 2000. This configuration produced the single-pass interferometry and during this period, SRTM mission imaged the Earth’s entire land surface between 60 degrees north and 50 degree south. The C-band SRTM data is being processed into DEMs on a continent-by continent basis (Peltzer, 1999).

To get the data represents one of the most significant requirements to complete researches and studies which will be help to get the results in term of achieve & facilitated many works in different fields’. In this research used three main methods for generated DEM.

3.2Study Area

The location of study area is (Sufyan oil field) block 6 in East Darfur State. Geographically, the study area located between latitude 11° 32´ 00˝ N, 11°48´00˝N and longitude 26°30´ 00˝E, 26°58´00˝E.

The study area extension is about (39* 25 km), and surface is almost flat. Figure (3-1) represents the study area.

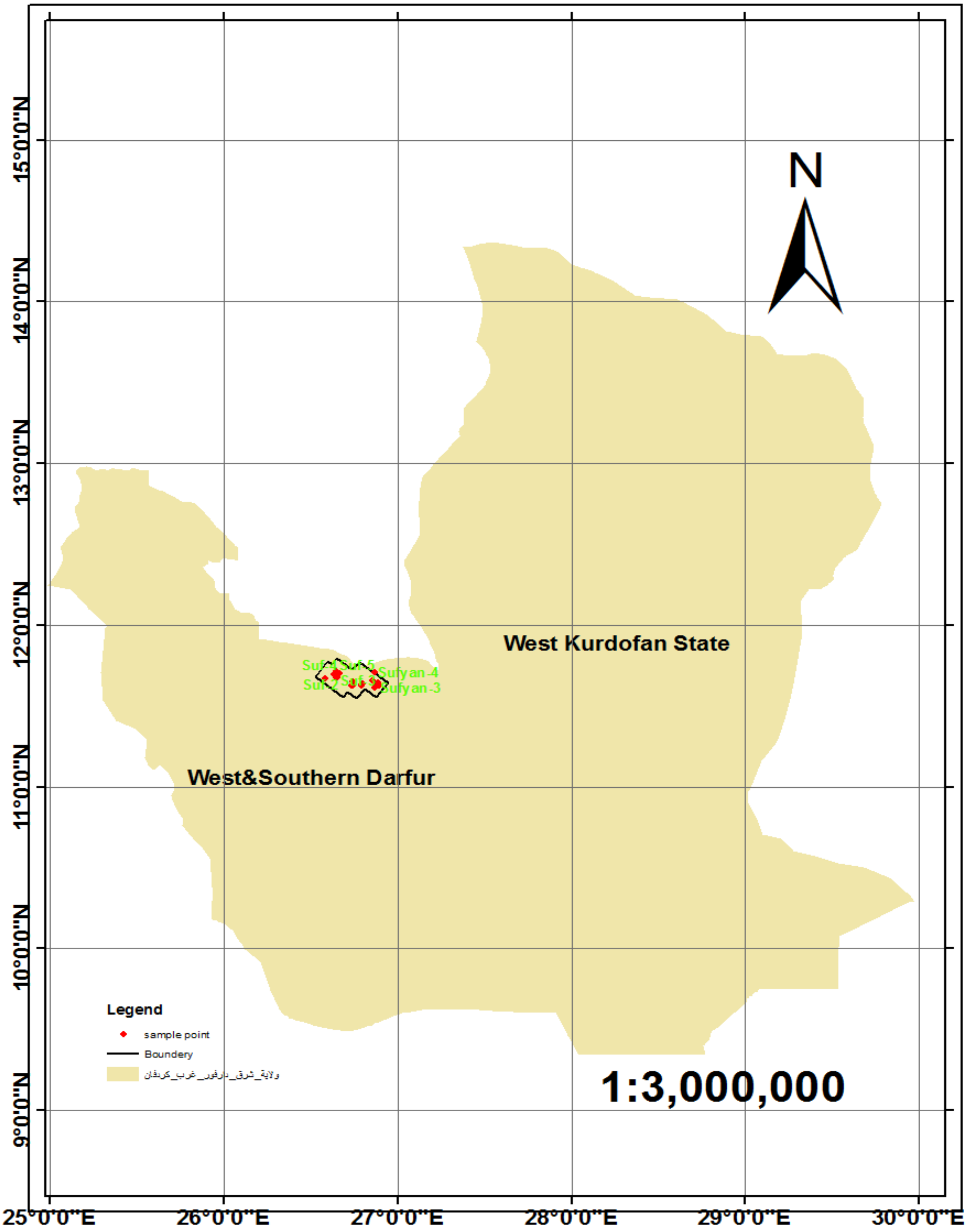

Figure (3.1) The Study Area.

3.3 Data Source:

In this research, data were obtained from three sources.

3.3.1 Real-Time Kinematic Global Positioning System (RTK GPS) techniques:

RTK GPS can deliver almost instantaneous point coordinates with centimeter-level accuracy. There are many applications that can take advantage of RTK technology, including topographic surveying, engineering construction, geodetic control, vehicle guidance and automation, etc. (Riley et al., 2000).

RTK positioning uses a static GPS receiver as a reference station located at a known point. Another receiver was used as the rover which move and observe any points ofinterest figure (3.2) represent RTK Data map. Both receivers make observations of the GPS signals at the same time and aradio data link between the two receivers permits data to be sent from reference torover, where the calculation of coordinates is carried out.

Field survey had been done where; the reference receiver station is set up on top of a hill at a pillarwhich precise coordinates are known. The rover is carryby GPS operator within radio link coverage,which is approximately 9 ~ 10km in radius from the reference station. At the end of the field survey the RTK GPS dataare imported into Geographic Information System (GIS) software for DEMgeneration,Shown in RTK data (APEINDEX A).

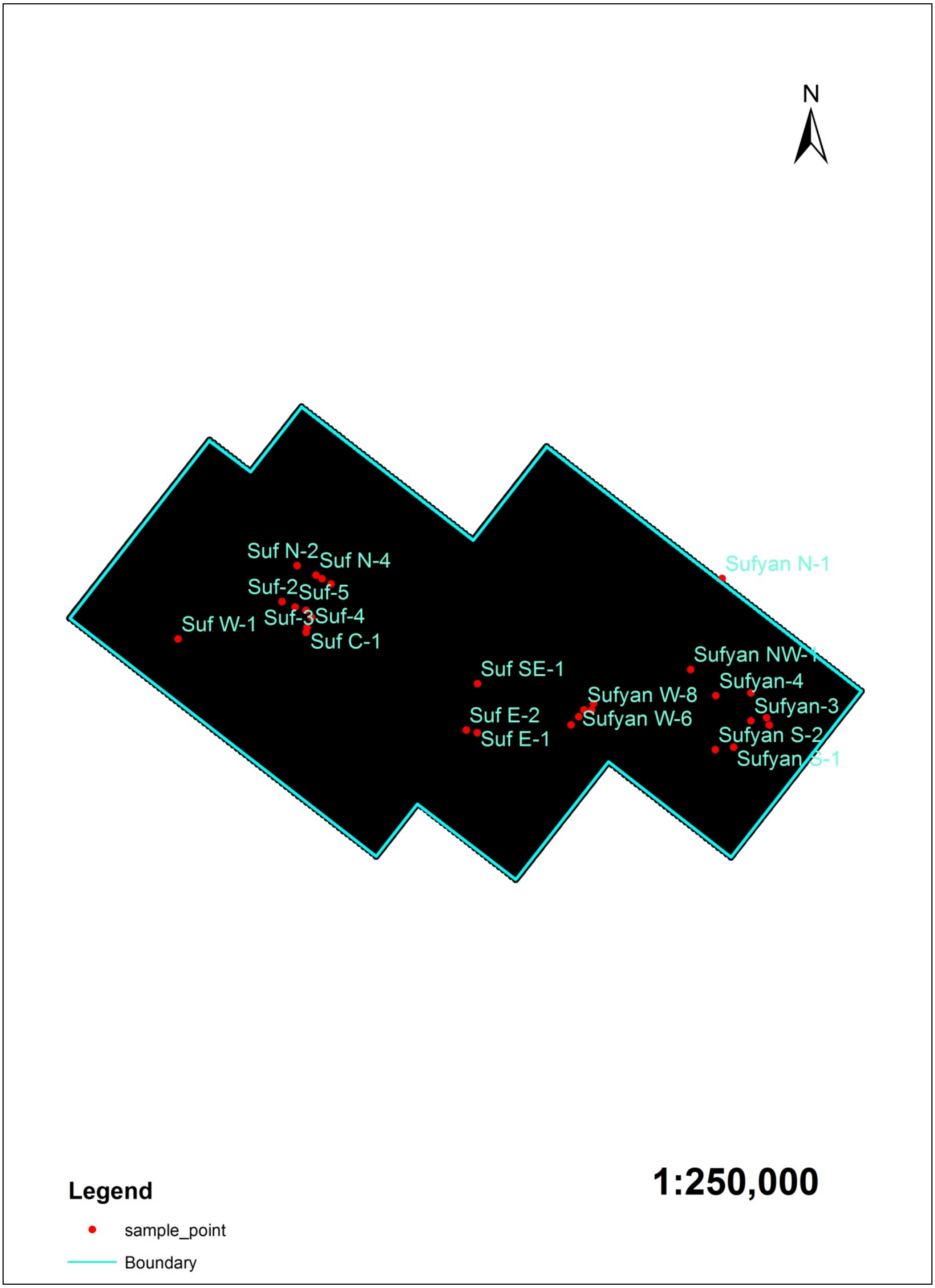

Figure (3.2) RTK Data Mapfor Study Area.

3.3.2 Google Earth Data

Google Earth is a computer program that renders a simulacrum of the Earth based on satellite imagery. It maps the Earth by the superimposition of images obtained from satellite imagery, aerial photography and geographic information system (GIS) onto a 3D globe.

It was originally an eponymous product sold by Keyhole, Inc. After Keyhole's acquisition by Google, Google Earth was released in June 2005, driving public interest in geospatial technologies and applications.

Google Earth displays satellite images of varying resolution of the Earth's surface, allowing users to see things like cities and houses looking perpendicularly down or at an oblique angle (see also bird's eye view). Imagery resolution ranges from 15 meters of resolution to 15 centimeters. Most areas in Google Earth are only shown in 2D aerial imagery, but for other parts of the surface, 3D images of terrain and buildings are available. Google Earth uses digital elevation model (DEM) data collected by NASA's Shuttle Radar Topography Mission (SRTM).This means one can view almost the entire earth in three dimensions. Google Earth allows users to search for addresses for some countries, enter coordinates, or simply use the mouse to browse to a location.

One of the methods used in the generation of a digital elevation model (DEM).Bydownload the image from Google Earth as shown in figure (3.3) and then convert this image to data (latitude,longitude,height)usingGPS visualizer software. The total points acquired from GoogleEarth 243points. Table (3-1) represents the total points from Google Earth.

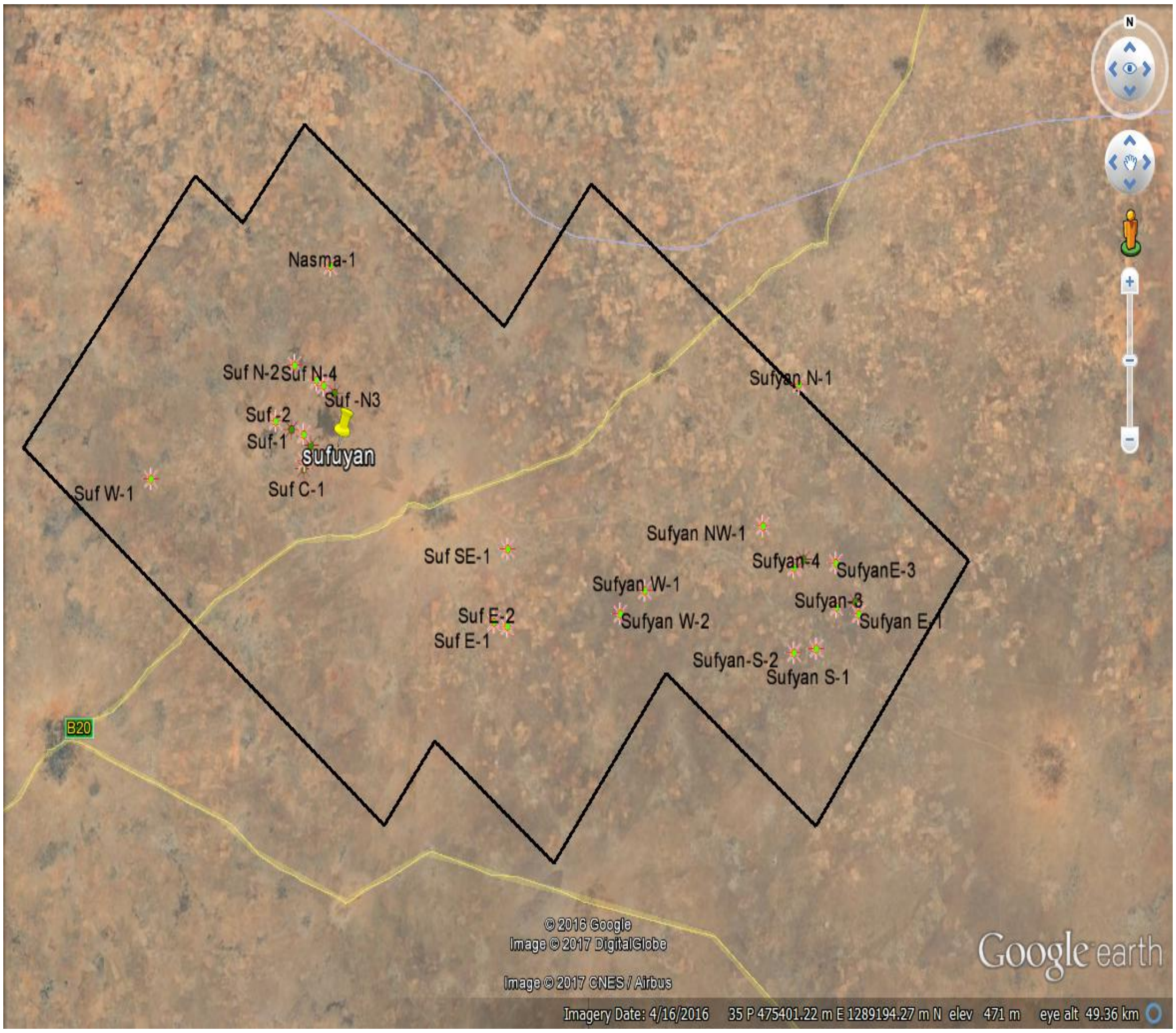

Figure (3.3)Google Earth Image of Study Area.

Table (3-1) Points from Google Earth

Station	Latitude	Longitude	elevation	Station	Latitude	Longitude	elevation
1	11.49178	26.57887	468.0	122	11.66921	26.89705	467.6
2	11.76802	26.56357	482.6	123	11.66926	26.88991	469.0
3	11.76773	26.60955	477.6	124	11.56109	26.97637	463.7
4	11.50277	26.62617	467.7	125	11.56108	26.97780	462.4
5	11.50400	26.66483	463.4	126	11.53874	26.97624	461.2
6	11.75626	26.64829	478.1	127	11.81015	26.98495	476.5
7	11.76058	26.63107	479.9	128	11.81335	26.92635	472.7
8	11.74514	26.63104	477.2	129	11.80665	26.87911	476.0
9	11.71282	26.63815	477.9	130	11.80389	26.87195	472.4
10	11.71291	26.62380	476.4	131	11.80255	26.86335	475.9
11	11.71303	26.60370	479.2	132	11.79322	26.79031	476.6
12	11.68900	26.63523	474.4	133	11.79350	26.74733	477.8
13	11.68759	26.63522	473.2	134	11.79399	26.67563	477.7
14	11.65120	26.62511	476.3	135	11.79836	26.65267	479.3
15	11.65129	26.60933	478.1	136	11.79872	26.59809	481.6
16	11.62735	26.63080	471.1	137	11.79896	26.56072	486.8
17	11.59516	26.62500	468.8	138	11.79482	26.54921	488.0
18	11.56293	26.63064	469.6	139	11.59465	26.97086	468.6
19	11.55873	26.63063	467.2	140	11.59652	26.88956	462.5
20	11.55593	26.63062	468.7	141	11.58152	26.82238	465.2
21	11.54193	26.63058	467.8	142	11.58154	26.81952	464.2
22	11.52372	26.63482	469.4	143	11.58158	26.81238	466.6
23	11.51530	26.64196	468.8	144	11.58165	26.79809	467.7
24	11.50990	26.59611	466.7	145	11.57917	26.73949	471.1
25	11.56868	26.59912	469.1	146	11.57918	26.73663	469.9
26	11.61497	26.58632	471.9	147	11.57659	26.69799	472.5
27	11.61761	26.61788	471.4	148	11.57381	26.69369	474.4
28	11.61759	26.62075	469.0	149	11.56995	26.62636	470.7
29	11.61756	26.62648	469.8	150	11.52055	26.98184	461.1
30	11.61713	26.70528	472.7	151	11.51078	26.98178	460.7
31	11.61686	26.75535	470.5	152	11.51230	26.95899	462.2
32	11.61951	26.78252	469.4	153	11.52068	26.95904	463.8
33	11.62480	26.83685	468.8	154	11.56538	26.95929	465.2
34	11.62310	26.88826	465.1	155	11.63943	26.96398	468.2
35	11.62298	26.90824	465.5	156	11.69125	26.95571	471.0
36	11.62824	26.96392	466.3	157	11.73318	26.96736	470.7
37	11.64289	26.60645	472.3	158	11.73076	26.90735	469.3
38	11.68359	26.59935	474.5	159	11.71828	26.88728	469.6
39	11.72011	26.59223	479.6	160	11.73470	26.94880	471.8
40	11.74541	26.58653	476.0	161	11.75851	26.94893	472.5

41	11.76087	26.58512	481.9	162	11.77960	26.93904	472.4
42	11.71602	26.57212	475.5	163	11.79240	26.91194	470.7
43	11.71317	26.57930	478.2	164	11.77141	26.90469	472.4
44	11.71283	26.86439	469.3	165	11.73068	26.92021	475.1
45	11.73951	26.85450	470.2	166	11.72928	26.92020	474.2
46	11.72801	26.89876	470.8	167	11.67883	26.92708	466.5
47	11.76151	26.91894	471.9	168	11.64246	26.92547	467.9
48	11.77250	26.95330	477.0	169	11.60328	26.92954	463.1
49	11.67525	26.58642	475.9	170	11.58372	26.92801	465.3
50	11.66824	26.58640	475.6	171	11.56275	26.92933	463.0
51	11.65558	26.59356	473.4	172	11.55018	26.92926	461.8
52	11.68513	26.57495	475.4	173	11.53621	26.92918	463.4
53	11.68462	26.66390	474.2	174	11.52364	26.92912	461.9
54	11.68549	26.75271	477.5	175	11.51401	26.90198	460.1
55	11.68799	26.80423	468.8	176	11.58113	26.89233	462.8
56	11.68896	26.87285	468.4	177	11.58253	26.89234	461.9
57	11.68871	26.91428	469.8	178	11.58813	26.89094	461.7
58	11.69141	26.93001	468.3	179	11.69446	26.89003	466.7
59	11.63877	26.59066	474.8	180	11.73789	26.88738	469.6
60	11.63035	26.59208	476.1	181	11.76879	26.87751	473.4
61	11.58270	26.59486	471.8	182	11.77466	26.83891	474.4
62	11.55330	26.59478	468.9	183	11.75224	26.83596	474.6
63	11.51211	26.99319	463.0	184	11.76247	26.77302	474.2
64	11.53580	27.00188	462.2	185	11.71576	26.84295	469.5
65	11.56649	27.00777	463.6	186	11.71592	26.81864	471.0
66	11.60561	27.00800	467.0	187	11.71595	26.81292	470.9
67	11.66296	27.00407	469.0	188	11.71631	26.75568	473.2
68	11.70494	27.00432	469.0	189	11.71696	26.64963	477.7
69	11.74133	27.00597	468.2	190	11.67797	26.83993	468.6
70	11.76516	27.00326	469.2	191	11.67097	26.83990	469.8
71	11.77498	27.00189	468.7	192	11.66257	26.83987	467.6
72	11.79605	26.99487	473.1	193	11.65697	26.83984	465.7
73	11.77089	26.98472	471.9	194	11.61775	26.84682	466.5
74	11.76808	26.98471	469.6	195	11.61634	26.84824	466.1
75	11.75691	26.98036	472.2	196	11.56452	26.86371	461.1
76	11.72331	26.97731	468.8	197	11.55753	26.86367	463.4
77	11.70927	26.98294	469.6	198	11.52406	26.85067	460.9
78	11.66587	26.98554	466.7	199	11.52565	26.81499	463.0
79	11.54070	26.59475	469.2	200	11.55361	26.81368	461.1
80	11.52398	26.57751	466.8	201	11.62221	26.80111	466.5
81	11.52906	26.68924	465.1	202	11.67261	26.79988	468.3
82	11.54377	26.82364	465.1	203	11.70203	26.79856	469.9
83	11.55309	26.90931	461.2	204	11.72725	26.79865	473.6
84	11.55427	26.94782	465.7	205	11.74547	26.80015	474.7

85	11.76310	26.67557	479.6	206	11.75419	26.75151	478.0
86	11.50949	26.68918	465.0	207	11.72196	26.74854	475.8
87	11.50515	26.71920	463.5	208	11.67847	26.75555	476.4
88	11.55965	26.72654	466.4	209	11.64204	26.75972	470.0
89	11.74322	26.71136	476.5	210	11.58739	26.77239	465.7
90	11.76291	26.70425	477.6	211	11.55800	26.77656	467.5
91	11.77116	26.73008	477.1	212	11.53563	26.77647	466.9
92	11.51474	26.76067	463.6	213	11.52305	26.77642	462.9
93	11.51593	26.80210	463.4	214	11.51187	26.77638	461.7
94	11.74704	26.77296	474.9	215	11.51202	26.74495	464.5
95	11.75377	26.81736	473.9	216	11.54978	26.74366	466.8
96	11.66686	26.82416	466.6	217	11.60012	26.74528	471.5
97	11.66158	26.76980	470.9	218	11.66598	26.73548	475.9
98	11.65636	26.70395	472.8	219	11.74593	26.72570	478.6
99	11.56051	26.82942	464.6	220	11.75861	26.71714	475.5
100	11.52279	26.82640	461.4	221	11.75894	26.66695	476.5
101	11.51839	26.86634	464.3	222	11.75935	26.60235	480.7
102	11.60081	26.87245	465.0	223	11.60251	26.82104	463.5
103	11.67076	26.87420	468.6	224	11.59087	26.64218	465.1
104	11.73939	26.87309	470.5	225	11.76719	26.69279	475.0
105	11.77591	26.86038	473.0	226	11.74757	26.68987	478.3
106	11.78831	26.89334	470.0	227	11.74335	26.69129	475.1
107	11.50695	26.91620	456.9	228	11.70970	26.68977	476.1
108	11.50401	26.94469	460.5	229	11.70549	26.69119	472.5
109	11.57661	26.94937	467.3	230	11.68441	26.69830	471.7
110	11.66894	26.94274	470.4	231	11.64938	26.69964	472.0
111	11.74463	26.92885	473.8	232	11.61011	26.70955	469.4
112	11.77407	26.92615	474.4	233	11.58632	26.70947	474.5
113	11.80074	26.92342	472.4	234	11.58072	26.70945	476.7
114	11.78224	26.96335	472.0	235	11.56815	26.70655	470.8
115	11.70373	26.97434	469.2	236	11.54437	26.70646	467.1
116	11.69813	26.97431	468.2	237	11.54157	26.70645	466.8
117	11.69252	26.97570	472.0	238	11.52060	26.70495	467.7
118	11.68691	26.97852	467.8	239	11.51935	26.67204	465.5
119	11.61835	26.98098	468.2	240	11.54172	26.67497	466.0
120	11.58760	26.98080	467.8	241	11.60327	26.68090	472.4
121	11.66734	26.97413	466.9	242	11.65515	26.66956	472.4
				243	11.72529	26.66400	480.1

3.3.3 SRTM Data

The Shuttle Radar Topography Mission is an international project spearheaded by the U.S. National Geospatial-Intelligence Agency (NGA) and the U.S. National Aeronautics and Space Administration (NASA). NASA transferred the SRTM payload to the Smithsonian National Air and Space Museum in 2003; the canister, mast, and antenna are now on display at the Steven F. Udvar-Hazy Center in Chantilly, Virginia.(From Wikipedia).the data for this research download DEM 30m resolution from United States Geological Survey(USGS) as shown in figure (3.4).

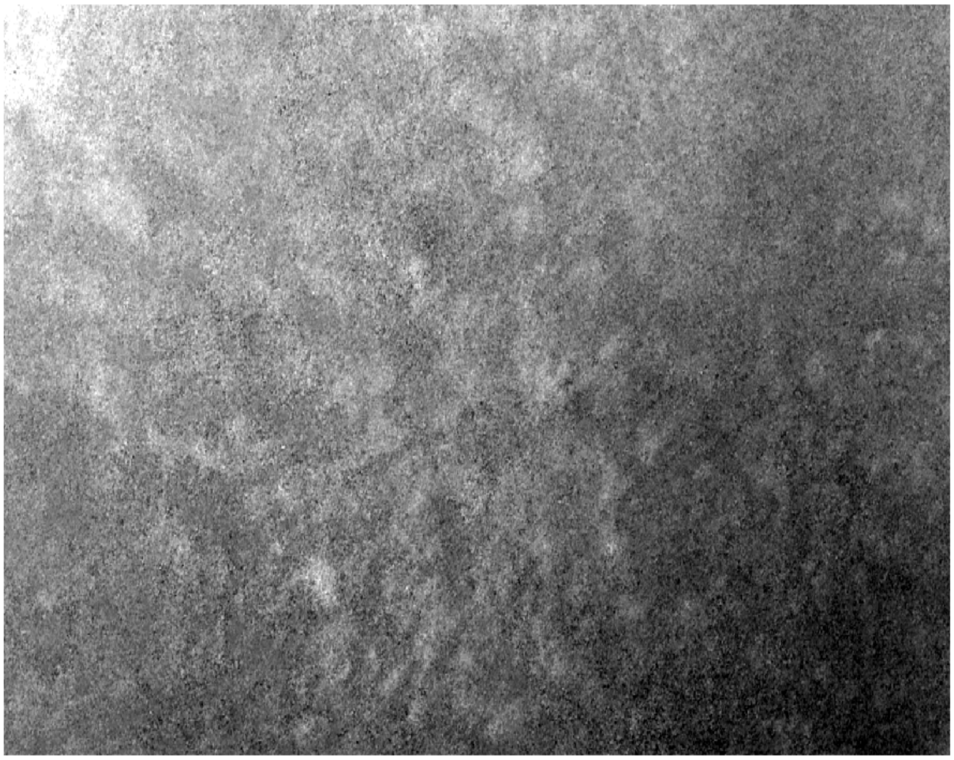

Figure (3.4) SRTM DEM 30mResolution for Study Area

3.3.3.1 SRTM Data Products

The level of processing and the resolution of the data will vary by SRTM data setSRTM Non-Void Filled elevation data were processed from raw C-band radar signals spaced atintervals of 1 arc-second (approximately 30 meters) at NASA's Jet Propulsion Laboratory (JPL). This version was then edited or finished by the NGA to delineate and flatten water bodies, better define coastlines, remove spikes and wells, and fill small voids. Data for regions outside the United States were sampled at 3 arc-seconds (approximately 90 meters) using a cubic convolution resampling technique for open distribution.

SRTM Void Filled elevation data are the result of additional processing to address areas of missing data or voids in the SRTM Non-Void Filled collection. The voids occur in areas where the initial processing did not meet quality specifications. Since SRTM data are one of the most widely used elevation data sources, the NGA filled the voids using interpolation algorithms in conjunction with other sources of elevation data. The resolution for SRTM Void Filled data is 1 arc-second for the United States and 3 arc-seconds for global coverage. Product specification for SRTM represented in Table (3-2).

Table (3-2)Product Specifications for SRTM

Product Specifications	
Projection	Geographic
Horizontal Datum	WGS84
Vertical Datum	EGM96 (Earth Gravitational Model 1996)
Vertical Units	Meters
Spatial Resolution	1 arc-second for global coverage (~30 meters) 3 arc-seconds for global coverage (~90 meters)
Raster Size	1 degree tiles
C-band Wavelength	5.6 cm

3.2.4 Sample point

There are 28 sample points were selected instudy area for this research,points of known coordinates represented intable (3-3). After generated DEM by GIS software and using Inverse distance weighted (IDW) interpolated tool to get new elevation values for sample points, (IDW) interpolation determines cell values using a linearly weighted combination of a set of sample points. The weight is a function of inverse distance. The surface being interpolated should be that of a locationally dependent variable shown in figure (3.5).

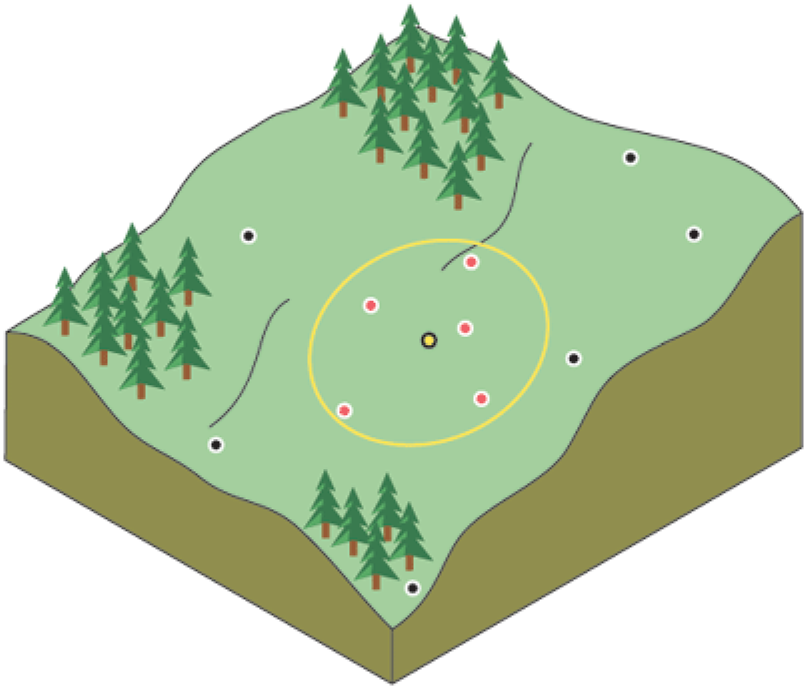

Figure (3.5) IDWneighborhood for selected point.

This method assumes that the variable being mapped decreases in influence with distance from its sampled location. For example, when interpolating a surface of consumer purchasing power for a retail site analysis, the purchasing power of a more distant location will have less influence because peopleare more likely to shop closer to home.

Table (3-3) Known Coordinates for 28 Sample Points.

Staion	Name	NORTHING	EASTING	Elevation	LATITUDE	LONGITUDE
0	Sufyan-3	1285814.118	487367.318	464.378	11°37'53.57531"N	26°53'02.79204"E
1	Sufyan-4	1287274.438	485335.676	466.392	11°38'41.08968"N	26°51'55.67214"E
2	Sufyan N-1	1294097.787	485695.293	466.23	11°42'23.24194"N	26°52'07.44494"E
3	Sufyan E-1	1285552.999	488432.330	462.712	11°37'45.08759"N	26°53'37.96837"E
4	Sufyan E-2	1285996.295	488271.023	463.817	11°37'59.51800"N	26°53'32.63557"E
5	Sufyan E-3	1287434.519	487364.984	463.815	11°38'46.33058"N	26°53'02.69310"E
6	Sufyan S-1	1284282.424	486361.867	459.134	11°37'03.69409"N	26°52'29.60823"E
7	Sufyan S-2	1284134.691	485293.717	462.491	11°36'58.86848" N	26°51'54.33556" E
8	Sufyan W-1	1286426.236	478137.533	467.142	11°38'13.33662"N	26°47'57.95517 "E
9	Sufyan W-2	1285569.309	476960.413	469.068	11°37'45.41003"N	26°47'19.10006"E
10	Sufyan W-6	1286050.735	477399.999	470.117	11°38'01.09427"N	26°47'33.60604"E
11	Sufyan W-7	1286813.972	478250.021	466.836	11°38'25.96263"N	26°48'01.66129"E
12	Sufyan W-8	1286454.996	477705.000	468.611	11°38'14.26291"N	26°47'43.66942"E
13	Sufyan NW-	1288803.737	483865.554	464.895	11°39'30.85508"N	26°51'07.09127"E
14	Suf C-1	1291237.609	461678.497	474.218	11°40'49.45660"N	26°38'54.17634"E
15	Suf-1	1292236.556	461609.174	471.165	11°41'21.97580"N	26°38'51.84543"E
16	Suf-2	1292740.688	460228.559	470.65	11°41'38.33144"N	26°38'06.21905"E
17	Suf-3	1290952.809	461623.636	474.582	11°40'40.18235"N	26°38'52.37590"E
18	Suf-4	1291823.412	461942.105	472.909	11°41'08.53882"N	26°39'02.85974"E
19	Suf-5	1292430.411	461000.080	473.311	11°41'28.26209" N	26°38'31.71754" E
20	Suf E-1	1285122.128	471529.684	470.125	11°37'30.70431"N	26°44'19.76083"E
21	Suf E-2	1285268.987	470888.058	469.433	11°37'35.46615"N	26°43'58.56655"E
22	Suf N-1	1293784.736	463074.765	474.986	11°42'12.43715" N	26°39'40.19600" E
23	Suf N-2	1294843.703	461110.308	472.729	11°42'46.83435"N	26°38'35.25794"E
24	Suf N-3	1294074.967	462541.032	473.821	11°42'21.86499"N	26°39'22.55298"E
25	Suf N-4	1294282.254	462195.120	474.323	11°42'28.59972"N	26°39'11.11761"E
26	Suf SE-1	1287964.352	471537.959	468.478	11°39'03.23793"N	26°44'19.94782"E
27	Suf W-1	1290578.674	454224.791	473.256	11°40'27.67346"N	26°34'48.00441"E

3.4softwareand Hardware Used:

A Geographic Information System (GIS Software) was designed to store, retrieve, manage, display, and analyze all types of geographic and spatial data. GIS software lets you produce maps and other graphic displays of geographic information for analysis and presentation.Moreover to generate DEM and interpolation sample points in this research.

GPS Trimble R8 rovers and base station were used to collected data for this study, also center processing unit (CPU) and monitoring screen for input and output data.

3.5Research Methods:

In this study, digital elevation model were produced using different techniques.

3.5.1DEM Generation using RTK data:

One of the modern methods used for generation DEM, the accuracy will increase paralleldepend on number of points observed.In this study the dataobserved usingGPS Trimble R8totally 47172 points acquired. The data were interpreted using GIS software, which provides an ideal environment forDatum conversion, geo-referencing, profile extraction, interpretation and visualization.
For interpolated sample point usingInverse Distance Weighting (IDW) function in ArcGIS tool.

The output value for a cell using inverse distance weighting (IDW) is limited to the range of the values used to interpolate. Because IDW is a weighted distance average, the average cannot be greater than the highest or less than the lowest input. Therefore, it cannot create ridges or valleys if these extremes have not already been sampled (Watson and Philip 1985).the result show in figure (3.6)

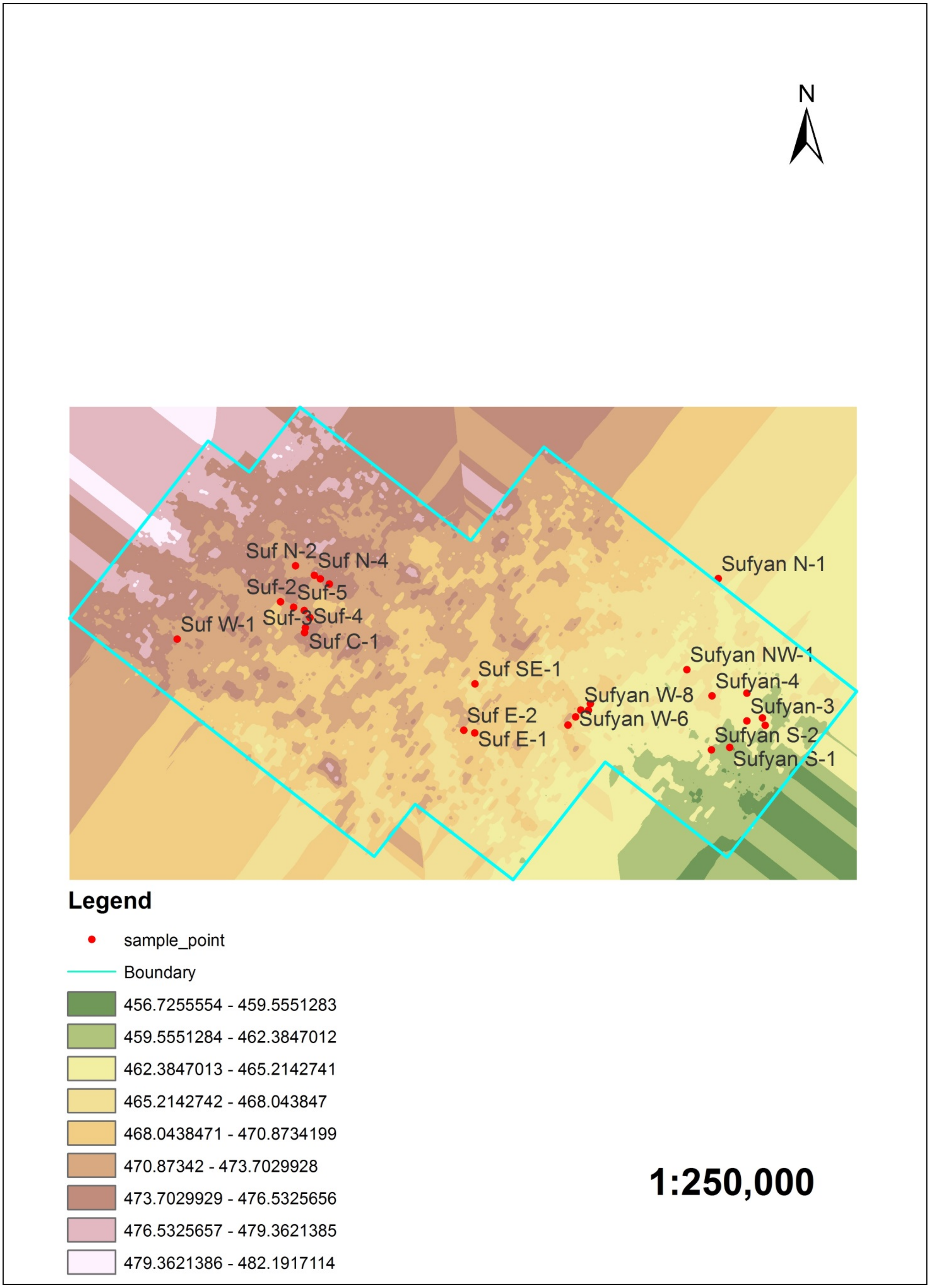

Figure (3.6) DEM Generation using RTK Data by GIS Software.

3.5.2 DEM Generation using Google Earth data:

The availability of data from Google Earth is considered one of the methods used for creating Digital elevation model in many applications.

After selecting the study area in Google Earth and convert data used GPS visualizer software to (latitude, longitude, elevation). Then the points entered in ArcMap to generate digital elevation model.Show in Figure (3.7).

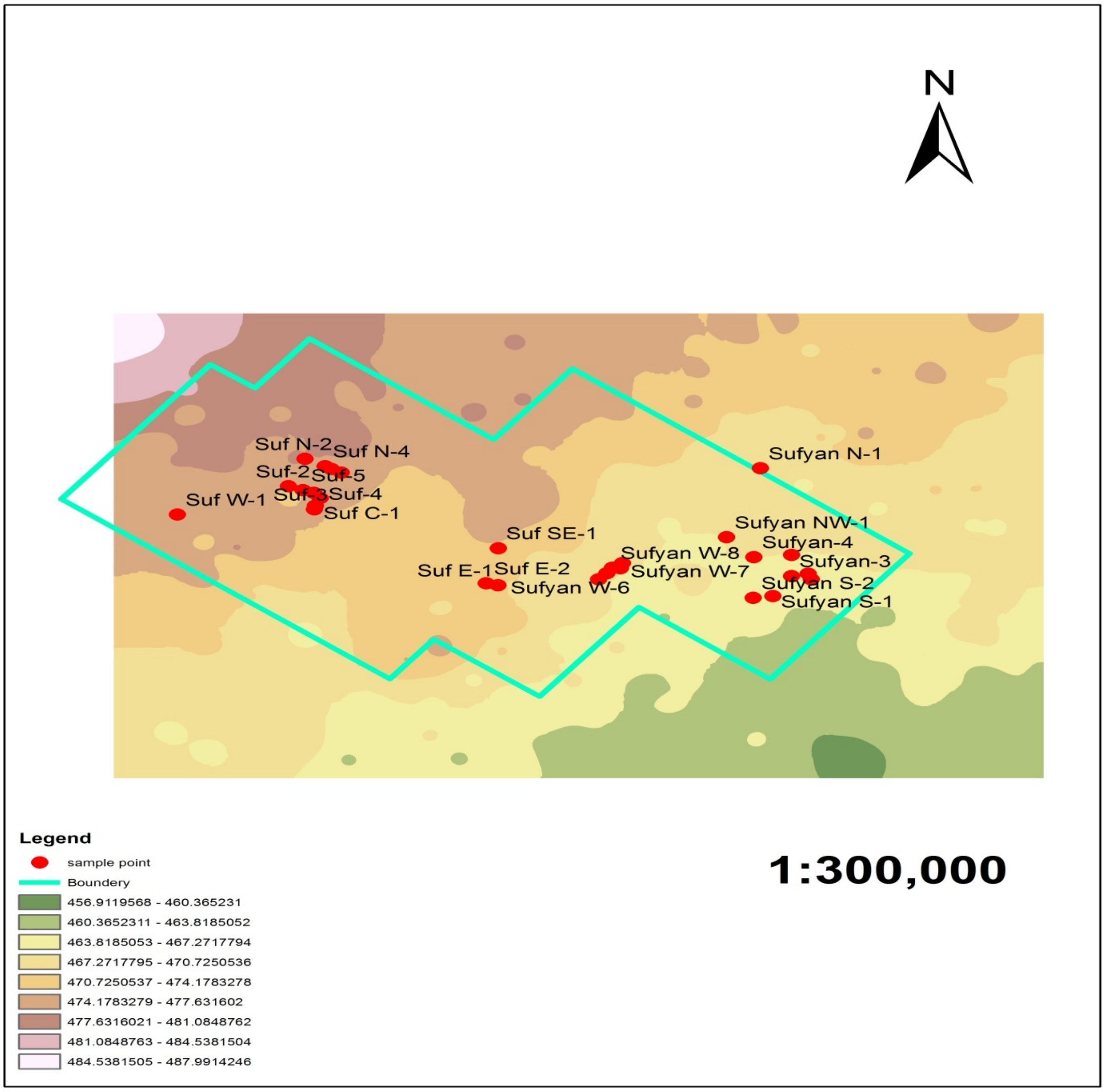

Figure (3.7) DEM Generation using Google Earth Data by GIS Software.

3.5.3DEM Generationusing SRTM Data:

The study area in raster image (pixel 30*30 m) was downloaded from USGS web site and then processed inArcMap converting the raster image (pixel)to vectordata (points)in order to generateDEM.Shown in figure (3.8).

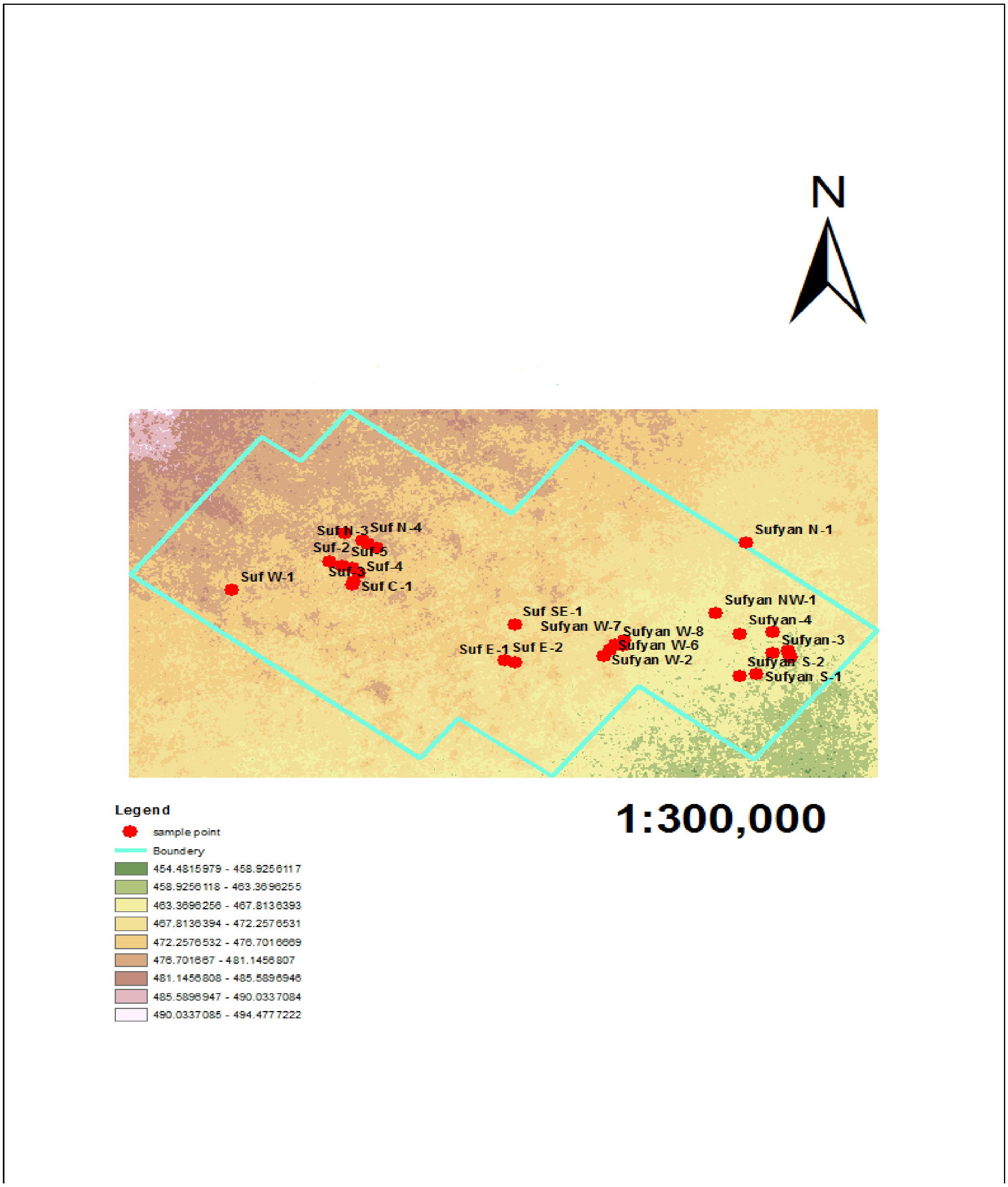

Figure (3.8) DEM Generation using SRTM (raster image)by GIS Software.

CHAPTERFOUR

RESULTS AND ANALYSIS

4.1 Introduction:

One of the most essential topics focus on research,28 sample points of oil well with known elevation were calculated using DEM generated by using three data sources, RTK GPS ,Google Earth and SRTM. Comparison between calculated values and known values had been studied.

4.2 Results:

Results of each method revealed in the form of tables showing the differences between the actual elevation of the points and the elevation computed from digital elevation models (DEM).

4.3 Analysis of Results:

The analysis is one of the crucial steps to reach the desired result of the research, after obtaining the height of the test points from the three methods of digital elevation model (DEM) which was generated, and calculating the difference between the known values &obtained one show in table (4-4). Then we found that the elevation from RTK data is closest to the real values of the points. Secondly Google earth method and SRTM at the end .Show that in chart. The Root Mean Square Deviation (RMSD) has been confirmed that.

4.2.1 RTK DEM Vs Known values:

Table (4-1) represents a comparison betweenknown elevation values and elevation from RTK DEM for sample points.

Table (4-1) Comparisonbetween Known Elevation Values and Elevation from RTK DEM for Sample Point.

Name	NORTHING	EASTING	Elevation	LATITUDE	LONGITUDE	HEIGHT	RTK DEM elev	Difference
Sufyan-3	1285814.118	487367.318	464.378	11°37'53.57531"N	26°53'02.79204"E	462.977	463.996	0.382
Sufyan-4	1287274.438	485335.676	466.392	11°38'41.08968"N	26°51'55.67214"E	465.773	466.432	-0.040
Sufyan N-1	1294097.787	485695.293	466.23	11°42'23.24194"N	26°52'07.44494"E	465.119	466.426	-0.196
Sufyan E-1	1285552.999	488432.330	462.712	11°37'45.08759"N	26°53'37.96837"E	461.301	462.608	0.104
Sufyan E-2	1285996.295	488271.023	463.817	11°37'59.51800"N	26°53'32.63557"E	463.716	464.401	-0.584
Sufyan E-3	1287434.519	487364.984	463.815	11°38'46.33058"N	26°53'02.69310"E	463.633	463.934	-0.119
Sufyan S-1	1284282.424	486361.867	459.134	11°37'03.69409"N	26°52'29.60823"E	457.684	459.564	-0.430
Sufyan S-2	1284134.691	485293.717	462.491	11°36'58.86848" N	26°51'54.33556" E	461.039	462.071	0.420
Sufyan W-1	1286426.236	478137.533	467.142	11°38'13.33662"N	26°47'57.95517 "E	465.796	467.541	-0.399
Sufyan W-2	1285569.309	476960.413	469.068	11°37'45.41003"N	26°47'19.10006"E	467.701	468.985	0.083
Sufyan W-6	1286050.735	477399.999	470.117	11°38'01.09427"N	26°47'33.60604"E	468.763	469.915	0.202
Sufyan W-7	1286813.972	478250.021	466.836	11°38'25.96263"N	26°48'01.66129"E	465.503	466.554	0.282
Sufyan W-8	1286454.996	477705.000	468.611	11°38'14.26291"N	26°47'43.66942"E	467.269	468.332	0.279
Sufyan NW	1288803.737	483865.554	464.895	11°39'30.85508"N	26°51'07.09127"E	463.604	464.945	-0.050
Suf C-1	1291237.609	461678.497	474.218	11°40'49.45660"N	26°38'54.17634"E	473.189	473.863	0.355
Suf-1	1292236.556	461609.174	471.165	11°41'21.97580"N	26°38'51.84543"E	470.172	471.748	-0.583
Suf-2	1292740.688	460228.559	470.65	11°41'38.33144"N	26°38'06.21905"E	469.692	471.198	-0.548
Suf-3	1290952.809	461623.636	474.582	11°40'40.18235"N	26°38'52.37590"E	473.544	474.164	0.418
Suf-4	1291823.412	461942.105	472.909	11°41'08.53882"N	26°39'02.85974"E	471.898	473.030	-0.121
Suf-5	1292430.411	461000.080	473.311	11°41'28.26209" N	26°38'31.71754" E	472.333	472.903	0.408
Suf E-1	1285122.128	471529.684	470.125	11°37'30.70431"N	26°44'19.76083"E	469.077	469.728	0.397
Suf E-2	1285268.987	470888.058	469.433	11°37'35.46615"N	26°43'58.56655"E	468.103	469.300	0.133
Suf N-1	1293784.736	463074.765	474.986	11°42'12.43715" N	26°39'40.19600" E	474.528	474.701	0.285
Suf N-2	1294843.703	461110.308	472.729	11°42'46.83435"N	26°38'35.25794"E	471.834	472.523	0.206
Suf N-3	1294074.967	462541.032	473.821	11°42'21.86499"N	26°39'22.55298"E	472.881	474.168	-0.347
Suf N-4	1294282.254	462195.120	474.323	11°42'28.59972"N	26°39'11.11761"E	474.425	474.442	-0.119
Suf SE-1	1287964.352	471537.959	468.478	11°39'03.23793"N	26°44'19.94782"E	467.233	468.397	0.081
Suf W-1	1290578.674	454224.791	473.256	11°40'27.67346"N	26°34'48.00441"E	472.311	473.176	0.080

4.2.2Google Earth DEMVs Known values:

Table (4-2) represents a comparison betweenknown elevation values and elevation fromGoogle earth DEM for sample points.

Table (4-2) Comparisonbetween Known Elevation Values and Elevation from Google earth DEM for Sample Points.

Name	NORTHING	EASTING	Elevation	LATITUDE	LONGITUDE	HEIGHT	G.E DEM elev	Difference
Sufyan-3	1285814.118	487367.318	464.378	11°37'53.57531"N	26°53'02.79204"E	462.977	465.548	-1.170
Sufyan-4	1287274.438	485335.676	466.392	11°38'41.08968"N	26°51'55.67214"E	465.773	467.330	-0.938
Sufyan N-1	1294097.787	485695.293	466.23	11°42'23.24194"N	26°52'07.44494"E	465.119	469.173	-2.943
Sufyan E-1	1285552.999	488432.330	462.712	11°37'45.08759"N	26°53'37.96837"E	461.301	465.234	-2.522
Sufyan E-2	1285996.295	488271.023	463.817	11°37'59.51800"N	26°53'32.63557"E	463.716	465.505	-1.688
Sufyan E-3	1287434.52	487364.984	463.815	11°38'46.33058"N	26°53'02.69310"E	463.633	467.109	-3.294
Sufyan S-1	1284282.424	486361.867	459.134	11°37'03.69409"N	26°52'29.60823"E	457.684	464.919	-5.785
Sufyan S-2	1284134.69	485293.717	462.491	11°36'58.86848" N	26°51'54.33556" E	461.039	465.273	-2.782
Sufyan W-1	1286426.236	478137.533	467.142	11°38'13.33662"N	26°47'57.95517 "E	465.796	467.568	-0.426
Sufyan W-2	1285569.309	476960.413	469.068	11°37'45.41003"N	26°47'19.10006"E	467.701	468.392	0.676
Sufyan W-6	1286050.735	477399.999	470.117	11°38'01.09427"N	26°47'33.60604"E	468.763	467.888	2.229
Sufyan W-7	1286813.972	478250.021	466.836	11°38'25.96263"N	26°48'01.66129"E	465.503	467.801	-0.965
Sufyan W-8	1286454.996	477705.000	468.611	11°38'14.26291"N	26°47'43.66942"E	467.269	467.927	0.684
Sufyan NW	1288803.737	483865.554	464.895	11°39'30.85508"N	26°51'07.09127"E	463.604	467.505	-2.610
Suf C-1	1291237.609	461678.497	474.218	11°40'49.45660"N	26°38'54.17634"E	473.189	474.589	-0.371
Suf-1	1292236.556	461609.174	471.165	11°41'21.97580"N	26°38'51.84543"E	470.172	474.746	-3.581
Suf-2	1292740.688	460228.559	470.65	11°41'38.33144"N	26°38'06.21905"E	469.692	474.362	-3.712
Suf-3	1290952.809	461623.636	474.582	11°40'40.18235"N	26°38'52.37590"E	473.544	474.587	-0.005
Suf-4	1291823.412	461942.105	472.909	11°41'08.53882"N	26°39'02.85974"E	471.898	474.612	-1.703
Suf-5	1292430.411	461000.080	473.311	11°41'28.26209" N	26°38'31.71754" E	472.333	474.356	-1.045
Suf E-1	1285122.128	471529.684	470.125	11°37'30.70431"N	26°44'19.76083"E	469.077	471.088	-0.963
Suf E-2	1285268.987	470888.058	469.433	11°37'35.46615"N	26°43'58.56655"E	468.103	471.413	-1.980
Suf N-1	1293784.736	463074.765	474.986	11°42'12.43715" N	26°39'40.19600" E	474.528	476.032	-1.046
Suf N-2	1294843.703	461110.308	472.729	11°42'46.83435"N	26°38'35.25794"E	471.834	477.586	-4.857
Suf N-3	1294074.967	462541.032	473.821	11°42'21.86499"N	26°39'22.55298"E	472.881	476.731	-2.910
Suf N-4	1294282.254	462195.120	474.323	11°42'28.59972"N	26°39'11.11761"E	474.425	477.078	-2.755
Suf SE-1	1287964.352	471537.959	468.478	11°39'03.23793"N	26°44'19.94782"E	467.233	473.547	-5.069
Suf W-1	1290578.674	454224.791	473.256	11°40'27.67346"N	26°34'48.00441"E	472.311	475.645	-2.389

4.2.3 SRTM DEMVs Known values:

Table (4-3)represents a comparisonbetweenknown elevation valuesand elevation from SRTM DEM for sample points.

Table (4-3) Comparisonbetween Known Elevation Values and Elevation from SRTM DEM for Sample Points.

Name	NORTHING	EASTING	Elevation	LATITUDE	LONGITUDE	HEIGHT	SRTM DEM elev	Difference
Sufyan-3	1285814.118	487367.318	464.378	11°37'53.57531"N	26°53'02.79204"E	462.977	465.374	-0.996
Sufyan-4	1287274.438	485335.676	466.392	11°38'41.08968"N	26°51'55.67214"E	465.773	465.047	1.345
Sufyan N-1	1294097.787	485695.293	466.23	11°42'23.24194"N	26°52'07.44494"E	465.119	469.813	-3.583
Sufyan E-1	1285552.999	488432.330	462.712	11°37'45.08759"N	26°53'37.96837"E	461.301	463.746	-1.034
Sufyan E-2	1285996.295	488271.023	463.817	11°37'59.51800"N	26°53'32.63557"E	463.716	465.674	-1.857
Sufyan E-3	1287434.519	487364.984	463.815	11°38'46.33058"N	26°53'02.69310"E	463.633	463.344	0.471
Sufyan S-1	1284282.424	486361.867	459.134	11°37'03.69409"N	26°52'29.60823"E	457.684	462.222	-3.088
Sufyan S-2	1284134.691	485293.717	462.491	11°36'58.86848" N	26°51'54.33556" E	461.039	466.132	-3.641
Sufyan W-1	1286426.236	478137.533	467.142	11°38'13.33662"N	26°47'57.95517 "E	465.796	468.859	-1.717
Sufyan W-2	1285569.309	476960.413	469.068	11°37'45.41003"N	26°47'19.10006"E	467.701	470.156	-1.088
Sufyan W-6	1286050.735	477399.999	470.117	11°38'01.09427"N	26°47'33.60604"E	468.763	471.883	-1.766
Sufyan W-7	1286813.972	478250.021	466.836	11°38'25.96263"N	26°48'01.66129"E	465.503	470.182	-3.346
Sufyan W-8	1286454.996	477705.000	468.611	11°38'14.26291"N	26°47'43.66942"E	467.269	471.011	-2.400
Sufyan NW-1	1288803.737	483865.554	464.895	11°39'30.85508"N	26°51'07.09127"E	463.604	466.823	-1.928
Suf C-1	1291237.609	461678.497	474.218	11°40'49.45660"N	26°38'54.17634"E	473.189	477.594	-3.376
Suf-1	1292236.556	461609.174	471.165	11°41'21.97580"N	26°38'51.84543"E	470.172	473.293	-2.128
Suf-2	1292740.688	460228.559	470.65	11°41'38.33144"N	26°38'06.21905"E	469.692	469.857	0.793
Suf-3	1290952.809	461623.636	474.582	11°40'40.18235"N	26°38'52.37590"E	473.544	477.013	-2.431
Suf-4	1291823.412	461942.105	472.909	11°41'08.53882"N	26°39'02.85974"E	471.898	478.917	-6.008
Suf-5	1292430.411	461000.080	473.311	11°41'28.26209" N	26°38'31.71754" E	472.333	473.539	-0.228
Suf E-1	1285122.128	471529.684	470.125	11°37'30.70431"N	26°44'19.76083"E	469.077	472.488	-2.363
Suf E-2	1285268.987	470888.058	469.433	11°37'35.46615"N	26°43'58.56655"E	468.103	470.194	-0.761
Suf N-1	1293784.736	463074.765	474.986	11°42'12.43715" N	26°39'40.19600" E	474.528	479.879	-4.893
Suf N-2	1294843.703	461110.308	472.729	11°42'46.83435"N	26°38'35.25794"E	471.834	475.169	-2.440
Suf N-3	1294074.967	462541.032	473.821	11°42'21.86499"N	26°39'22.55298"E	472.881	479.961	-6.140
Suf N-4	1294282.254	462195.120	474.323	11°42'28.59972"N	26°39'11.11761"E	474.425	475.475	-1.152
Suf SE-1	1287964.352	471537.959	468.478	11°39'03.23793"N	26°44'19.94782"E	467.233	471.476	-2.998
Suf W-1	1290578.674	454224.791	473.256	11°40'27.67346"N	26°34'48.00441"E	472.311	474.513	-1.257

Tables (4-4) Explain Difference between Three Methods and Known Elevation Values of the Points.

well name	known elevation	RTK Difference	SRTM Difference	Google Earth Difference
Sufyan-3	464.378	0.38154	-0.996207	-1.169638
Sufyan-4	466.392	-0.03958	1.345278	-0.938475
Sufyan N-1	466.23	-0.196483	-3.583141	-2.943004
Sufyan E-1	462.712	0.104181	-1.033697	-2.521734
Sufyan E-2	463.817	-0.584093	-1.856981	-1.688402
Sufyan E-3	463.815	-0.119143	0.471036	-3.293856
Sufyan S-1	459.134	-0.429995	-3.087527	-5.784732
Sufyan S-2	462.491	0.41965	-3.641263	-2.781583
Sufyan W-1	467.142	-0.399016	-1.7171	-0.426329
Sufyan W-2	469.068	0.082832	-1.087884	0.675941
Sufyan W-6	470.117	0.201595	-1.765965	2.228725
Sufyan W-7	466.836	0.282014	-3.345519	-0.965453
Sufyan W-8	468.611	0.279091	-2.399834	0.683784
Sufyan NW-1	464.895	-0.049977	-1.927754	-2.610096
Suf C-1	474.218	0.354566	-3.375719	-0.370562
Suf-1	471.165	-0.582742	-2.127725	-3.581002
Suf-2	470.65	-0.548212	0.793372	-3.712061
Suf-3	474.582	0.417724	-2.430604	-0.004914
Suf-4	472.909	-0.121029	-6.00845	-1.702786
Suf-5	473.311	0.407527	-0.227666	-1.044988
Suf E-1	470.125	0.397247	-2.363281	-0.963165
Suf E-2	469.433	0.133378	-0.761153	-1.980086
Suf N-1	474.986	0.285438	-4.893486	-1.04583
Suf N-2	472.729	0.205929	-2.439823	-4.857395
Suf N-3	473.821	-0.347152	-6.140121	-2.910415

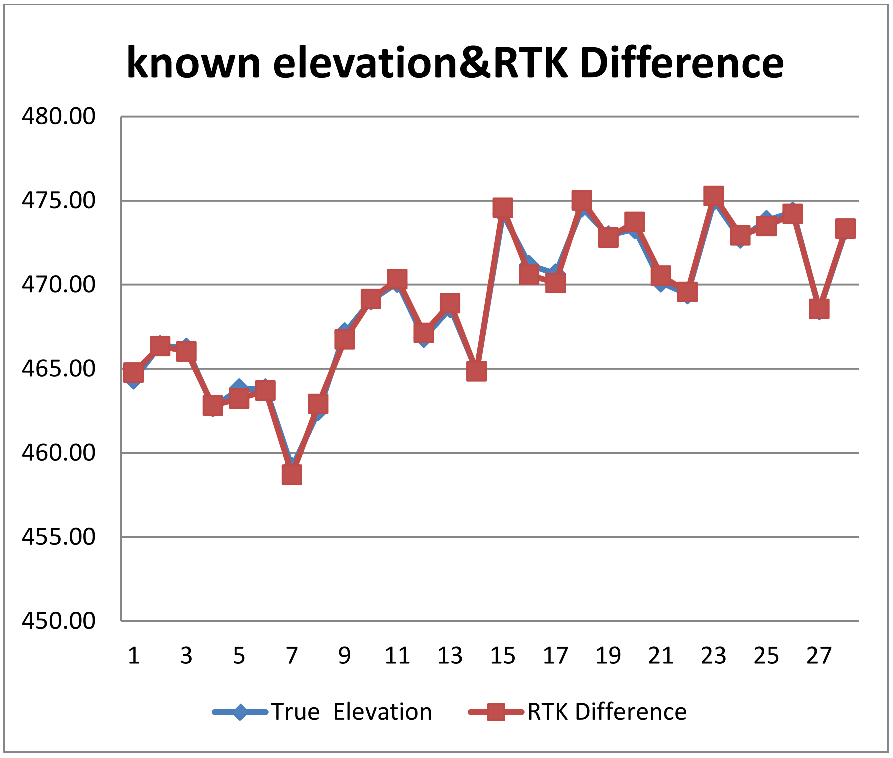

Figure (4.1) The Graph shows for Known Elevation and RTK Difference

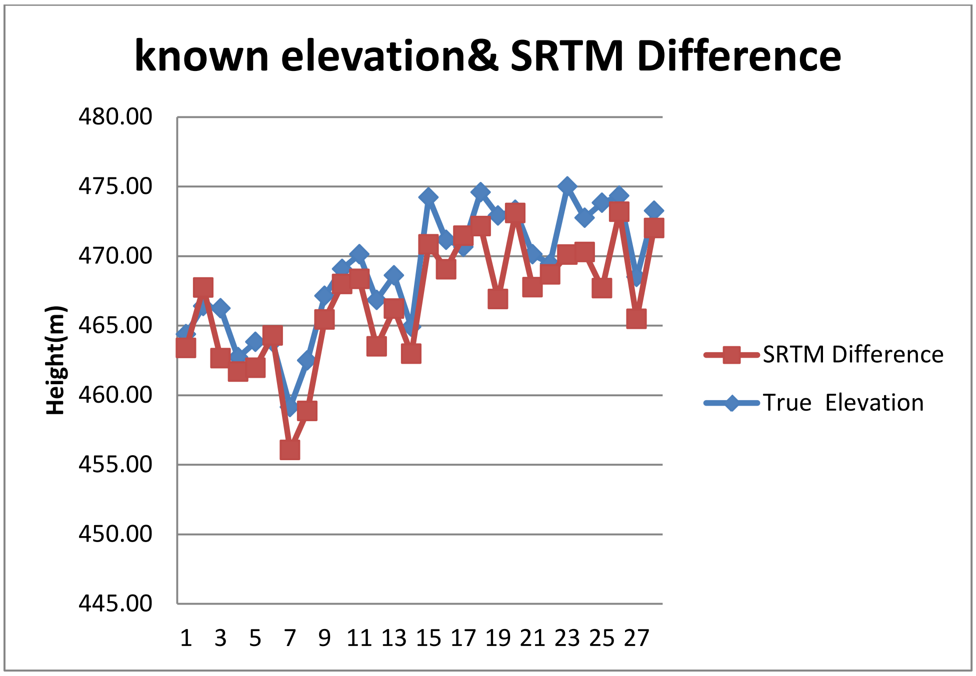

Figure (4.2)The Graph shows for Known Elevation and SRTM Difference

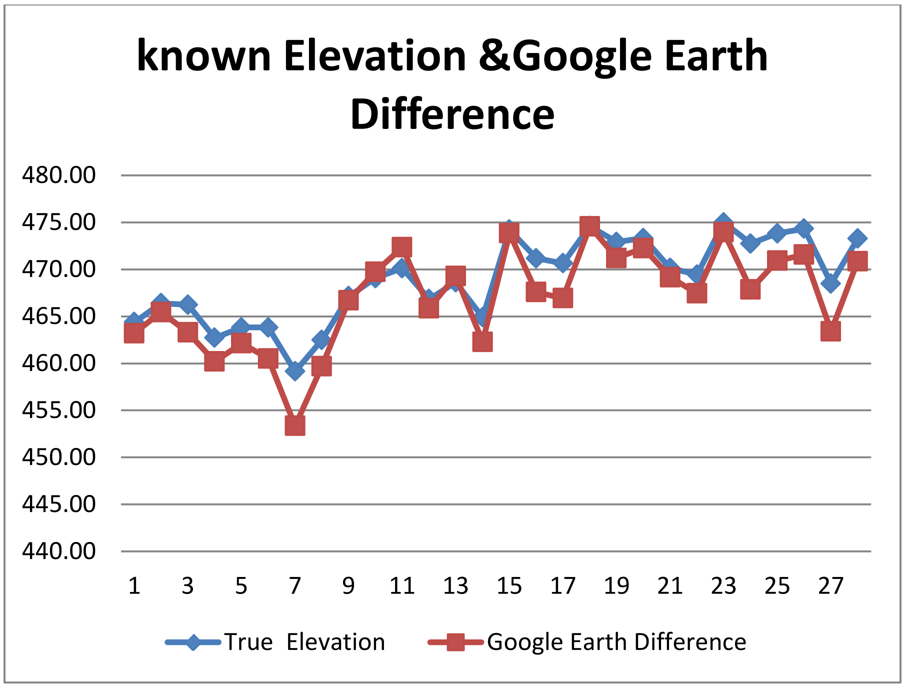

Figure (4.3) The Graph shows Known Elevation and Google Earth difference

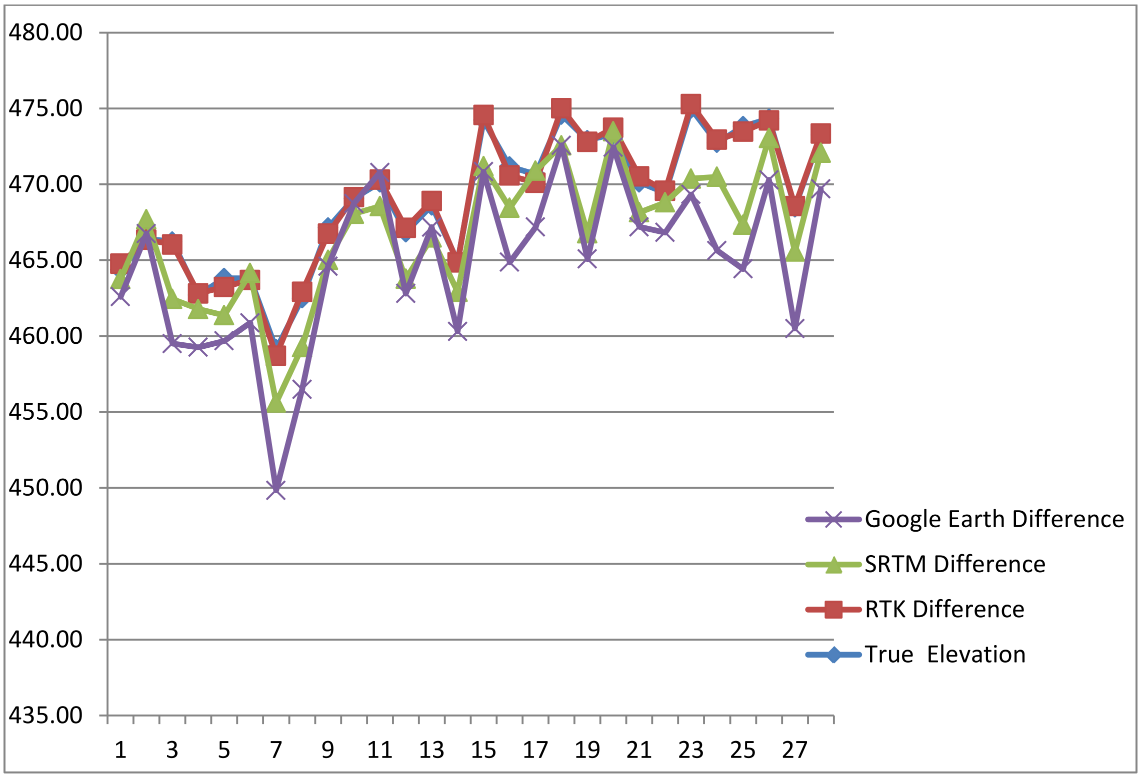

Figure (4.4) The Graph showscomparison between three Methods

4.4 Root Mean Square(RMS)

The root-mean-square deviation (RMSD) or root-mean-square error (RMSE) is a frequently used measure of the differences between values (sample and population values) predicted by a model or an estimator and the values actually observed. The RMSD represents the sample standard deviation of the differences between predicted values and observed values. These individual differences are called residuals when the calculations are performed over the data sample that was used for estimation, and are called prediction errors when computed out-of-sample. The RMSD serves to aggregate the magnitudes of the errors in predictions for various times into a single measure of predictive power. RMSD is a measure of accuracy, to compare forecasting errors of different models for a particular data and not between datasets, as it is scale-dependent (Hyndman, Rob J.; Koehler, Anne B. 2006).

Although RMSE is one of the most commonly reported measures of disagreement, some scientists misinterpret RMSD as average error, which RMSD is not. RMSD is the square root of the average of squared errors, thus RMSD confounds information concerning average error with information concerning variation in the errors. The effect of each error on RMSD is proportional to the size of the squared error thus larger errors have a disproportionately large effect on RMSD. Consequently, RMSD is sensitive to outliers (Willmott, Cort; Matsuura, Kenji 2006).

$$\mathrm{RMSD} = \sqrt{\frac{\sum_{t=1}^{n}(\hat{y}_t - y_t)^2}{n}}. \qquad \text{……………………………………………..4-1}$$

$\hat{y}_t$=summation of known elevation.

y_t=summation of computing elevation.

n=number of points.

Equation 4-1 used to compute RMSD for the three methods as shown in table (4-5)

Table (4-5) RMSD Values for Three Methods

methods	RMSD values(m)
RTK	0.026
GOOGLE earth	1.928
SRTM	2.143

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

In this research, three methods were compared to generate DEM, and then using above methods to obtaining the heights of sample points, in addition to comparing the values of the heights obtained with the known heights values. The results showed that RTK is best method, this because the values obtained by RTK for the elevation points are close the mostknownvalues. Google Earth method followed by and SRTM the third one. Therefore, digital elevation models from RTK data can be used to obtain the elevations of new oil wells, which help a lot in saving time and cost.

5.2 Recommendations

The following are recommended in future studies:

- Comparison of accuracy between SRTM method and Google Earth method in different terrain.
- Using Radar remote sensing in generating DEM and elevation determination.

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