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GIS for Water Resources

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Abstract

GIS is a powerful tool which provides solutions for water resources problems; such as assessing water quality, determining water availability, managing flood problems, understanding the natural environment, and managing water resources on local and regional levels. The advent of ArcGIS created an opportunity to introduce ways of representing water resources data.

The availability of reliable GIS data sets from official map making agencies such as GCS, MOMRA, KACST (Name t hem not just the abbreviation), and the development of standardized data models like Arc Hydro can provide powerful solutions to water resources problems in Saudi Arabia. For instance, Watershed simulation models in a GIS environment can be generated for many areas in Saudi Arabia using these reliable tools and data. Many of the traditional tasks that engineers and scientists have performed manually can be automated allowing the modeler to perform detailed hydrologic and hydraulic studies in more depth and in less time at superior quality. Hydrologists use GIS technology to integrate various data and applications into one manageable system. The bundles of tools contained in Arc Hydro model facilitate the creation, manipulation, and display of hydro features and objects within the ArcGIS environment. This paper aimed at describing the practical implementation of Geographic Information Systems (GIS) to serve the management of water resources in Makkah area as a case study using Arc Hydro tools,

Key Words: Makkah, GIS, Watershed, Risk Assessment, Flood

Introduction

Flooding is a serious geo-environmental issue and natural risk phenomena which causes damage each year. Changes in land use pattern especially development from the rural area to the urban area can have an effect on flood risk such as building houses or putting down concrete where , several areas of the countries are at a heightened risk for flooding. It causes damage to everything around it, as well as Water pollution by soil particles and chemicals, some agricultural areas have already declined due to flood

erosion. It is necessary to establish water conservation measures which can reduce land damage and assure a sustainable management of water resources. The implementation of effective water conservation measures has to be preceded by a spatially distributed flooding risk; the implementation of Geographic Information System (GIS) has been used widely for Government agencies scientific management and policy-making since the 1960s. It is becoming one of the powerful tools for Government Agencies Office Automation especially in flood risk and management. Therefore, proper flood management mapping based on advanced information techniques including remote sensing (RS) and Geographic Information Systems (GIS) is needed.
The flooding model is based on the ArcHydro which was not originally developed for regional applications, it tends to overestimate the effect of slope, however it's Applicability to other areas is uncertain. It is necessary to develop a “cognitive” flooding erosion model for Makkah based on factors influencing water flooding. In this context, the objective of this study is to provide a flood erosion risk map of a representative region of Makkah, evaluate its degree and classify the level of danger. Available data from existing maps, satellite images and local expert knowledge are combined based on qualitative decision rules and hierarchical organization of effective parameters.

Flooding can't be prevented entirely, however can be managed, which means reducing the likelihood of them occurring in the first place, and minimizing there impact.

The prediction of flood disaster can be applied by a collection of models used for monitoring, forecasting, simulation, evaluation and analysis. Moreover Geographic Information System (GIS) can be used for reducing the damage in different stages. Before the risk, distribution of dangerous areas can be organized according to their heights, and Hydrologists can get recommendations by analyzing the distribution of historical flood risks. During the risk period, GIS can help in predicting water flood risk, such as flood peak time, water flood range and level, and organizing rescue actions. This way it becomes possible to give different stages of floods to the government or non government organizations before disaster in order to get suitable decision and actions to be made.

Being the holiest city of the world, Makkah has a very important rank and is the most respectable city for Muslims all over the world. It accommodates millions of Muslims every year that come from every part of the world for praying and meditating especially for performing Hajj - which is one of the pillars of Islam. Each year, over 2,000,000 people visit Makkah during the month of pilgrimage. Makkah is located on the sandy, narrow valley of the Wadi Ibrahim and is surrounded by hills from 60 to 150 m high. The 914-m-high Jabal Khandama is located nearby making it as the biggest watershed in this area,Makkah looks like the sink between hills where all the water flows into. Water accumulates there and causes the flooding risks, this city may be under flooding risk during pilgrim season, the tents of Pilgrims could be destroyed by water, all of these reasons make Makkah under a risk of flooding every year. The major problem arises when hajj and rain season starts at the same period.

For all reasons, the most important concern thing was how to protect this city from the flooding by means of physical control of storm water, by monitoring, analyzing and managing the details of flood risks.

The following are the main objectives of the study:

- To locate the area of possible flooding according to DEM data and the location of flooding from previous years
- To Identify and asses flood risks paused by aging flood damage reduction infrastructure,
- To find the best location for the pilgrims settlement.
- To define the watershed for each location in the study area.
- To locate the place of drainage collector (basin).
- To locate danger places such as collapsible places and water accumulation.

Study Area

Makkah, the sacred city of the Muslims, is situated in the Hijaz district, 72 Km to the East of Jeddah and 112 km east of the Red Sea. The holly city lies at an elevation of 277m above the sea level in the sandy narrow valley of Wadi Ibrahim and surrounded by rocky hills varying from about 60 to 150 m of altitude.

Makkah is located at 72 km east of Jeddah, its port on the Red Sea, and about 485 km south of Medinah. The city is located on the sandy, narrow valley of the Wadi Ibrahim and is surrounded by hills from 60 to 150 m high. The 914-m-high Jabal Khandama is located nearby. The city is surrounded by mountains.

The geology of the study area is assessed on the work of Brown et al. (1963); Palister (1986); Moore and Al-Rehaili (1989); Alshanti (1993). Precambrian Rocks, The late Precambrian rocks are classified into layered and intrusive rocks. The layered rocks consist of volcanic, volcanoclastic, and metamorphic rocks, which are intruded by igneous bodies

Background Knowledge

The flowing table shows records of flooding risks in Makkah .it shows the highest flooding level corresponding to the years listed below. For example: in the 1941 we had a very high level of flood; the pilgrims were doing Al-Tawaf by swimming. This flood was repeated again in 2008

Table. 1 The flood history of the study area.

Year	Level
1941	V High
1942	High
1965	High
2008	High

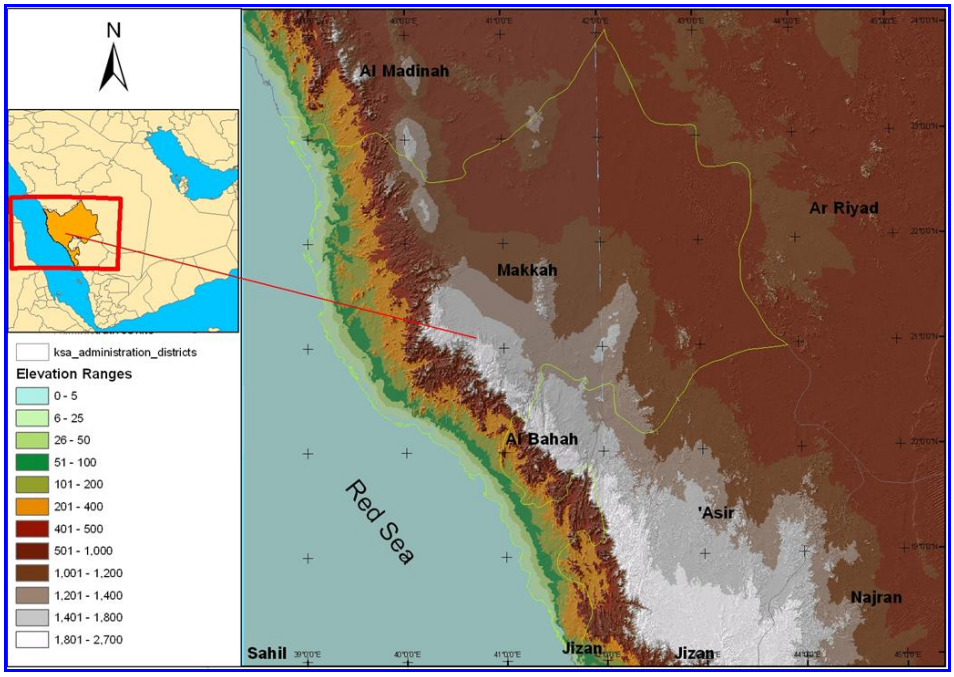


Figure 1: study area

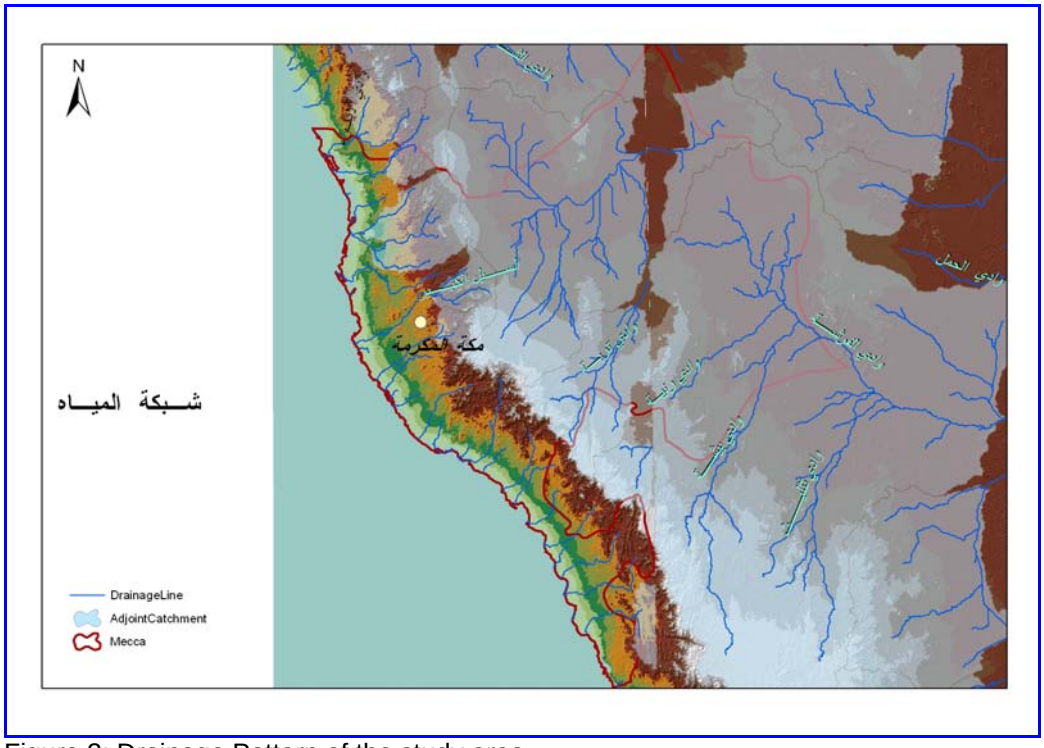


Figure 2: Drainage Pattern of the study area

Figure 3: Al-Haram in Makkah in 1941
Water level is up to The Black Stone and Muslims do Al-Tawaf by swmming.

Material and Methodology

GIS in a wide-range meaning and Arc Hydro in particular were used in the development of input data set for a conceptual small watershed runoff generation model (SWARGEM). which takes into consideration of the geomorphologic features of the watershed. The entire data was analyzed in the PC ARC/INFO (ver 9.0) GIS domain. DEM (10) m were the only input data used to extract the surface flow to the outlet of the watershed.

The Ikonos (I m) were used to execute visual interpreter for the study area, based on a digital elevation model (DEM) and a GIS system. The spatial extent of these flood events was visualized. For calibration of the floodplain model and the flood mapping results, use of historical flood information. In the past, only information was available about the maximum spatial extent of the historical floods from the previous years. Based on this flood information is needed, the 'map of floods' was derived. Additional use was made of satellite derived flood maps. That project demonstrated improvements in flood modeling performance by use of earth observation products for flood mapping, and IKONOS imagery for land use mapping and damage assessment).

We confined the extent of the study area to the holy places Mina, Arafat and Muzdalefa. Hajeej (people performing Al-Hajj) stay in this holly places

Then the data about Hajeej residential places, Mina's maps, Hajeej flow directions and Hajeej traverse path.

Below is a description of the application developed for this study, in order to predict the flooding risk in Masher Moqudasah area,

Hydrology Application

Flood Basin /Point.

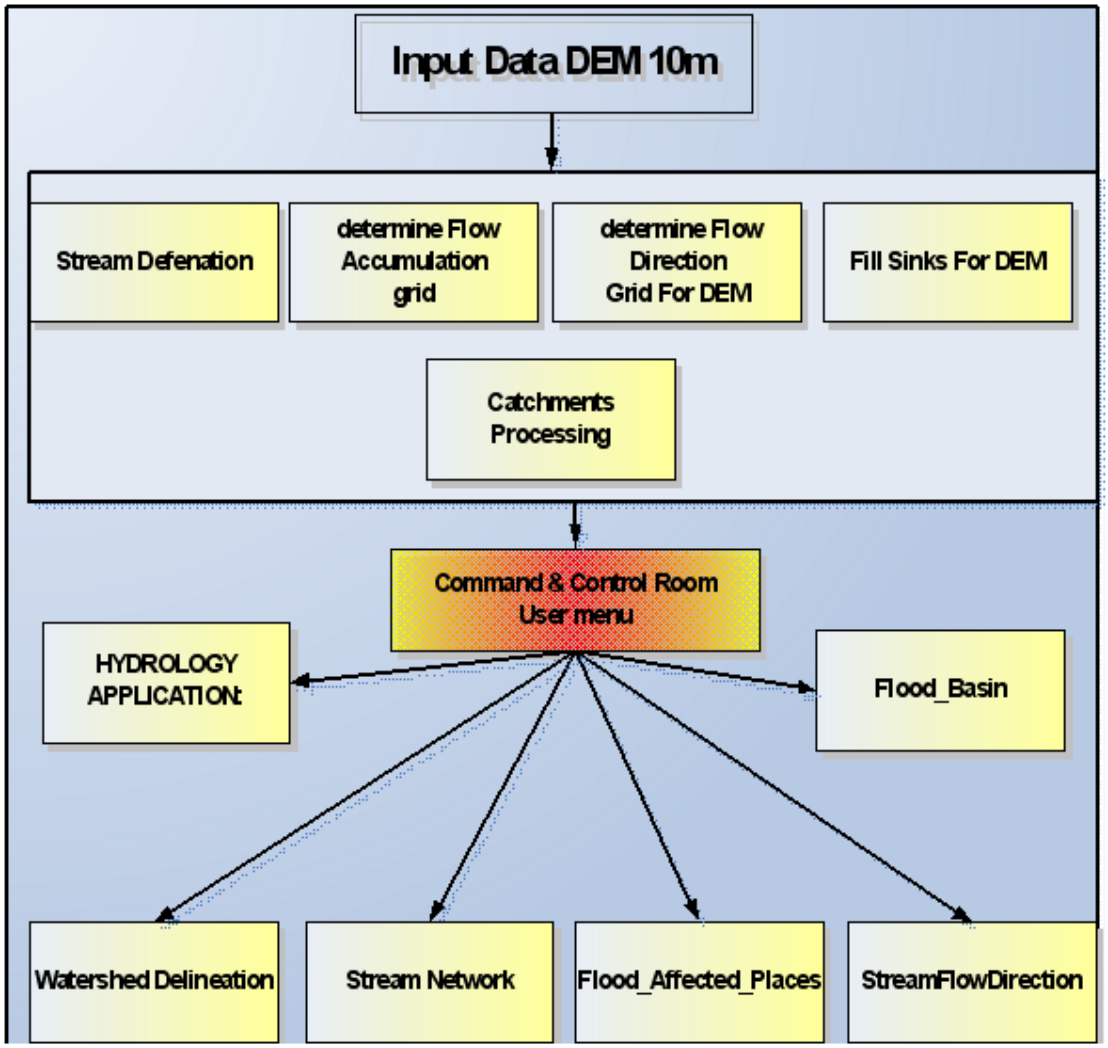
This application is used to locate the area of possible flooding according to DEM data and /or the location of flooding from previous years. Clicking this button will show pop-up Viewer form.

Dangerous/Safe Places_ Flooding.

This application show the map of Dangerous and safe places identified by civil defense. The information available in this map is for Mina area only.

Dangerous Areas.

By using these applications, we can determine the place of accumulate torrent water and specify the type of the flood risk in this area.



Results and Discussion

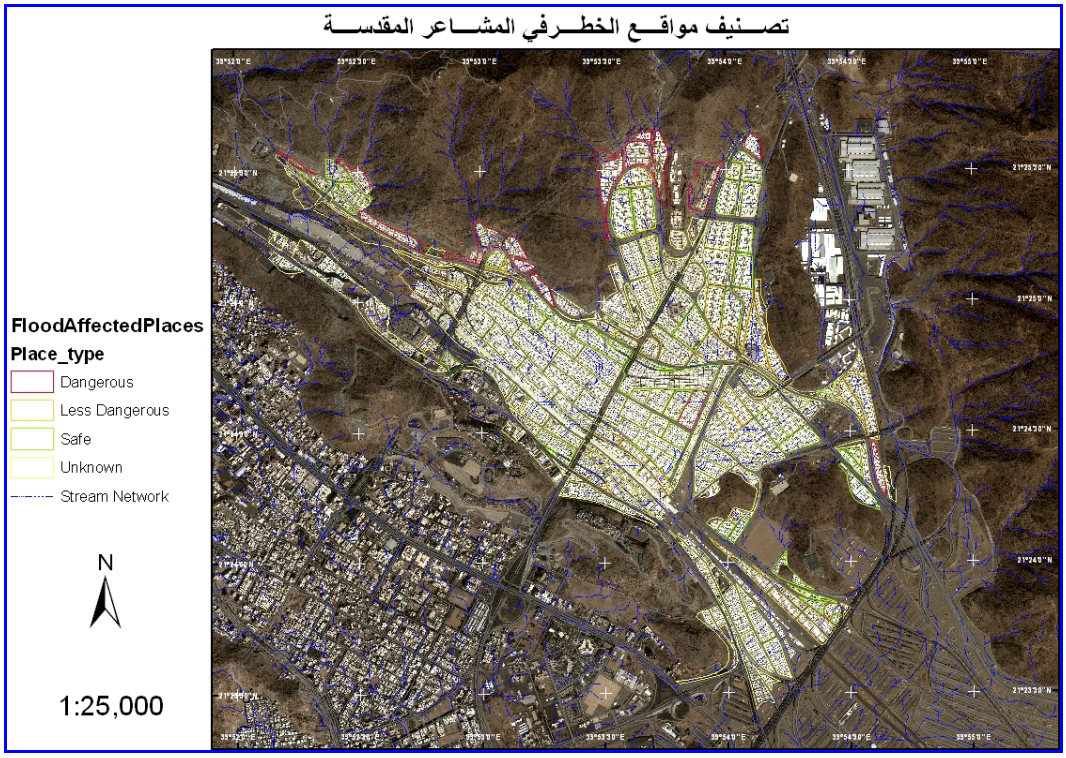


Figure 4: Drainage Pattern of the study area

The following are the findings of the study, which have been found after the analysis of the area:

1. Determine the source and the sink of the streaming
2. Determine the places of water collection
3. Determine Dangerous and safe places identified by civil defense.
4. Determine Evacuation places
5. Determine the best location for pilgrimage.

We could classify the study area into three classes:

- High Risk
- Medium Risk
- Low Risk

And the area of each class as shown in the following table:

Table. 2 The Area of Each Class in The Study Area

Type	Area/Km2
Dangerous	0.367668
Less Dangerous	0.629464
Safe	0.88004
Unknown	2.292725
Total	4.169897

Suggestions and Recommendations

This Application can be developed to give more accurate information. the GIS was proved to be a powerful tool for monitoring and controlling water objects data, Accordingly the resulted application can be very useful and helpful to start with analyzing the risk factors that can affect the hajj process and pilgrims life.

- There were lots of missing data in this study thus the input data should contain: soil map, geology map, and rainfall information.
- Time series. These models predict of a real time discharges and water levels at selected locations along the river, based on historical forecasted rainfall, hydrological and hydraulic simulation models. Instantaneous model errors are forecasted for future time steps through a data assimilation procedure (model updating). The real-time forecasting models should be adapted. Such an application will be very useful if it was published on the internet.

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