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APPLICATION OF GIS AND REMOTE SENSING IN DISASTER MANAGEMENT: A CRITICAL REVIEW OF FLOOD MANAGEMENT

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ABSTRACT

Disasters are an uncertain and unavoidable event in nature, which affect adversely social, economic, environmental and humanitarian sectors. The main objective of the study is to identify a significant pattern of a certain disaster over time using Remote Sensing (RS) and Geographic Information System (GIS) applications to understand its nature which will help to solve complex planning and management problem and decision making. It will provide a starting point for researchers on a direction of strategy making to reduce the damage. Obtaining Multi-temporal spatial data from Electromagnetic Radiation (EMR) wavelengths and sensors, give a framework to pretend the nature of the disaster in GIS. Satellite covers a larger area than any other platform to analyze micro climate and damage detection in large scale natural disaster. This review paper will work as a tool for applying GIS & RS in disaster management. This technology can be utilized in some phase of a disaster management such as prevention, preparedness, relief, reconstruction, warming and monitoring and will create scope for further analysis for disaster management.

Keyword: Remote Sensing, Geographic Information System, Pattern identifying, Strategy making

Introduction

Flood is a common disaster in this subcontinent. It affects a lot of people. According to registered disaster data, from the time period of 1990 to 1999, 13% of total disaster happened in Europe, mostly 42% occurs in Asia. Flood normally occurs in monsoon season from June to September. It has caused many devastations in Bangladesh in many time. 1966,1987,1988, 1998 these are some remarkable year for the flood. Bangladesh has suffered from another flood in July, this year. Due to heavy runoff from the Himalaya, riverbank areas mostly Uttarbanga (Northern portion) of Bangladesh has suffered from flood. In addition, the flood is a combined effect of the inadequate drainage system, river embankment (Farakka Badh), filling up the river. As Bangladesh is a riverine country, the flood is one of the prime concern. In this review paper, it is shown, how the pattern of the flood over time could be specified by using GIS & RS applications. The advantage of using GIS is not the only visualization of the flood situation but also scope for further flood analysis (Hausmann *et al.*, 1998). Flood mapping shows the possibility of hazard and predicts the next flood season (Godschalk, 1991). In addition, change of wetland in spatial and temporal dynamics can be quantified obtaining images from four Landsat and processing through some classification algorithm and the post classification change detection technique in GIS environment. This will help to save wetlands and flood water can discharge faster. It will help to reduce damage and save more lives by analyzing and detecting flood nature and pattern.

Applications of Remote Sensing in Flooded Area

Application of Optical Remote Sensing

Remote Sensing can be used as a tool of mapping flooded area. This tool is not only a new technology but also came from the 20th century. In the initial stage, Multi Spectral Scanner (MSS) with 80 m resolution was available from Landsat. The Landsat was used for flood mitigation in the USA. The MSS was suitable for distinguishing water from the dry soil with band 7 (0.8-1.1 μm) due to near infrared range of the spectrum

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(Smith, 1997). Landsat Thematic Mapper (TM) imageries with 30 m resolution from the early 1980s became the prime source of data for monitoring floods and the boundary of inundation. It took special attention of monsoon flooding in the developing countries like India (Bhavsar, 1983). Landsat TM contains band 4 which proves underlying discrimination of water from the dry land surface. But Landsat TM NIR band cannot be used developed land such as downtown and commercial areas because NIR band reflect very little energy from asphalt areas and creates black imageries. Therefore, Wang *et al.* (2002) solved the problem by adding Landsat TM band 7 to the NIR band 4 to delineate the inundated areas. In Band4+Band7 image, become easier to identify asphalt areas as well as better food monitoring. But still, a limitation exists in the band which is found in density slice or supervised classification cannot be identified enough in inundated areas.

Later SPOT multi spectral imageries were also used for monitoring floods that water has a very low reflectance in near infrared portion of the spectra. SPOT imageries were also used in monsoon area like Bangladesh (Brouder, 1994) along with Digital Elevation Model (DEM).

Advanced Very High-Resolution Radiometer (AVHRR) is also fruitful imageries for floods of a regional dimension (Islam *et al.*, 2001, 2002). The resolution of AVHRR imageries are coarse and frequently contaminated by cloud cover in high temporal resolution. It has a huge advantage to monitor the progress of floods in real time. From AVRR image Normalized Difference Vegetation Index (NDVI) can be used to monitor river inundation more effectively and ensures the capability of near infrared band. Water has a unique spectral signature which is different from other surface feature. So NDVI value changes considerably from the normal situation when the surface feature is inundated.

Application of Microwave Remote Sensing

During capturing images from satellite, bad weather condition is a vital issue which affects the images. The existence of cloud cover appears significant issue of flood monitoring during bad weather condition (Rashid *et al.*, 1993). Now Synthetic Aperture Radar (SAR) and optical remote sensing imagery is the most common approach for managing flood (Chen *et al*., 1999). The most significant advantage of using SAR imagery is, it can capture a sharp image in all-weather conditions. The radar back scatter is captured as a function of the incidence angle of the sensor and Digital Number (DN) (Chen *et al*., 1999). For the same area, capturing two imageries are taken before and after the flood, the multi data SAR can be projected to red, green and blue channels to create a color composite (Long *et al*., 2001).

In recent years, both optical and microwave remote sensing technologies can synthesize the advantage of flood mapping, especially in mountains. Landsat TM with SAR imageries can solve the problem with better accuracy by capturing land use pattern (Islam *et al.*, 2001). For successful flood mitigation and knowing the pattern of the flood, this continuous remote sensing data can be a useful tool.

Flood Mapping with GIS and Remote Sensing

Floods are among the most frequent and costly natural disasters in terms of human hardship and economic loss. So, a reliable flood map is one of the latest concerns of flood management. In flood management, preparing maps of flooded area is the latest concern. Different approaches have been taken already for potential flood mapping. Depending on the estimated depth of inundation, flood risk maps are prepared. So, the most important indicator of flood management is flooded depth (Islam *et al.*, 2001, 2000; Townsend *et al.*, 1998). It is important to classify the phenomenon of river flooding for identifying flood depth and have significant implications for formulating the GIS model.

In the initial stage, to measure the depth of inundation (Townsend *et al.*, 1998), the concept of topographical convergence or wetness index was used (Wolock *et al.*, 1995). But it has a limitation that when a slope tends to zero, the wetness index becomes undefined.

In recent years, NOAA AVHRR imageries have been more popular, innovative and cost effective solution for flood management (Islam *et al.,* 2001). The process of measuring flood depth from NOAA AVHRR imageries simply by the tonal difference of the flood water. Using supervised classification Islam *et al.* (2001) assessed, the flood affected area was subdivided into the different depth of flood zones. AVHRR data was superimposed over a DEM to identify the training sets accurately. The risk of the flood has been measured by calculating a weighted score for each land use, physiographic and geologic division of the country. The methodology is that; it assigns greater weight to the categories of deeper flood depth in an exponential manner.

Digital Elevation Model (DEM) in Flood Management

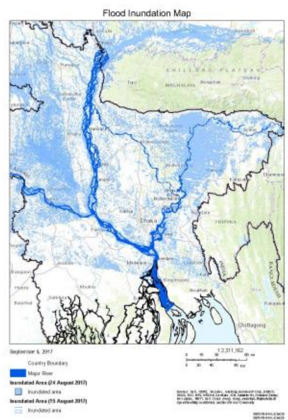
Digital Elevation Model (DEM) is a 3D representation of terrain's surface. DEMs picture the flood zone with flood depth. Furthermore, water depth is calculated by subtracting water level from the elevation of each cell

in a raster. Though it has some drawbacks like high dependency on remotely sensed data. 1M vertical error of DEM model may generate 100s sq. a kilometer in flood estimation. In hydrological modeling, it is important for DEMs to recognize errors. In flood mapping, this issue has been addressed from the significant point of view (Hunter *et al*., 1995). DEMs requires a flat terrain for flood mapping, multi-date SAR imaginaries can be used as an alternative for monsoon Asia. Namely, Multi date Radar sat imaginaries were used a monsoon Asia to draw a complete picture flood (Chen, 1999). This particular process creates a visual image of inundation from river channel to the adjacent low elevated area of the flood plain. Multi date Radar sat image can be used as an alternative though it has limitation for determining flood depth. Recent days, LIDAR (Light Detecting and Ranging) sensor is used for flood management. In addition, this technology is also very popular for creating DEMs for more likely for flood areas. This sensor can directly read the difference between landform and used as a strong tool for accuracy (Sanyal *et al*., 2004). Although it provides with more accurate data with the location, the accuracy decreases with the density of vegetation cover of the ground (Hodgson *et al.*, 2003). However, LIDAR sensor is used for flood mapping in the extremely plain flood plains. Though LIDAR data is more expensive than the SAR imaginaries, sometimes it provides more accurate and necessary data for flood mapping in the extremely flat flood plains (Sanyal *et al*., 2004). Resolution of LIDAR data depends upon the intensity of laser pulse. More laser pulse means more resolution. To make the survey more accurate, increasing of laser pulse also increases the cost of the data exponentially.
Herold *et al*. (2006) in a case study for utilization of GIS during flood emergencies, Estimates of peak-flow magnitude for ungauged stations were obtained by statistical means, performing several regressions on the basin variables. This "regression" method is processed on two test-zones situated in North and South America.

Assessment of GIS and Remote Sensing for Pre and Post Flood Management

The natural disasters are inevitable and it is almost impossible to fully recoup the damage caused by the disasters. But it is possible to minimize the potential risk by early warning strategies, preparing and implementing developmental plans. With the help of RS imageries and interpreting the data capturing from RS imageries in GIS and creating suitable framework can mitigate flood risk. Earth observation satellite providers required a database for pre disaster preparedness programs and post-disaster preparedness programs. They provide comprehensive, synoptic and multi temporal coverage of large areas in real time. Although flood has shown in the last few decades a drastic increase in magnitude and frequency, capturing these pattern it can be observed that there has been a dramatic improvement in technical capabilities to mitigate its effects. Disaster management consists of two phases. First one is taking place before the flood occurs, which is disaster prevention and disaster preparedness. The second one is taking place after the flood occurs, which are disaster relief, rehabilitation, and reconstruction.

1. In the flood prevention phase, GIS is used to manage the large volume of data with the help of RS imageries which are needed for the hazard and risk assessment.
2. In the flood preparedness phase, it is a tool for the planning of evacuation routes, for the design of centers for emergency operations, and for the integration of satellite data with other relevant data in the design of disaster warning systems.
3. In the flood relief phase, GIS is extremely useful in combination with Global Positioning System (GPS) in search and rescue operations in areas that have been devastated and where it is difficult to find one's bearings.
4. In the flood rehabilitation phase, GIS is used to organize the damage information and the post-disaster census information, and in the evaluation of sites for reconstruction.



Source: ICIMOD

The International Centre for Integrated Mountain Development (ICIMOD) has prepared flood inundation maps in view of the floods and landslides that this year's (24 and 29 June and 5 July 2017) monsoon has triggered in Bangladesh. The maps have been prepared using Advanced Land Observing Satellite 2/ Phased Array L-band Synthetic Aperture Radar (ALOS-2/PALSAR) and Sentinel-1 satellite images made available by the Japan Aerospace Exploration Agency (JAXA) and the European Space Agency (ESA).
Hence, GIS and Remote Sensing is a useful tool in flood management if it is used effectively and efficiently.

Conclusions

The preceding discussion about various methods and tools of GIS & RS, which is used for flood management. Clearly, identifying pattern of the flood will help to prevent it and reduce more damage by taking necessary steps in time. In addition, it is also important to calculate the loss. Since flood problem is very common to this region, it should grab some more attention. GIS technology is an effective tool for monitoring and measures flood risk. Flood risk assessment parameter such as slope, flow direction, stream network can be easily extracted using DEMs. The limitation of the process is the availability of satellite data, which is not always guaranteed for the time of peak flood. But, as GIS data and satellite images are relatively cheap and dependable so, local authorities should adopt this technology. This technology can be very useful for a planner to generate an effective strategy to prevent this disaster. Hence this tool can be used by a policy maker, which will help them to make a decision before the flood to prevent more economic and social loss.

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