بسم الله الرحمن الرحيم

Sudan University of Science and Technology

College of Graduate Studies

College of Computer Science and Information Technology

Title:

USE OF 3D CITY GIS FOR SUSTAINING AND RECONSTRUCTING CITIES

(A CASE STUDY :AL-MOGRAN AREA-KHARTOUM STATE-SUDAN, FUTURE INFRASTRUCTURE)

إستخدام تقنية نظم المعلومات الجغرافية ثلاثية الأبعاد في تنميـــــــــــة وإعادة بناء المدن

(دراسة الحالة : البنية المستقبلية لمنطقة المقرن)

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قال الله تعالي في محكم تنزيله:

بسم الله الرحمن الرحيم

(يَا بُنَيَّ إِنَّهَا إِن تَكُ مِثْقَالَ حَبَّةٍ مِّنْ خَرْدَلٍ فَتَكُن فِي صَخْرَةٍ أَوْ فِي السَّمَاوَاتِ أَوْ فِي الْأَرْضِ يَأْتِ بِهَا اللَّهُ ۚ إِنَّ اللَّهَ لَطِيفٌ خَبِيرٌ (16))

صدق الله العظيم

(سورة لقمان)

Dedication

This thesis is dedicated:

To Mom,Dad.

To Hena, Wedo, Lano, Soma, Mahoya, Manora and Abody, also to my little sister Azzoza, who always loved me unconditionally and whose good examples have taught me to work hard for the things that I aspire to achieve.

To my lovely husband Alwaleed, who has been a constant source of support and encouragement during the challenges of graduate studies and life.

Lastly I dedicate this work to my small daughter Rahaf - she gives me another meaning to my life. I am truly thankful for having her and her father in my life.

Acknowledgement

Foremost, I want to thank my God Allah for giving me the great blessings for science and knowledge, and I ask my Lord to preserve and provide it.

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Finally, my deepest gratitude goes to my family for their unflagging love and unconditional support throughout my life and my studies. Thanks for listening to my problems and providing me a great perspective. You made me live the most unique, magic and carefree childhood, that has made me who I am now!

Finally, I would like to thank my husband, Alwaleed. You have been continually supportive during my graduate education. Thank you for the little things you haved one, like serving me dinner, when I worked late nights. Thank you for those weekends, when you serviced the computer, so that my work would go a little quicker. You have been patient with me, when I was frustrated, you celebrated with me when even the littlest things went right, and you are there whenever I need you, just to listen. I would not be the person who I am today without all your support.

Abstract

Three-dimensional GIS modeling is growing rapidly with the evolving new technologies. It supports various applications and keeps these moving to a new direction for the geospatial community. Three-dimensional modeling is a real simulation of reality, especially if it is relatively accurate. On the other hand, the use of three-dimensional modeling in the GIS environment provides a flexible interactive system to provide the best visual interpretation processes, plannings and decision-makings. Modeling using the third dimension is one of the most important technologies and is most effective for the management of spatial data infrastructures and analysis.

The aim of this work is to show, how to create the required projects to build or restructure modern cities, using 3D geographic information systems integrating digital photogrammetry techniques, and other spatial technologies. For our studies we have chosen the Al-Mogran Area as a Testbed, which is located in the State of Khartoum, being a meeting place for the White and Blue of Nile, and reflecting the importance of cultural life and tourism. Nevertheless, it is independent of any optimal ratio of geographical, economic and cultural locations. Therefore, this study aims at geographic analyses using modern techniques and reflecting the importance of three-dimensional modeling for buildings, such as housing, hotels, offices, being used by commercial markets, companies, leisure or health facilities. In addition, the infrastructures of modern municipal service providers are to be considered, to name here the distribution of electricity, gas, sanitary water and sewage pipes, which should be excellent.

The experience of this research is the basis to enable the State and the decision-makers and investors to have a clear vision for the future of this region. On display is the best-case scenario they can benefit from. This reverses the importance of three-dimensional modeling and its role in the development of cities. Hopefully, this experiment can be expanded to the entire state of Khartoum and the country as a whole.

المستخلص

نمذجة نظم المعلومات الجغرافية ثلاثية الأبعاد تتزايد بسرعة مع التكنولوجيات الجديدة المتطورة والدعم لمختلف التطبيقات وقد رسم ذلك اتجاه جديد لمجتمع الجغرافية المكانية فهي محاكاة حقيقية للواقع، لا سيما إذا كان دقيقا نسبيا.

من ناحية أخرى فإن إستخدام النمذجة ثلاثية الأبعاد في بيئة نظم المعلومات الجغرافية يوفر نظام تفاعلي مرن لتقديم أفضل عملية للتفسير البصري والتخطيط وصنع القرار. فقد أصبحت النمذجة ثلاثية الأبعاد واحدة من أهم التقنيات وأكثرها فعالية لإدارة البيانات المكانية والبنى التحتيه وتحليلها وتصميمها والمساهمه بتنفيذها بتوفير المعلومات الدقيقه. والهدف من هذا العمل هو عرض كيفية إنشاء المشاريع المطلوبة في بناء المدن الحديثة أو إعادة هيكلتها باستخدام نموذج نظم المعلومات الجغرافية الثلاثية الأبعاد بإستخدام تقنيات المسح التصويري الرقمي، وتقنيات أخرى. ومن ثم عكس فائدة النمذجة ثلاثية الأبعاد عبر مناقشة العديد من المشاريع الرائدة والسابقه في إعادة هيكلة وبناء المدن الحديثة. أخترنا منطقة المقرن التي تقع في ولاية الخرطوم والتي هي ملتقي لكل من النيلين الأبيض والأزرق مما يعكس أهميتها الحضارية والسياحيه للدولة والتي يجب الإهتمام بها. رغم ذلك فهي غير مستقله الإستقلال الأمثل نسبة لموقعها الجغرافي والإقتصادي والثقافي لذا فإن هذه الدراسة التحليلية الجغرافية المنتجة بتقنيات حديثة تعكس وتعرض الواقع بصورة واضحة وتوزيع البنايات الصالحة للسكن ، لفنادق ، لمكاتب ، للأسواق التجارية ، للشركات ، للمباني الترفيهية أوالصحية وغيرها في اي منطقة بصورة صحيحة مما يساهم في توزيع البنية التحتية من أسلاك كهرباء وغاز انابيب المياه الصحيه ومياه الصرف الصحي بصورة ممتازه.

تجربة هذا البحث تعتبر أساس لتمكين الدوله وصناع القرار والمستثمرين من الرؤية الواضحه لمستقبل هذه المنطقة وعرض أفضل سيناريو يمكنهم من الاستفادة منها وبالتالي عكس أهمية النمذجة ثلاثية الأبعاد ودورها في تطوير المدن ومن ثم تعميم التجربة علي كامل ولاية الخرطوم ثم القطر ككل.

Acronyms

Acronym	Meaning
GIS	Geographic Information System
GPS	Global Positioning System
2D	2 Dimensional
3D	3 Dimensional
3D modeling	**three-dimensional modeling**
RGB	Red Green Blue color model
TIN	Triangulated Irregular Network
GRID	Mesh or regular pattern in the x,y-plane
LOD	Level of Detail
DTM	**Digital Terrain Model**
DSM	**Digital Surface Model**
nDSM	**Normalized Digital Surface Model**
GSD	Ground Sampling Distance
DIM	Dense Image Imaging
DMS	Degrees Minutes Seconds

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CHAPTER ONE

Introduction

Chapter (1)

Introduction

1.1 Overview

There is an increasing demand for 3D visualization of urban areas, for planning, architecture, engineering and GIS. By using reality-based 3D city models the urban environment is presented to any user in a way, they are familiar with, to see the world in 3 dimensions instead of a synthesized 2D map. The fundamental challenge for the development, implementation and designing of geo-visualizations is to avoid complexity, as well as too detailed and too dense visualizations.

The integration of visualization in scientific computing, cartography, image analysis, information access, exploratory data analysis and GIS is very important, because all fields provide theory, methods and tools for visual exploration, analysis, synthesis and presentation of spatial data.Thus, 3D geo-visualization can be applied at different phases, with distinct levels of detail (LOD), according to the user requirements and applications. 2D will give the geographical location of a feature in x and y co-ordinates. 3D data are represented along the x, y and z axis. Moreover, it gives a clear perspective of the area. This realistic 3D view gives an idea to planners and decision makers, to get a clear view of how the city or urban area would look like. By changing the looking angle, the view and the feel can also be changed. This is an added advantage of 3D, which is not possible in 2D. One can further take the 3D model by applying some special effects, textures and also by using 3D symbols for a more realistic feel. 3D visualization models have a variety of applications in geography and urban studies. Accurate cartographic feature extraction, map updating, and 3D city models in urban areas are essential for many applications, such as military operations, disaster management, mapping of buildings and their heights, simulation of new buildings, updating and keeping cadastral databases current, change detection and virtual reality. While they are generally used to simply visualize the built environment, there are early signs of them being used as 3D interfaces to more sophisticated simulation models.

3D city models are derived in different level-of-details (LODs) with different types of facade textures from various input data like stereo aerial imagery (standard or oblique), laser scanner data, photogrammetry and 2D building footprints.

Other commercial softwares can be used to generate 3D models. Models generated using COLLADA (.dae), Open Flight 15.8 (.flt), SketchUp 6.0(.skp), 3ds max (.3ds), or VRML 2.0 models (.wrl), or Billboards (PNG, JPG, BMP,TIF, GIF, etc.) can be imported into ArcGIS after generating shape files. These files can also be created by digitizing spatial data from Google Earth, also to be imported into ArcGIS. The shape file can be extruded using the height as attributes. The attribute can either be the height information or the floor details.

3D models can be used as a user-friendly interface for querying the urban environment as a Geographic Information Systems (GIS), for hyper-linking Web-based information, for visualizing model results, and for accessing functional simulation models. A general classification of 3D city models, based on their operational purposes, might be organized around four main types of 3D CAD (computer aided design) models of cities. These types are: (1) static 3D GIS (geographic information systems) models of cities, (2) Navigable 3D GIS models of cities, (3) 3D urban simulation models, and (4) 3D models to be generated for any proposed project, even before the project is started. This helps the planners or engineers to get an idea of how the project would look like after it has been completed. If anything has to be changed, they can visualize that and it can be implemented in the final project. Accurate 3D city models are used to perform GIS analysis like line-of-sight (LOS) views and view sheds, flood modeling, solar panel optimization and volumetric calculation etc.. Furthermore, they can be linked to further building information coming from 2D maps. For example, first responses within emergency management centres (e.g. fire, police, rescue teams) can evaluate the location of incidents faster and more accurate, which results in a detailed situation awareness to safe and rescue more lives.

Virtual 3D city models and real-time visualization allow the user to freely navigate through an urban environment and to calculate secure paths using line-of-sight analysis or to use augmented reality by draping live video streams of surveillance cameras onto the virtual 3D model, they reduce the level of abstraction and move closer to reality. In general, 3D models provide intutive representaion for the environment that can be easily understood by human.

Textured 3D city models and highly detailed 3D landmarks increase the visual recognition of the urban surrounding within a car navigation system. Web-based visualization of large 3D terrain and city model datasets combined with tourism-relevant data (e.g. hotel and restaurant information, shops etc.) help the potential visitors in their decision process and increases the occupancy within the tourist region.

1.2 Research Background

3D GIS are systems being able to represent, manage, analyze and manipulate 3D spatial data. Furthermore, information links with other 3D phenomena can be provided. The 3D GIS data model is the key to develop and establish a 3D GIS, and is a big topic in the five major research fields of 3D GIS: WebGIS, data presentation, spatial analysis, data model and data collection. The selected data model to represent 3D objects of a 3D GIS for a specific application will determine methods to store, access, manage, and handle the display and the data constraints.

1.3 Problem Statement

The key of success of the aforementioned applications is there for the 3D GIS data model. This conceptual study focuses on the presentation of 3D GIS data models helping to change the face of the Testbed Al-Mogran Area, that is located in Khartoum city. Here, we are investigating the change in spatial data management, from an old infrastructure to new models of infrastructure, to demonstrate the efficiency of modern infrastructure data handling.

1.4 Aims and Objectives

The aim of this project is to transform the 2D map of the urban area using various sources in 3D, with associated 3D visualizations. in particular To create a digital database for the study area from various sources, we develop a 3D urban city model.

1.5 Research Methodology

The primary data collection (field survey) provides attributes of buildings (height, number of floors, owner, etc.) The secondary data collection integrates household data, vector map creations, linking of attribute data, and some versions of 2D features to 3D features, with the aim to generatea 3D city model.

1.6 Research Questions

We will try to answer the follwing questions: How can we restructure the Al-Mogran area and then improve its structure and take advantage of its geographic location using 3D GIS technology?

1.7 Research Motivation

Take full advantage of the unique geographical location of the Al-Mogran area, which is the White Nile associated with the Blue Nile, to being the River Nile, which is considered one of the most beautiful rivers in the world, So encourages the competitive environment of investment and tourism of the area and thus transforming it into a urban area full of residential towers, corporate buildings, hotels and parks,..etc.

This research attempts to benefit from the technology of the three-dimensional geographic information systems in the reconstruction and construction of the area of Al-Muqrin.

1.8 Research Scope

The scope of this study is focussing on the City of Khartoum. In near future it will have a vibrant downtown with the Al-Mogran Area, which will serve as Testbed for our research.

AlMogran is also known for its effective communication. It is seen as a town that functions as "one", where elected officials, city staff and their citizens come together to plan the future, solve past problems, and preserve a truly unique community.

The focus in this presentation is on medium scale models (LOD1, LOD2, and LOD3).

1.9 Expected Results :

A three-dimensional map of Al-Muqarn area showing part of the existing buildings of the area, and part of the buildings proposed for future development in the region to benefit from the geographical location.

CHAPTER TWO
Literature Review And Related Work

Chapter 2
Literature Review And Related Work

2.1 Literature Review

2.1.1 Data Representation

GIS data represents real objects (such as roads, land use, elevation, trees, waterways, etc.) with digital data determining the mix. Real objects can be divided into two abstractions: discrete objects (e.g., a house) and continuous fields (such as rainfall amount, or elevations). Traditionally, there are two broad methods used to store data in a GIS for both kinds of abstractions mapping references: **raster images** and **vector**. Points, lines, and polygons are the results of mapped location attribute references. A new hybrid method of storing interactive mapping, and raster data is that of identifying point clouds, which combine three-dimensional points with RGB information at each point, returning a "3D color image".

2.1.2 3D Model

In 3D computer graphics, **3D modeling** (or **three-dimensional modeling**) is the process of developing a mathematical representation of any three-dimensional surface of an object (either inanimate or living) via specialized software. The product is called a **3D model**. It can be displayed as a two-dimensional image through a process called 3D rendering or used in a computer simulation of physical phenomena. The model can also be physically created using 3D printing devices.

Models may be created automatically or manually. The manual modeling process of preparing geometric data for 3D computer graphics is similar to plastic arts such as sculpting.

3D modeling software is a class of 3D computer graphics software used to produce 3D models. Individual programs of this class are called **modeling applications** or **modelers**.

2.1.3 3D City Model

3D city models are digital models of urban areas that represent terrain surfaces, sites, buildings, vegetation, infrastructure and landscape elements as well as related objects (e.g., city furniture) belonging to urban areas. Their components are described and represented by corresponding two-dimensional and three-dimensional spatial data and geo-referenced data. 3D city models support presentation, exploration, analysis, and management tasks in a large number of different application domains. In particular, 3D city models allow "for visually integrating heterogeneous geoinformation within a single framework and, therefore, create and manage complex urban information spaces (see fig. 2.1).

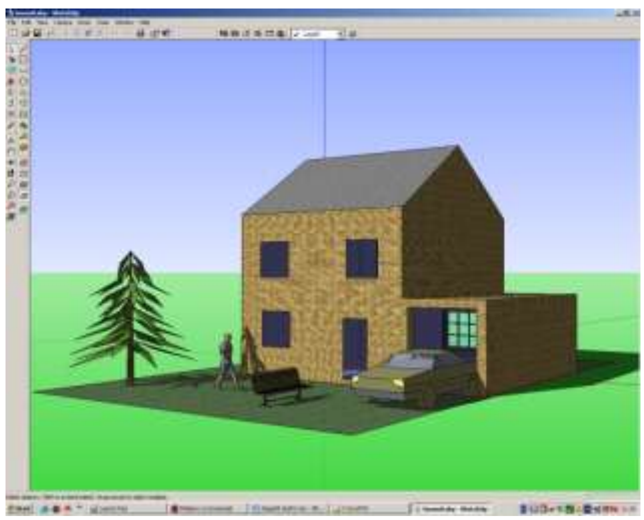

Figure 2.1: Virtual 3D environment

2.1.4 Model Classification

- **Small Scale Models**

  GIS based Terrain Modeling and Analysis

  Models: Contours, TIN, GRID

  Analysis: Slope, line of sight…

  Fly-through

- **Medium Scale Models**
  City level

  City planning, emergency response…

- **Large Scale Models**
  Building or room level

  Simulations, games…

First of all, let us define some Levels of Details, which are used since the beginning of the 1990s for 3D City modeling processes (see Fig. 2.2)

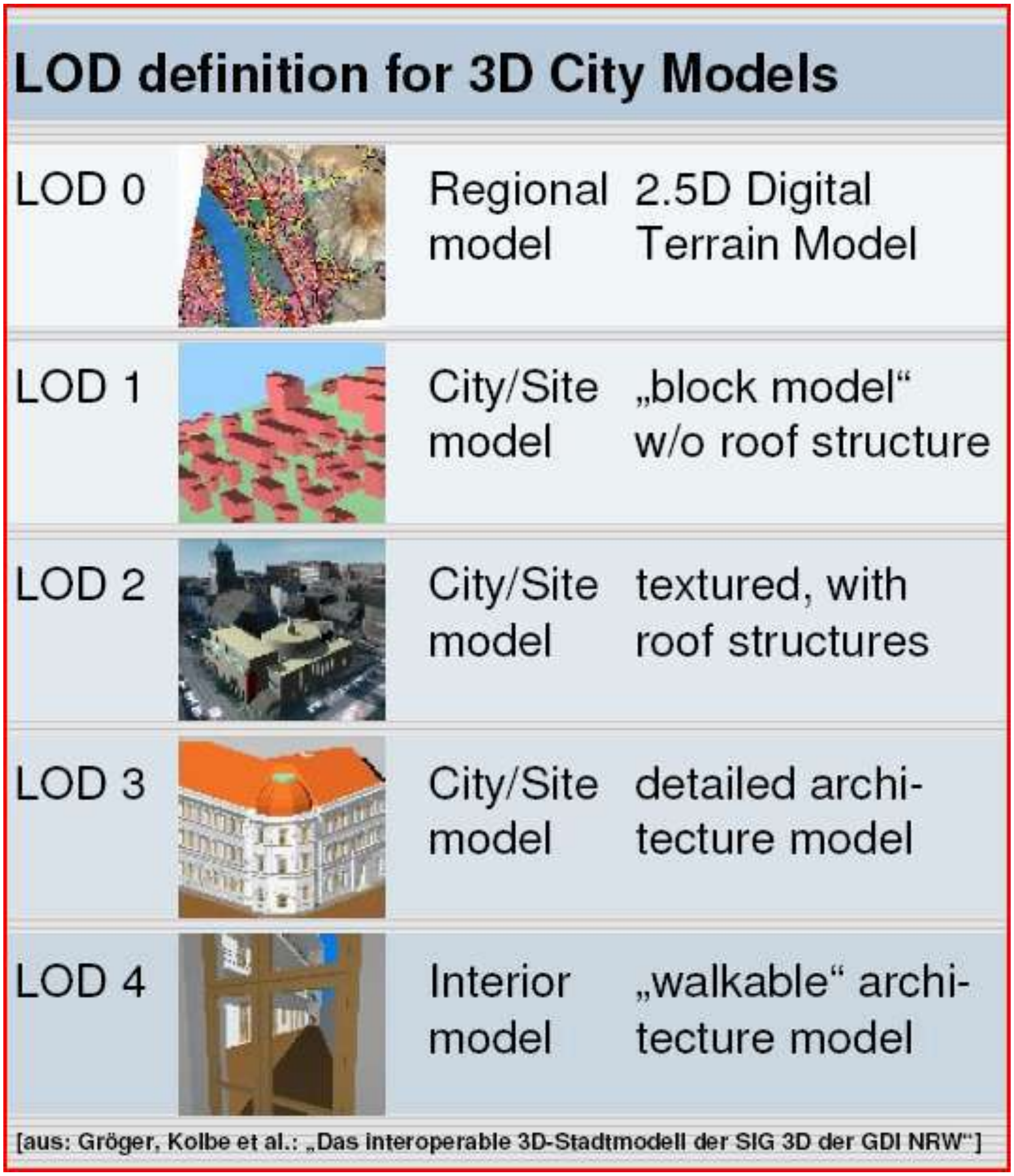

Figure 2.2: Definition of Level-of-Detail (LOD)

Moreover we will show several scaled models just to demonstrate the options for representing 3D city models, indoors and outdoors (see Fig. 2.3-2.5).

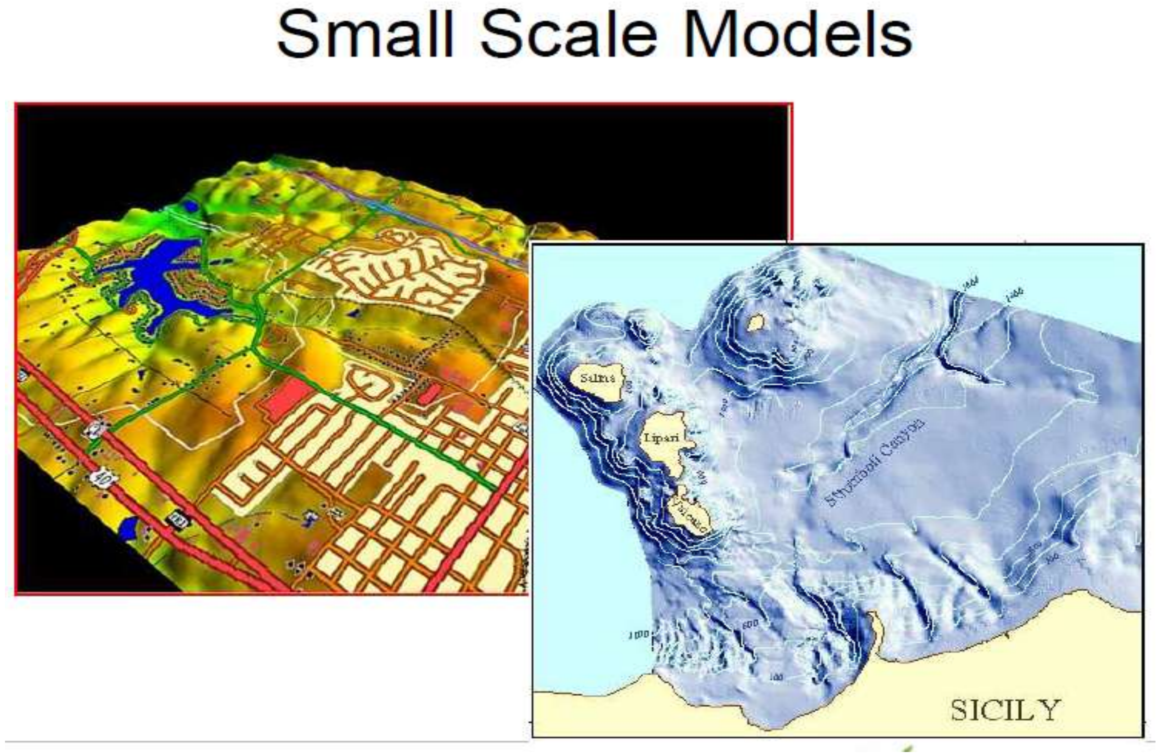

Figure 2.3: Demonstration of a small scale model (2.5D)

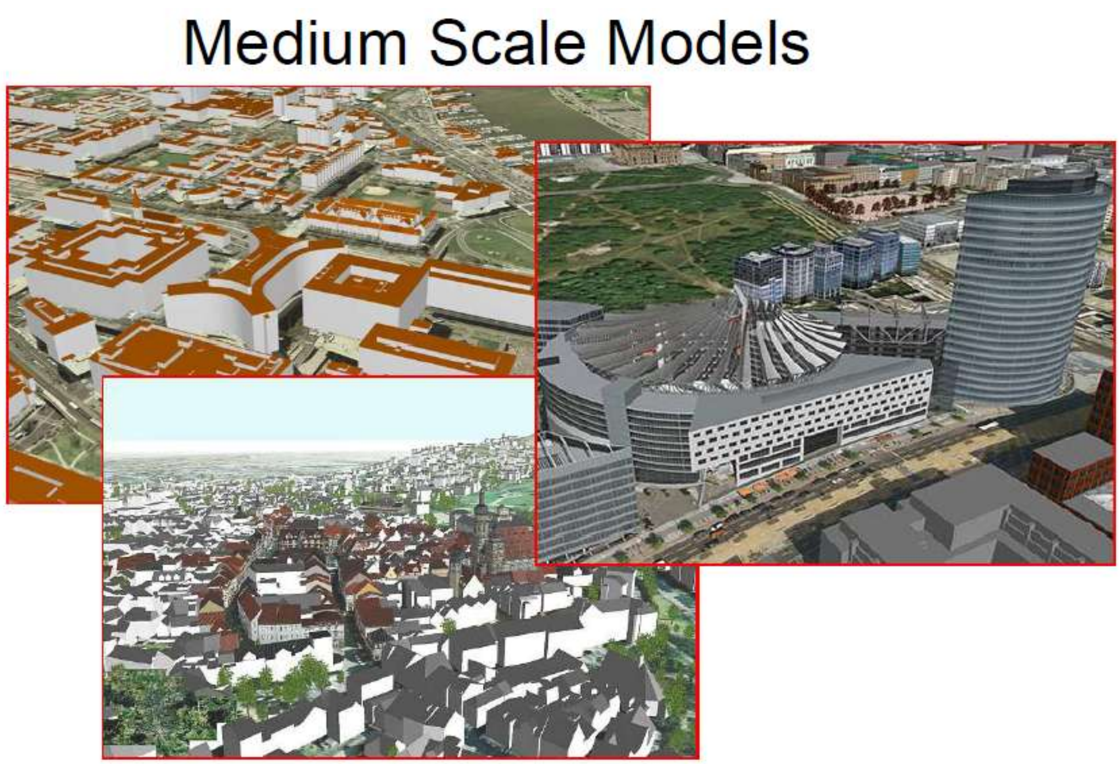

Figure 2.4: Demonstration of a medium scale model (3D)

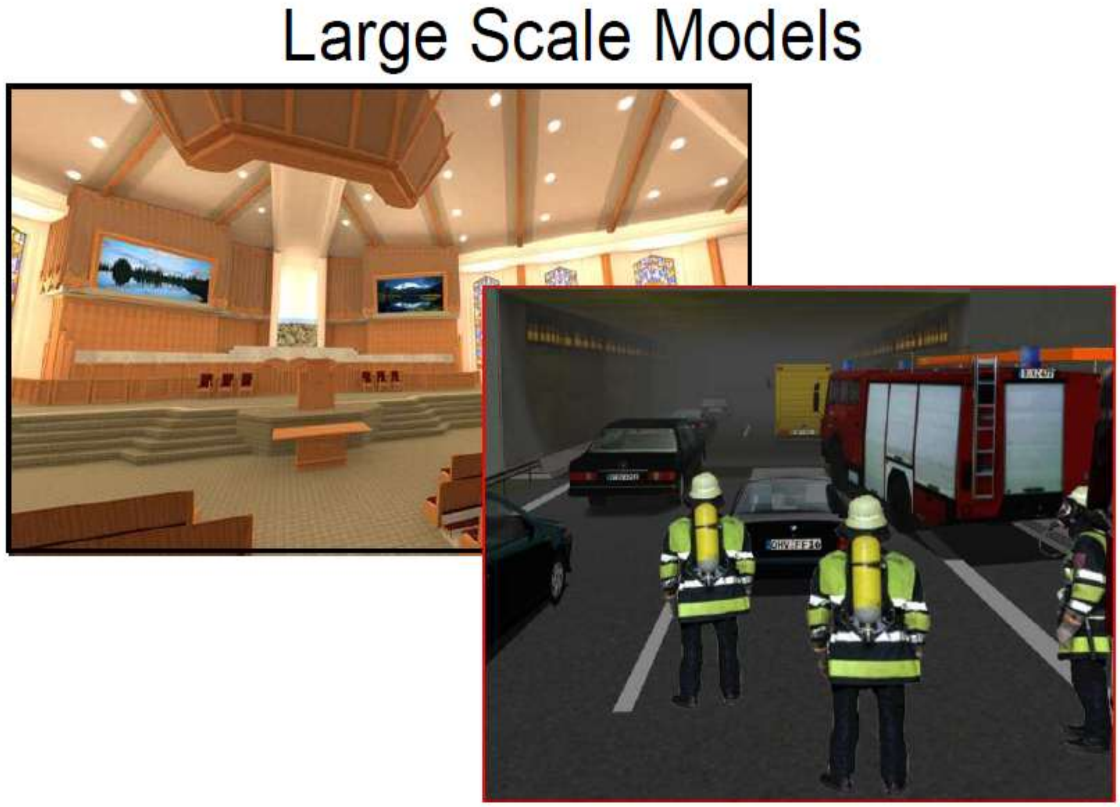

Figure 2.5: Indoors 3D models (LOD4)

2.2 Related Work

The digital 3D reconstruction of buildings, cities and landscapes is under research since more than twodecades. Many disciplines are interested in rendered and augmented 3D models of reality, to start fromarchaeology, and architecture and to stop with photogrammetry and serious gaming. With the invention ofairborne laser scanning (early 1990s), first attempts were made to reconstruct roof landscapes automaticallyfrom the point clouds, using the food prints of the buildings (Brenner&Haala, 1998). This was a milestone inthe fast and accurate production of virtual city models. These methods have been further developed, tointegrate 3D generalization into the modeling process, to differentiate between important and non-importantdetails and structures (Kada, 2009). Many of these developments are implemented in geo-processing softwareproviding 3D city models of Level-of-Detail 2 (LOD2), which is the textured 3D silhouette of buildings with anaccurate roof structure.

With the invention of terrestrial laser scanning towards the end of the 1980s it took at least ten years to bringthis technology into daily operations. Today, laser scanners are provided, which combine time-of-flight andcontinuous wave sampling to deliver up to 1 Million points per second. Furthermore, RGB cameras areembedded to collect high quality imagery for texturing the laserscan point cloud. The data collection (laserscans and photo shootings) is highly automated – so is also the registration process. As a well-known fact,laser scanning might have some problems to get the right signal back, from mirroring or black surfaces,windows and at corners.

Thus, a complemented data collection using additional still photographs mayovercome these defects (Moussa et al, 2012, Moussa, 2014). With a set of additional photos dense imagematching is used to provide a high density point cloud, which is generated independently of the laser scanpoint cloud. Thus a merger of two point clouds is the solution to overcome weaknesses in both technologies– laser scanning and classical photogrammetry. In order to come to virtual reality 3D models of buildingsand man-made objects the point clouds are processed by well-suited software packages, often delivered byvendors of laser scanning technologies. With the availability of virtual globes, such as Google Earth,Microsoft Bing Maps 3D, etc. those models can easily be integrated and revisited using these visualizationinterfaces.On the other hand, proposals were made for modeling and rendering architectural scenes from sparse sets of photographs (Debevec, 1996). This approach has led to rendered building models of superb quality – thesame technologies are used today for 3D reconstructions of the present and the past, to be seen inarchitectural planning, museums, movies, and other media.It is therefore interesting to look at the workflows and processing pipelines of both strategies, the in-situdata collection with follow-up processing and 3D reconstruction and the graphical methods leading to model and render architectural 3D models. This study is necessary to bridge the gap between thegeo-data community and the computer vision and computer graphics community.

2.2.1 Urban MappingFrom Pretty Pictures to 3D GIS, An Esri White Paper, December 2014, Case Study of Hawaiian Islands:

The State of Hawaii, Office of Information Management and Technology, is now offering3D GIS building models covering more than 25 square kilometers and consisting of19,500 measured buildings of Honolulu as part of its Open Data Program. These highlyaccuratebuilding models were created from stereo aerial imagery by CyberCity 3D as part of the Hawaii Office of Planning's efforts to gather,analyze, and provide information to the governor to assist in the overall analysis andformulation of state policies and strategies. To help the state plan for its futuresustainability, the 3D building models have been used to show the potential for solarrenewable energy for buildings, with solar exposure values calculated on actual roofareas and orientation of the roofs to the north.

2.2.2 Case Study of Portland City:

The City of Portland, Oregon, has developed 3D building models for its urban map. Inaddition to typical visualization possibilities, city planners can now perform analysis andobtain a variety of useful information. For example, by displaying existing zoning lawswith the 3D buildings, it is easy to see which buildings are in compliance.In addition, by changing an area's possible zoning, a map can quickly be created showingdevelopment potential by building, providing information that can be utilized to updateexisting zoning laws. A third application enables planners to accurately calculate the shadowing impacts of aproposed new building, which might negatively impact neighboring buildings as well as anearby park (see fig. 2.6).

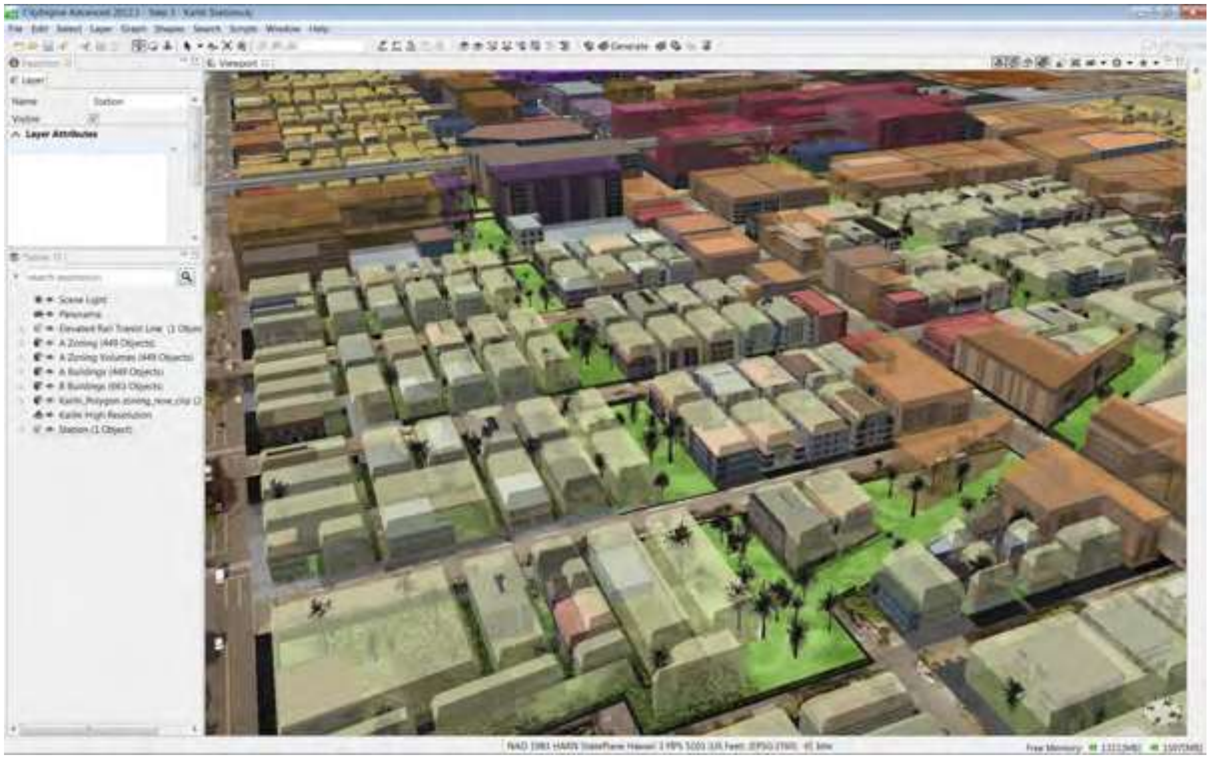

Figure 2.6: 3D modeling allows planners to visualize the impact of newurban development in a realistic manner.

Chapter 3

New Ideas and Methodology

Chapter (3)

New Ideas and Methodologies

3.1 Overview

As a follow-up of the previous chapters we found out, that it is possible to do 3D city reconstructions. Main products required for this task are a Digital Surface Model (DSM) and a Digital Terrain Model (DTM).Some methods use 2D building floor plans in the shape file format, as additional input data. Based on this data, building reconstructions may recognize approx. 80% of the building forms correctly, and moreover, topologically valid 3D models, based on the floor plans.

3.2 Proposed Ideas

3.2.1 Workflow to Create a Simple 3D City Model

For users who have access to GIS data such as 2D building footprints as well as airborne LiDAR data of reasonable resolution (>1 point per square meter), the following workflow will create simple 3D building models enabling numerous applications to be performed afterwards (see fig. 3.1).**Preparing the Data:** First, set-up a map document with a file database containing the 2Dbuilding footprints. For the purpose of terrain modeling and the extraction of 3D building models, three basic raster surfaces are required:

1. **Digital Terrain Model (DTM):** A raster representing the elevation of the bare earth, with structures and vegetation removed. This surface is used as the base elevation in the3D scenes (ArcGlobe, ArcScene, CityEngine). Only the lidar points classified as ground return points are used.
2. **Digital Surface Model (DSM):** A raster representing the elevation of all structures and natural features on the earth—the same kind of surface you would get if you "shrink-wrapped" the landscape. The lidar points classified as first return points are used.
3. **Normalized Digital Surface Model (nDSM):** This surface is used to model the height above the ground surface of structures and vegetation. This is derived by subtracting the DSM from the DTM (DSM – DTM = nDSM).

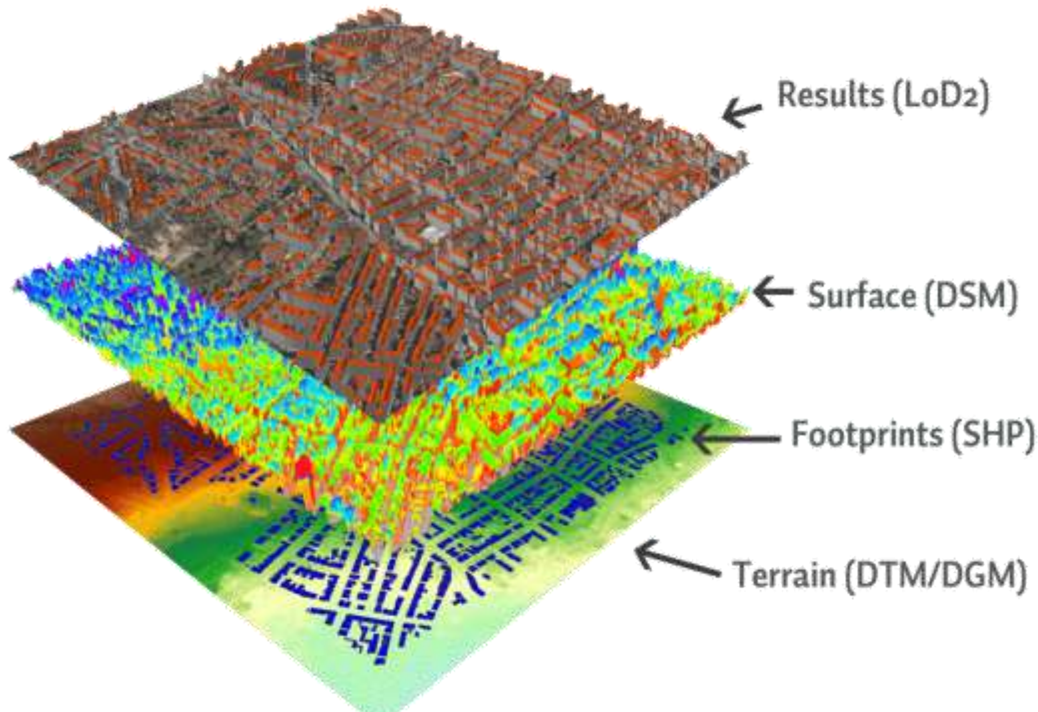

Figure 3.1: Workflow to create LOD2 City Models

The DTM and DSM raster surfaces can be created from the lidar point cloud using ArcGIS (see fig. 3.2). High-resolution imagery can also be added to the map, if available.

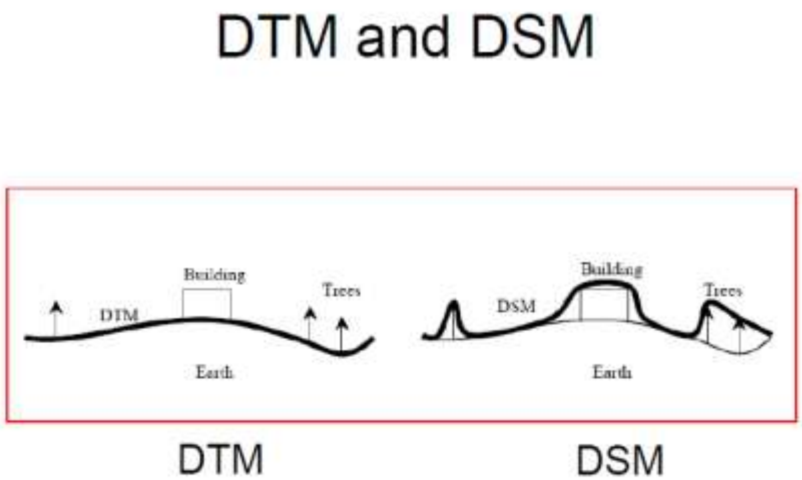

Figure 3.2: Differentiation of DTM and DSM

3.2.2 Determining the Elevation of the Buildings

After successfully creating the raster surfaces as described, the next step is to determine the elevation of the buildings by generating a set of random sample points for each building footprint. Elevation information from the nDSM raster elevation surface can now be added to each sample point and stored in the building feature class (see fig. 3.3).

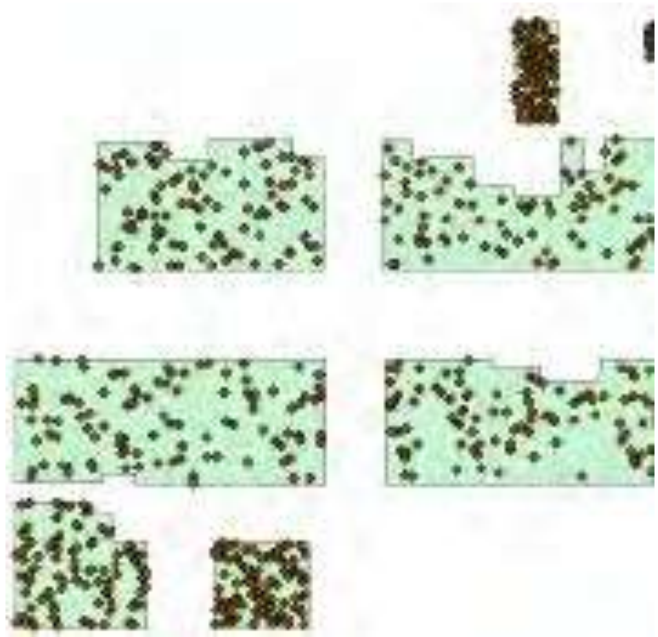

Figure 3.3: Allocating heights to the building footprints

3.2.3 Extruding 3D Building Models

Now that all the random points have an elevation, or z-value, the next step is to get the average or mean elevation for each building, which is done using the ArcGIS Summary Statistics tool. Now that the Building footprint layer has height information, thereafter Esri ArcScene can be used to generate the 3D buildings (fig 3.4).

Figure 3.4: Generation of simple 3D building models with ArcScene

3.3 Applications and Tools

3.3.1 ArcGIS for Desktop

For this thesis, we are using ArcGIS Desktop 10.2, although ArcGIS Desktop 10.4 is the latest version of the popular GIS software produced by Esri. ArcGIS for Desktop allows to analyze any kind of spatial and non-spatial data and to author geographic knowledge to examine relationships, test predictions, and ultimately make better decisions.

ArcGIS Desktop is comprised of a set of integrated applications, which are explained in the following:

- Arc Map is the main mapping application, which allows you to create maps, query attributes, analyze spatial relationships, and layout final projects.
- Arc Catalog organizes spatial data contained on your computer and various other locations and allows to search, preview, and add data to Arc Map as well as manage metadata and set up address locator services (geocoding).
- Arc Toolbox is the third application of ArcGIS Desktop. Although it is not accessible from the start menu, it is easily accessed and used within Arc Map and Arc Catalog. Arc Toolbox contains tools for geoprocessing, data conversion, coordinate systems, projections, and more. This workbook will focus on Arc Map and Arc Catalog.

With ArcGIS extensions, you can do the following:

- Analyze data in a realistic perspective.
- Conduct advanced spatial analysis to get specific answers from the data.
- Use advanced statistical tools to investigate data.
- Perform complex routing, closest facility, and service area analysis.
- Reveal and analyze time-based patterns and trends.
- Represent and understand any network.

3.3.2Google Earth Pro

For this thesis, we are also using Google Earth Pro v.4.2.0205.5730. Google Earth displays satellite images of varying resolution, with accuracies of about (2-5)m of the Earth's surface, allowing users to see things like cities and houses, and looking perpendicularly down or at an oblique angle (see also bird's eye view). The degree of resolution available is based somewhat on the points of interest and popularity, but most land (except for some islands) is covered in at least 15m of resolution (GSD, Ground Sampling Distance). Google Earth allows users to search for addresses for some countries, enter coordinates, or simply use the mouse to browse to a location.

Google Earth is simply based on 3D maps, with the capability to show 3D buildings and structures (such as bridges), which consist of users' submissions using SketchUp, a 3D modeling program software. In prior versions of Google Earth (before Version 4), 3D buildings were limited to a few cities, and had poorer rendering with no textures. Many buildings and structures from around the world now have detailed 3D structures. They have been produced by photogrammetric Dense Image Matching (DIM) algorithms.

Google Earth may be used to perform some day-to-day tasks and for other purposes. Some of them are mentioned in the following:

- Google Earth can be used to view areas subjected to widespread disasters.
- One can explore and place location bookmarks on extraterrestrial bodies, such as Moon and Mars.
- One can get directions using Google Earth, using variables such as street names, cities, and establishments.
- Google Earth can function as a hub of knowledge, pertaining the users location. By enabling certain options, one can see the location of gas stations, restaurants, museums, and other public establishments in their area.
- One can create custom image overlays for planning trips, hikes on handheld GPS units.

- Google Earth can be used to map homes and select a random sample for research in developing countries and more.

3.3.3 Adobe Photoshop

Adobe Photoshop is a raster graphics editor developed and published by Adobe Systems for macOS and Windows.

Photoshop was created in 1988 by Thomas and John Knoll. Since then, it has become the de facto industry standard in raster graphics editing, such that the word "photoshop" has become a verb as in "to Photoshop an image," "photoshopping" and "photoshop contest", though Adobe discourages such use. It can edit and compose raster images in multiple layers and supports masks, alpha compositing and several color models including RGB, CMYK, Lab color space, spot color and duotone. Photoshop has vast support for graphic file formats, but also uses its own PSD and PSB file formats, which support all the aforementioned features. In addition to raster graphics, it has limited abilities to edit or render text, vector graphics (especially through clipping path), 3D graphics and video. Photoshop's feature set can be expanded by Photoshop plug-ins, programs developed and distributed independently of Photoshop, that can run inside it and offer new or enhanced features.

Chapter 4

The Testbed Al-Mogran Area

Chapter 4

The Testbed Al-Mogran

4.1 Study Area

Our study area is located in the middle of Khartoum, the capital of Sudan, and was named Al-Mogran, because its joining place of the Blue and White Niles to become the Nile River. There is no doubt, it is one of the most beautiful areas of in the world – it is one of the rare tourist areas and most wonderful. However, it is not yet fully developed, and therefore some research, commercial and tourist projects did not succeed. To mention here is the huge **Al-Mogran Commercial development project,** under taken by **Al-Sunut Company,** at a cost of over $4 billionin 2004 and planned for completion by 2014. This project covers an area of

11,000,000 square meters, (1,000,000 m2) of office space, 1,100 villas, housing for 45,000 residents and visitors, and jobs for 60,000 Sudanese, but the project has not succeeded so far.

Thus we can say, that Al-Mogran is one of the best choices for the treatment of Migraines of decision makers and politicians. Fig. 4.1-4.3 show the location of the test bed area.

Figure 4.1: Showing the Al-Mogran Area in a whole of Sudan

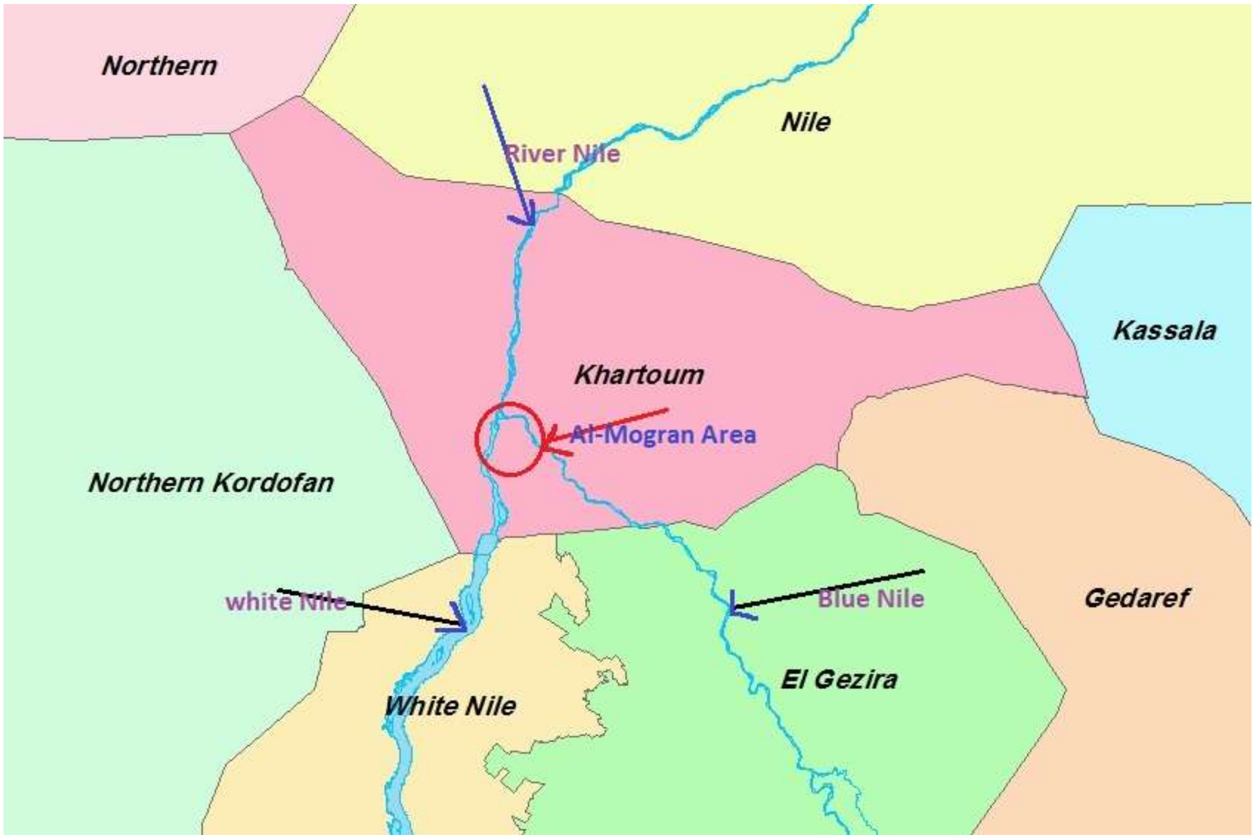

Figure 4.2: Color Map ofthe Al-Mogran Area in the Khartoum State

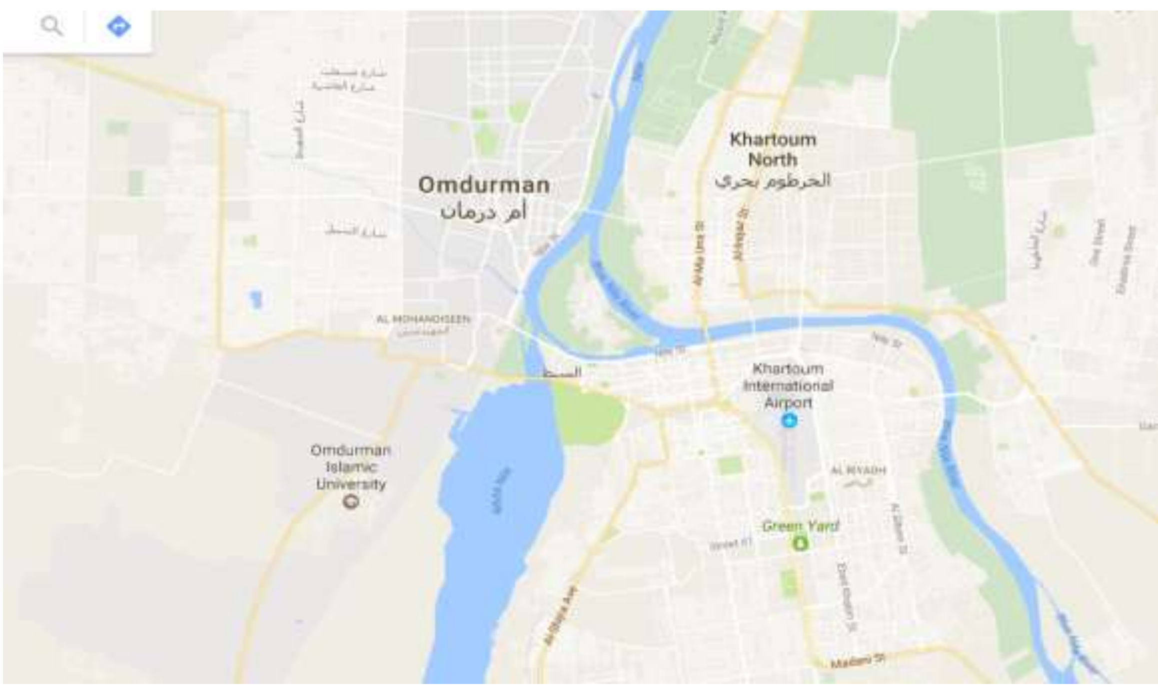

Figure 4.3: Google Earth Map Showing the Al-Mogran Area

4.2 Data Collection

A satellite perspective image map is used from theMicrosoft Bing Maps (see fig. 4.4)

Figure 4.4: Satellite image covering the Al-Mogran Area

Chapter 5

Results and Simulations

Chapter 5

Results and Simulations

5.1 Creating the Street Layer:

First, we downloaded a Raster Image after the identification of the testbed Al-Mogran Area in the **OpenStreetMap** Site. Afterwards we defined this as a Street Layer (see fig. 5.1).

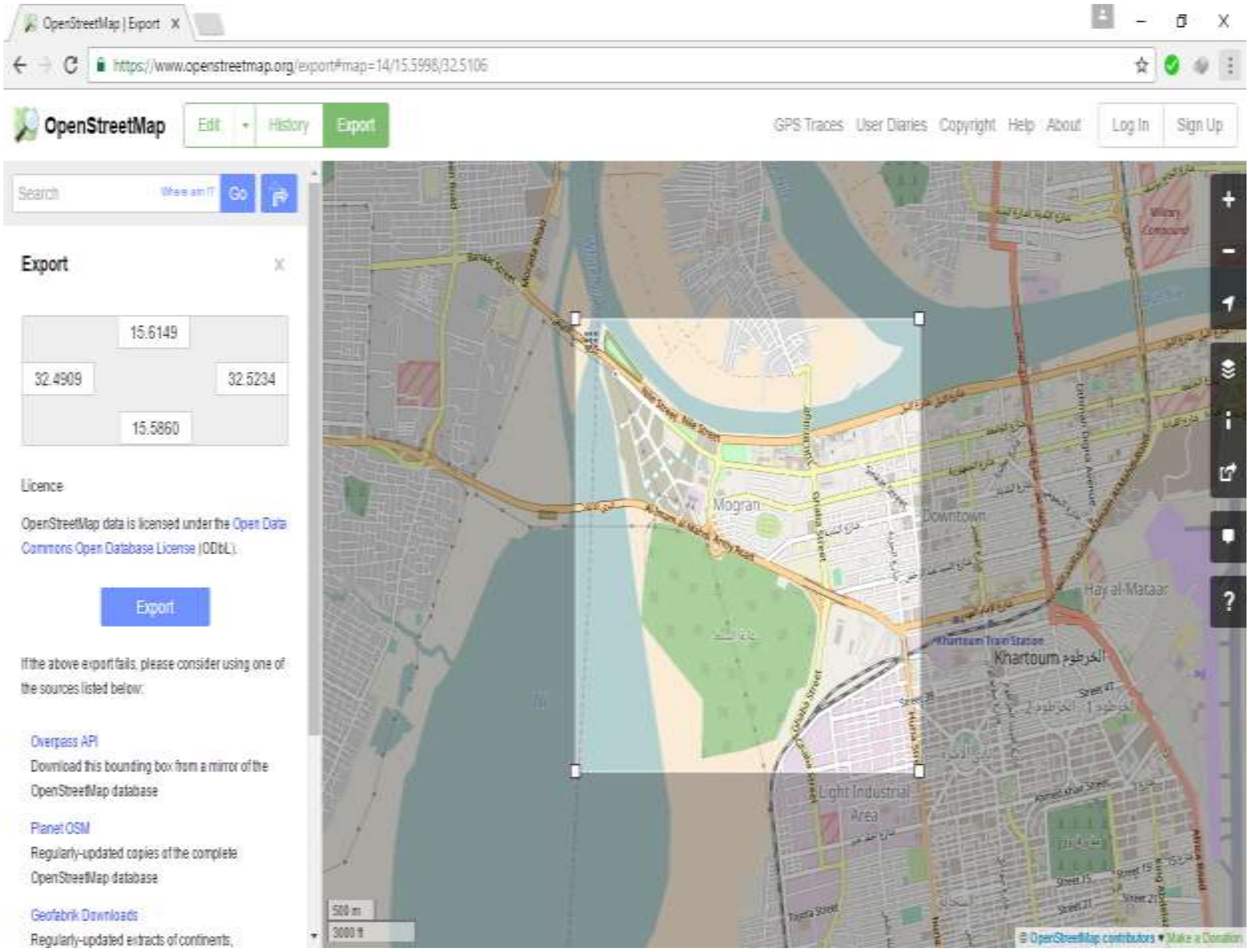

Figure 5.1: The Street Map of Al-Mogran Area at OSM

5.2 Creating the Reference Surface Layer

As described previously, we need a reference surface for the right location of buildings in z direction. Therefore we downloaded a DEM map for the Testbed Al-Mogran Area from the ASTER website. This DEM is added as the Reference Layer (see fig. 5.2).

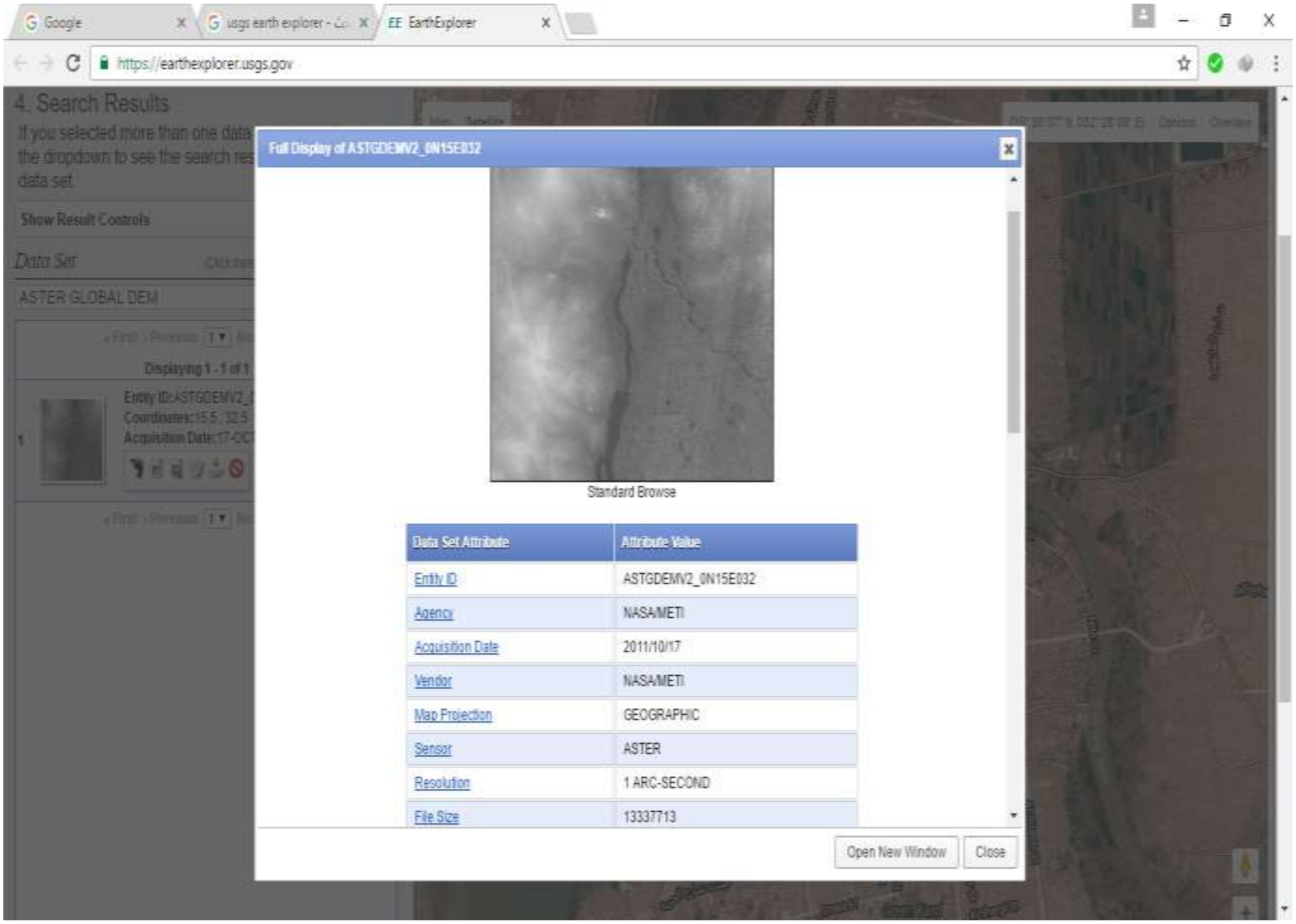

Figure 5.2: The DEM reference layer as it appears at the ASTER website

5.3 Processing the Reference Surface Layer

Using the raster DEM as a reference surface we can do further processing and refinements. At first we create a Contour Layer (see fig. 5.3), and then we derive a 3D TIN scene. For this processing the EsriArcScenesoftware package is used.

- ArcScene is an application, that allows for displaying and navigating data in 3d.
- A new untitled scene opens and we can add our 2D layers onto it

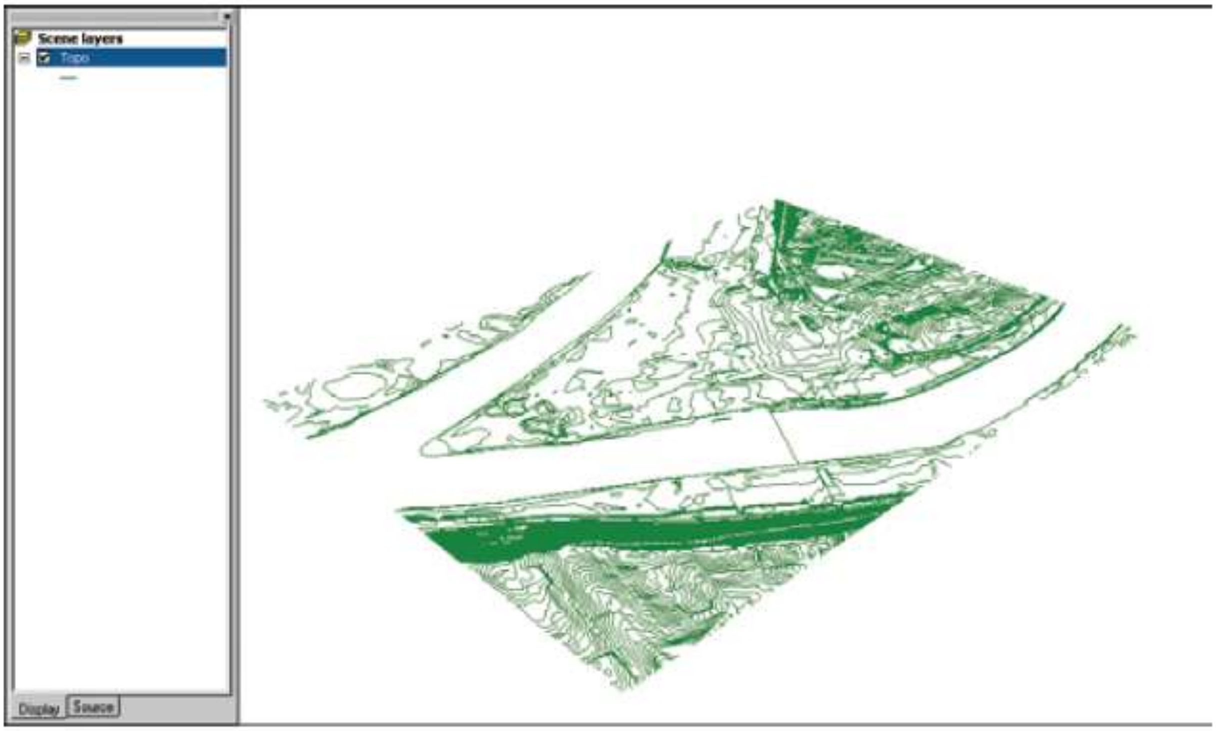

Figure5.3: Shows the topography layer of contours as a 3D view

Furthermore we create a TIN from the contours, as the 2.5D topography known as TIN uses elevations data of the 2.5D topographic lines as input.

A TIN is a vector data model of contiguous non-overlapping triangles, whose vertices are created from sample points carrying x,y and z values. It can be displayed as a surface model.

The Esri3D Analyst creates a triangulated irregular network (TIN) from the topography contour lines and add it as a new layer (see fig. 5.4).

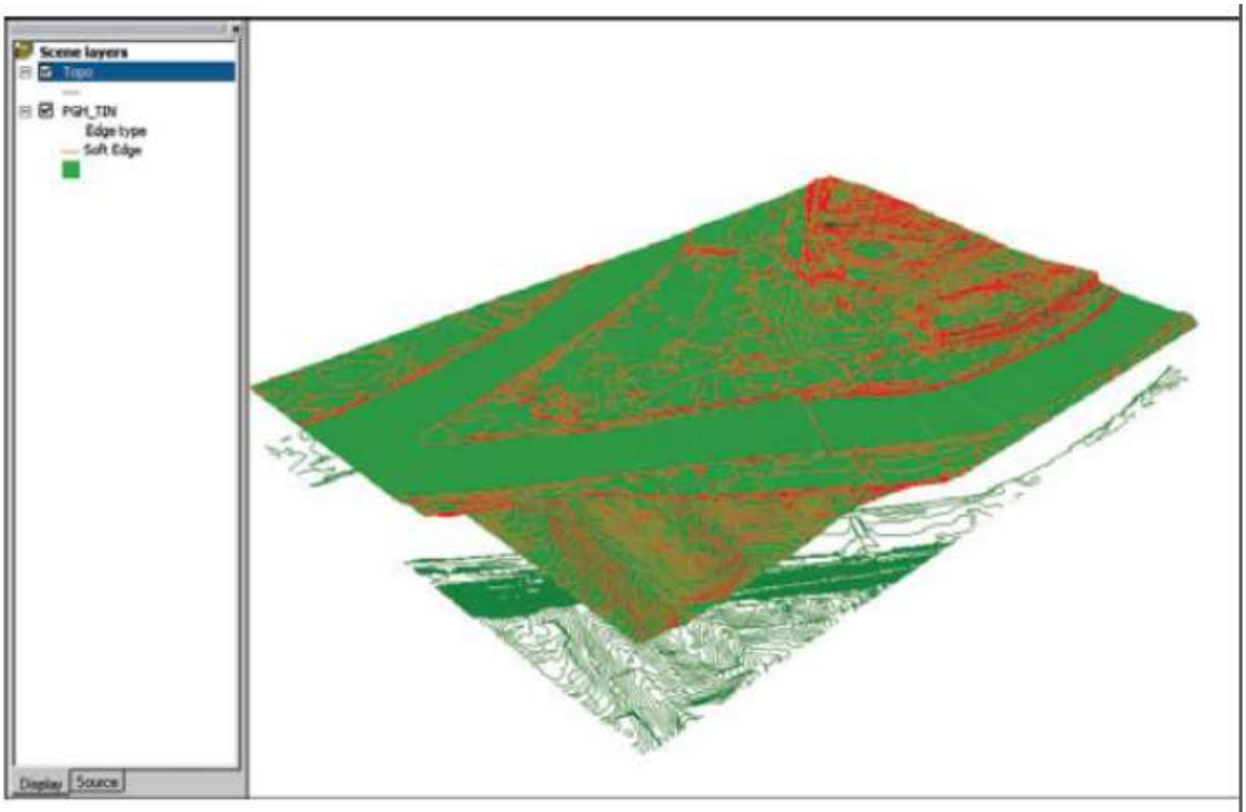

Figure 5.4: Showing the TIN layer derived from the Contour layer

5.4 Creating Building Block Features:

After having defined the reference surface layer we start with the digitization process to obtain the Features layer from the raster image. For this process we are using the Esri ArcInfo basic package. The results are given in fig. 5.5. For this digitization the following parameter settings have been used:

- Number of control points.
- Type of 2D transformation.

Figure 5.5: Showing theAl-Mogran Features (a) without River Nile, (b) with River Nile

5.5 Create a Detailed Features Layer

For the detailed Features Layer we continue the digitization process, using the Raster image as a background. The continue digitization has used the same parameters as given in section 5.4.

5.6 Draping the Features Layer onto the TIN Layer (DEM Layer)

In order to facilitate the mapping process with the existing layers we drape the detailed features layer onto the TIN layer (see fig. 5.6). This demonstrates already the skeleton for integrating the 3D buildings afterwards.

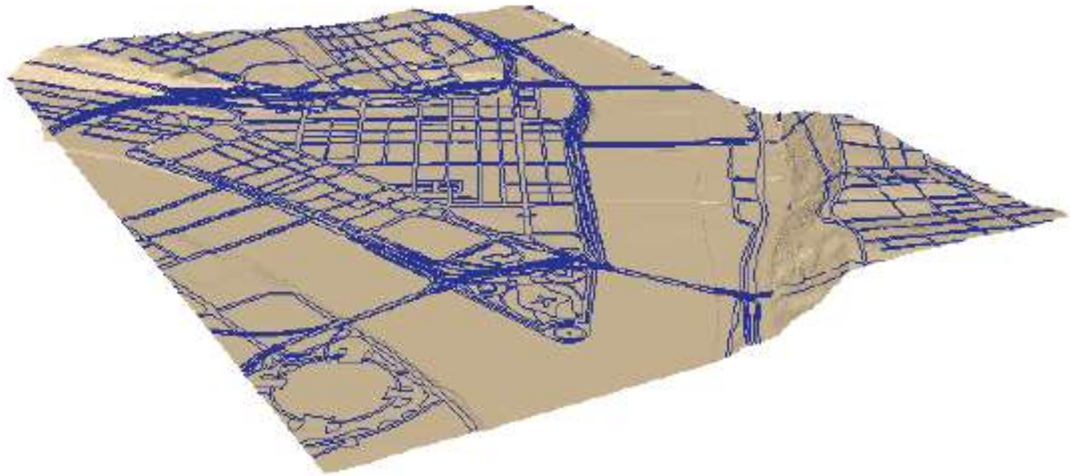

Figure 5.6: Shows the features layer draped onto a TIN Layer

5.7 Create 3D buildings

As described previously we can extrude the building footprints using the height info for every building. The resulting view are buildings with various heights, all positioned onto the topography TIN reference surface (see fig. 5.7).Here we used the Esri ArcScene software package.

Figure 5.7: Shows buildings with Real heights

Figure 5.8: Shows buildings with Real heights

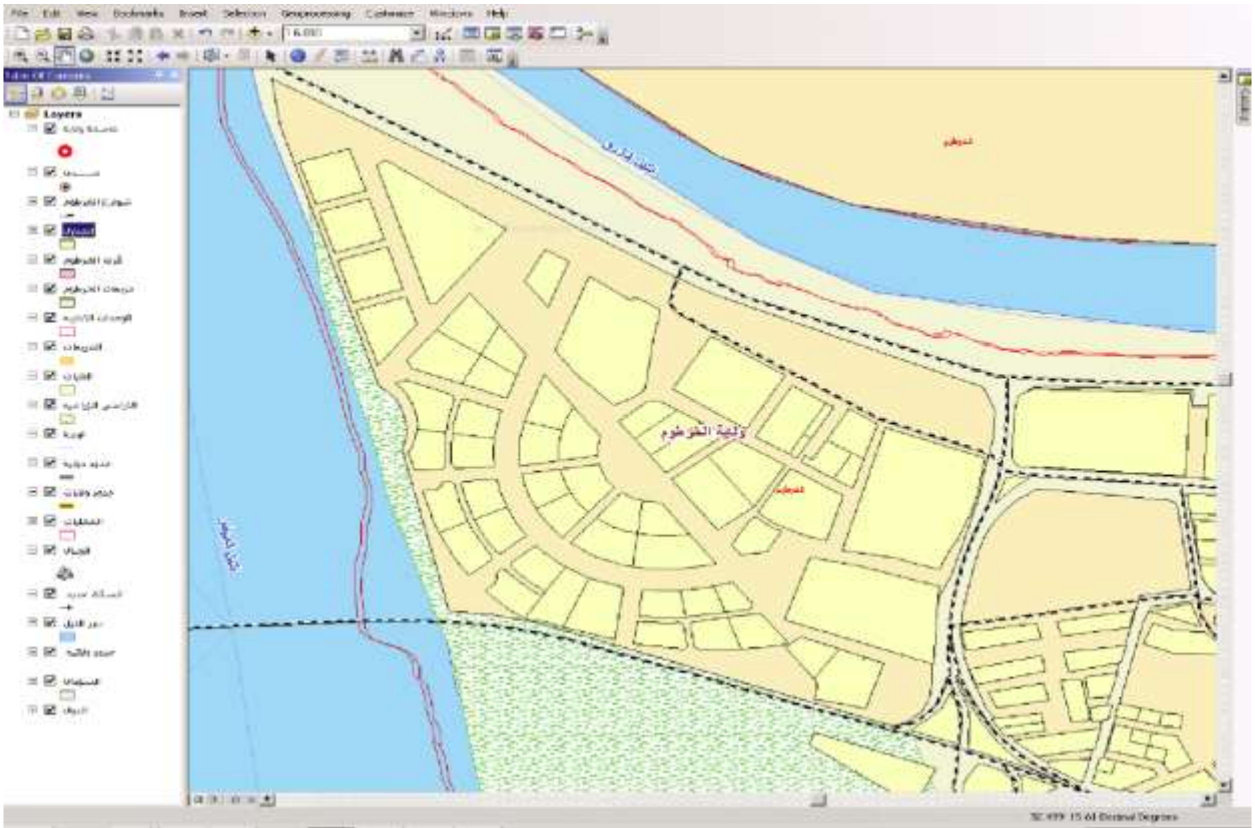

Figure 5.9: Shows 2d map without heights

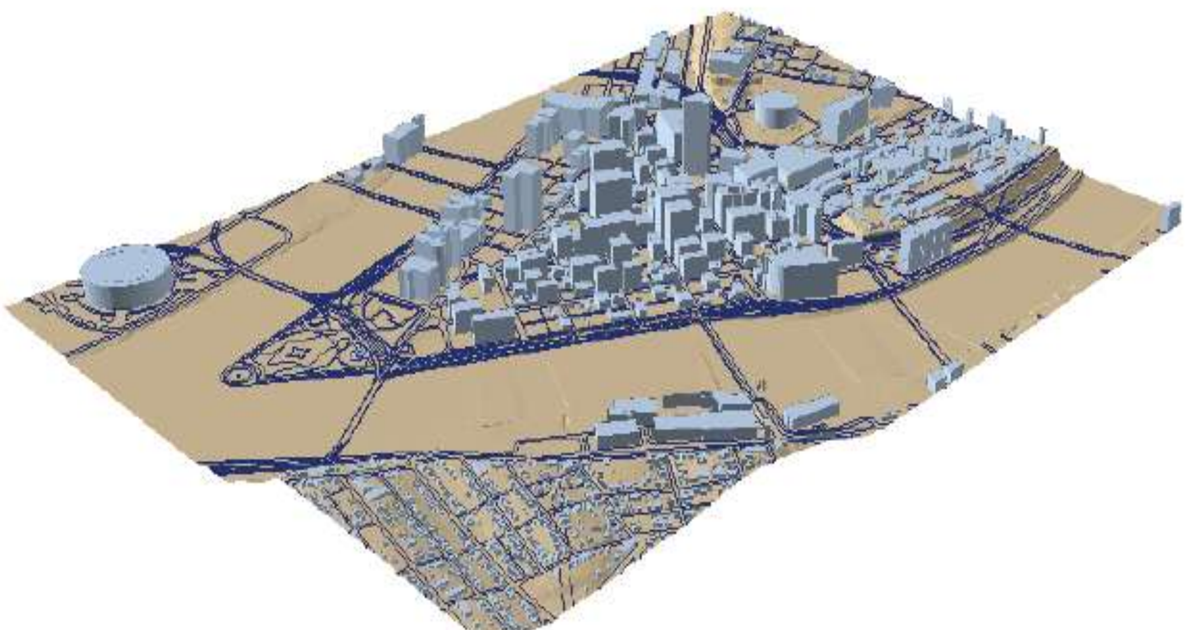

Figure 5.10: Shows buildings with various heights

Chapter 6

Conclusions and Recommendations

Chapter 6

Conclusions and Recommendations

6.1 Conclusions :

In chapter one, we introduced a brief description of our research background, motivation, methodology and objectives.
In chapter two we gave an overview of selected literature dealing with our problem. We learned about the scientific background of the methodology which was specified in the first chapter. Some studies have been discussed in this chapter.

Chapter three presented details of the methodology, which was introduced in chapter one. Here we described how the experiments to be performed will deliver the results we were looking for.

In chapter 4 and 5 we described the results obtained after the analyses of terrain parameters. Also, we gave a brief discussion about how our research and GIS can support actual issues providing better of reconstructing of cities by using 3d gis .

Now we can say , after the analysis and the results that there the technology of the three-dimensional geographic information systems have an active role in changing and reconstructing cities for the better by adding the third dimension of the 2d map which is the height which helps to clear the buildings in a good way to contribute to the planning of each area in the best way.

The journey of going from a 2D to 3D urban map will take time. There are numerous real-world challenges to overcome However, with realistic requirements and proper planning, predictable results can be obtained and the significant investment in the existing GIS leveraged and maintained.

We can say that the three-dimensional GIS technology will change the face of the world in general and smart cities in particular because of its great and major benefits.

6.2 Recommendations :

We Recommended that to complete the large scale of details to this Study, that it consider the Interior Model of design.

Chapter 7

References

Chapter 7

References

7.1 Articles and Conference Papers:

1. Fritsch, D., and Klein, M. 2017.3D Preservation of Buildings – Reconstructing the Past. Multimedia Tools and Applications (MTAP), Vol. Vol. 76, Issue 13. Springer, New York.

2. Brenner, C., Haala, N., 1998. Fast Production of Virtual Reality City Models. Int. Archives Photogrammetry, Remote Sensing, Vol. 32/4, pp 77-84.

3. Debevec, P., 1996. Modeling and Rendering Architecture From Photographs. PhD Thesis, Univ. Berkely.

4. Fritsch, D., 1999. Virtual Cities and Landscape Models – What has Photogrammetry to offer? In: PhotogrammetricWeek ’99, Eds. D. Fritsch/R. Spiller, Wichmann, Heidelberg, pp. 3-14.

5. Fritsch, D., Becker, S., Rothermel, M., 2013. Modeling Facade Structures Using Point Clouds From Dense Image Matching. Proceed. Intl. Conf. Advances in Civil, Structural and Mechanical Engineering. Inst. Research Eng. &Doctors, Hong Kong, pp. 57-64.

6. Esri, 2014. 3D Urban Mapping: From Pretty Pictures to 3D GIS AnEsri White Paper, Redlands, CA.

7.2 Books:

1. Establishing and implementing a national 3D Standard in The Netherlands , Stoter, J. et al, van den Brink et al., PFG 2013 / 4, 0381–0392).

2. CityGML – Interoperable Access to 3D City Models. Thomas H. Kolbe, Gerhard Gröger, Lutz Plümer, Springer, Berlin, Heidelberg

7.3 WebSites:

1. http://help.arcgis.com/en/webapps/flexviewer/help/index.html#//01m300000018000000
2. https://en.wikipedia.org/wiki/Autodesk_3ds_Max
3. ArcMap - Wikipedia, the free encyclopedia.