Project Final Report

Natural Hazards Assessment Using GIS Technology

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May 19, 2012
Abstract

Different types of Geological hazards such as earthquake, volcanic eruption, flooding, rock falls, sand problems, and subsidence will endangering people and their properties in Saudi Arabia. Identification, evaluation and mitigation of Geohazards are a vital task should be considered in the city planning, urbanization program that are planned to be placed in Saudi Arabian landforms. This term project is formulated to identify, allocate, and classify the different Geohazards distributed and experienced in Saudi Arabia using the GIS technology. Results and outreaches of this project shed more light on the importance of GIS technology on defining and zoning the type and magnitude of Geohazards distributed in the Saudi Arabian land, giving an adequate tools to the engineers and planners to select the suitable sites for urbanization and development programs, and consequently defining and designing the most efficient control measures (solutions) to stop, minimize, or avoid the adverse impacts that could endanger the planned projects.
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I. Introduction

Geological hazards are natural phenomena that cause major problems all over the world. The expansion and development of cities leads to an increase in impact and damage due to geological hazards. In general, most of the geological hazards associated with desert environments are related to natural conditions, although some may be due to human activities. Potential geological hazards that might occur under desert conditions include erosion and deposition associated with sand drifting and dune movement, corrosion, low bearing capacity of sediments, sabkha zones that are unsuitable for construction, land subsidence due to loose soil, salt domes, rock falls, landslides, earth fissures and sinkholes, subsidence, flash floods, and many more.

At the meanwhile, the use of Geographic Information Systems (GIS) is increasing in deferent application and fields such as: Government Agencies, Emergency Services, Communication technology, Weather forecasting, Marketing purposes and much more.

One of the applications that GIS could be utilized in is ‘Safety in Urbanization programs’

Research activities include the application of remote sensing, digital elevation models and GIS to the assessment of resources, Geohazards and environmental state, landslides, neo-tectonics, badland erosion and water resource, and at mine sites, in the UK, Spain, Italy, East Europe and China. In 2003, research involved the assessment of land stability and landslide hazard in the mountainous terrain of the Three-Gorge area along Yangtze River, where the largest dam/reservoir was put into operation. The study is based on land sat imagery and digitalized maps together with field observation data.

In this project, using ArcGIS and physical and mechanical characteristics triggering natural hazards, exact location, area being affected, etc… will enable to build an interactive GIS model showing varicose types, spatial distribution, and intensity of natural hazards on the Saudi Arabian landforms.

II. Objective

The Main objective of this project is directed to identify and evaluate the type and magnitude of natural hazards in Saudi Arabia using GIS technology that could endanger the urbanization programs developed with the Saudi Arabian lands. Additionally, Outcome of this project will shed more light on the importance of GIS technology that can be utilized by the engineers and planners to build adequate decision to avoid and minimize the adverse impacts associated with natural hazards.
III. Natural Setting

Saudi Arabia as a part of the Arabian Peninsula is an ancient massif composed of stable crystalline rock (Arabian Shield) in the western part, Arabian Shelf mainly composed of sedimentary rocks in the central region, and eolian sand and sabkhas in the eastern parts of Saudi Arabia. Geological units in Saudi Arabia have been affected with many tectonic events that developed many structural features as faults, shear zones, joints and folding system.

Saudi Arabian map show many geomorphological units such as Jebal Asir, Hejaz escarpment, Jebal Tuwayq, Najd plateau, As Summan Plateau coastal plains along the Red Sea, and Arabian Gulf, and number of pronounced sand bodies distributed in four major sand seas namely An Nafud, Ad Dahna, Jafurah, and Rub al Khali sand seas.

Topographic map of the Arabian Peninsula (Figure 1) shows that Jebal Asir-Hejaz with high altitudes are located in the western parts, while lowland flat landforms with lower relief are shown in the eastern parts.

![Figure 1: Topographic Map of Arabian Peninsula](image)

Climatology, Saudi Arabia is located in arid and hyperarid region that is characterized with high temperature, high evaporation rate and sparse of rainfall. Records of rainfall over the last decades show that numbers of heavy rains have been recorded in the Western parts that triggered floods hazards.
Natural setting encompassing Saudi Arabian land including geological units, tectonic features, topography and geomorphic features, climatic conditions in addition to the man-made activities that disturb the natural equilibrium of natural setting altogether concluded that many placed in Saudi Arabia are vulnerable susceptible for different natural hazards such as floods, earth shaking, land sliding and rock fall, subsidence, and sand movement problems. Major natural hazards triggered Saudi Arabia have been summarized by Saudi Geologic Survey and mapped in Geohazards map Figure 2).

![Geohazards map for the Kingdom of Saudi Arabia.](image)

**Figure 2: Generalized Geohazards map for the Kingdom of Saudi Arabia.**

### IV. Major Natural Hazards in Saudi Arabia

As discussed above, the Saudi Arabian land is venerable for many natural hazards. Literature review and historical records indicated that the following natural hazards have triggered many areas within the Saudi lands and endangered human and their properties:

1. **Earthquakes Hazards**

   Arabian peninsula is classified as a stable plate, but due to its continues movement away from the African plate and moved NNE towards Eurasia and Persian plates, number of earthquakes have been experienced in the NW and SW parts of Saudi Arabia. Historical records indicated that Haqel area has been triggered in 1995 with major (magnitude 7.3) which caused significant damage on both sides of the Gulf of
Aqaba and was felt hundreds of kilometers away. Earthquakes of magnitude 6 are common along the spreading axis of the Red Sea but generally they are not felt onshore and appear to pose little risk to infrastructure. On 19 May, 2009, 19 earthquakes of M4.0 or greater took place in the volcanic area of Harrat Lunayyir to the north of Yanbu, including an earthquake of M5.4 event that caused minor damage to structures in the town of Al Ays (40 km to the SE). This event produced the spectacular ground cracks seen in Figure 3.

![Figure 3: showing the spectacular ground fissures due to Al Ays Earth Shaking, 2009.](image)

2. Volcanic Eruption Hazards

At the present day it is known that the Arabian tectonic plate is migrating away from the African Plate at a rate of around 2 cm per year. In north-western and central western Arabia crustal extension is also occurring, and has resulted in significant Cenozoic volcanism. The two most common types of volcanic emission (more than 80 percent) in Saudi Arabia are shield volcanoes, with fairly flat slope (2° to 6°), due to thin fluid basalt lava flows and with a clearly-marked crater, and cinder (scoria) and spatter cones making degassing points along fissures. Ash cones may also occur, such as in Harrats Lunayyir and Kishb.

The first phase of the volcanism took place 20 to 30 million years ago, and was associated with the opening of the Red Sea. These older lava fields are so eroded that no morphological volcanoes remain on the surface. The more recent basaltic lava fields and volcanoes date from 10 million years ago up to the historic eruptions. They lie along a 900 km line within the shield that extends south from the Great Nafud Desert, through the cities of Al Madinah and Makkah, and then as far south along the coastal plain as Al Qunfudah. The northernmost 600 km length of this trend takes the form of a north-south graben structure about 600 km long through which the main Cenozoic basaltic lava fields (harrats) have been erupted. This zone has been named the Makkah-Madinah-Nafud (MMN) Volcanic line, and includes HarratsRahat, Khaybar and Ithnayn. Harrat Rahat (shown in the
picture), which extends between Makkah and Madinah, covers about 20,000 km², and has 644 scoria cones, 36 shield volcanoes and 24 domes. The MMN volcanic line is a weakly propagating rift zone where crustal extension has averaged about 0.054 mm per year over the past 10 million years, and is distinct from the main Red Sea rift zone. It forms the axis of uplift in western Saudi Arabia, and geothermal phenomena are observed along this trend.

It has been suggested that most of the volcanism in western Saudi Arabia occurs due to a northward flow or channel in the asthenosphere (the hot plastic layer under the more rigid upper mantle and crust) that extends from the Afar triple junction at the southern end of the Red Sea, where the East African rift joins the spreading centers of the Red Sea and the Gulf of Aden. The Afar junction is probably underlain by an upwelling mantle plume, a convection phenomenon that arises from deep within the Earth’s mantle. The channeled northward flow under western Saudi Arabia then provides the material that generates the observed surface volcanism by upwelling along the MMN axis and incipient rifts related to seafloor spreading and regional tension within the Arabian plate. Low level geothermal activity and seismicity indicate that the MMN trend remains active. The areas of Cenozoic volcanism and the MMN volcanic line are shown in the map of the harrats. In active volcanoes located in the western parts of Saudi Arabia along the Red Sea are shown in Figure 4.

Figure 4: Inactive Volcanoes distributed over Harrat, Western parts of Saudi Arabia
**Historic volcanic activity**

The areas of Tertiary volcanism in western Saudi Arabia appear to be largely inactive volcanoes:

- The Cenozoic volcanic lava field of Harrat Rahat, which is about 310 km long and lies between Makkah and Al Madinah, has experienced volcanism in historic times. The total volume of lava in this Harrat is about 2000 km$^3$, and volcanism commenced about 10 million years ago, with the more recent flows toward the northern end of the Harrat.

- The oldest lavas near Madinah are geologically very young, only about 2 million years old. In this area the youngest “Post-Neolithic” lavas (less than 6000 years old) resulted from 11 eruptions, with 2 historic eruptions in AD 641 and AD 1256.

- The 641 AD eruption resulted in a small line of cinder cones to the southwest of the city. The last well-documented eruption in Saudi Arabia occurred in the northern end of Harrat Rahat near Al Madinah in 1256 AD/ 654 AH, and was preceded by significant earthquake activity for several days. Fountains of basalt lava were then seen 19 km to the southeast of the city, and lava advanced toward the city Figure 5. The eruption continued for 52 days, and the lava flow reached to within 12 km of the city before activity ceased. The area continues to be of some concern, especially since the city is now expanding into the area of the flow, a local seismograph network around this end of the Harrat and the city have been established to warn of any impending risk from an eruption, although there is a very low probability of this happening.

![Figure 5: Showing lava flow in Harrat Rahat and the city of Al Madinah in the left side of the image (see lava with darkest color, volcanic cones red/orange color)](image)

It is worth mentioning that recent volcanic eruptions have been recorded in Al Ays area in 2009. Jabal al-TairVolcano (15.55°N / 41.83°E) erupted on 30 September 2007, throwing lava and ash hundreds of meters into the air. Subsequently, at least
one stream of lava was seen flowing down into the sea. It was reported that 29 Yemeni soldiers (around 50 according to one report) were evacuated from the island shortly before the eruption, but 8 were unaccounted for. Several bodies were recovered from the water. It was reported that the western part of the island, where the Yemeni military base was, had collapsed, Figure 6.

Figure 6: Jabal al-Tair volcano in 2007

3. Flood Hazards

Floods are the most frequently encountered natural disaster in Saudi Arabia. They have been the cause of 7 of the 10 most damaging natural disasters in the history of the country between 1900 and 2010 (refer to Table 1).

Compounding this problem is the geography of some of the most populated cities in Saudi Arabia. Cities, such as Jeddah and Makkah, are on low ground and are surrounded by mountains. When rains fall on these mountains, water runs in valleys towards these cities. With poor drainage systems, this continuous flow of water could easily lead to a flash flood.

Table 1: Flood hazards and its adverse impacts that are triggered Saudi Arabia for the period 1964 to 2010, (source: International Disaster Database)

<table>
<thead>
<tr>
<th>Disaster</th>
<th>Date</th>
<th>Number of casualties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flood</td>
<td>24/11/2009</td>
<td>163</td>
</tr>
<tr>
<td>Flood</td>
<td>28/04/2005</td>
<td>34</td>
</tr>
<tr>
<td>Flood</td>
<td>24/12/1985</td>
<td>32</td>
</tr>
<tr>
<td>Flood</td>
<td>22/01/2005</td>
<td>29</td>
</tr>
<tr>
<td>Flood</td>
<td>4/04/1964</td>
<td>20</td>
</tr>
<tr>
<td>Flood</td>
<td>8/04/2002</td>
<td>19</td>
</tr>
<tr>
<td>Flood</td>
<td>11/11/2003</td>
<td>12</td>
</tr>
</tbody>
</table>
Although the average rainfall in the coastal areas of the Kingdom is very small, rainstorms on the nearby mountains can generate flash floods that damage properties and result in loss of life.

**History of floods in Saudi Arabia**

- **1985 flood:** on 24 December 1985, heavy rains poured on north-western regions of Saudi Arabia, leading to what has been described as the worst flood in the area in 50 years. Estimates of damage were not recorded, except that there were at least 32 people killed from the flood.

- **Yanbu flood:** heavy rains poured on western Saudi Arabia in January 1997, mainly affecting Yanbu and peripheries of Jeddah. The rain lasted for 24 hours, killing 10 people and causing damage to an area of over 130,000 km² of land.

- **Asir flood:** Asir is a province in the Southwest of Saudi Arabia. On Monday 25 March 1997, heavy rains poured on the region, leading to floods that resulted in 16 fatalities and damaged an area of just below 100,000 km² of land.

- **Makkah 2002 flood:** heavy rains started falling on Makkah area on 8 April 2002 and lasted for a whole week. This led to flooding of water in some areas, claiming the lives of 19 people; hundreds of Makkah residents were rescued that week.

- **Makkah 2003 flood:** not quite recovered from previous year’s rain, Makkah experienced yet another heavy shower described as the worst rains in Makkah in 25 years. Water levels were reported to have reached 6 meters. Twelve people were killed; however, estimates of physical damage are not available.

- **Jizan 2004 floods:** less than four months apart, two floods hit the Jizan region, leading to what has been described as Jizan’s worst floods in 45 years. The floods left over 400 people homeless, killed 13 people and devastated many roads and farms.

- **Medina 2005 flood:** very heavy showers fell on Medina region in January 2005. This resulted in a flood that caused the Yatamah dam to fail, killing 29 people. Seventeen people were injured, 50 were left homeless and 43 had to be evacuated.

- **Riyadh 2005 flood:** heavy rains poured on the Riyadh region of Saudi Arabia, as well as on other areas in neighboring countries (i.e. Oman and the United Arab Emirates). The resultant flood claimed the lives of seven people; 700 people had to be evacuated by helicopters and another 700 were left homeless.
Jeddah 2009 flood: at around 6:30 a.m. on Wednesday 25 November 2009, rain started falling heavily in Jeddah, and continued for around 12 hours. The amount of water in this relatively brief downpour (around 90 mm³) doubled the average annual rainfall in Jeddah. With a sound infrastructure and a proper drainage system lacking, this rain turned into the worst disaster that Jeddah has experienced in 27 years or so. The downpour resulted in the formation of water tides coming from the hills on the east of the city, heading west towards the Red Sea and cutting their way through the city.

Major roads of the city were blocked by meters-high of water waves or by cars that have been washed out.

Power and telecommunication services were not spared either. As early as 11 a.m., floods had already resulted in a temporary power outage on the whole western region of Saudi Arabia (i.e. Makkah, Medina and Jeddah). Many people were not even able to call for help as communication with emergency services (e.g. civil defense forces, police or emergency medical services) failed due to the overwhelmed network and power outage.

Overall, 161 people lost their lives as a result of the floods, either drowning or from car crashes. This disaster had an estimated cost of around US$900 million to reconstruct Jeddah and help its victims, Figure 7.

Figure 7: Catastrophic impacts of flood triggered Jeddah City in 2009.
• **Riyadh 2010 flood:** on 3 May 2010, Riyadh city experienced a brief 45-minute water shower, accompanied by light hail and winds gusting up to 24 km/hour. As brief as the downpour was, however, it resulted in floods and car crashes across the city.

4. **Rock Fall Hazards**

Landslides are rock, earth, or debris flows on slopes due to gravity. They can occur on any terrain given the right conditions of soil, moisture, and the angle of slope. Integral to the natural process of the earth's surface geology, landslides serve to redistribute soil and sediments in a process that can be in abrupt collapses or in slow gradual slides. Also known as mud flows, debris flows, earth failures, and slope failures, they can be triggered by rain, floods, earthquakes, and other natural causes as well as human-made causes, such as grading, terrain cutting and filling, excessive development, and so on. The factors affecting landslides can be geological or by man-made, and can occur in developed or undeveloped areas, or in areas where the terrain has been altered for roads, houses, utilities, buildings and mining activities.

Landslides may be more devastating than all other natural hazards combined, and can affect utilities, transportation, and public and private infrastructure. Most of the rock slopes along the descents between the Arabian Shield Mountains and the Red Sea coast that cut through the escarpment are subject to slope instability and rockfalls, especially after rain storms. It is experienced that rock fall hazards along Al-Hada road have devastated the roads and causing adverse impacts for human, Figure 8.

Figure 8: Impacts of rock fall hazards along Al-Hada road between Makkah and Taif.
5. Sand Dunes Movement

Drifting sand and sand dunes movement are some of the most serious natural hazards facing the Arabian Peninsula due to the expansion of cities, roads, industries, and agricultural development. It has been experienced that placement of urban facilities in the sandy deserts without control measures, movement of sand dunes creates severe problems for industrial plants, residential areas, roads, power lines, and pipelines, Figure 9.

Figure 9: Shows the impact of sand dune movement
V. Methodology (GIS Model)

After describing the Natural Setting and the related Natural Hazards affecting Saudi Arabia, systematic procedure have been used to build the model using ArcGIS as shown in Figure 10.

![Figure 10: Procedure of GIS Model Preparation](image)
Parameters describing Natural Hazards mentioned above have been summarized and tabulated in an interactive dBase; structure of the dBase is shown in Figure 11.

<table>
<thead>
<tr>
<th>SN</th>
<th>Date : Time</th>
<th>Y-Coordinate</th>
<th>X-Coordinate</th>
<th>Depth (km)</th>
<th>Magnitude</th>
<th>Impacts of EQs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2002 01 06 20:15:44.57</td>
<td>23.386</td>
<td>37.075</td>
<td>10</td>
<td>4.1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2002 01 24 06:13:04.65</td>
<td>28.195</td>
<td>54.626</td>
<td>40</td>
<td>4.6</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>2002 01 31 00:43:29.59</td>
<td>34.579</td>
<td>34.005</td>
<td>25</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>2002 02 03 20:14:37.62</td>
<td>29.767</td>
<td>51.148</td>
<td>33</td>
<td>3.8</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>2002 02 17 13:03:52.71</td>
<td>28.093</td>
<td>51.755</td>
<td>33</td>
<td>5.4</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>2002 02 17 15:15:12.06</td>
<td>27.998</td>
<td>51.766</td>
<td>33</td>
<td>3.8</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>2002 02 17 16:49:26.57</td>
<td>28.239</td>
<td>51.633</td>
<td>33</td>
<td>4.2</td>
<td></td>
</tr>
</tbody>
</table>

Figure 11: structure of Database

A. Base map selection

Selecting the base map that suits the application is one of the most important and tedious stages in the project.

The required base map Characteristics can be summarized in the following:

- Saudi Arabia’s cities should show clearly on the map allowing us to zoom and locate hazardous areas.
- Saudi Arabian map should also show many geomorphological units such as Jebal Asir, Hejaz escarpment, Jebal Tuwayq, Najd plateau, As Summan Plateau coastal plains along the Red Sea, and Arabian Gulf, and number of pronounced sand bodies distributed in four major sand seas namely An Nafud, Ad Dahna, Jafurah, and Rub al Khali sand seas.
- Topographic map of the Arabian Peninsula showing high altitudes are located in the western parts, while lowland flat landforms with lower relief are located in the eastern parts.
As a start and with the help of the ‘Gulf Consult- Khobar Office’ I managed to get an AutoCAD drawing of the Arabian Peninsula with some details on it, the DWG file was suitable to open on ArcMap, as shown in Figure 12

The above map includes the following information:
- Saudi Arabian Borders
- Arabian Shield in the western part
- Volcanic Formation (Harrat) shown as polygons
- Volcanic Eruptions shown as pink points on the map
- Sand Seas Areas shown as Orange points

The problem faced with this map is that it has no relevant coordination reference; the coordinate system has no meaning with this map. Also no features can be added or changed, in order to add features on a map you need to have both the Map and the feature on the same coordination system.

Another problem faced is that some of the information is projected on the map in a wrong way, for example you can clearly notice that the Sand Seas Areas are projected as orange points whereas it should be shown as Polygons covering different Sand Areas.

To overcome these problems and with the help of “Mr. Razi-GIS lab administrator at KFUPM” I started to extract the needed layers from this map and exporting it to shape files (.shp) while using the Geo-referencing tool in the ArcMap toolbox to re-coordinate the shape files with the most common coordination system (WGS 1984). I managed successfully to extract a layer showing the Borders of Saudi, the Arabian Shield layer and the Volcanic Formation layer in its accurate WGS coordinates as shown in Figure13.
Furthermore, this data can be used as separate layers on the required Base map.

**Using ArcGIS Maps online**

After a lot of searching and studying maps of Saudi Arabia I came across the ArcGIS website “[www.arcgis.com](http://www.arcgis.com)” which was a very good source because it allows you to choose and work on various types of base maps, for example: imagery Base Map, Topology Base Map, National Geography Base Map, streets Base Map, etc… as shown in Figure 14.

![Figure 13: Exported layers](image)

![Figure 14: ArcGIS online](image)
It is possible to work on these maps online and get exact information due to its brilliant resolution, but unfortunately adding the layers is limited. Also it is able to add these data from the resource center to ArcMap as shown in Figure 15, which enabled adding the layers freely.

The problem faced here was that the maps could not be saved or exported to shape files, and therefore I had to be connected to a fast internet connection to have access to the online ArcGIS tool.

**ArcGIS Maps**

More searches was done on how to get full access to base maps similar to the ones from the resource center, thanks to the GIS-lab in KFUPM an excellent base maps were provided.

The following Base maps are accurately coordinated using (WGS 1984) witch suites the requirements and would be sufficient to complete the project successfully, figures 16, 17 and 18 shows three different base maps.
Figure 16: Imagery and Shaded Relief Base Map

Figure 17: Elevation Base Map
With these base maps, all general ground characteristics of Saudi Arabia that could be related to Geological Hazards are shown. And based on these maps and the additional information that will be plugged on them as layers, we will be able to locate every Geo-Hazardous area in Saudi Arabia.
B. Generating GIS Layers and Integrating the dBase

Due to the high resolution, *The Imagery and Shaded Relief Base Map* (Figure 19) will be selected and activated to carry out the work on it. Furthermore, the other base maps exists in the file and when needed can be activated as well.

![Figure 19: Selected Base Map](image)

To make the best use of such a map and to precisely locate the hazardous areas, some components need to be composed in different layers on the above selected map.

Layers generated on ArcMap:

- Saudi Arabia’s borders and provinces borders
• Saudi Arabia’s Cities, surrounding countries boundaries, names and capitals

• Saudi Arabia’s Road Network
Volcanic Formation (Harrat) in the western area of Saudi Arabia

This layer was extracted from the starting map (Figure 12) but unfortunately it was not projected in its actual location, actual location is shown in Figure 4. Shifting the layer to its correct location will be carried out using the ArcMap Toolbox.

Using the Special Adjustment tool in ArcMap I managed to relocate the Harrat layer in its actual location. By selecting 2 or more points on the layer and specifying the new location for each point, the whole layer will be shifted to the new location as shown in Figure 20.
Volcanic Eruption Records

Using exact location of every historic eruption occurred in the Kingdom I managed to transfer the database entries shown in Figure 20 using ArcMap.

Figure 21: Volcanic Eruption Records

Figure 22: Volcanic Eruptions on the Map
• Earthquakes Records

As done for the Volcanic Eruption Records, the same is done for earthquakes records.

After transferring database entries that consists of more than 1300 record, earthquakes were categorized and symbolized as shown in Figure 22 below.

![Figure 23: Earthquakes records on the Map](image)

• Sand Body in Saudi Arabia

With the help of the satellite image and using the Editor option in ArcMap I managed to select and show the location of the sand distributed in Saudi Arabia as shown in Figure 24.

![Figure 24: Sand Body in Saudi Arabia](image)
- Rock fall Vulnerable roads

Using the Road Network Layer I managed to select and extract a separate layer showing the roads in the western area that are hazardous to rock fall as shown in Figure 25.

![Figure 25: Rock fall hazardous map](image)

And by zooming to the important area, figure 26 shows that the roads connecting Mecca-Taif-Abha-Najran are the most vulnerable to Rock Fall Hazards.

![Figure 26: Rock fall vulnerable roads](image)
• Subsidence endangered areas
  
  **Under Preparation**
  
• Flood hazardous zones
  
  **Under Preparation**

**Fully Activated Model**

After applying all layers and activating them, all special distributions are visible on the map as shown in Figure 27

![Figure 27: Activated Model](image-url)
VI. Testing of the Model

By testing the data in the model, I found some of the data in the layers where not in its actual location. As mentioned before, the volcanic formation layer was not located in its actual location, this was only figured by testing the location of each data entry in the layers.

VII. Application on the Model

GIS technology can be utilized in different discipline to build adequate decisions and scenarios in different applications such as: civil engineering, agricultural, environmental, geological application. This project shed more light on the importance of GIS technology in natural hazards study.

Results and findings of this study can be concluded as follows:

- Different natural hazards distributed in Saudi Arabia have been identified and allocated in interactive model.
- GIS illustrates the special distribution of natural hazards in the Saudi Arabia’s map.
- GIS showed clearly the interrelationship between frequency/magnitude of major natural hazards and the urbanization program distributed in Saudi Arabia.
- GIS technology as shown in this project can evaluate the impact of natural hazards that are endangering the existing urban facilities.
- Results of this project proved clearly that GIS can predict the type and magnitude of Geohazards that could be aggravated in the planned projects.
- The aid of GIS in identification and evaluation of Geohazards can be utilized successfully to define the adequate mitigation program to minimize or avoid the adverse impact of Geohazards.
- For example Jeddah city have been affected by severe flood hazards, GIS can be utilized as a successful application to delineate and classify the degree of flooding, such result will help the planners and engineers to define and design the suitable solutions.
- Al-Medina area have been affected by recent volcanic activities, this GIS model can provide accurate scenarios if any future eruptions occurred, this will help to build the best emergency plan.
- Many urban facilities in Saudi Arabia have been affected by sand hazards as shown in this study, GIS model will play an interactive role to identified, delineated and classify the sand hazards that consequently will help the engineers to stop the problem that could endanger the urban facilities such as Sheebah projects, roads, rail roads, farms, etc.
- Results of this project using GIS showed that number and magnitude of earthquakes have been increased recently in Saudi Arabia and adjacent counties. Such observations should be taken into consideration by engineers and planners so select the suitable sites infrastructure.
## VIII. Timetable

<table>
<thead>
<tr>
<th>Phase</th>
<th>Description of Work</th>
<th>Start Date</th>
<th>End Date</th>
</tr>
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<tbody>
<tr>
<td>Phase One</td>
<td>Literature Reading</td>
<td>February 19, 2012</td>
<td>March 4, 2012</td>
</tr>
<tr>
<td>Phase Two</td>
<td>Collecting the critical Data</td>
<td>March 5, 2012</td>
<td>March 26, 2012</td>
</tr>
<tr>
<td>Phase Three</td>
<td>Developing the Database</td>
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<td>Phase Four</td>
<td>Merging Database with Map</td>
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<td>May 1, 2012</td>
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<tr>
<td>Phase Five</td>
<td>Testing &amp; Implementing the Model</td>
<td>May 2, 2012</td>
<td>May 10, 2012</td>
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</tbody>
</table>
IX. References

- “Natural Hazards”, Saudi Geological Survey
- Advanced National Seismic System (ANSS)
- Al-Saafeen, Adli K, Personal Communication, Engineering Geology & Geohazards Section, Gulf Consult
- Global Volcanic Program “ http://www.volcano.si.edu/world/region.cfm?rnum=0301”
- ESRI Map packages at KFUPM GIS lab