Flood Hazard Mapping using Aster Image data with GIS

1 author:

Eric Kwabena Forkuo
Kwame Nkrumah University Of Science and Technology

INTERNATIONAL JOURNAL OF GEOMATICS AND GEOSCIENCES
Volume 1, No 4, 2011

Research article ISSN 0976 – 4380

Flood Hazard Mapping using Aster Image data with GIS

Eric Kwabena Forkuo
Department of Geomatic Engineering, Kwame Nkrumah University of Science & Technology, Private Mail Bag, Kumasi, Ghana
eforkuo.soe@knust.edu.gh

ABSTRACT

Flood is one of the most devastating natural hazards which lead to the loss of lives, properties and resources. It has therefore become important to create easily read, rapidly accessible flood hazard map, which will prioritize the mitigation effects. This study addresses the need for an efficient and cost-effective methodology for preparing flood hazard maps in Ghana, particularly those regions where floods pose a recurrent danger. An additive model was utilized to create a composite flood hazard index of the study area. Taking Northern region as an example, and using available topographical, land cover and demographic data, the study created a district level map indicating flood hazard prone areas. A composite flood hazard index was developed incorporating variables of near distance to the White Volta River, population density, number of towns in each district, area of cultivated savanna (crops), and availability of high ground (Shelter). Also, maximum flood hazard zones were mapped in a GIS environment. The study demonstrated the potentials of GIS applications in flood hazard mapping.

Keywords: GIS Modeling, Hazard Maps, DEM, Hazard Rank, Land Cover/use Classification

1. Introduction

Flood hazard mapping is a vital component for appropriate land use in flood areas. It creates easily read, rapidly accessible charts and maps (Bapalu and Sinha, 2005) which facilitates the identification of risk areas and prioritize their mitigation effects. Flood hazard mapping is not a new endeavor in the developed countries of the world. One of the most active and well known in this sphere is Federal Emergency Management Agency (FEMA, 2006). Floods are of many types including flash flooding (Gruntfest and Handmer, 2001), flooding due to rising of ground water (Burt et al, 2002), coastal flooding (Doornkamp, 1998, Nicholls, 2002) and flooding due to the opening of a dam or reservoir. This research focuses on developing a methodology to delineate the flood hazard areas in Northern region of Ghana in a Geographic Information System (GIS) environment. The Northern part of Ghana is traditionally noted for its flood proneness.

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. The study area is characterized by

Research article ISSN 0976 – 4380

heavy rainfall in August and September which results in flooding. In addition, the Bagre Dam in neighboring Burkina Faso discharges water into the White Volta River in these months, exacerbating the flooding. The floods damage houses; collapse bridges; destroy water supply systems, schools, and roads; and impact crops and livestock. Many families are displaced and mostly seek shelter in school buildings and churches. In most cases state of emergency are declared in the three flood-affected regions (OFDA/CRED, 2002).

This research seeks to synthesize the relevant database in a spatial framework to create a flood hazard map of the Northern Region of Ghana. Flood is one of the most devastating natural hazards which lead to the loss of lives and properties hence the need to have proper mechanisms in place for it mitigation or effective response. In addition to the loss of lives and properties, resources are pumped in to restore the people of the affected areas. The amount to be spent during such situation could be reduce significantly when there are easily read, rapidly accessible flood hazard maps, which will prioritize the mitigation effects. This paper, therefore, describes the integration of GIS and ASTER imagery in flood hazard mapping. Also, land use classification and Digital Elevation Modeling using elevations digitized from the topographic map are described. The highest elevation of each district under study, proximity of each district to the catchments area and proportions of properties at risk are determined within GIS environment. 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.

The purpose of flood hazard such assessment is to identify the areas within a development plan that are at risk of flooding base on factors that are relevant to flood risks. Policies are then outline to be applied to such areas to minimize and manage such risk. A flood hazard map based on administrative units is a quick, accurate and cost effective means for planners and administrators to formulate remedial strategy. In addition it makes the process of resource allocation simple resulting in a smooth and effective implementation adopted flood management strategy. A small scale leads to identification of the higher hazard zone upon which a large scale and a detailed mapping eventually identifies the high hazard areas (Sanyal and Lu, 2005).

Of late, considerable attention has been given to the use of GIS and Remote Sensing to manage and control floods. In series of papers (Skelton and Panda, 2009; Singh and Sharma 2009; Leenaers and Okx, 1989; Cova and Church, 1997; Balabanova and Vassilev, 2010; Islam and Sado, 2000a; Islam and Sado, 2000b; Sinha et al, 2008; ; and Sanyal and Lu, 2004), various methodologies for creating flood hazard maps are presented. They provide an initial solution to the problem of flood management and control using GIS and remote sensing. For example, authors (Sanyal and Lu, 2005) discussed how the expansion of the Jangal River during the wet season posed a serious threat to lives, crops and property in the surrounding towns and villages.

In most of these papers, satellite images of the affected area were analyzed and GIS was used to create hazard zones in the event of a flood. These hazard zones were further divided into blocks and each block was assigned a hazard index that reflected the extent

Research article ISSN 0976 – 4380

of the hazard that confronted the block in question. In addition, hazard indices were assigned for population density, proximity and frequency of flood inundation over a period. This informed the authorities about resource allocation, evacuation practices and other mitigation options to adopt in the event of a flood. However, a closer look reveals that these hazard maps in nature are very data intensive and primarily depends upon very high resolution terrain data.

Other researchers like Islam and Sado (2002) integrated population density in the flood hazard maps in order to create land development priority maps. Also, Sun et al (2008) and Solaimani et al (2005) developed strategic flood risk assessment in GIS environment. In their paper, projections were made with regards to how floods which are brought about by tides will negatively affect the area. As in the first case GIS enabled them to create flood hazard maps which enabled them to construct embankments at strategic locations near the sea to combat the effect of tides and their resultant flooding.

The following sections summarize the methods used in data acquisition, image classification, DEM generation and flood hazard mapping. In addition, conclusions and possible related future works are discussed.

2. Flood Hazard Mapping

As previously stated, this study develops an approach to synthesize the relevant database in a spatial framework to evolve a flood hazard map of the northern region of Ghana. The purpose of flood risk assessment is to identify the areas within a development plan that are at risk of flooding base on factors that are relevant to flood risks. Policies are then outline to be applied to such areas to minimize and manage such risk in the Northern Region of Ghana (see Figure 1).The major river basins of the Northern region are the White Volta and the Black Volta. These two rivers are the distributaries of Volta River.

This study considered the White Volta River due to its devastating effect when the Bagre Dam in neighboring Burkina Faso releases water into it. The northern region 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.

For this study, topographic map (Figure 1b) covering the study area at a scale of 1:50000, level 1b ASTER imagery (Figure 1c), digitized contour lines, water bodies and district thematic map within our study area and population census data were used.

INTERNATIONAL JOURNAL OF GEOMATICS AND GEOSCIENCES
Volume 1, No 4, 2011

Research article ISSN 0976 – 4380

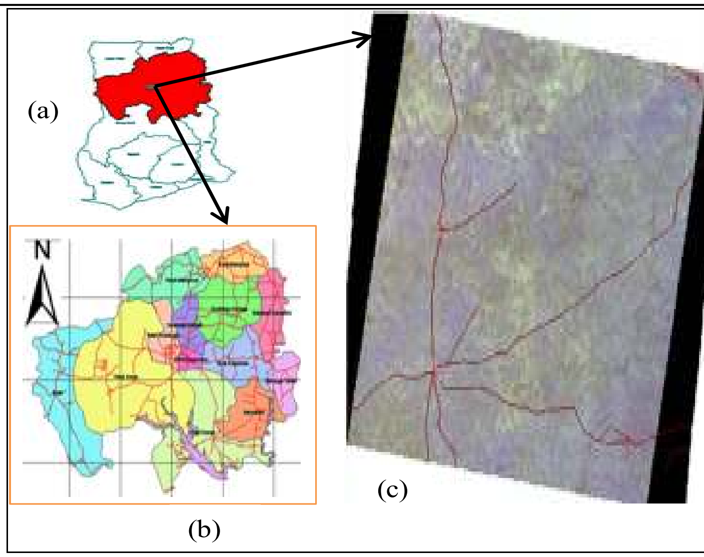

Figure 1: Location of the Study Area

The general methodology carried out in producing the flood hazard map is discussed in the subsequent sections. For this research report, mainly ESRI ArcGIS (McCoy and Johnston, 2005) software was used for digitizing the topographic map and also used as a GIS analysis. Before digitizing topographic contour map, it was imperative that certain factors and map properties were critically tested in order to produce a digitized topographic contour map which would be compatible with other maps of the same area. In the case of this project the following map properties were identified and tested: map scale (1: 2500); coordinate system (Ghana grid); map units; and grid interval (1000ft). After ascertaining map quality and properties, the control points with which the map will be registered later, were established before digitizing begun. In all, eight grid intersections, evenly distributed over the map were selected for the purpose of georeferencing. All districts have been digitized into a single polygon shape file from this 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.

2.1 Digital Elevation Models and their Applications in Flood Hazard Mapping

A digital elevation model (DEM) is a digital representation of the Earth's relief that consists of an ordered array of elevations relative to a datum, and referenced to a geographic coordinate system (Forkuo, 2010). DEMs are the main source to produce information of land topography. Today, the advancement in both information technology and computing power and graphics visualizations capabilities have led to the rapid growth of DEM usage in many fields, such as landscaping, mapping and GIS (Forkuo, 2008). It provides elevation information that is useful for many environmental applications including hydrologic modeling and flood management planning (McDougall et al, 2008). They provide the opportunity to model, analyze and display phenomenon

INTERNATIONAL JOURNAL OF GEOMATICS AND GEOSCIENCES
Volume 1, No 4, 2011

Research article ISSN 0976 – 4380

related to topography and other surfaces. DEM generation in principles requires elevation data for the area you wish to investigate and a set of methods to derive terrain specific information (Forkuo, 2008).

Typically, sources of of DEM data are derived from photogrammetric data, satellite image data, laser scanning data, cartographic data sources and ground surveys though accurate is expensive, time consuming and requires skilled personnel (Forkuo, 20080. Since ASTER relative DEM with a spatial resolution of 30m digital data is not suitable to meet 1:250,000 map accuracy standard and the investigation as stated is using a district level scale, the DEM was generated from contour extracted from topographic map as investigated in Forkuo (2008).

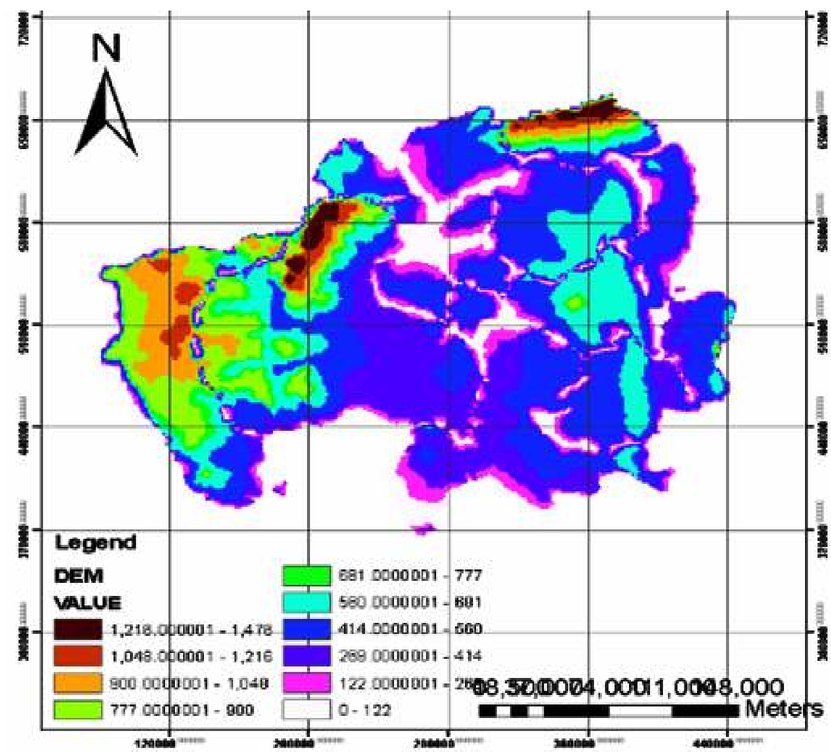

Figure 2: Contour Derived DEM

In the paper, initial implementation and results of contour derived DEM , which includes, the effect of interpolation methods, effects of different grid resolutions, accuracy of the generated DEMs and the sampling density along the contour lines, have been discussed. Also, the two most commonly used data formats for DEMs (i.e., triangular irregular networks and GRID DEMs) were discussed. To generate a DEM using data extracted from contours, the triangular irregular networks (TIN) model was first generated and then the TIN model was converted to DEM. As investigated in Forkuo (2008), natural neighbour interpolation was conducted in ESRI ArcGIS (McCoy and Johnston, 2005) environment and resultant DEM produced is shown in Figure 2.

Research article ISSN 0976 – 4380

2.1.1 Extraction of Highest Elevation

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 (McCoy and Johnston, 2005) zonal statistics function. The raster map in Figure 3 indicates the highest elevation obtained for each district.

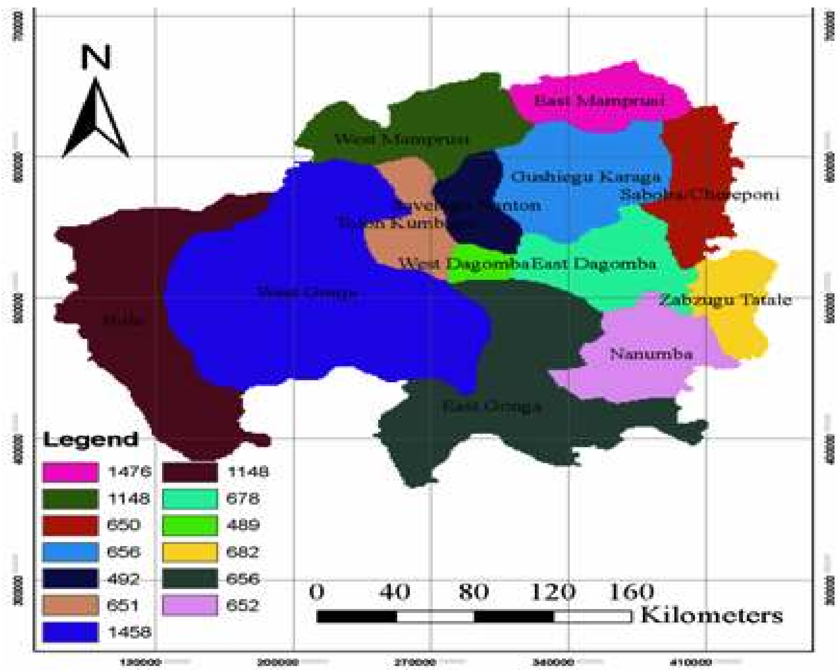

Figure 3: Highest Elevation of each District

2.2 Materials properties

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. This data is geometrically and radiometrically calibrated (Forkuo, 2010) with 15m spatial resolution in the visible and near-infrared (VNIR). The nine reflective bands of ASTER were used, covering the spectral range from 0.52 to 2.43 µm (Marcal et al, 2005). More detailed information on ASTER can be found in Forkuo (2010). The method for the land use classification included two steps: (a) georeferencing and (b) image classification. A vector map of road intersections that we clearly identified on the raster image was used to georeference the image. Identifiable four control points common to both the raster imagery and the vector map within our area of interest were selected. Some of the commonly used identifiable features include: intersection of roads, natural utility infrastructure (e.g., fire hydrants, corner of building and manhole covers), survey benchmarks and intersection of agricultural plots of land (Forkuo, 2010). A first order polynomial transformation (Affine transformation) was chosen and the control points were used to build a polynomial transformation that converted the raster dataset from its

INTERNATIONAL JOURNAL OF GEOMATICS AND GEOSCIENCES
Volume 1, No 4, 2011

Research article ISSN 0976 – 4380

existing location to the spatially correct location. The image was overlaid with the existing vector layer of roads as can be seen in Figure 1c.

2.2.1 Classification

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 (ACRoRS, 1999). It uses spectral or spectrally defined features, such as density, texture etc. in the feature space and then divides the feature space into several classes based on a decision rule. Unsupervised classification was performed to extract the land cover spectral pattern from the imagery. A total of six classes were selected for the unsupervised classification upon field investigation and the following classes were obtained; settlement, grassland, cultivated savanna, savanna woodland, riverine savanna and water body.

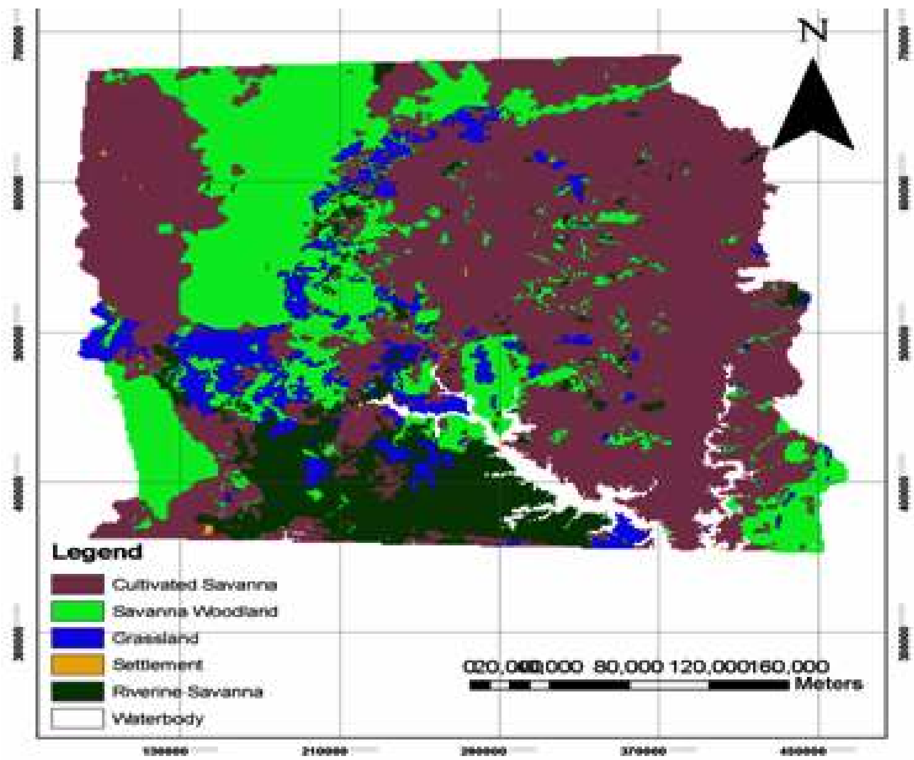

Figure 4: Classified Land Cover Map

This was necessary because most of the original classes were related in one way or the other. For instance classes like highly cultivated and low cultivated savanna were classified under one broad category. The land cover classification map as shown in Figure 4 was overlaid with the existing land cover shape file. This was done to compare the classified image with the land cover obtain in order to assess its accuracy. Google

Research article ISSN 0976 – 4380

earth imagery and topographical map were also used to check the accuracy of the land cover. The land cover layer was clipped to extract the portion that covers the study area.

2.3 Area Extraction

The reclassified map was converted to polygon features for overlaying. The landcover shape file was overlaid with the District feature class using the Union function of Analysis Tools of ArcToolbox and subsequently clipped it using the ArcGIS (McCoy and Johnston, 2005) clip function. The area of each land cover (as can be seen in Table 1) of the various revenue districts were computed, using the Tabulate Area function of the Spatial Analyst Tools.

Table 1: Area under Different Land use/Land cover Categories

District	Cultivated Savana	Savana Wood	Glassland	Riveerine Savana	Water Body
East Mamprusi	2664.983	345.815	0.000	11.772	2.943
West Mamprusi	3174.141	803.468	859.387	61.805	0.000
Saboba/Chereponi	3277.149	25.016	26.488	35.317	27.959
GushieguKaraga	5137.193	367.888	145.684	100.066	0.000
SaveluguNanton	1965.995	52.976	0.000	0.000	0.000
TolonKumbugu	2267.664	98.594	8.829	5.886	0.000
West Gonja	4604.491	7897.827	3698.014	957.981	388.490
Bole	4218.944	3449.321	1091.893	899.119	23.545
East Dagomba	3904.031	269.294	0.000	41.203	0.000
West Dagomba	656.313	70.635	0.000	4.415	0.000
ZabzuguTatale	2107.264	69.163	30.903	114.781	10.300
East Gonga	5881.799	969.754	420.864	1910.076	1164.413
Nanumba	3814.266	155.985	52.976	64.748	97.123

2.4. Proximity to White Volta River.

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 5 to define the midpoints of the various districts. The distances of the various districts (as shown in Table 2) in Kilometers were then extracted using Near Function of Analysis Tools.

Research article ISSN 0976 – 4380

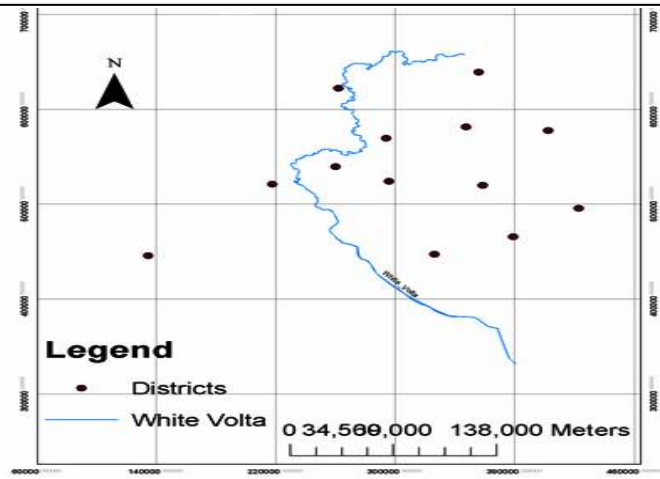

Figure 5: Points feature class of districts

Table 2: Distances from districts midpoints to White Volta

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

2.5 Flood Hazard Mapping

As previously stated, the purpose of flood risk such assessment is to identify the areas within a development plan that are at risk of flooding base on factors that are relevant to flood risks. Policies are then outline to be applied to such areas to minimize and manage such risk. FEMA is one of the most active and well known in the sphere of Mapping flood hazard. However, a closer look reveals that these hazard maps in nature are very data intensive and primarily depends upon very high resolution terrain data. Islam and Sado (2000a) formulated methodology to prepare flood hazard map for Bangladesh. Later,

Research article ISSN 0976 – 4380

efforts have been made to integrate population density in the flood hazard maps in order to create land development priority maps (Islam and Sado, 2002). In the study the issue of flood hazard mapping can be addressed from perspective of different mapping scale in a GIS environment in which administrative units are selected as the unit of investigation. A flood hazard map based on administrative units is particularly handy for the planners and administrators for formulating remedial strategy. In addition it makes the process of resource allocation simple resulting in a smooth and effective implementation adopted flood management strategy. A small scale leads to identification of the higher hazard zone upon which a large scale and a detailed mapping eventually identifies the high hazard areas (Sanyal and Lu, 2005).

Managing and analyzing flood hazard is one of the most important factors. Usually, hydrological models have been used to calculate hydrological parameters of a flood such as water depth, flood wave velocity etc in order to estimate flood hazard. The decision on which floodplain features should be included in or excluded from a flood hazard modeling requires a large amount of field knowledge combined with modeling experience. For instance, roads and railway embankments can be identified as the key features in the floodplain that could present a potential barrier to floodplain flow paths. Hydraulic structures, such as culverts or pipes underneath the roads and railway embankments would influence flooding mechanisms. These features locations and dimensions could be obtained through a combination of terrain and mapping analysis, from previous asset surveys and site visits (Sun et al, 2008).

2.5.1 Flood Hazard Index

Table 3: Proximity to catchments area ranks

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

An additive model has been adopted for creating a composite flood hazard map. It is recognized that the principle of assigning rank to the variables is very crucial in this entire process of hazard mapping. In this project the process of assigning rank to the

Research article ISSN 0976 – 4380

flood hazard indicators is primarily knowledge based. The variable 'Near_Dist' which is the proximity to the river has been attached high importance because where the risk of inundation is very low other variables do not contribute anything to the element of flood hazard. Districts have been assigned rank for each of the 5 hazard indicators. The ranking scheme for flood hazard indicators is presented in Tables 3, 4, 5, 6 and 7. 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.

Table 4: Property density ranks

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 5: Highest Elevation ranks

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 6: Property ranks

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

Research article ISSN 0976 – 4380

Table 7: Agricultural Produce ranks

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

2.5.2 Flood hazard index model

For preparing a composite index, a model is normally adopted. The variables and the principle of assigning ranks to the variables are very crucial in arriving at a flood composite index in process of hazard mapping. Mostly, the process of assigning ranking to flood hazard indicators is knowledge based.

Table 1: Flood Hazard Index (FHI)

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).

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

Research article ISSN 0976 – 4380

for properties, and R_crop is rank for agricultural produce at risk. The attribute tables bearing the various indicators ranking, were join and field calculations performed to obtain the index for the districts. The table with the flood hazard indices for the various districts is shown in Table 8.

2.5.3 Hazard categories

After the final flood hazard index was devised it has been represented in a graduated colour map using ArcMap. It has been classified into 4 hazard categories by natural breaks (Jenks) scheme since the data ranges are not very familiar. In this process ArcMap identifies break points by identifying inherent clustering pattern of the data. Class boundaries are set where there are relatively big jump in the data values (Minami, 2000). Hazard values have been divided into 4 classes on the basis of 3 quartiles measurements. The first, second and third quartiles of the hazard index values are 8.00, 10.48 and 13.23 respectively. The classification scheme is summarized in Table 9 and the final flood hazard map produced is shown in Figure 9.

Table 2: 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
6.180 – 8.000	2	Low
8.001 – 10.480	5	Moderate

3. Analysis of Results

For the study a total of thirteen (13) districts been analyzed, mean area is 4185.098Sq. Km. Five factors have been taken into consideration for developing the composite flood hazard index. Each of the factors has been assigned different ranking to quantify the severity of hazard. In Figure 6, the final flood hazard map is represented in a graduated colour map. It was classified into 4 hazard categories by natural breaks. The flood hazard map (as can be seen in Figure 6) exhibits that there is no defined pattern in the disposition of flood hazard zones. Also, the flood hazard distribution for all the districts is graphed in Figure 7. Contrary to the overall topographic configuration high hazard zones are not necessarily located very near to White Volta River. In the central northern side of the area four districts depict very high hazard situation. This high hazard potential might be as a result of their higher population density. The west Gonja district in which the river almost runs through it middle depicts medium hazardous zone.

Research article ISSN 0976 – 4380

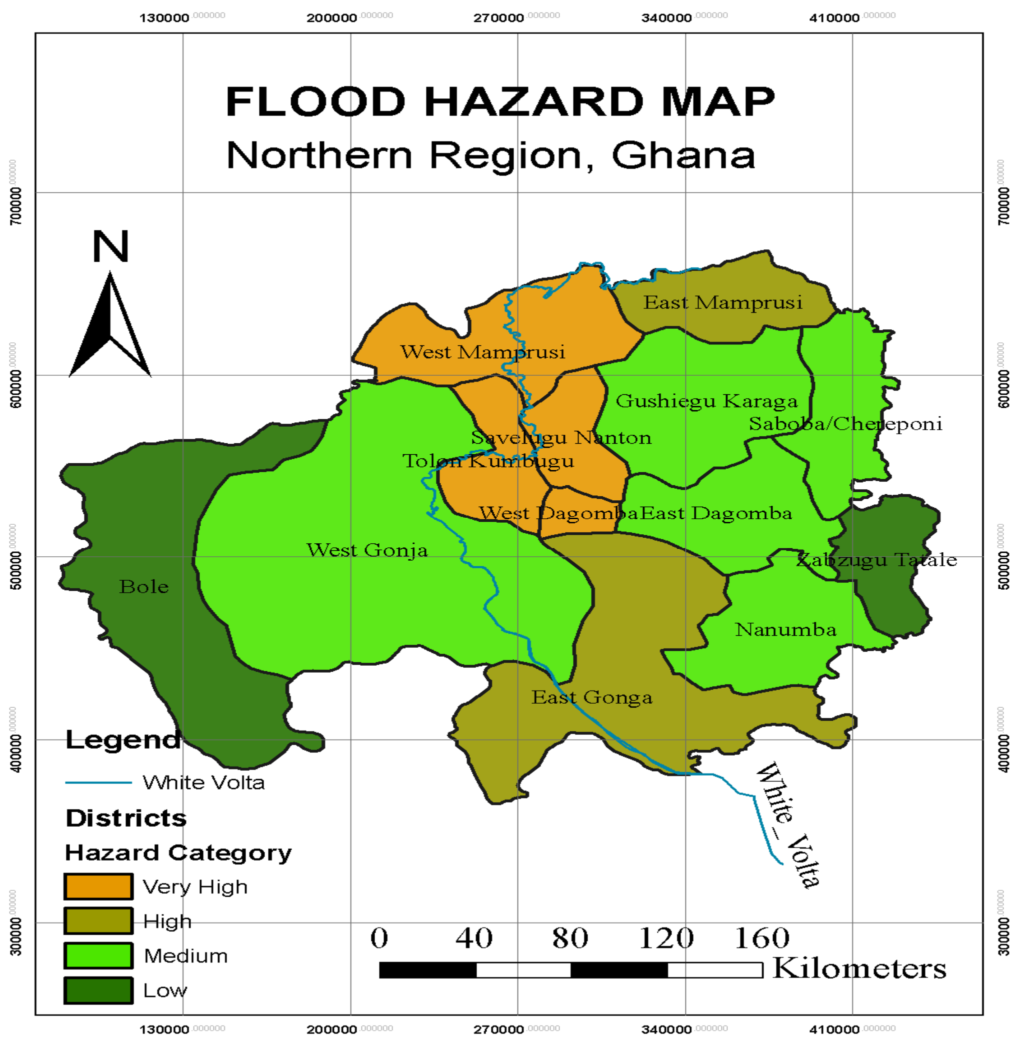

Figure 6: Flood Hazard Map

The result obtained for the indicators proximity ('Near_Dist'), maximum heights (shelter) and cultivated savanna are graphed in Figures 8, 9 and 10 respectively. Proximity (Figure 8) of the districts from the river has been considered as the measure of flood proneness of a particular district. To quantify the lives under potential flood threat population density of each was as another important variable. Figure 9 (the indicator shelter) takes into account the aspect of flood emergency management. During the time of inundation, affected population are required to be evacuated to a safe place for temporary shelter (i.e., that is a relatively higher ground), not likely to be submerged by flood water. Cultivated Savanna (as in Figure 10) was the indicator that takes into account agricultural produce that will be affected in times of flood. Number of towns in each district was considered to quantify the economic assets under potential flood threat. This was considered rather than

Research article ISSN 0976 – 4380

settlement because many structures are thatch roofed and therefore in classification they might appear as grassland.

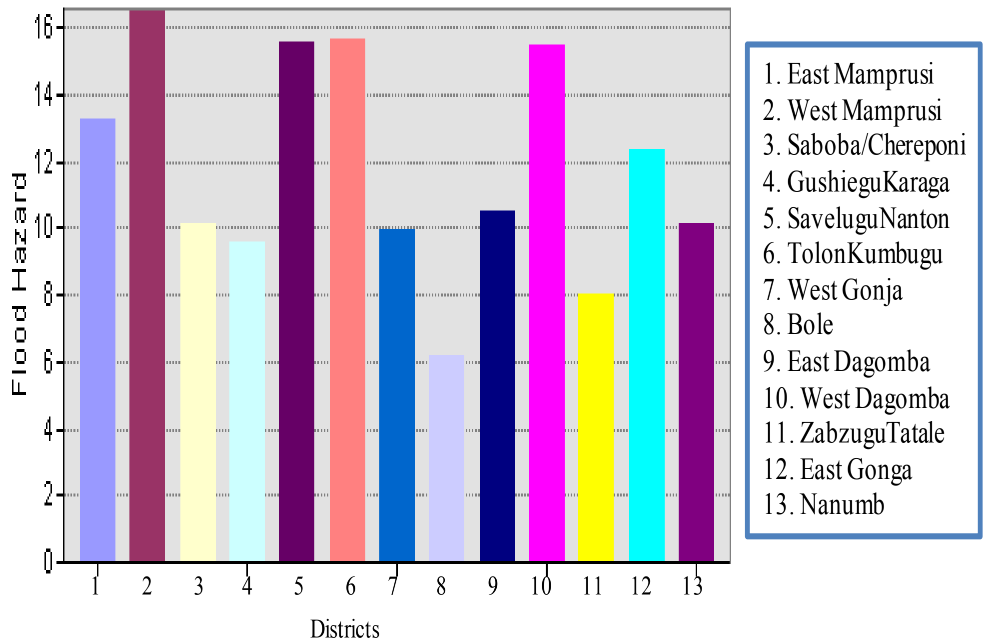

Figure 7: Flood hazard distribution for various districts

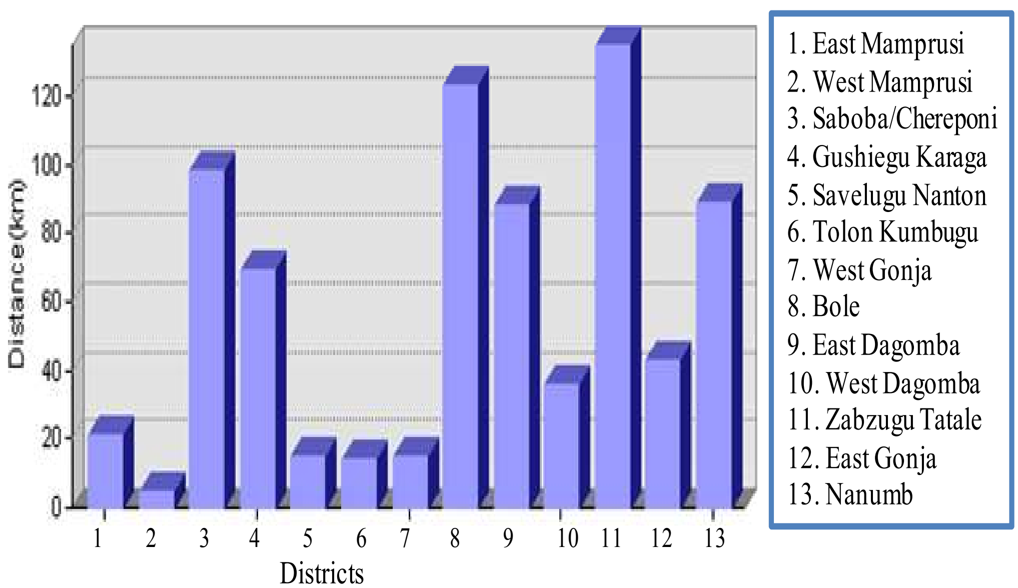

Figure 8: Proximity

Research article ISSN 0976 – 4380

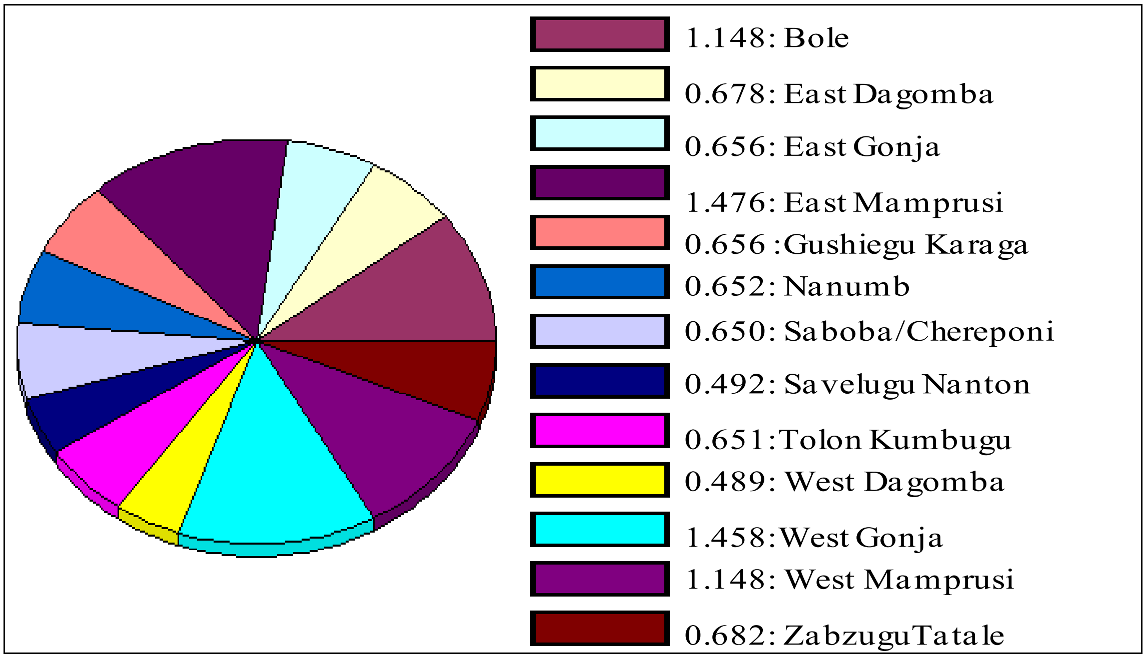

Figure 9: Maximum heights (km)

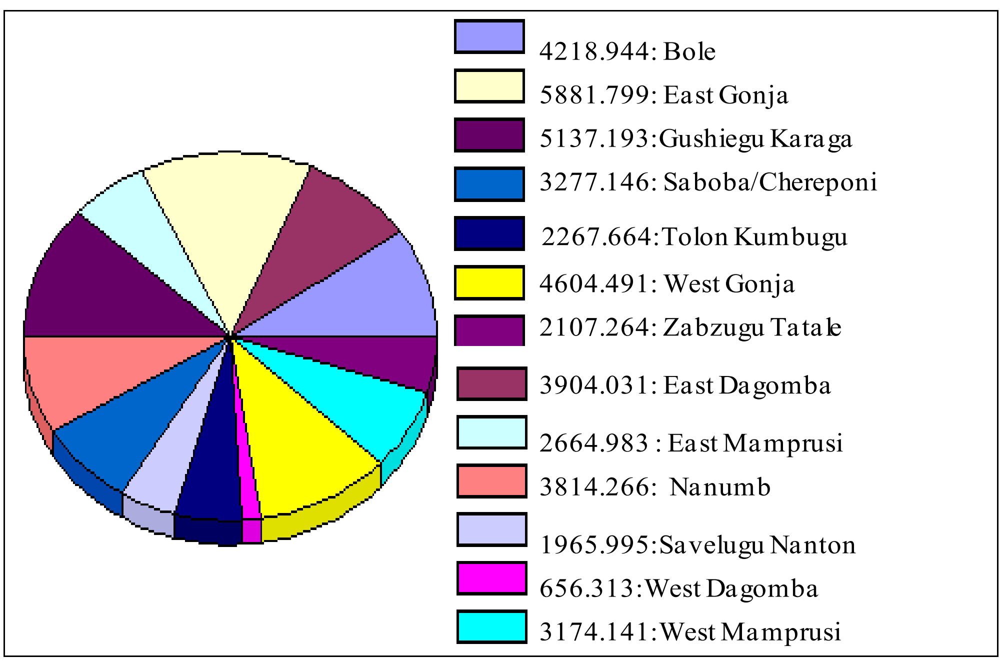

Figure 10: Cultivated savanna distribution (km^2)

Research article ISSN 0976 – 4380

4. Conclusions and Recommendations

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. 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. 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. Also, maximum flood-prone areas were mapped using high resolution DEM and these areas were extracted by applying spatial analysis on GIS. These results obtained in this study provide essential information for planners and administrators to analyze and manage flood hazards, and also to formulate remedial strategy. However, one thematic area that could have been factored into the flood hazard modeling is the ease of evacuation of lives and property in the event of a flood. This theme considers access routes to and from flood zones in the event of a flood. Other factors, which could also improve the results are, flood inundation statistics, flood depth, velocity and flood progression but are not investigated.

5. References

1. ACRoRs., 1999. Instruction of Remote Sensing Notes and GIS Work Book CD-ROM Version 1.0. Prepared by Asian Center for Research on Remote Sensing (ACRoRS) in Asian Institute of Technology (AIT). Available at http://ksrs.or.kr/library/index.htm. Accessed on 20th May 2010.

2. Balabanova , S., and Vassilev, V., 2010. "Creation of Flood Hazard Maps". Water Observation and Information System for Balkan Countries (BALWOIS) 2010 - Ohrid, Republic of Macedonia - 25, 29 May 2010.

3. Bapalu, G. V., and Sinha, R., 2005. "GIS in Flood Hazard Mapping: A Case Study of Kosi River Basin, India". GIS Development Weekly, 1(13), pp 1-3. Accessed from http://www.gisdevelopment.net/application/natural_hazards/floods on 10th October 2008.

4. Burt, T.; Bates, P.; Stewart, M.; Claxton, A.; Anderson, M.; and Price, D., 2002. "Water Table Fluctuations within the Floodplain of the River Severn, England", Journal of Hydrology, 262(1-4), pp 1-20.

5. Cova, T. J., and Church, R. L., 1997. "Modeling Community Evacuation using GIS", International Journal of Geographical Information Science, 11, pp 763–84.

6. Doornkamp, J. C., 1998. "Coastal Flooding, Global Warming and Environmental Management", Journal of Environmental Management, 52, pp 327-333.

7. FEMA (Fedaral Emergency Management Agency)., 2006. Accessed from http://www.fema.gov/hazard/flood on 20th December 2008.

Research article ISSN 0976 – 4380

8. Forkuo, E. K., 2010. "Digital Elevation Modelling Using ASTER Stereo Imagery", Journal of Environmental Science and Engineering, 52(2), pp 81-92.

9. Forkuo, E. K., 2008. "Digital Terrain Modelling in a GIS Environment". The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences, 37(B2), pp 1023-1029.

10. Gruntfest, E., Handmer, J., 2001. Dealing with Fash Foods: Contemporary Issues and Future Possibilities. In: Gruntfest, E., Handmer, J. (Eds.), Coping with Flash Floods. Kluwer Academic Publishers, Dordrecht, pp 3–10.

11. Islam, M. M., and Sado, K., 2000a. "Flood Hazard Assessment in Bangladesh using NOAA AVHRR Data with Geographical Information System", Hydrological Processes, 14(3), pp 605-620.

12. Islam, M. M., and Sado, K., 2000b. "Development of Flood Hazard Maps of Bangladesh using NOAA-AVHRR Images with GIS", Journal of Hydrological Sciences, 45(3), pp 337-355.

13. Islam, M. M., and Sado, K., 2002. "Development of Priority Map Flood Countermeasures by Remote Sensing Data with Geographic Information System", Journal of Hydrologic Engineering, Volume 7, Number 5, pp- 346-355.

14. Leenaers, H., and Okx, J. P., 1989. "The Use of Digital Elevation Models for Flood Hazard Mapping", Earth Surface Processes and Landforms, 14(6-7), pp 631-640.

15. Marcal A, R. S., Borges J. S; Gomes J. A; and Pinto Da Costa J. F.; 2005. "Land Cover Update by Supervised Classification of Segmented ASTER Images", International Journal of Remote Sensing, 26(7), pp 1347-1362.

16. McDougall, K., Liu, x., Basnet, B., and Apan, A., 2008. "Evaluation of current DEM Accuracy for Condamine Catchment", Proceedings of the 8th International Symposium on Spatial Accuracy Assessment in Natural Resources and Environmental Sciences Shanghai, P. R. China, June 25-27, 2008, pp 71-78.

17. McCoy, J., and Johnston, K., 2005. "Using ESRI AcrGIS Spatial Analyst", Accessed from http://www.esri.com on 5th June 2010.

18. Minami, M. (2000). "Using ArcMap", ESRI, Environmental system research institute, Inc, USA, pp- 146.

19. Nicholls, R. J., 2002. "Analysis of Global Impacts of Sea-level Rise: A Case Study of Flooding, Physics and Chemistry of the Earth", 27, pp 1455–1466.

Research article ISSN 0976 – 4380

20. OFDA/CRED (The Office of U.S. Foreign Disaster Assistance/Centre for Research on Epidemiology of Disasters), 2002. The OFDA/CRED International Disaster Database, Accessed from http://www.cred.be/emdat on 3rd March 2009.

21. Sanyal, J., andvLu, X. X., 2004. “Application of Remote Sensing in Flood Management with Special Reference to Monsoon Asia: A Review”, Natural Hazards, 33(2), pp 283-301.

22. Sanyal, J., and Lu, X. X., 2005. “Remote Sensing and GIS-based Flood Vulnerability Assessment of Human Settlements: A Case Study of Gangetic West Bengal, India”, Hydrological Processes, 19, pp 3699–716.

23. Sinha, R., Bapalu, G. V., Singh, L. K., and Rath, B., 2008. “Flood Risk Analysis in the Kosi River Basin, North Bihar using Multi-Parametric Approach of Analytical Hierarchy Process”, Journal of the Indian Society of Remote Sensing, 36(4), pp 335-349.

24. Singh, A. K., Sharma, A. K., 2009. “GIS and a Remote Sensing Based Approach for Urban Flood-Plain Mapping for The Tapi Catchment, India”, Journal of Hydrological Sciences, 331, pp 389-394.

25. Skelton, S., Panda, S . S., 2009. “Geo-spatial Technology use to Model Flooding Potential in Chestatee River Watershed”, Proceedings of Georgia Water Resources Conference, April 27–29, 2009, at the University of Georgia, pp 6.

26. Solaimani, K., Mohammadi, H., Ahmadi, M. Z., and Habibnejad, M., 2005. “Flood Occurrence Hazard Forecasting Based on Geographical Information System”, International Journal of Environmental Science and Technology, 2(3), pp 253-258.

27. Sun, Y. E., Neil, G., Daniel, W., 2007. “Use of GIS in Flood Risk Mapping”. National Hydrology Serminar on GIS in Hydrology Applications – Modelling - Data Issues”, Tullamore, Ireland, pp 1-12. Accessed from http://www.opw.ie/hydrology/data/ on 2nd January 2011.