# INTRODACTION TO GIS

**King Fahd University Of Petroleum and Minerals**
**CRP 514: Introduction to GIS**
**- Term Report**

# GIS Applications in Assessment of Flood Hazard

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## ABSTRACT

Flood is an inevitable natural phenomenon occurring from time to time in all rivers and natural drainage systems, which not only damages the lives, natural resources and environment, but also causes the loss of economy and health. The impact of floods has been increased due to a number of factors, with rising sea levels and increased development on flood plain. Recurring flood losses have handicapped the economic development of both developed and developing countries. In recent years, there has been a considerable amount of attention of using GIS application in assessment of flooding hazard. Despite the current solution to avoid the effects of flooding, there is a lack in using proper solution in many countries. The goal of this study is how to use GIS application in assessment of flooding hazard and to propose solution to avoid such disasters in future.

## 1. NTRODUCTION

This term paper aims to present and discuss the applications and linking of the available GIS software (Arcinfo, Arcview) as well as the hydraulic modeling for two cases studies developed in two different countries as follows.

The first case study conducted by Al Saud, (2010) in 2009 discusses creating the flood assessment hazards of Jeddah. The study area was in Jeddah, Saudi Arabia. Jeddah is a city located in the west of the kingdom near the Red Sea. In November 2009, it has received a strict event. The flooded water attacked the urban areas and caused a lot of damage in roads, buildings, homes, cars and infrastructures etc. Many people died due to this event. The case study conducted in this area in 2009 aimed to assess the flood hazard risk in this important region by identifying the areas related to flood and then ordering the impacts factors at different levels of effect. The study used and focused on IKONOS satellite images and GIS tool. The method used in this study followed three major phases of work. These phases are Delineation of Drainage System, GIS Application, and Images Processing.

The second case study conducted by Forkuo in 2011in Northern of Ghana. In this case study, flood hazard assessment was implemented using the integration of GIS and

Advanced Spaceborne Thermal Emission and Reflectance Radiometer (ASTER) imagery. Also, land use classification and Digital Elevation Modeling using elevations digitized from the topographic map are used. In this study, flood hazard mapping is also addressed from perspective of different mapping scale in which administrative units are selected as the unit of investigation.

## 2. General Applications of GIS

### *1.1. GIS Definition and History*

GIS is an information system able of capturing, storing, analyzing, and displaying geographic information (Clarke, 1986). The power of GIS is the ability to combine geospatial information in unique ways—by layers or themes—and extract something new.

GIS technology integrates common database operations such as query and statistical analysis with the unique image and geographic analysis benefits offered by maps. These abilities distinguish GIS from other information systems and make it valuable to a wide range of public and private enterprises for explaining events, predicting outcomes, and planning strategies ("Overview of CIS,").

Work on GIS began in late 1950s, but first GIS software came only in late 1970s from the lab of the Environmental Systems Research Institute (developer of geographic information systems (GIS) software, Redlands, California) (ESRI). Canada was the pioneer in the development of GIS as a result of innovations dating back to early 1960s· Much of the credit for the early development of GIS goes to Roger Tomilson· Evolution of GIS has transformed and revolutionized the ways in which planners, engineers, managers etc. conduct the database management and analysis ("Overview of GIS,”).

GIS is used by private and public organizations worldwide to perform a broad range of mission-critical tasks including: water resources, hydrologic and hydraulic modeling, urban planning, and terrain analysis, mapping of a company's sales and product information linked to a customer's address; managing vital ecological systems such as forests and wetlands; serving maps, data and geographic analysis tools over the Internet; analyzing demographic trends at the local, regional, national and global levels; real-time tracking and coordination of transportation functions such as package deliveries and fleet management; and maintaining infrastructure networks in the telecommunications and utilities industries.

### *1.2. GIS Solutions for Civil Engineering*

Civil engineering is about developing and sustaining infrastructure. The profession covers many areas of interest and a broad range of expertise· As a result, civil engineers work with a voluminous amount of data from a variety of sources. Geographic information system (GIS) technology provides the tools for creating, managing, analyzing, and visualizing the data associated with developing and managing infrastructure· GIS allows civil engineers to manage and share data and turn it into easily understood reports and visualizations that can be analyzed and communicated to others. This data can be related to both a project and its broader geographic context. It also helps organizations and governments work together to develop strategies for sustainable development. Thus, GIS is playing an increasingly important role in civil engineering companies, supporting all phases of the infrastructure life cycle (ESRI, 2008).

## 3. PROBLEM STATEMENT

Flood is a big challenge facing the world in the present century. During these days floods occur in many places worldwide such as Saudi Arabia (e.g., Jeddah, Tabouk, and Hail), as well as, Pakistan, Yemen, Ghana, etc. Due to the importance of assessment, evaluate, and management of flooding, this term paper will focus on the applications of GIS. This can be achieved through presenting and discussing the assessment of flood hazard in two cases studies in different places to show the importance of this technology in this field.

## 4. OBJECTIVE

The goal of this term paper is to evaluate the hazard of flood in study areas. It aims identify the zones subjected to flood. It firstly gives background information about GIS. Then, it covers previous research carried out in the field of assessment of flood hazard as well as role of GIS technology in the field of monitoring, prediction, and assessment of flood. In addition, it concludes some notations which can help decision makers in the study areas to make better and management to protect people living in there region.

## 5. METHODOLOGY

The research methodology of this paper will focus on acquiring the knowledge through an extensive literature review about the GIS Applications in Assessment of flood hazard. In addition, it will include case studies the first one on flood assessment hazards of Jeddah and the second case study conducted in Northern region of Ghana.

## 6. LITERATURE REVIEW

Several studies have been conducted in GIS Applications to assess flood hazard which can be count these in the following:

F. Forte, et al., (2005) identified the distribution of areas with different risk degrees using a Geographic Information System (GIS) method. The data, referring to events that occurred from 1968 to 2004, have been collected in a database extracted in an easily consultable table. The final goal is the development of a risk map where the areas that are affected by floodings. The results show that more than 50% of the Salento peninsula shows high or very high risk values. The several maps that were utilized and generated represent an important basis in order to measure the flood risk, according to the model using historic records.

Charlchai. , et al., (2004) mentioned that Hat Yai Municipality suffered many flood events which caused the loss of life and destruction of property. Two digitized thematic maps that included basin boundaries, as well as 1982 and 2000 land-use maps were developed by using Geographic Information Systems (GIS). All GIS computations and coverage overlays were performed with PC ArcInfo software. Basin boundaries were digitized from the 1 : 50,000 topographic maps. Land-use coverage was generated in ArcInfo format by digitizing from land-use maps visually interpreted from Landsat TM images of the areas studied. A contour map showing variations in flood water levels at all locations across the municipality was generated from water level data obtained by use of the surface analysis function of ArcView 3.2 software.

G. Gambolati et al., (2001) indicated that GIS is employed in their study with two main objectives, i.e., georeferencing and processing geographic field data, and integrating the simulation results from each numerical model used to study the littoral dynamics and perform the risk analysis over the coastal lowlands.

Evans, et al., (2007) reported that GIS played a central role in integrating, organizing, processing and visualizing the spatial data from multiple sources. Its application is fundamental to the efficient and effective creation of DTM and for the construction of a 2D model. Representation of the model results, such as flooding extent, depth, velocity, flood progression, and flood hazard levels in a GIS environment has been a very effective way of conveying the flood risk and flood hazard.

P., Deckers, et al., (2007) indicate that the Flemish administration proposed a new approach in the1990s as a better solution. This approach focuses on minimizing the consequences of flooding instead of attempting to prevent floods. To implement this approach, large amounts of data were gathered for the Flemish Region. Using a Geographic Information System (GIS), a risk-based methodology was created to quantitatively assess flood risk based on hydrologic models, land use information and socio- economic data. Recently, this methodology was implemented in a specifically designed GIS-based flood risk assessment tool called LATIS. By estimating the potential damage and Number of losses during a flood event, LATIS offers the possibility to perform risk analysis quickly and effectively.

## 7. CASE STUDIES

### 7.1. Assessment of Flood Hazard of Jeddah Area 2009, Saudi Arabia – case study (1)

#### *7.1.1. Study area*

Jeddah is a city located in the west of the Kingdom near the Red Sea. It is an important port city as it is considered the center of international trade in Saudi Arabia. In November 2009, it suffered a disaster. The flooded water attacked the urban areas and caused a lot of damage in roads, buildings, homes, cars and infrastructures. Many people died due to this event. With the city’s close proximity to the sea, it is affected by high temperatures and humidity on summer with temperatures rising to over 40 degrees centigrade. According to Momani and Fadil (2010), "The nature of the ground makes it hard for it absorbs water in case of high rainfall, causing the floods".

Maghrabi's (2010) study mentioned the following: By the end of 2009, Jeddah was afflicted by heavy rains that lasted few hours and caused massive floods which left behind several casualties in addition to massive destruction in buildings, main highways and private properties in the eastern part of Jeddah governorate. Although the physical casualties were circumscribed accurately to put forwards adequate compensations for the residents in the affected area however, the impact of the disaster on the mental and psychological conditions has not been elaborated.

Figure 1: Flood plain area for Jeddah city, (Momani & Fadil, 2010)

### *7.1.2. The Causes of Flooding in Jeddah*

According to this case study, there are two main reasons causing the flooding in Jeddah. These are: Natural and manmade Causes. The natural causes might be occurs in Jeddah due to heavy rain which continues for many hours on the 25th of November, 2009. It was described as the worst in the past 27 years by the civil defense. These heavy rains happened with little or no warning and caused the largest loss of human life. Another factor that contributes to this problem, in addition to heavy rain, the topography such as surface conditions and slope of the receiving basin of many areas in Jeddah. According to Momani & Fadil (2010), "These areas is land

and plains by a slight decline from east to west vary from zero to 12.5 m" (p.424).

The manmade Causes are including insufficient drainage capacity and treatment and disposal of sewage, unsuitable building structure, mismanagement of main infrastructure, bad transportation management, and other human factors. Jeddah's latest flood is evidence of the failure of managers in addressing critical weaknesses that relate to the poor city planning, insufficiency of the drainage system, and absence of emergency readiness. Jeddah administration did not worry to put in place measures and precautions to deal with such a disaster in case of a similar occurrence.
The last flooding event in Jeddah shows the carelessness and possible corruption in Jeddah's flood drainage and disposal infrastructure and sewage treatment. Poor predicting and alleged corruption opened the way to random expansion of weakly constructed buildings.

### *7.1.3. The Effects of Flooding in Jeddah*

- Effects on Human Life

According to Momani & Fadil (2010), more than 121 fatalities and billions of dollars in losses in addition to around 20,000 sheltered families which cause a shift in public policy to deal with natural disasters in Saudi Arabia (p.426).
The effects on human health as a result of flooding can be very serious and there is sign that in some flood events more victims have occurred due to waterborne and water-related disease or injuries, rather than by drowning. With reference to Momani & Fadil (2010), " Director of Health Affairs in Jeddah invite parents to stay away from gatherings of water and torrential rains for fear of diseases that may cause and the announcement of the high death toll to 83 people" (p.425).

- Economic Costs

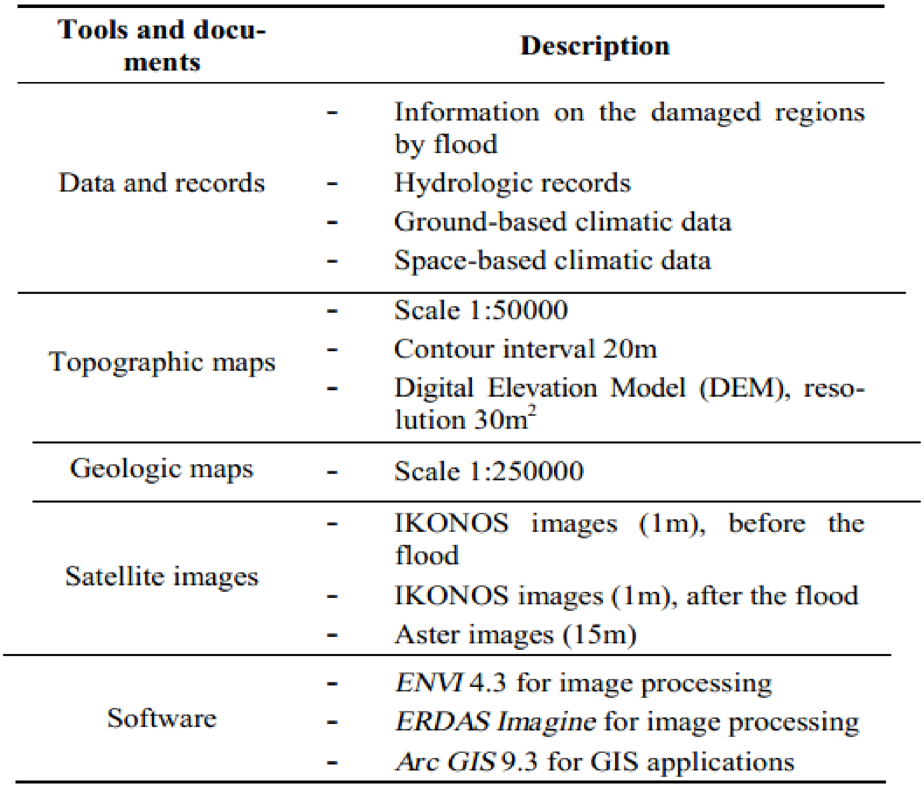
Public and private transport can be severely disrupted by floodwater, as well as communication, also it often creates personal catastrophes when people are carried away and killed. As written by Momani & Fadil ( 2010 ), " the monetary losses amounted to about 3 billion riyals, long installations and government facilities and compensation for those affected is estimated at 5.1 billion riyals" (p.426).

### *7.1.4. Method*

Flood process is influenced by several factors and these factors differ from one region to another depending mainly on the physical setting of the area under study. According to Al Saud (2010), these factors, as existed in the study area, were found to attribute to: basin width /outlet ratio, drainage density, slope, valleys intersection, valley cross-section, depressions, and fracture systems and sediments accumulation in valleys. However, these factors may act or not at different magnitude and scale. For example, the influence of sediments accumulation in the studied region of Jeddah may be replaced by diverse acting agent in another region, such as topography instability and mass movement. Also, rainfall regime may differ and some regions subjected to floods at lower rainfall intensity than other region.

Thematic maps and satellite images, indicating the physical characteristics of the region and the spatial distribution of the flood and destroyed regions are needed. The used tools and documentation in this study are shown in Table 1.

Table1. Major used tools and documents in the study, (Al Saud, 2010).



| **Tools and documents** | **Description** |
|---|---|
| Data and records | - Information on the damaged regions by flood<br>- Hydrologic records<br>- Ground-based climatic data<br>- Space-based climatic data |
| Topographic maps | - Scale 1:50000<br>- Contour interval 20m<br>- Digital Elevation Model (DEM), resolution 30m$^2$ |
| Geologic maps | - Scale 1:250000 |
| Satellite images | - IKONOS images (1m), before the flood<br>- IKONOS images (1m), after the flood<br>- Aster images (15m) |
| Software | - *ENVI* 4.3 for image processing<br>- *ERDAS Imagine* for image processing<br>- *Arc GIS* 9.3 for GIS applications |

"The applied method in this study followed three major phases of work. They were applied in a time sequence, even though some applications in satellite images processing and GIS were overlapped when it was necessary"(Al Saud, 2010). These phases are following:

### *a) Delineation of Drainage System*

Flood is just related to surface water regime, so the drainage area where flood may take place must be identified. This step includes the cartography of the outer limit of each catchment area (i.e. watershed), as well as the included streams network within this area.

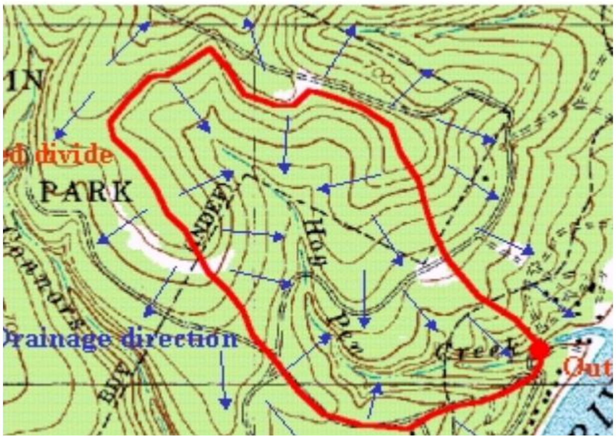


Figure 2. Manual delineation of drainage areas on a topographic map,(Furnans & Olivera , 2001)

This information will help identifying the characteristics of surface water basin and its influence in surface run-off behavior. In addition, many other hydrologic parameters can be identified and calculated. These parameters can be used for detailed analysis of drainage system characteristics whether for flood assessment or prediction. The study used topographic map (1:50000 scale) to obtain the approach of drainage system delineation and water divides were also identified. At the same time GIS digital applications were directly carried out using Arc GIS 9.3. The production of drainage network and catchments area in GIS form help in applying different measuring procedures and data integration, as well as it can help in modifying geo-spatial data whenever it is needed. Moreover, to support the resulted cartography obtained from topographic maps Digital Elevation Model was also utilized because it is able to apply automated tracing of streams and water basins.

### *b) Images Processing*

.It will not be possible to identify the comprehensive form of areas subjected to floods directly from ground investigation. As a result, this study used Satellite images which have become important tools of Earth observation since they can be used in several terrain applications and the processes occur. Because the area of study has unique geomorphologic and geologic characteristics, this study used IKONOS satellite images of the region before and after the flood and these images were processed. Nine images scenes were used in order to cover the whole region and they were processed by using ENVI 4.3 and ERDAS Imagine which have the ability to distinguished topography features. Consequently, digital data was subjected to pre-processing procedures such as atmospheric and geometric correction(Al Saud, 2010)

### *c) GIS Application*

This study used Geographic Information System (GIS) as an integral tool in all procedures applied in this study to produce data in digital form, as well as in storing digital data, thus accessibility of data modification and manipulation. The software which used for these procedures was Arc GIS 9.3.

It was used to determine area boundary and analysis, it also helped in diagnosing the drainage basins characteristics. Basin areas, slope gradient, width/length ratio, drainage density, etc which are some of flood-governed characteristics were identified. Thematic maps were produced by GIS application from available topographic and geologic maps as well as those geo-spatial data derived from satellite images processing. It is also severed in the integration of different thematic layers by superimposing these layers with each other to induce a comprehensive figure of different geo-spatial data(Al Saud, 2010).

### *7.1.5. Results*

Jeddah city is located in the flood plain of a group of wadis from the east side, which has width ranges from 5 to 10 km and limited from east by a number of mountain chains with average height 200m. Figure (3) shows that there are 24 basins in the study area and their area is about 688km2(Al Saud, 2010).

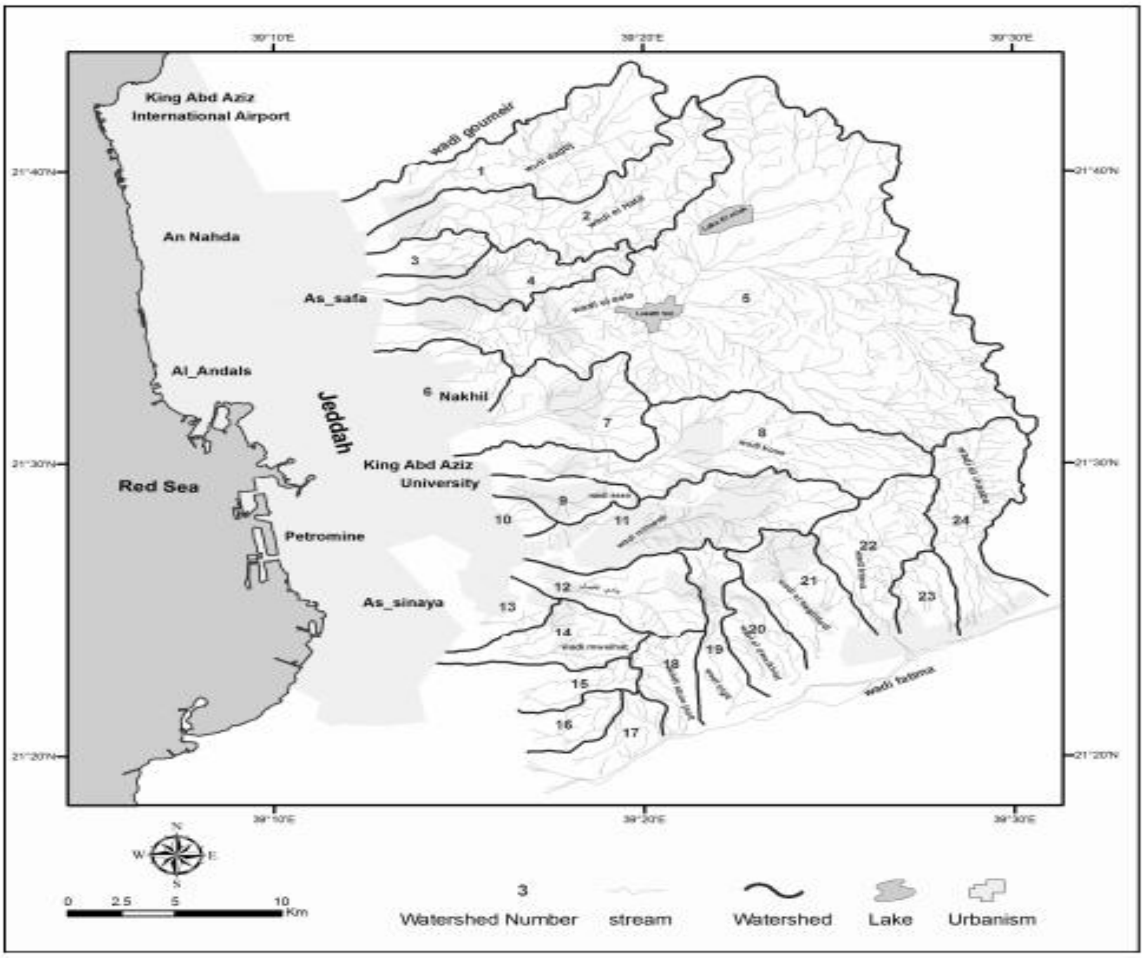


Figure 3. Watersheds map of Jeddah region, (Al Saud, 2010)

Sixteen of these basins open towards Jeddah city in the west and the rest open in the southwest direction and almost towards a large rift valley (Wadi Fatima). The basins (number 6, 10, 13, 15, 16, 17 and 23) have no specified shape, and thus unidentified outlet, especially when they open into urban areas (Figure 3). The identified basins are less than 100km2, so it considered as small-scale ones except Wadi Elasla, the biggest one, with approximately 299 km2(Al Saud, 2010). However, these basins together form a huge rocky basin surrounded by mountain chains. Therefore, rainfall water accumulates in this basin and when the sediments of the basin's valleys are oversaturated with water they tend to move downward Jeddah city and Wadi Fatima (Figure 4).

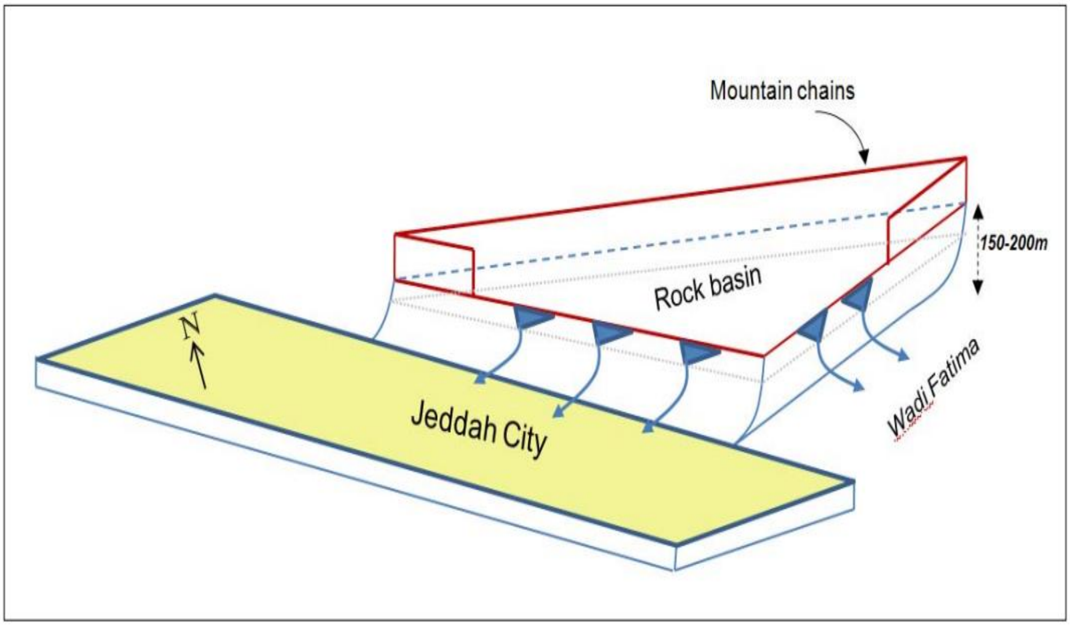


Figure 4. Schematic figure showing the rock basin, (Al Saud, 2010).

GIS and DEM applications were used to study the hydrologic and geomorphic specifications of the drainage basins. Consequently area, length, drainage density, basin width/outlet ratio and slope were measured (Table 2). This will help characterizing these basins and find out the relationship between these specifications and the regions where flood has taken place·

Table2.Major hydrologic and geomorphologic specifications of existing basins in the study area, (Al Saud, 2010)

| # | Basin | Area ($km^2$) | No. of valleys | Length ($km$) | W/O ratio | DD ($km/km^2$) | Slope ($m/km$) |
|---|---|---|---|---|---|---|---|
| 1 | Daghbj | 60.5 | 2 | 19.7 | 2:1 | 0.96 | 29.8 |
| 2 | El Hatiel | 62.9 | 2 | 23.0 | 2:1 | 1.36 | 11.65 |
| 3 | Basin # 3 | 12.2 | ST | 3.7 | 1.6:1 | 0.41 | 17.5 |
| 4 | Basin # 4 | 26.1 | ST | 15.5 | 1:1 | 1.15 | 8.4 |
| 5 | El Assla | 298.7 | 7 | 83.5 | 9:1 | 1.76 | 8.67 |
| 6 | Basin # 6 | ND | ST | 4.6 | - | 0.61 | 14.1 |
| 7 | Mreikh | 39.3 | 1 | 9.3 | 3.5:1 | 1.76 | 11.8 |
| 8 | Kawes | 72.2 | 3 | 53.9 | 2.5:1 | 1.37 | 6.57 |
| 9 | Asheer | 13.2 | 1 | 6.6 | 2:1 | 0.54 | 17.2 |
| 10 | Basin # 10 | ND | ST | 2.3 | - | 0.35 | 41.5 |
| 11 | Methweb | 53.1 | 1 | 12.4 | 5:1 | 1.33 | 14.5 |
| 12 | Ghlil | 27.3 | 1 | 8.9 | 4:1 | 0.85 | 5.4 |
| 13 | Selsli | ND | 1 | 3.4 | - | 0.53 | 8.8 |
| 14 | Muwaieha | 22.4 | 1 | 7.5 | 5.5:1 | 1.02 | 23.7 |
| 15 | Basin # 15 | ND | ST | 6.8 | - | 1.13 | 24.2 |
| 16 | Basin # 16 | ND | ST | 5.6 | - | 0.97 | 25 |
| 17 | Basin # 17 | ND | ST | 3.8 | - | 1.2 | 30.2 |
| 18 | Abou JeAlah | 14.9 | 1 | 6.9 | 1.8:1 | 1.53 | 13.7 |
| 19 | Al Ayah | 20.5 | 1 | 11.3 | 0.85:1 | 1.27 | 10.2 |
| 20 | Ed-Dowikhlah | 17.7 | 1 | 7.8 | 0.4:1 | 1.24 | 9.6 |
| 21 | El-Baghdadi | 29.9 | 1 | 8.9 | 0.5:1 | 1.14 | 12.3 |
| 22 | Ketanah | 33.1 | 1 | 9.7 | 4:1 | 1.25 | 11.2 |
| 23 | Basin # 23 | ND | ST | 5.3 | - | 1.23 | 28.3 |
| 24 | Esh-Shoaaba | 42.3 | 1 | 15.1 | 1.2:1 | 2.20 | 13.9 |

IKONOS satellite images of the region before and after the flood were used to identify the geographic distribution of flooded zones. As a result, comparative analysis on the basis of before-and after process can be applied. Moreover, the most obvious discrimination of topography features and more certainly the flooded zones. The recognized flooded zones were directly digitized and put as a separate layer, depending on direct visual interpretation (example in Figure 5) which was combined with digital and optical analysis(Al Saud, 2010)

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Figure 5. Example showing flooded zone as identified for IKONOS image, (Al Saud, 2010)

Therefore, a map showing flooded zones with different levels of damage was produced (Figure 6). The classification process from satellite images was followed by field verification to confirm the reliability of the extracted data, and more certainly to figure out the degree of impact on natural features. For this purpose GPS was used to correct the information observed on satellite images with ground observations. Depending mainly on the observations from satellite images and on-situ investigation, the obtained map was classified into five damage categories: very high, high, moderate, low and very low (Figure 6).

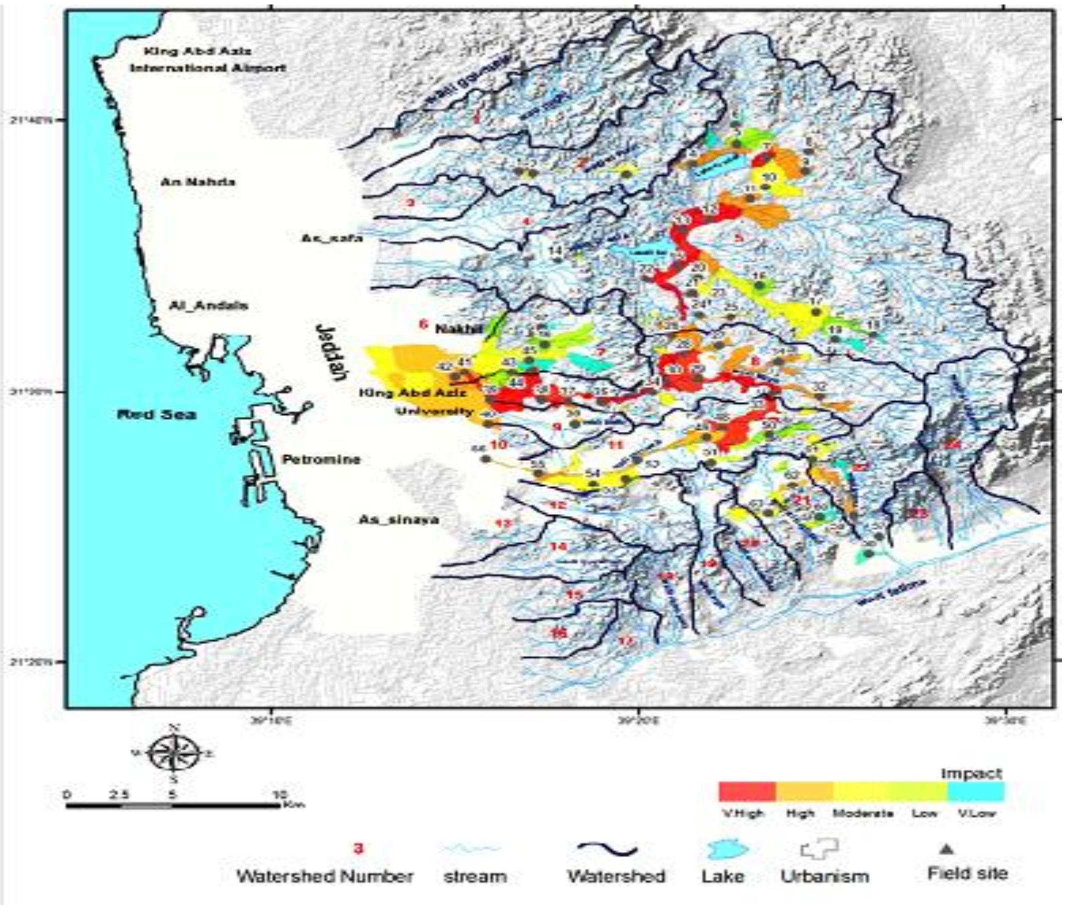


Figure6. Flooded zones in Jeddah region (November 2009) with five damage, (Al Saud, 2010)

A number of findings related to the mechanism of flood process were resulted by analyzing the produced map, in combination with field verification.

The main results are The location where rainfall has taken place, the maximum width of the flooded zones, The geographic distribution of flooded zones, and sudden cutout along some flooded zones due to human influence.

The total area of the flooded zones was measured as 124.58 km$^2$ , where the distribution of this spatial area were: 30.59 km2 , 40.79 km2, 32.89 km2, 13.54 km2 and 6.77 km2 to the impact levels of very high, high, moderate, low and very low; respectively. This means that approximately 57% (71.38 km2) of the flooded zones were subjected to high magnitude of catastrophism due to floods and torrents(Al Saud, 2010).

## 7.2. Flood Hazard Mapping using ASTER Image data with GIS -The Case of Location (Northern region of Ghana) - Case study (2)

### *7.2.1. Study Area*

The northern region of Ghana is located in the northern part of Ghana and bounded in the north by the upper east and the upper west regions, in the east by Togo, Cote Devoir in the west and in the south by the Brong Ahafo and Volta Regions. The study area lies between latitudes 11°00’ N and 8°30’ N, and longitudes 2°45’ W and 1°45’ E. It is the region with the largest area in Ghana of 5810 square kilometers. Its population as of year 2000 was 2,006,442(Forkuo, 2011).

### *7.2.2. Flood Hazard Mapping*

The aim of this study is to create a flood hazard map of the Northern Region of Ghana, particularly those regions where floods cause a recurrent danger. The purpose of this map is to identify the areas within a development plan that are at risk of flooding base on factors that are relevant to flood risks. According to this map, Policies put plans to minimize and manage such risk in the Northern Region of Ghana (see Figure 7). A flood risk map was produced based on administrative units which are a quick, accurate and cost effective means for planners and administrators to prepare remedial plan.

The White Volta and the Black Volta are the major river basins of the Northern region. These two rivers are the distributaries of Volta River. This study considered the White Volta River due to its destructive effect when the Bagre Dam in neighboring Burkina Faso releases water into it. Topographic map (Figure 7b) covering the study area at a scale of 1:50000 was used in this study, also this study used level 1b ASTER imagery (Figure 7c), digitized contour lines, water bodies and district thematic map within our study area and population census data. All districts have been digitized into a single polygon shape file from rectified image. Each polygon has been assigned a unique identity number ( i.e., ID) in the attribute table that represents a revenue district so that composite hazard index can be joined to the GIS data base using the common unique ID(Forkuo, 2011).

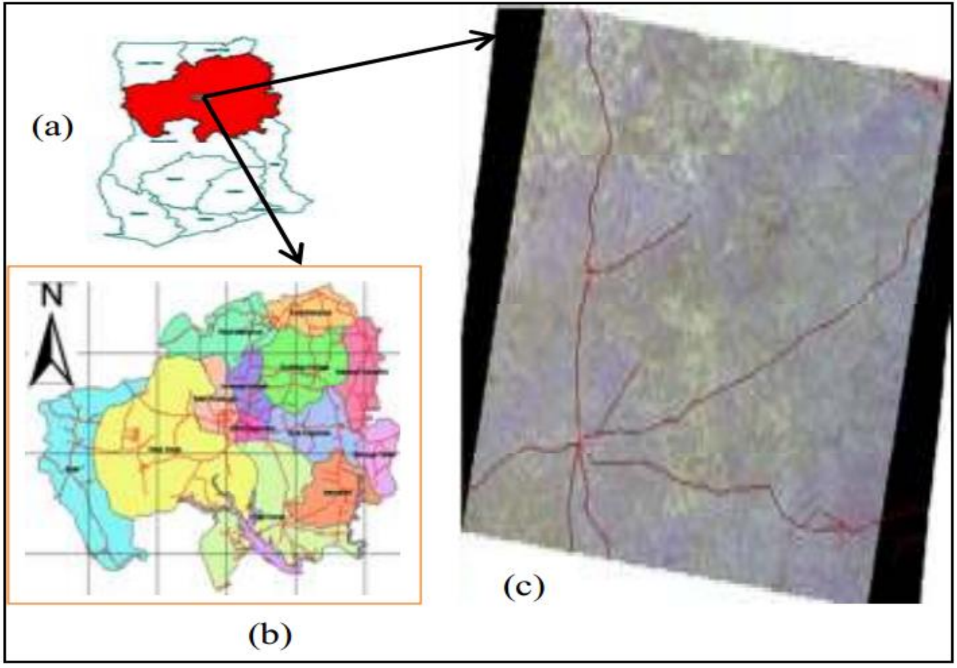


Figure 7: Location of the Study Area, (Forkuo, 2011)

Digital Elevation Models (DEMs) are the main source to produce information of land topography. It provides elevation information that is useful for many environmental applications including hydrologic modeling and flood management planning (Forkuo, 2011). They provide the opportunity to model, analyze and display phenomenon related to topography and other surfaces. the DEM was generated from contour extracted from topographic map as investigated in (Forkuo, 2011).

The DEM generated has been used to extract the highest point for each revenue district. The district boundary layer has been overlaid to the DEM and highest elevation for each polygon has been extracted using ArcGIS zonal statistics function (Forkuo, 2011). The raster map in Figure 8 indicates the highest elevation obtained for each district.

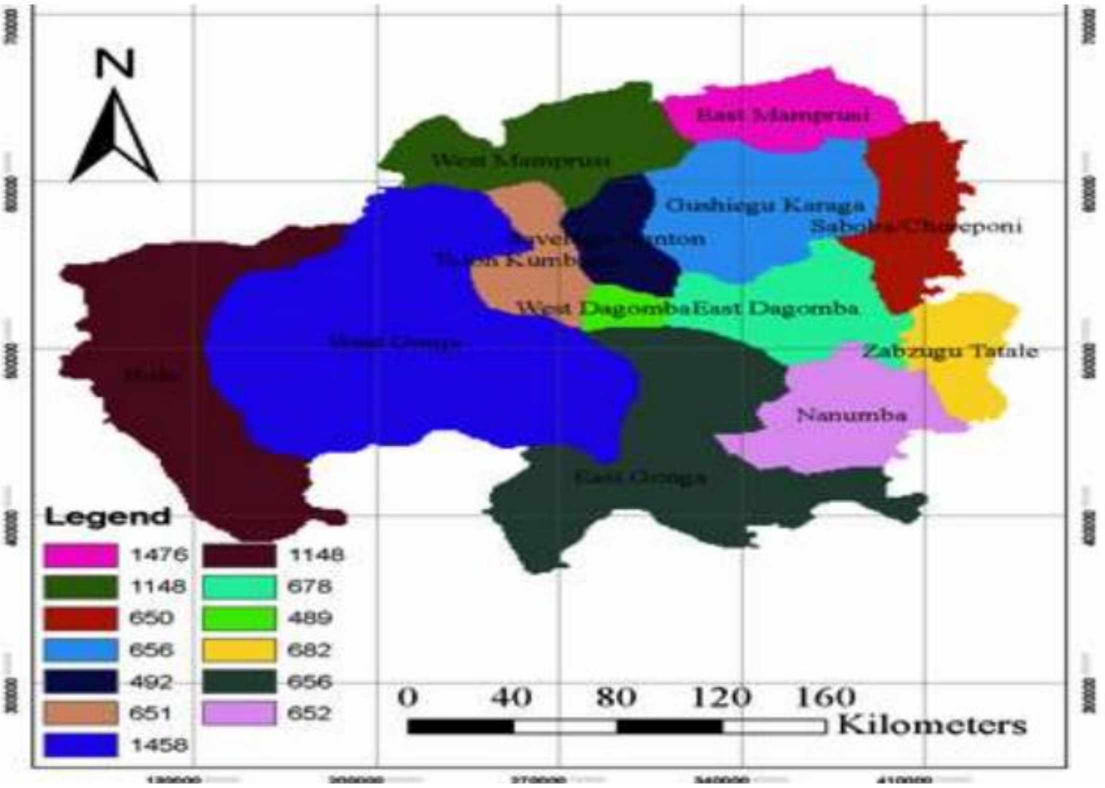


Figure 8: Highest Elevation of each District, (Forkuo, 2011)

The level-1B of ASTER (Advanced Spaceborne Thermal Emission and Reflectance Radiometer)image data was used to produce a high-resolution land use map for the study area. The method for the land use classification included two steps: (a) georeferencing and (b) image classification. A vector map of road intersections was used to georeference the image.

Classification of remotely sensed data is used to assign corresponding levels with respect to groups with homogeneous characteristics, with the aim of discriminating multiple objects from each other within the image (Forkuo, 2011).

For the analysis, various district distances from the White Volta River were determined. The midpoints of the districts were considered. Since the districts were digitized into polygons, it was firstly converted into point feature as shown in Figure 9 to define the midpoints of the various districts. The distances of the various districts (as shown in Table 3) in Kilometers were then extracted using Near Function of Analysis Tools.

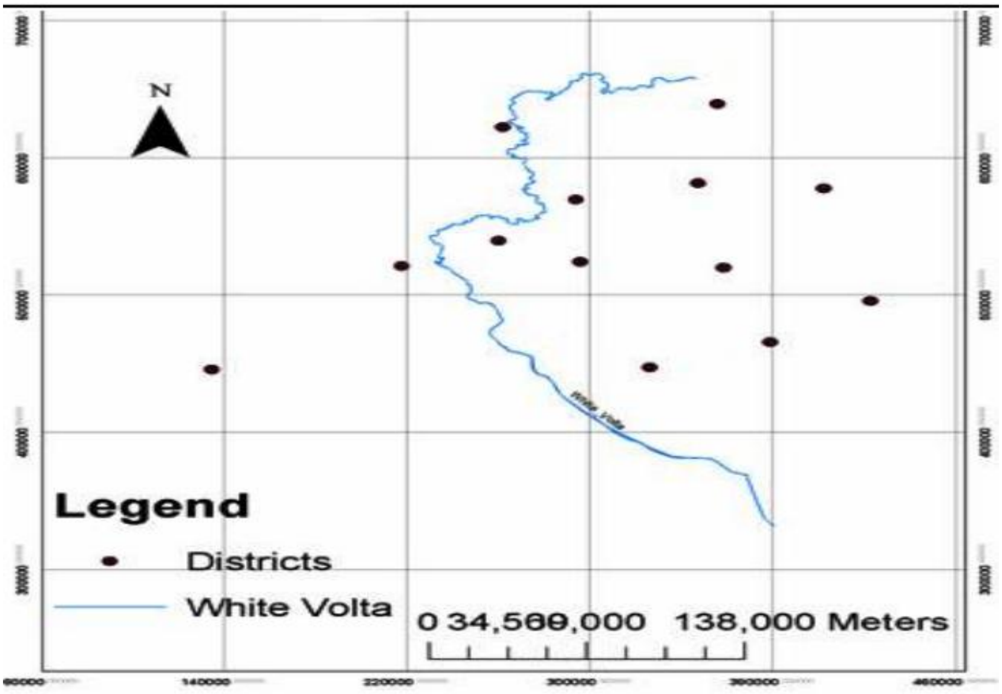


Figure 9: Points feature class of districts, (Forkuo, 2011)

Table 3: Distances from districts midpoints to White Volta, (Forkuo, 2011)

| FID | District | | Near_Distric | Near_FID |
|---|---|---|---|---|
| 0 | East Mamprusi | | 20.997 | 33 |
| 1 | West Mamprusi | | 4.496 | 33 |
| 2 | Saboba/Chereponi | | 98.120 | 33 |
| 3 | GushieguKaraga | | 69.619 | 14 |
| 4 | SaveluguNanton | | 14.628 | 33 |
| 5 | TolonKumbugu | | 13.719 | 18 |
| 6 | West Gonja | | 14.924 | 23 |
| 7 | Bole | | 123.592 | 33 |
| 8 | East Dagomba | | 88.121 | 14 |
| 9 | West Dagomba | | 36.260 | 14 |
| 10 | ZabzuguTatale | | 134.916 | 33 |
| 11 | East Gonga | | 42.744 | 0 |
| 12 | Nanumba | | 88.791 | 33 |

The study has described the integration of GIS and ASTER imagery in combination of DEMs in delineating flood hazard extent of each revenue district of the study area. An additive model was utilized to create a composite flood hazard index based on administrative units. It is recognized that the principle of assigning rank to the variables is very critical in this entire process of hazard mapping. In developing this model five variables (near distance to the White Volta River, population density, number of towns in each district, area of cultivated savanna, and availability of high ground) were investigated and the ranking scheme is presented in Tables 4, 5, 6, 7 and 8. These ranking scheme clearly displays that very low or 0 ranking have been applied at very high ‘Near_Dist’ value to prevent the far districts from getting a higher flood hazard index on the basis of other factors. On the other hand, ranking have been increased at rate with higher risk of flood occurrence. Each of the factors has been assigned different ranking to quantify the severity of hazard and this can be modified and improved in future research(Forkuo, 2011).

Table 4: Proximity to catchments area ranks, (Forkuo, 2011)

| Distance(km) from catchments Area (Near_Dist) | Hazard Rank (Dist_R) |
|---|---|
| 120 and above | 0 |
| 100-120 | 1.50 |
| 78-99 | 1.80 |
| 56-77 | 2.63 |
| 32-55 | 4.50 |
| 11-31 | 6.75 |
| 0-10 | 8.80 |

Table 5: Property density ranks, (Forkuo, 2011)

| Population Density (persons/hectare) (Pop_dens) | Hazard Rank (R_pop) |
|---|---|
| 0 | 0.25 |
| 0.001-5.40 | 1.0 |
| 5.41-7.84 | 1.5 |
| 7.85-11.62 | 2.5 |
| 11.63-80.29 | 4.0 |
| 80.30 and above | 6.0 |

Table 6: Highest Elevation ranks(Forkuo, 2011)

| Highest elevation (shelter) | Hazard Rank (R_shelter) |
|---|---|
| 1400 and above | 1.0 |
| 1151-1399 | 1.5 |
| 895-1150 | 2.5 |
| 630-894 | 3.0 |
| 629 and less | 3.0 |

Table 7: Property ranks(Forkuo, 2011)

| Number of Towns (Property) | Rank (R_prop) |
|---|---|
| 0-10 | 0.20 |
| 11-18 | 0.52 |
| 19-27 | 0.68 |
| 28-36 | 0.88 |
| 37 and above | 1.14 |

Table 8: Agricultural Produce ranks(Forkuo, 2011)

| Cultivate Savanna (Crops) | Rank (R_crop) |
|---|---|
| 0.00-0.20 | 0.02 |
| 0.20-0.50 | 0.04 |
| 0.60-0.80 | 0.06 |
| 0.80 and above | 0.08 |

For preparing a composite index an additive model has been adopted. It is recognized that the principle of assigning rank to the variables is very critical in this entire process of hazard mapping. Mostly, the process of assigning ranking to flood hazard indicators is knowledge based.

Table 9: Flood Hazard Index (FHI) (Forkuo, 2011)

| FID | Distric | Pop_R | Dist_R | Town_R | Height_R | Cult_R | FHI |
|---|---|---|---|---|---|---|---|
| 1 | East Mamprusi | 4.00 | 6.75 | 1.00 | 1.00 | 0.80 | 13.23 |
| 2 | West Mamprusi | 4.00 | 8.80 | 2.50 | 2.50 | 0.60 | 16.58 |
| 3 | Saboba/Chereponi | 4.00 | 1.80 | 3.00 | 3.00 | 0.80 | 10 .12 |
| 4 | GushieguKaraga | 2.50 | 2.63 | 3.00 | 3.00 | 0.80 | 9.61 |
| 5 | SaveluguNanton | 4.00 | 6.75 | 3.50 | 3.50 | 0.80 | 15.57 |
| 6 | TolonKumbugu | 4.00 | 6.75 | 3.00 | 3.00 | 0.80 | 15.69 |
| 7 | West Gonja | 1.00 | 6.75 | 1.00 | 1.00 | 0.04 | 9.93 |
| 8 | Bole | 2.50 | 0.00 | 2.50 | 2.50 | 0.04 | 6.18 |
| 9 | East Dagomba | 4.00 | 1.80 | 3.00 | 3.00 | 0.80 | 10.48 |
| 10 | West Dagomba | 6.00 | 4.50 | 3.50 | 3.50 | 0.80 | 15.48 |
| 11 | ZabzuguTatale | 4.00 | 0.00 | 3.00 | 3.00 | 0.80 | 8.00 |
| 12 | East Gonga | 4.00 | 4.50 | 3.00 | 3.00 | 0.00 | 12.38 |
| 13 | Nanumba | 4.00 | 1.80 | 3.00 | 3.00 | 0.8 | 10.12 |

Final flood hazard index (FHI) for district scale is created from an additive model which was adapted for this study (Sanyal and Lu, 2003; Forkuo, 2011).

FHI = (Dist_R + R_shelter + R_pop + R_prop +R_crop)

Where:

Dist _R is rank for the districts' proximity to the river,

R _shelter is rank for districts' highest elevation,

R _pop is rank for districts population density,

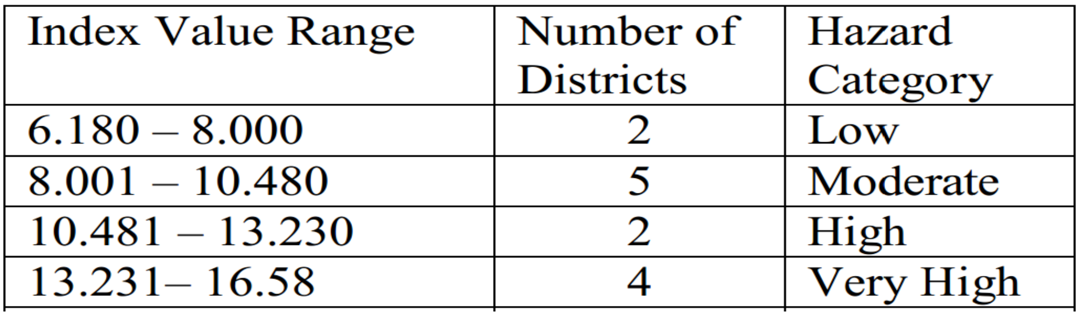
R _prop is rank for properties, and

R _crop is rank for agricultural produce at risk.

Table 8 shows with the flood hazard indices for the various districts

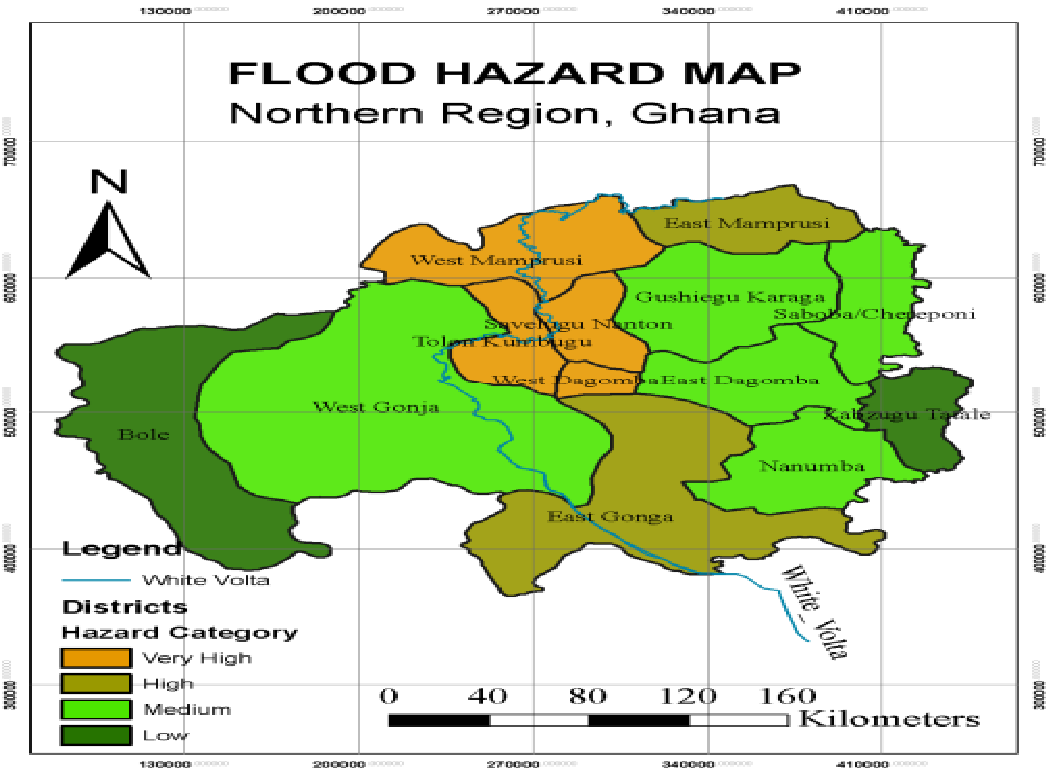
After the final flood hazard index was devised it has been represented in a graduated color map using ArcMap. Hazard values have been divided into 4 classes on the basis of 3 quartiles measurements. 1st, 2nd and 3rd quartiles of the hazard index values are 8.00, 10.48 and 13.23 respectively. The classification scheme is summarized in Table 10 and the final flood hazard map produced is shown in Figure 10(Forkuo, 2011).

Table 10: Classification of composite hazard ranks into qualitative hazard intensity classes



| Index Value Range | Number of Districts | Hazard Category |
|---|---|---|
| 6.180 – 8.000 | 2 | Low |
| 8.001 – 10.480 | 5 | Moderate |
| 10.481 – 13.230 | 2 | High |
| 13.231– 16.58 | 4 | Very High |

Figure 10: Flood Hazard Map (Forkuo, 2011)



## 8. RESULTS and DISCUSSION

The basic idea of flood hazard and risk assessment and mapping as undertaken in this study is to regulate land use by flood plain zoning in order to restrict the damages. It can be said that flood risk mapping, being an important non-structural flood management technique, will go long way in reducing flood damages in areas frequented by flood. This study confirmed that the method used in the north region of Ghana was able to integrate all the flood hazard causative factors and the components of flood risk as well in a GIS environment while in Jeddah did not take all the flood hazard causative factors. So the method used in the northern region of Ghana is more accuracy than that in Jeddah. However, composite maps were generated to assess flood risk of study areas. The flood hazard maps obtained from the overlay analysis of flood causative factors in the study area soundly agree to each other. And therefore, the combination of the two results would be a step forward for flood management and mitigation strategies. Although flooding is a natural phenomenon, we can’t completely stop it; we can minimize its bad effects by better planning. The study has shown that automatic flood map delineation can be produced for big river system in short time with the support of GIS and satellite images.

Flood management strategies in these regions have been geared towards ‘compensating’ the people of the affected areas after flood occurrence. Very little attention is paid on formulating rational land use planning to reduce flood induced disaster. Preparation of a flood hazard map for these regions would be the one of most crucial steps for implementing non-structural remedial measures.

## 9. CONCLUSIONS and RECOMMENDATIONS

We conclude that GIS technology is a powerful, sensitive, and an effective application in terms of flood risk assessment. It can be used to evaluate the areas affected by flood which can help people lives in these areas, GIS can be used as an indicator for decision makers to put the suitable plans to protect the people from such disaster. We found that GIS software enables risk consultants to simulate flooding because of the three functions: (1) automatic definition of the calculation area, (2) automatic acquisition of topographic data, and (3) rapid output of the result. Moreover, the information generated by the developed software enables risk consultants to precisely assess the risks and to develop measures against them. So we recommended that An early warning system must be established to reduce or avoid the effects of flooding. Awareness programs to reduce and prevent the dangers of flood and the role of the community should be activated. On the other hand, suitable hydraulic structures must be built by qualified engineers in the appropriate positions. These structures will help to reduce and prevent the effect of flooding.

# REFERENCES

Alexander, M., Viavattene, C., Faulkner, H., & Priest, S. (2011 , July ). *A GIS-based Flood risk assessment tool: supporting flood incident management at the local scale* rieved from Flooding/A GIS-based Flood Risk Assessment tool Supporting Flood Incident Management at the local scale.pdf

Al Saud, M. (2010). Assessment of flood hazard of Jeddah area 2009, Saudi Arabia. (2), 839-847. Retrieved from http://www.scirp.org/journal/PaperDownload.aspx?paperID=2729

Al Saud, M. (2012). Use of Remote Sensing and GIS to Analyze Drainage System in Flood Occurrence, Jeddah - Western Saudi Coast, Drainage Systems, Prof. Muhammad Salik Javaid (Ed.), ISBN: 978-953-51-0243-4, InTech, DOI: 10.5772/34008. Available from: http://www.intechopen.com/books/drainage-systems/use-of-remote-sensing-and-gis-to-analyze-drainage-system-in-flood-occurrence-jeddah-western-saudi-co

Al-Sulami Muhammad. (2011, Dec 10). Jeddah to have permanent rainwater drainage system. *McClatchy - Tribune Business News*. Retrieved from

http://search.proquest.com/docview/909967151?accountid=27795

Australian Government Australian Emergency Management Institute, (2009). *Flood*: *preparedness*. Retrieved from Attorney-General’s Department website http://www.bom.gov.au/australia/flood/EMA_Flood_preparedness_manual.pdf

Brisbane City Council (2011). *Engineering solutions for flood mitigation in Brisbane*. Retrieved from GHD website: http://www.brisbane.qld.gov.au/2010 Library/2009 PDF and Docs/5.Community Support/5.4 Emergency management/Engineering_solutions_for_flood_mitigation_in_Brisbane.pdf

Esri (2008). GIS Solutions for Civil Engineering. Retrieved from Retrieved from http://www.esri.com/library/brochures/pdfs/gis-sols-for-civil-engineering.pdf

Evans, S., Gunn, N., & Williams, D. (2007). Use of GIS in flood risk mapping . *5*(4), Retrieved from: https://idrc-gisworkshop.pbworks.com/f/Use of GIS in flood risk Mapping.pdf

Furnans, J., & Olivera , F. (2001). *Drainage Systems, ArcGIS hydro data model*. University of Texas at Austin Retrieved from http://www.crwr.utexas.edu/gis/gishydro01/book/chapter4/chapter4.pdf

Forkuo, E. (2011). Flood hazard mapping using aster image data with GIS. *1*(4), 932-950. Retrieved from http://www.ipublishing.co.in/jggsvol1no12010/EIJGGS2051.pdf

Forte, F., Pennetta, L., & Strobl, R. O. (2005). Historic records and GIS applications for flood risk analysis in the Salento peninsula (southern Italy). *Natural Hazards and Earth System Science*, *5*(6), 833–844. Retrieved from http://hal.archives-ouvertes.fr/docs/00/30/16/59/PDF/nhess-5-833-2005.pdf

Gambolati, G., & Teatini, P.(2002). GIS simulations of the inundation risk in the coastal lowlands of the northern Adriatic Sea. *35*, 963-972. Retrieved from

http://www.mssanz.org.au/MODSIM99/Vol%204/Gambolati.pdf

Jha, A., Bloch, R., & Lamond, J. (2012). Cities and flooding. Washington, DC: The World Bank. Retrieved from ***http://www.gfdrr.org/sites/gfdrr.org/files/urbanfloods/pdf/Citiesand*** Flooding uidebook.pdf

Momani, N., & Fadil, A. (2010). Changing public policy due to Saudi city of Jeddah flood disaster. 6(3), 424-428. Retrieved from http://thescipub.com/abstract/10.3844/jssp.2010.424.428

Overview of gis. Retrieved from (n.d.). http://www.megwrm.aun.edu.eg/sub/workshop1/overview_of_gis.pdf

T anavud, C., Y Ongchalermchal, C., Bennui, A., & D Ensreeserekul, O. (2004). Assessment of flood risk in hat yai municipality, southern thailand, using gis. (2044). *26*(1), 1-14. Retrieved from http://jsnds.sakura.ne.jp/contents/jnds/26_1_1.pdf