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ASIAN JOURNAL OF SCIENCE AND TECHNOLOGY

ISSN: 0976-3376

Asian Journal of Science and Technology
Vol. 5, Issue 12, pp.843-846, December, 2014

REVIEW ARTICLE

VULNERABILITY OF FLOOD IN INDIA: A REMOTE SENSING AND GIS APPROACH FOR WARNING, MITIGATION AND MANAGEMENT

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ARTICLE INFO

Article History:
Received 22nd September, 2014
Received in revised form
17th October, 2014
Accepted 14th November, 2014
Published online 30th December, 2014

Key words:
Flood, Remote Sensing Geographic Information System,
Digital Elevation Model,
Hazard Mapping,
Monsoon.

ABSTRACT

The conventional means to record hydrological parameters of a flood often fail to record an extreme event. Remote sensing technology along with Geographic Information System (GIS) has become the key tool for flood monitoring in recent years. Development in this field has evolved from optical to microwave remote sensing, which has provided all weather capability compared to the optical sensors for the purpose of flood mapping. The central focus in this field revolves around delineation of flood zones and preparation of flood hazard maps for the vulnerable areas. In this exercise flood depth is considered crucial for flood hazard mapping and a Digital Elevation Model (DEM) is considered to be the most effective means to estimate flood depth from remotely sensed or hydrological data. The aim of this review is to synthesize the state of art literature in the application of Geographical Information Systems (GIS) and Remote Sensing (RS) techniques in all the flood management stages (pre-flood, during flood and post-flood stages. This paper presents a review of application of remote sensing and GIS in flood management with particular focus on the developing county like India.

INTRODUCTION

Floods have been a recurrent phenomenon in India and cause huge losses to lives, properties, livelihood systems, infrastructure and public utilities. India's high risk and vulnerability is highlighted by the fact that 40 million hectares out of a geographical area of 3290 lakh hectares is prone to floods. On an average every year, 75 lakh hectares of land is affected,1600 lives are lost and the damage caused to crops, houses and public utilities is Rs. 1805 cores due to floods. The maximum numbers of lives (11,316) were lost in the year 1977. The frequency of major floods is more than once in five years. The recent floods like Kosi mega flood occurred 2008, august 18th in state of Bihar and Jammu Kashmir flood in 2014 which caused lots of damage. Floods have also occurred in areas, which were earlier not considered flood prone. An effort has been made in these Guidelines to cover the entire gamut of Flood Management. 80% of the precipitation takes place in the monsoon months from June to September. The rivers bring heavy sediment load from the catchments. These, coupled with inadequate carrying capacity of the rivers are responsible for causing Floods, drainage congestion and erosion of riverbanks.

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Flood is a state of high water level along a river channel or on coast that leads to inundation of land which is not normally submerged. Flood is an attribute of physical environment and thus is an important component of hydrological cycle of drainage basin. Flood is a natural phenomenon in response to heavy rainfall but it becomes a hazard when it inflicts loss to the lives and properties of the people e. The Rashtriya BarhAyog, set by Government in 1976 put the country's flood prone area at about 40 mha. This report, thus, revealed a rapid increase in flood proneness in just over a decade. Most of these areas lie in Ganga basin, the Brahmaputra basin comprising the Barak, the Tista, the Torsa, the Sabarmati, the Sankosh, the Jaldhaka, the Dibang, and the Dihang. The most flood prone basin are those of the Gang and Brahmaputra in Uttar Pradesh, Bihar, West Bengal and Assam, followed by Baitarani, the Brahmani, and the Subarnarekha basin in Orissa. These five states are the most flood prone area. But the commission analysed the share of damage went up from 25 to 50 percentage of the total and chronically flood prone Bihar area has been increasing.

Flood vulnerability

Vulnerability is certainly one of the most important concepts that have widely been studied in hazard risk management. With reference to flood hazard management, Adelekan (2011) suggests that sound assessment of community vulnerability to floods is required. Flood vulnerability has been defined in several ways in several studies (Alcantara-Ayala, 2002; Pelling, 2003; ISDR, 2004; Barroca *et al*., 2006), but generally used to refer to conditions that can be physical, social, economic and environmental, that make a given population more susceptible to the impact of flood hazard. Furthermore, Weichsel Gartner (2001) and Adelekan (2011) suggest that vulnerability should be studied in three distinct categories of vulnerability indicators; susceptibility, exposure and coping indicators. Susceptibility indicators are a measure of the sensitivity of subject being confronted by the flood hazard (Adelekan, 2011). According to Adelekan (2011) building types, people's awareness and preparedness before the flood and their ability to cope up after the flood event can be used as indicators of susceptibility. Weichsel Gartner (2001) considers proximity of the area to rivers, elevation of an area as well as frequency of floods in a given area as exposure indicators, while Messner and Meyer (2006) combine the latter's definition and flood characteristics such as inundation depth, duration and flood velocity to indicate exposure. In addition, Jonkman and Kelman (2005) suggest water depth rise rate, wave characteristics and water temperature should be included in the computation of flood hazard action. Coping indicators on the other hand are said to depend on the social response and tempered responses (Adelekan, 2011). They include general information on age, gender, level of education, poverty, proportion of vulnerable population and institutional development (Weichsel Gartner, 2001; Adelekan, 2011). As will be shown in the subsequent part of this review, information on flood vulnerability and flood hazard is of paramount importance in determining the flood risk of any given area.

Flood Risk

Risk is generally described as the uncertain product of a hazard and its potential loss (Crichton, 2002; Kron, 2005). Flood risk has been defined as a degree of the overall adverse effects of flooding. It incorporates the concepts of threat to life and limb, the difficulty and danger of evacuating people and their possessions during a flood, the potential of damage to the structure and contents of buildings, social interruption, loss of production and damage to public property. Like other studies (Karim *et al*., 2005; Kron, 2005; Apel *et al*., 2009), Dang *et al*. (2010) define flood risk as a product of flood hazard and flood vulnerability, equation (1); where flood vulnerability includes exposure:

Flood Risk=Flood hazard X Flood vulnerability…………. (1)

Essentially this definition shows a direct influence that flood hazard as well as the level of flood vulnerability have on flood risk, the higher the values of these two, the higher will be the level of flood risk. In line with this, Dang *et al*. (2010) suggest that flood risk assessment requires interdisciplinary approaches and studies. They specifically suggest that the potential flood risk can be reduced by decreasing the level of vulnerability, reducing the exposure value and by reducing the hazard.

Flood Damage

Flood damage is widely accepted as the main indicator for the impact of damaging floods (Pielke and Downton 2000; Munich and Topics, 2005). Dutta *et al*. (2003) have classified flood related damages as either tangible or intangible. Tangible damages are further divided into direct damages such as agricultural and environmental damages caused by direct contact with flood and indirect tangible damages such as business interruption, impact of floods on regional or national economy. Intangible damages on the other hand include health and psychological losses. It is worth noting that both types can be expressed in Res. J. Appl. Sci. Eng. Technol., 6(10): 1884-1894, 20131887 monetary terms, for example Huang *et al*. (2008) computed flood damages in monetary terms having classified property loss due to floods as a direct tangible damage and income loss calculated as the difference in income between the year preceding the flood and the year of the flood, as an indirect tangible damage. On the other hand an increase in medical cost for households in the flood year compared to the preceding year was calculated and categorized as intangible damage due to flood.

Vulnerability is the degree to which a system or unit is likely to experience harm due to exposure to perturbations or stress. The concept of vulnerability originated in research communities examining risks and hazards, climate impacts, and resilience. The vulnerability concept emerged from the recognition by these research communities that a focus on perturbations alone (environmental, socioeconomic, technological) was insufficient for understanding the responses of, and impacts on, systems (social groups, ecosystems, places) exposed to such perturbations With the concept of vulnerability, it became clear that the ability of a system to attenuate stresses or cope with the consequences through various strategies or mechanisms constituted a key determinant of system response and, ultimately, of system impact. A clearer understanding of coping strategies or mechanisms can thus throw light on who and what are at risk from what, and how specific stresses and perturbations evolve into risks and impacts.

Perturbations evolve into risks and impacts. Vulnerability in the social sciences is typically identified in terms of three elements: system exposure to crises, stresses and shocks; inadequate system capacity to cope; and consequences and attendant risks of slow (or poor) system recovery. This perspective e suggests that the most vulnerable individuals, groups, classes, and regions or places are those that: experience the most exposure to perturbations or stresses; are the most sensitive to perturbations or stresses (i.e. most likely to suffer from exposure); and have the weakest capacity to respond and ability to recover.

Space Technology: A Review

The unique capabilities of satellites to provide comprehensive, synoptic and Multi-temporal coverage of very large areas at regular interval and with quick Turnaround time have been very valuable in monitoring and managing flood dynamics. In fact, it is only space technology, which has for the first time provided the basic information needed in the space, time and frequency domain. In order that the appropriate flood control and anti-erosion works are scientifically planned, executed, monitored and maintained as per the best standards, it is necessary to acquire timely and reliable information about the flooded areas, watershed areas, river behavior and configurations, etc. prior to floods, during floods, and after floods. Such information is difficult to acquire in time for decision making from conventional ground survey methods in vogue, which are arduous, time consuming and beset with various limitations, especially while studying floods of large river basins. The earth Observation satellites provide comprehensive, synoptic and multitemporalcoverage of large areas in real time and at frequent intervals and, thus, have become valuable for continuous monitoring of atmospheric as well as surface parameters related to flood. Satellites, by virtue of their remote sensing and data transmission capabilities to provide comprehensive multi – date and multi-spectral information on dynamic phenomena covering very large as well as small river basins, have been found to be admirably suited for mapping/monitoring and studying (i) flood inundated and drainage congested areas, (ii) extent of damages to crops, structures etc. (iii) river configuration, silt deposits, shoals etc. and vulnerable areas of bank erosion (iv) watershed characteristics and land cover/land use in command areas and (v) hydrological and meteorological data transmission from data collection platforms. The flooded areas, which extend to several thousands of square kilometers, could be mapped very effectively using the satellite data. They are also useful in delineating the boundaries of flood prone zones. Digital analysis of satellite data can detect changes on the sections of the inundated flood plains as well as in water quality. The multi temporal data from satellites are proved to be very valuable in the identification of the site ideal for taking up structural measures to control floods. Geostationary satellites provide continuous and synoptic observations over large areas on weather including cyclone monitoring.

The use of meteorological satellites for forecasting heavy rainfall events, snowmelt runoff and monitoring of convective/frontal systems has improved the observational system greatly. The use of high resolution data from Indian Remote Sensing satellites has greatly contributed to our understanding of various parameters relevant to rainfall run -off analysis, flood forecasting and flood mapping including flood damage assessment. The vast capabilities of communication satellites are available for timely dissemination of early warning and real-time coordination of relief operations. Satellite communication capabilities, fixed and mobile, are vital for effective communication, especially in data collection, distress alerting, position location and coordinating relief operations in the field. Space technology can play an important role in providing valuable information particularly useful in the flood assessment, mitigation and preparedness phases of flood besides weather monitoring and effective communication for early warning and management of the floods. Some of the applications of Space Technology are development of early warning Systems, monitoring and assessment, preparation of developmental plans for relief, rehabilitation and post-flood assessment, apart from tele-medicinal services. Advancement in the sensor technologies and hydrological and hydraulic models has paved the tremendous scope for remote sensing to play a greater role in the field of flood management

Remote Sensing and GIS in Flood Warning, Mitigation and Management

Advancements in the remote sensing technology and the Geographic Information Systems (GIS) help in real time monitoring, early warning and quick damage assessment of flood disasters. Geographic Information "System is a tool that can assist floodplain managers in identifying flood prone areas in their community". With a GIS, geographical information is stored in a database that can be queried and graphically displayed for analysis. By overlaying or intersecting different geographical layers, flood prone areas can be identified and targeted for mitigation or stricter floodplain management practices. Remote Sensing can be very effective for flood management in the following way Detailed mapping that is required for the production of hazard assessment maps and for input to various types of hydrological models. Developing a larger scale view of the general flood situation within a river basin with the aim of identifying areas at greatest risk and in the need of immediate assistance.

Remote sensing and GIS technique has successfully established its application in following areas of flood management such as flood inundation mapping, flood plain zoning and river morphological studies. Remote sensing and GIS provides a data base from which the evidence left behind by disasters that have occurred before can be interpreted, and combined with other information to arrive at hazard maps, indicating which areas are potentially dangerous. The zonation of hazard must be the basis for any disaster management project and should supply planners and decision-makers with adequate and understandable information. Remote sensing data, such as satellite images and aerial photos allow us to map the variability's of terrain properties, such as vegetation, water, and geology, both in space and time. Satellite images give a synoptic overview and provide very useful environmental information, for a wide range of scales, from entire continents to details of a few meters.

Secondly, many types of disasters, such as floods, drought, cyclones, volcanic eruptions, etc. will have certain precursors. The satellites can detect the early stages of these events as anomalies in a time series. Images are available at regular short time intervals, and can be used for the prediction of both rapid and slow disasters. Then, when a disaster occurs, the speed of information collection from air and space borne platforms and the possibility of information dissemination with a matching swiftness make it possible to monitor the occurrence of the disaster. Many disasters may affect large areas and no other tool than remote sensing would provide a matching spatial coverage. Remote sensing also allows monitoring the event during the time of occurrence while the forces are in full swing. The vantage position of satellites makes it ideal for us to think of, plan for and operationally monitor the event. GIS is used as a tool for the planning of evacuation routes, for the design of centres for emergency operations, and for integration of satellite data with other relevant data in the design of disaster warning systems. In the disaster relief phase, GIS is extremely useful in combination with Global Positioning Systems (GPS) in search and rescue operations in areas that have been devastated and where it is difficult to orientate. The impact and departure of the disaster event leaves behind an area of immense devastation. Remote sensing can assist in damage assessment and aftermath monitoring, providing a quantitative base for relief operations

Flood mapping during the flooding and flood plain mapping after the flood recedes is essential. One of the important information required is the nature and extent of the damage caused by floods in the flood proneareas. Satellite remote sensing provides synoptic view of the flood-affected areas at frequent intervals for assessing the progression and recession of the flood inundation in short span of time which can be used for planning and organizing the relief operations effectively. Remote sensing can effectively be used for mapping the flood-damaged areas. For mapping purposes, a pre-flood scene and a peak flood image would be compared to delineate the inundated area. Flood inundation maps can be used

- To define spatial extent of flood inundation.
- To identify the worst flood affected areas.
- To evaluate impact of flooding on environmental concerns, such as, coastlines, forests, open space etc.
- To plan relief operation.
- To assess damage.

Conclusions

Floods are a natural phenomenon. Floods of varying intensity have been occurring in all the flood plains since time immemorial. However, the everincreasingoccupation (or shall we call it encroachment?) of the flood – plains results in huge loss of life and damages, causing the floods to be termed as' disasters'. The problem is intricate. The solution is equally intricate, if not elusive. Satellite Remote Sensing and GIS techniques have emerged as a powerful tool to deal with various aspects of flood management in prevention, warning, preparedness and relief management of flood disaster. They have greater role to play as an improvement over the existing methodologies.

REFERENCES

Adelekan, O.I., 2011. Vulnerability assessment of an urban flood in Nigeria: Abeokuta flood 2007. Nat. Hazards, 56: 215-231.

Alcan Tara-Ayala, I., 2002. Geomorphology, natural hazards, vulnerability and prevention of natural disasters in developing countries. Geomorphology, 47: 107-124.

Crichton, D., 2002. UK and global insurance responses to flood hazard. Water Int., 27:119-131.

Dang, N.M., M.S. Babel and H.T. Luong, 2010. Evaluation of food risk parameters in the day river flood diversion area, Red River Delta, Vietnam. Nat. Hazards, DOI: 10.1007/s11069 – 010 – 9558 – x

Dutta, D., S. Herath andK. Musiake, 2003. A mathematical model for flood loss estimation. J. Hydrol., 277: 24 - 49.

Huang, X., H. Tan, J. Zhou, T. Yang, A. Benjamin, S.W. Wen, S. Li, A. Liu, X. Li, S. Fen and X. Li, 2008. Flood hazard in Hunan province of China: An economic loss analysis. Nat. Hazards, 47: 65 – 73

ISDR (International Strategy for Disaster Reduction), 2004. A Global Review of Disaster Reduction Initiatives. Retrieved from: http://www.unisdr.org/eng/about_isdr/bd-lwr-2004-eng.htm (Accessed on Feb. 6th 2011)

Jonkman, S.N. and I. Kelman. 2005. "Deaths During the 1953 North Sea Storm Surge", pp. 749-758 in Proceedings of the Solutions to Coastal Disasters Conference, American Society for Civil Engineers (ASCE), Charleston, South Carolina, 8-11 May 2005.

Karim, M.F., N. Mimura and H. Nobuoka, 2005. Management of storm surge flood risk in the coastal region of Bangladesh. In: Proceedings of the 1st International Conference on Coastal Zone Management and Engineering in the Middle East

Kron, W., 2005. Flood Risk = Hazard · Values · Vulnerability. Water Int., 30(1): 58-68

Messner, F., and V. Meyer. 2006. "Flood damage, vulnerability and risk perception–challenges for flood damage research." Flood risk management: Hazards, vulnerability and mitigation Measures: 149- 167

Pelling, M. 2003. The vulnerability of cities; natural disasters and social resilience, Earthscan, London

Pielke, J.R.R.A. and M.W. Downton, 2000. Precipitation and damaging floods: Trends in the United States, 1932-97. J. Climate, 13: 3625-3637.

Weichselgartner, J. 2001. "Disaster mitigation: the concept of vulnerability revisited" Disaster Prevention and Management Volume 10, Number 2: 85-94

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