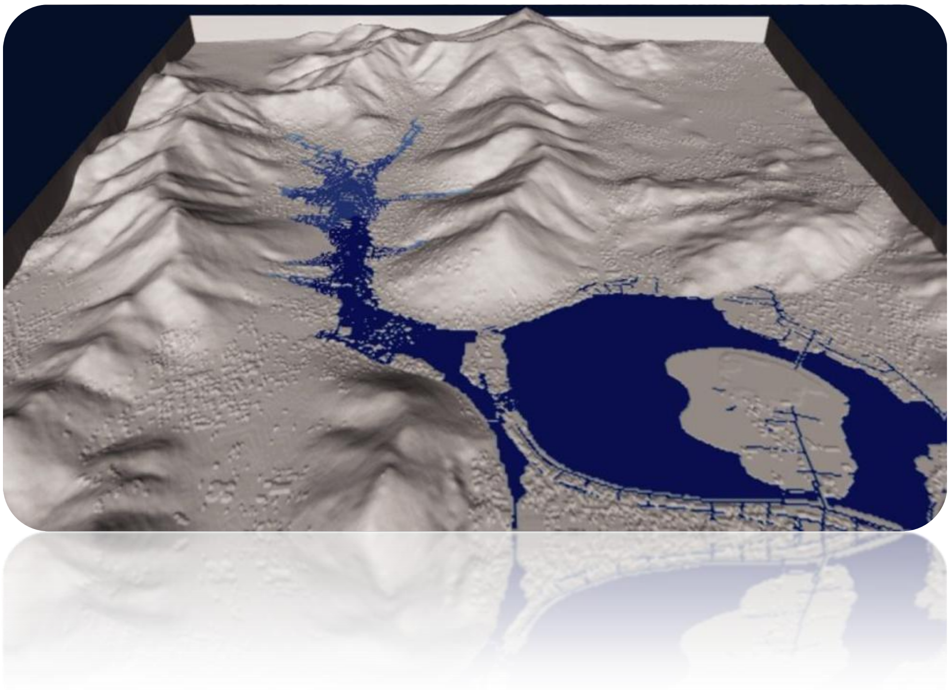
2011

King Fahd University of Petroleum & Minerals
College of Environmental Design
Geographical Information system

Assessing Environmental floods Hazards in Mina
Term paper study



Course Instructor:
Dr. Baqer Al-Ramadan
Date: 01/2011

Prepared by:
Ali Al-Zahrani

Table of Contents

Abstract

This term paper will focuses on studying of flood hazards and their effects on the fragile built environment of Mina(Makkah, Saudi Arabia) using GIS which was constructed to understand and analyze the locations, types, and sizes of the possible natural risks in Mina. The GIS can be used analyze slopes and investigate water drafting paths and the locations of possible falling rocks ,This tool can be utilized to estimate and calculate the slopes and flood stream networks of both natural and built areas. It could help as a decision support system for future urban development projects.

Introduction

One of the most things that is extremely dangerous to environment and people in the earth is natural hazards, it is a threat of a naturally occurring event that will have a negative effect on people or the environment (e.g., flood, tornado, hurricane, volcanic eruption, earthquake, or landslide). Many natural hazards are interrelated, e.g. floods from rain, the cost accrued by natural disasters worldwide has been US$ 24 billion, with over 60 million civilians affected by these disasters. The intensity of natural hazards, such as floods, is exacerbated by unsustainable environment and resource use practices, including deforestation, inappropriate land use, and poor management of natural resources.

A flood is an overflow of an expanse of water that submerges land (1).Flooding may result from the volume of water within a body of water, such as a river or lake, which overflows or breaks levees, with the result that some of the water escapes its usual boundaries(2). it is not a significant flood unless such escapes of water endanger land areas used by man like a village, city or other inhabited area.

Floods often cause damage to homes and businesses if they are placed in natural flood plains of rivers. While flood damage can be virtually eliminated by moving away from rivers and other bodies of water, since time out of mind, people have lived and worked by the water to seek sustenance and capitalize on the gains of cheap and easy travel and commerce by being near water. That humans continue to inhabit areas threatened by flood damage is evidence that the perceived value of living near the water exceeds the cost of repeated periodic flooding. one type of the dangerous flood is Flash Floods, A flash flood is a quick flood caused by a sudden cloudburst or thunder storm. Huge amounts of water fall in a short time and in cities and towns the drains overflow and roads become flooded. Flash floods also happen in mountainous areas, where steep slopes cause the water to travel at high speeds. The rushing water erodes the soil, washing it away down the slopes. Flash floods often occur rapidly and with little warning.

The floods some time associated with A landslide or landslip includes a wide range of ground movement, such as rock falls, deep failure of slopes and shallow debris flows, which can occur in offshore, coastal and onshore environments .

The effects and damage including structure, bridges, cars, buildings, sewerage systems, roadways, and canals. Also People and livestock die due to drowning. It can also lead to epidemics and waterborne diseases and Contamination of water.

GIS offers a superior method for floods and landslide analysis because it allows one to capture, store, manipulate, analyze, and display large amounts of data quickly and effectively. Because so many variables are involved, it is important to be able to overlay the many layers of data to develop a full and accurate portrayal of what is taking place on the Earth's surface. Researchers need to know which variables are the most important factors that trigger landslides in any given location. Using GIS, extremely detailed maps can be generated to show past events and likely future events which have the potential to save lives, property, and money.

GIS; definition and historical developments

Geographic information systems (GIS) or **geospatial information systems** is a set of tools that captures, stores, analyzes, manages, and presents data that are linked to location(s). In the simplest terms, GIS is the merging of cartography, statistical analysis, and database technology(3)

in a general sense, the term describes any information system that integrates, stores, edits, analyzes, shares, and displays geographic information for informing decision making.

GIS applications are tools that allow users to create interactive queries (user-created searches), analyze spatial information, edit data, maps, and present the results of all these operations (3) .Geographic information science is the science underlying the geographic concepts, applications and systems(4)

GIS technology can be used for: earth surface based scientific investigations; resource management, reference, and projections of a geospatial nature—both manmade and natural.

GIS may allow emergency planners to easily calculate emergency response times and the movement of response resources (for logistics) in the case of a natural disaster; GIS might be used to find wetlands that need protection strategies regarding pollution.

GIS was originally developed for use in environmental sciences, military and for computer assisted cartography. The tools developed for these uses are ill suited for the features of historical data.

The year 1962 saw the development of the world's first true operational GIS in Ottawa, Ontario, Canada by the federal Department of Forestry and Rural Development. Developed by Dr. Roger Tomlinson, it was called the "Canada Geographic Information System" (CGIS) and was used to store, analyze, and manipulate data collected for the Canada Land Inventory (CLI) – an effort to determine the land capability for rural Canada by mapping information about soils, agriculture, recreation, wildlife, waterfowl, forestry, and land use at a scale of 1:50,000. A rating classification factor was also added to permit analysis.

CGIS was the world's first such system and an improvement over "mapping" applications as it provided capabilities for overlay, measurement, and digitizing/scanning.

In 1964, Howard T Fisher formed the Laboratory for Computer Graphics and Spatial Analysis at the Harvard Graduate School of Design (LCGSA 1965-1991), where a number of important theoretical concepts in spatial data handling were developed, and which by the 1970s had distributed seminal software code and systems

By the early 1980s, M&S Computing (later Intergraph), Environmental Systems Research Institute (ESRI), CARIS (Computer Aided Resource Information System) and ERDAS emerged as commercial vendors of GIS software, successfully incorporating many of the CGIS features, combining the first generation approach to separation of spatial and attribute information with a second generation approach to organizing attribute data into database structures. In parallel, the development of two public domain systems began in the late 1970s and early 1980s.5] MOSS, the Map Overlay and Statistical System project started in 1977 in Fort Collins, Colorado under the auspices of the Western Energy and Land Use Team (WELUT) and the U.S. Fish and Wildlife Service.

The later 1980s and 1990s industry growth were spurred on by the growing use of GIS on Unix workstations and the personal computer.

By the end of the 20th century, the rapid growth in various systems had been consolidated and standardized on relatively few platforms, and users were beginning to export the concept of viewing GIS data over the Internet, requiring data format and transfer standards.

More recently, a growing number of free, open source GIS packages run on a range of operating systems and can be customized to perform specific tasks. Increasingly geospatial data and mapping applications are being made available via the world wide web(3) (6).

General Applications of GIS

The applications of Geographic Information Systems (GIS) are involve in solving real-world problems. For example, use in the studies of natural disasters, geohazards, water resources, hydrologic and hydraulic modeling, urban planning, and terrain analysis. Such as: GIS can be used to map locations. GIS allows the creation of maps through automated mapping, data capture, and surveying analysis tools, People map quantities, like where the most and least are, to find places that meet their criteria and take action, or to see the relationships between places(3). This gives an additional level of information beyond simply mapping the locations of features, mapping densities while you can see concentrations by simply mapping the locations of features, in areas with many features it may be difficult to see which areas have a higher concentration than others. A density map lets you measure the number of features using a uniform a real unit, such as acres or square miles, so you can clearly see the distribution and it can be used to find out what's occurring within a set distance of a feature as well as the GIS can be used to map the change in an area to anticipate future conditions, decide on a course of action, or to evaluate the results of an action or policy [7-8].

Using GIS In the environmental purpose

GIS is used every day to help protect the environment. As an environmental professional, you can use GIS to produce maps, inventory species, measure environmental impact, or trace pollutants. The environmental applications for GIS are almost endless(2).

One of the main benefits of GIS is better resource management both within and outside an organization. A GIS can link data sets together by common data, such as addresses or latitude and longitude, which helps members of the public, private environmental companies, and governmental departments share their data. By creating a shared database, information that can be collected once and be used (9).

GIS helps in Planning and Managing the environmental hazards and risks. In order to plan and monitor the environmental problems, the assessment of hazards and risks becomes the foundation for planning decisions and for mitigation activities. GIS supports activities in environmental assessment, monitoring, and mitigation and can also be used for generating Environmental models.

GIS Applications in the Environment of the developing world

In the developing world, GIS has been used for many years in the agricultural, natural resource, urban and regional planning, and tourism sectors. The health sector, however, has only recently begun to use this powerful tool. Many developing countries currently utilizing GIS for environmental applications such as (3) :

GIS applicable Areas :

- Wild Land Analysis
- Emergency Services like Fire Prevention
- Hazard Mitigation and Future planning
- Air pollution & control
- Disaster Management
- Forest Fires Management
- Managing Natural Resources
- Waste Water Management
- Oil Spills and its remedial actions
- Sea Water - Fresh water interface Studies
- Coal Mine Fires

CASE STUDY

Using 3D GIS to Assess Environmental Hazards in Built Environments in Mina

Background

The Muslim pilgrimage (Hajj) to Makkah and the Holy Places near Makkah, Saudi Arabia, is one of the most important events in the world. The pilgrimage occurs annually and attracts more than two million people from all over the globe pilgrims have to spend at least two nights in Mina. The increasing number of pilgrims, as shown in (Figure 1). The characteristics of Mina's natural and built environment also make Mina vulnerable to natural hazards, such as falling rocks and rain floods.

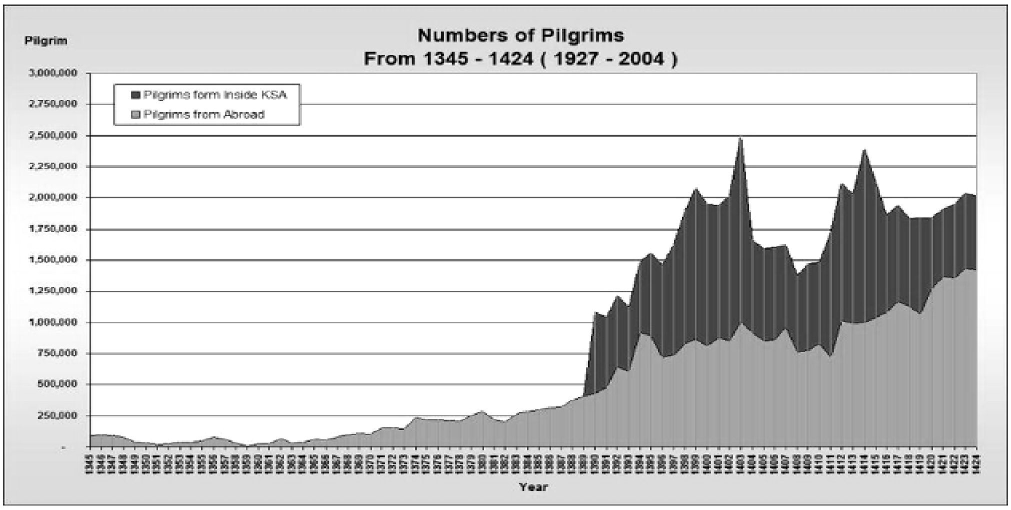


Figure (1): Number of pilgrims since 1927 to 2004
Source: Hajj Research Institute

A 3D GIS (Three Dimensional Geographic Information System) was constructed to understand and analyze the locations, types, and sizes of the possible natural risks in Mina. The 3D GIS used to analyze slopes and investigate water drafting paths and the locations of possible falling rocks. The case study provides illustrations of possible areas of risk, using 2D and 3D visualizations and offers recommendations to avoid future environmental hazards. It is also shows areas that are prime locations for future development and assesses their hazard-safety(11).

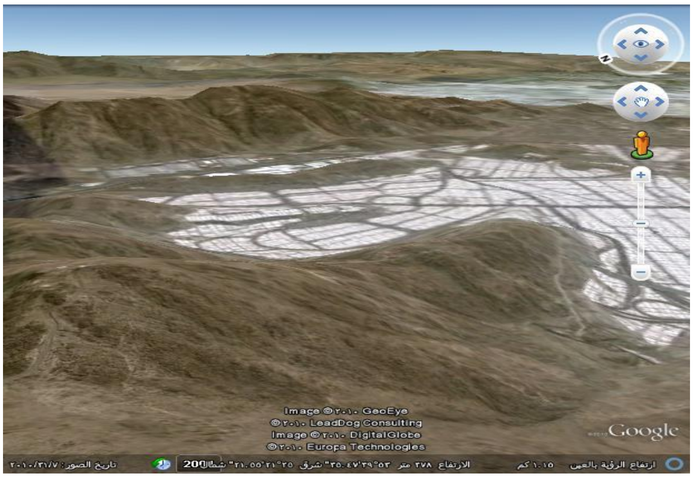
Natural Characteristics of Mina

Mina (near Makkah, Saudi Arabia) is a city of tents that accommodates around two million pilgrims during the season of Hajj . Mina's built environment has special characteristics, as it is mainly composed of light structured housing units (tents) in a valley surrounded by huge mountains. These characteristics make this built environment very vulnerable to natural hazards, such as falling rocks and floods from rain.

Mina is located a distance of 6 km from Central Makkah and measures approximately 8.12 km2; 52% of Mina's area is flat land. The satellite image in(Figure 2) shows the location of Makkah and Min. Mina is a ramped valley at about 300 meters above sea level. The valley is 3 km in length and 1.5 km in width (13).

Figure (2): A satellite image of Central Makkah and Mina
Source: Google Earth

Mina surrounded by two sets of mountains to the north and south(13) (12), (Figure 3) shows a satellite image of Mina's valley. The levels of the valley vary from 270 meters to 320 meters above sea level. Mountains rise in some of the surrounding area to 1000 m above sea level. The hilly parts of Mina are very steep slopes. (Figure 4) is an aerial photo that shows part of the valley and also the surrounding mountains [2].



(Figure 4) a satellite photo that shows part of the valley and also the surrounding mountains source: Google Earth.

The Built Environment of Mina

Mina is considered the largest tent city in the world. Mina is a unique case, because of the several reasons:

1) Mina is used for only three days each year with around two million pilgrims camping every years

2) Mina has defined religious spatial and temporal limits;

3) No permanent buildings are allowed for housing within the limits of Mina.

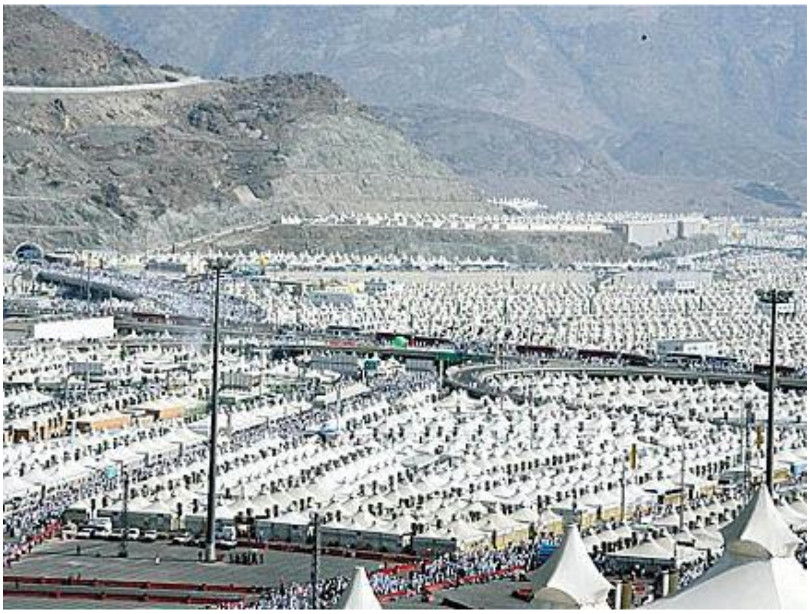
Mina’s built environment consists of:

1) housing tents, that are built of fabric and light structures .

2) Service buildings, police stations and medical services built of concrete structures.

3) a utilities infrastructure, including water tanks and electric transformers.

4) a traffic network of roads and bridges. (Figure 5) presents snapshots showing some characteristics of Mina's built environment(10)



. Figure 5: Mina’s built environment

Mina’s Environmental Hazards

Mina suffers from various types of life threatening hazards, including fires, floods, and falling rocks. the Hajj commencing period shifted to the rainy season in Mina a few years ago. This change has resulted in floods during the hajj season and a lot of trouble for pilgrims (Figure 5)

(Figure 5): heavy raining in mina during the Hjj – alriydh news paper

HYDROLOGIC ANALYSIS OF MINA -- USING 3D GIS

This research project built a 3D GIS of Mina for this reason. The following sections describe the creation of the 3D GIS model of Mina and the Hydrologic analysis then performed using that Model.Using the some sources including :

• A 2D AutoCAD (a CAD Software) maps of the tents within the studied area provided by the Municipality of Makkah 1418 H (Loaner Calendar)

• A 2D contour map every 2 meters also provided by the Municipality of Makkah 1418

• The results of a services and infrastructure survey conducted by the Hajj Research Institute (HRI) during the Hajj of 1424 H (13, 14).

• 60 cm accuracy satellite images of Mina dated 1424 H, captured by the Quick Bird Satellite licensed to HRI through KACST

• A Civil Defense report about rains during the Hajj of 1424 H (15).

the analysis/research/study took specific steps to create the GIS 3D Model.

The next phase was to model the land surface (terrain) using the Triangulated Irregular Network (TIN), which is a GIS vector representation model for the contours created using the ArcGIS (a GIS Software) and an extension called 3D Analyst (15).

The software uses CAD contour lines to create the TIN. (Figure 6) illustrates the TIN model of Mina.


(Figure 6) illustrates the TIN model of Mina.

After modeling the terrain, different features of the built environment (housing units, traffic network, service buildings) are represented as feature classes in the Geodatabase And illustrates a captured image of the feature classes of Mina's built environment elements. Using ArcScene 3D (part of 3D Analyst Extension), in the study they created a 3D representation of all features. These features were also elevated to their corresponding TIN elevation(Figure7)


(Figure 7): Top view of the 3D GIS model, representing the contours, tents, services, and traffic network of Mina

Using ArcScene for the 3D GIS model of the natural and built environments of Mina and it surroundings10 . (Figure8)

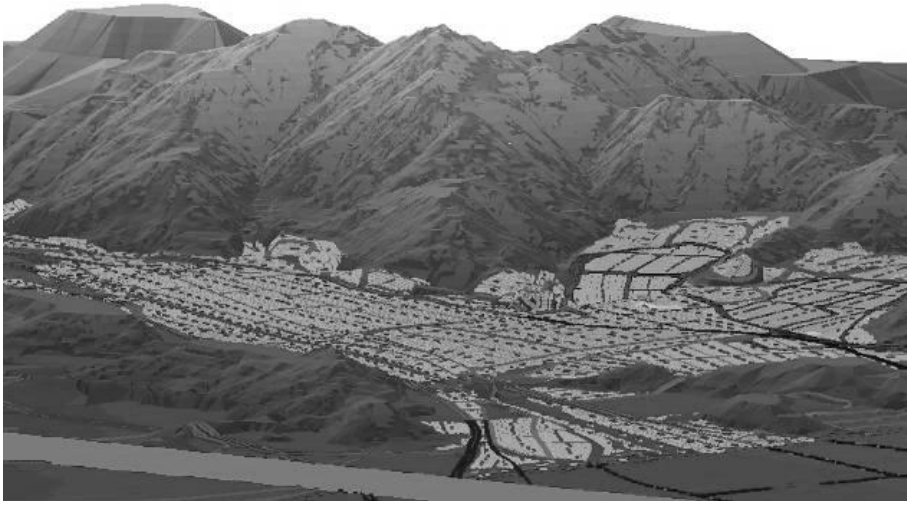


Figure (8): The perspective view of Mina's 3D GIS

Using ArcScene for the 3D GIS model of the natural and built environments of Mina and it surroundings(10)

Hydrological analysis Using ARCHYDRO GIS

Using the ArcHydro GIS extension, developed using the TIN, the drainage patterns of the land-surface terrain were analyzed. Drainage areas were traced upstream and downstream by:

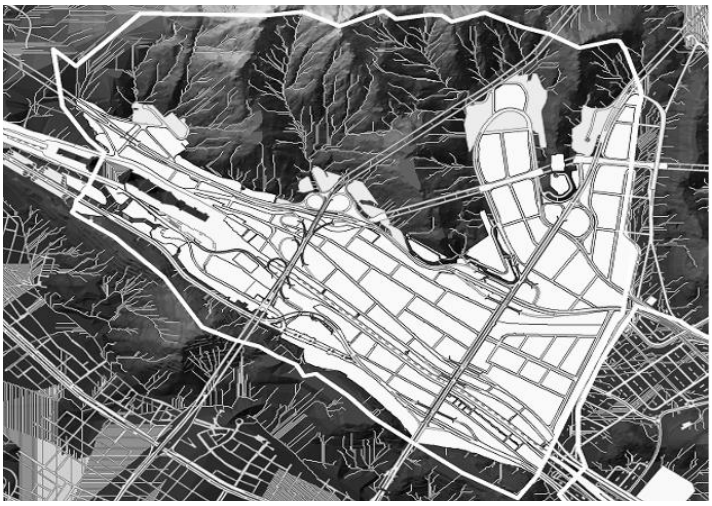
- Attaching drainage areas to the hydro network.
- Using area-to-area navigation.
- Identifying the region of hydrologic influence upstream and downstream from catchments or watershed.
- Generating water basins, water shades, water streams and catchment areas of the terrain surface, using Arc Hydro as illustrated in Figure 9

Figure 9: the terrain surface, using Arc Hydro as illustrated

the water stream networks of Mina surface created using the ArcHydro GIS extension presented over the TIN (15) see (Figure 10)

Figure 10 : Water streams of Mina created using ArcHydro

the TIN, the built environment, and the water streams. The data of recorded civil deafens reports were added to the map (blocks marked in yellow). In addition, all feature classes representing the built environment elements were added to the TIN and the rain water Hydro-Network (Figure 11).



(Figure 11): The TIN, built environment, and the water streams

Discussion and Recommendations

After hydrologic analysis of Mina's natural and built environment, the following
Remarks were made in the case study:

• The northern blocks of Mina's valley are the most vulnerable.

• Only blocks next to mountain areas (marked in grey) are affected by the rains.

• The northern mountains have the biggest heights and the sharpest overall slopes. This Topography causes the water to run with great speed and force.

• The Southern blocks were not affected for several reasons because Southern blocks are less vulnerable because the slopes go in the southern direction of the neighbouring valley or the Azzizyah area.

undeveloped areas within the Northern mountains with a slope less than 60% were defined.

- most of the suggested areas for future development are endangered areas. Developing such areas needs parallel coordinated projects for flood drainage to avoid future damaging floods [12]. In addition, future housing projects can be designed and planned to be in harmony with steep mountainous landscapes without damaging the natural environment of Mina (10).

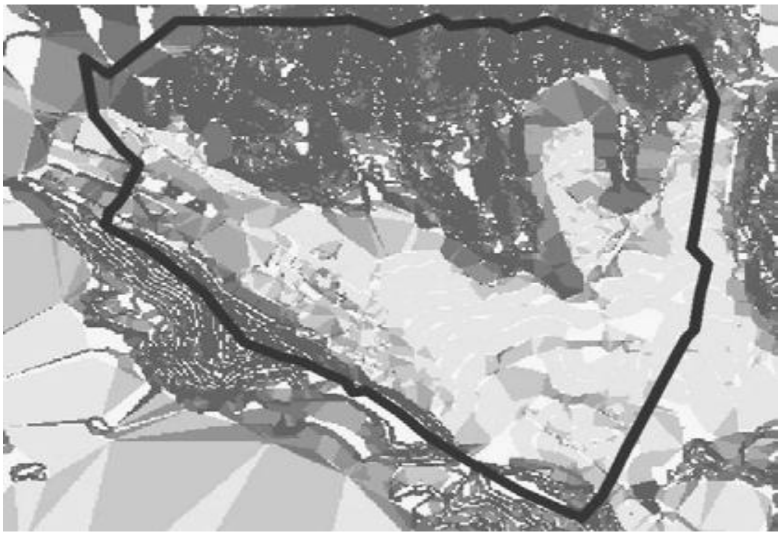


Figure (12): The raster image represents Mina's different slopes

- There is a need to build a more accurate and comprehensive 3D GIS for Mina. The far surrounding areas of Mina need to be captured for better estimate correlations with water drainage analysis

References

1- MSN Encarta Dictionary. Flood. Retrieved on 2006-12-28. Archived 2009-10-31.

2 - DIRECTIVE 2007/60/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 October 2007 on the assessment and management of flood risks.

3- Clarke, K. C., 1986. Advances in Geographic Information Systems, Computers, Environment and Urban Systems, Vol. 10, pp. 175-184.

4- Michael F., (2010). Twenty years of progress: GIScience in 2010. JOURNAL OF SPATIAL INFORMATION SCIENCE Number 1 pp. 3–20 doi:10.5311/JOSIS.2010.1.2. July 27, 2010.

5- "Open Source GIS History - OSGeo Wiki Editors". http://wiki.osgeo.org/wiki/Open_Source_GIS_History. Retrieved 2009-03-21.

6 -Fu, P., and J. Sun. 2010. Web GIS: Principles and Applications. ESRI Press. Redlands, CA. ISBN 158948245X.

7- Niraj Sharam, 1990, GIS Applications in Pollution Modelling

8-. http://en.wikipedia.org/wiki/Geographic_information_system#A

9- http://centrin.net.id/~agul/gis_apl.html

10 - GIS FOR HEALTH AND THE ENVIRONMENT, Don de Savigny, 1995

11- Using 3D GIS to Assess Environmental Hazards in Built Environments Ahmed M. Shehata and Nabeel A. Koshak. (Main reference)

12-. Nozha Yakzan Al-Gabry, (2004). Makkah Morphology – Study to Identify the Geographic, Economic and Social Zones of the Makkah Region, M.Sc. in Social Studies, Umm Al-Qura University, Makkah, Saudi Arabia

13. Shehata Ahmed and Fouda Abdulah, (2004). Services Destruction Within Mina and Muzdalifa During Hajj 1424 H. Research Project. Hajj Research Institute, Umm Al-Qura University, Makkah, Saudi Arabia.

14. Civil Defence of Makkah City, (2004). Report on Floods During Haj 1424 H. Al-Mahsaar Civil Defence Headquarter.

15. ESRI, (2005). Using ArcGIS' 3D Analyst. Environmental Systems Research Institute (ESRI), Redlands, CA, USA.

15. Maidment, David, (2002). Arc Hydro: GIS for Water Resources. ESRI Press. Environmental Systems Research Institute, Redlands (ESRI), CA, USA.