REMOTE SENSING AND GIS: A TOOL FOR FLOOD MANAGEMENT IN URBAN INDIA

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ABSTRACT

Remote sensing and GIS is a tool which helps to create and manage spatial and non spatial data. Remote sensing is the practice of collecting data by observing at a distance which is most often done by observation of earth surface from above, from either an aircraft or a satellite. Products of such observations are aerial photographs and satellite imageries which are timely, periodic, accurate and reliable spatial data. Integrated computer tools for handling, storing, processing, analyzing and representing of spatial and geo referenced data is called Geographic Information System(GIS). Urban flooding is a major challenge in India since historic times. Settlements are usually situated on riverine or marine banks. Flood risk and vulnerability increases manifold as urbanization expands rapidly in the country. Flood risk is increasing due to global climatic fluctuations whereas vulnerability increases because of the sheer size of the population exposed within urban settlements. As occurrence of floods become frequent, remote sensing and GIS becomes preferable tool for planners for effective flood management. Remote sensing helps to provide accurate and periodic spatial data and GIS helps in creating land suitability analysis and flood zone mapping of towns and cities, which, if, incorporated in preparation of master plans can help in flood management in urban India. Smart city concept can only be realized in realistic terms only by using these technologies for futuristic planning.

I.INTRODUCTION

Planning for flood management is inter-disciplinary and multi- sectoral activity which require both use of traditional methods and use of technology. India is one of the most flood prone countries in the world on account of its geoclimatic conditions and high socio economic vulnerability (MoHA 2011). The huge losses witnessed by India in Recent past due to various floods like Kedarnath flood, Jaipur flood, Srinagar floods and Chennai floods only underscore the above stated fact. India's public policy on flood management has shifted its focus from relief and rehabilitation efforts to holistic management of disasters (MoHA 20004). India's preparedness for disaster is being enhanced through initiatives such as mainstreaming disaster risk reduction in development plans, building capacity through education and greater awareness at all levels and utilizing advanced technology at all levels (MoHA 2011). These advanced technologies also include remote sensing and

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GIS. These technologies have been widely used in urban planning in developed countries- urban infrastructure management, construction of geographic database describing urban form, preparation of master plans, transportation planning, environmental planning, housing planning and disaster management. Urban local bodies in developed countries acquired these technologies much ahead of developing countries. With increased investment for urban overhauling under various programmes in India, too local bodies are acquiring these technologies. The present paper emphasizes the use of remote sensing and GIS technology in flood management in urban India.

II.FLOOD ZONE MAP OF INDIA

The major flood prone regions in India are Punjab, Haryana, most of the Gangetic plains including Uttar Pradesh, North Bihar and West Bengal, the Brahmaputra valley, coastal Andhra Pradesh and Orissa, and South Gujarat. Among the severely affected areas are the Brahmaputra valleys, north Bihar (Kosi River and north Gangetic plain) and lower West Bengal.

Source: www.mapsofindia.com

Apart from these, floods affect large areas in the following belts:

- The lower courses of rivers in the north Indian plains get silted and change their courses. These areas lie in the states of Punjab, Haryana, Himachal Pradesh, Delhi, Rajasthan, Uttar Pradesh, Bihar and West Bengal.

- The tributaries of the Indus – the Jhelum, Satluj, Beas, Ravi and Chenab – cause floods in Jammu and Kashmir, Punjab, Haryana, western Uttar Pradesh and Himachal Pradesh. Inadequate drainage in parts of Haryana and Punjab is the main cause of inundation.
- Certain areas in central India and the peninsula get flooded by the Narmada, Tapti, Chambal, Godavari, Krishna, Cauveri and Pennar.
- Certain areas along the east coast get flooded due to cyclonic storms.

III.URBAN FLOODING

Urban flooding is significantly different from rural flooding as urbanization leads to developed catchments, which increases the flood peaks from 1.8 to 8 times and flood volumes by up to 6 times. Consequently, flooding occurs very quickly due to faster flow times (in a matter of minutes). Urban areas are densely populated and people living in vulnerable areas suffer due to flooding, sometimes resulting in loss of life. It is not only the event of flooding but the secondary effect of exposure to infection also has its toll in terms of human suffering, loss of livelihood and, in extreme cases, loss of life. Urban areas are also centres of economic activities with vital infrastructure which needs to be protected 24x7. In most of the cities, damage to vital infrastructure has a bearing not only for the state and the country but it could even have global implications. Major cities in India have witnessed loss of life and property, disruption in transport and power and incidence of epidemics. Therefore, management of urban flooding has to be accorded top priority. Increasing trend of urban flooding is a universal phenomenon and poses a great challenge to urban planners the world over. Problems associated with urban floods range from relatively localized incidents to major incidents, resulting in cities being inundated from hours to several days. Therefore, the impact can also be widespread, including temporary relocation of people, damage to civic amenities, deterioration of water quality and risk of epidemics.

IV.URBAN FLOODING IN INDIA

There has been an increasing trend of urban flood disasters in India over the past several years whereby major cities in India have been severely affected. The most notable amongst them are Hyderabad in 2000, Ahmedabad in 2001, Delhi in 2002 and 2003, Chennai in 2004, Mumbai in 2005, Surat in 2006, Kolkata in 2007, Jamshedpur in 2008, Delhi in 2009 and Guwahati and Delhi in 2010. Among the important cities of India, the average annual rainfall varies from 2932 mm in Goa and 2401 mm in Mumbai on the higher side, to 669 mm in Jaipur on the lower side. The rainfall pattern and temporal duration is almost similar in all these cities, which receive the maximum rainfall from the south-west monsoons. The average rainfall for the month of July in Mumbai is 868 mm and this far exceeds the annual average rainfall of 611 mm in London.

Storm water drainage systems in the past were designed for rainfall intensity of 12 – 20 mm. These capacities have been getting very easily overwhelmed whenever rainfall of higher intensity has been experienced. Further, the systems very often do not work to the designed capacities because of very poor maintenance. Encroachments are also a major problem in many cities and towns. Natural streams and watercourses have formed over thousands of years due to the forces of flowing water in the respective watersheds. Habitations started growing into towns and cities alongside rivers and watercourses. As a result of this, the flow of water has increased in proportion to the urbanization of the watersheds. Ideally, the natural drains should have been widened (similar to road widening for increased traffic) to accommodate the higher flows of storm water. But on the contrary, there have been large scale encroachments on the natural drains and the river flood plains. Consequently the capacity of the natural drains has decreased, resulting in flooding. Improper disposal of solid waste, including domestic, commercial and industrial waste and dumping of construction debris into the drains also contributes significantly to reducing their capacities. It is imperative to take better operations and maintenance actions.

V.FLOOD ZONE MAP

A floodplain or flood plain is a low-lying area of land adjacent to a stream or river which stretches from the banks of its channel to the base of the enclosing valley walls, and which experiences flooding during periods of high discharge. A flood zone map is a map that shows areas identified to be susceptible to floods. These geographical areas called flood zones are given a specific ranking depending on the estimated flood risk. A ranking of the flood zone will determine how much damage is likely to be caused during a flood event, and what possible measures will be required for effective management. The primary benefit of such maps is to communicate and manage flood-related data. Making and maintaining an accurate flood map is a complex and expensive process. Since the flood zones are required to be mapped with a high degree of accuracy, land development and natural changes to the landscape or hydrologic systems create the need for continuous map maintenance and updates. To manage flood risk and minimize future disaster relief costs, the nation, through the National Disaster Management Authority (NDMA), has invested significant resources in mapping flood hazard areas. Transforming flood maps into digital format can greatly enhance their utility since digital maps are more versatile for floodplain management and other uses because they are easier to update.

VI.REMOTE SENSING

The term "remote sensing," first used in the United States in the 1950s by Ms. Evelyn Pruitt of the U.S. Office of Naval Research, is now commonly used to describe the science—and art—of identifying, observing, and measuring an object without coming into direct contact with it. This process involves the detection and measurement of radiation of different wavelengths reflected or emitted from distant objects or materials, by which they may be identified and categorized by class/type, substance, and spatial distribution. Most remote sensing instruments on aircraft or space-based platforms operate in one or more of these windows by making their measurements with detectors tuned to specific frequencies (wavelengths) that pass through the atmosphere. When a remote sensing instrument has a line-of-sight with an object that is reflecting sunlight or emitting heat, the instrument collects and records the radiant energy. While most remote sensing systems are designed to collect reflected radiation, some sensors, especially those on meteorological satellites, directly measure absorption phenomena, such as those associated with carbon dioxide (CO_2) and other gases. The atmosphere is nearly opaque to EM radiation in part of the mid-IR and all of the far-IR regions. In the microwave region, by contrast, most of this radiation moves through unimpeded, so radar waves reach the surface (although weather radars are able to detect clouds and precipitation because they are tuned to observe backscattered radiation from liquid and ice particles).

VII.GEOGRAPHIC INFORMATION SYSTEM

A geographic information system (GIS) is a system designed to capture, store, manipulate, analyze, manage, and present spatial or geographic data. The acronym GIS is sometimes used for geographic information science (GIScience) to refer to the academic discipline that studies geographic information systems and is a large domain within the broader academic discipline of geoinformatics. What goes beyond a GIS is a spatial data infrastructure, a concept that has no such restrictive boundaries.In general, the term describes any information system that integrates, stores, edits, analyzes, shares, and displays geographic information. GIS applications are tools that allow users to create interactive queries (user-created searches), analyze spatial information, edit data in maps, and present the results of all these operations. Geographic information science is the science underlying geographic concepts, applications, and systems.

GIS can refer to a number of different technologies, processes, and methods. It is attached to many operations and has many applications related to engineering, planning, management, transport/logistics, insurance, telecommunications, and business. For that reason, GIS and location intelligence applications can be the foundation for many location-enabled services that rely on analysis and visualization. GIS can relate unrelated information by using location as the key index variable. Locations or extents in the Earth space–time may be recorded as dates/times of occurrence, and x, y, and z coordinates representing, longitude, latitude, and elevation, respectively. All Earth-based spatial–temporal location and extent references should be relatable to one another and ultimately to a "real" physical location or extent. This key characteristic of GIS has begun to open new avenues of scientific inquiry.

VIII.USE OF REMOTE SENSING AND GIS IN URBAN FLOOD MANAGEMENT IN INDIA

Advancements in the remote sensing technology and the Geographic Information Systems (GIS) help in real time monitoring, early warning and quick damage assessment of urban flood disasters. A 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 risk analysis, vulnerability analysis, flood inundation mapping, flood plain zoning and river morphological studies.

IX.URBAN FLOOD INUNDATION 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 prone areas. 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 8 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.

XII.URBAN FLOOD ZONING

Flood hazard zone mapping can be used as a means of non-structural flood control planning of the flood plain and for making policy decisions to regulate the flood plain development activities. Using historic satellite data combined with hydrological and close contour data, a flood hazard zone map can be prepared for flood prone basins.

XIII.RIVER MORPHOLOGICAL STUDIES

River morphology is concerned with the structure and form of rivers including channel configuration, channel geometry, bed form and profile characteristics. Various flood control structural measures such as construction of embankments, channel improvements, raising of villages, selective dredging etc. have been implemented in past to reduce the impact of the flood disaster on human life and property. It is essential to monitor the embankments regularly to identify the vulnerable reaches. Conventional methods of river surveys are time consuming and expensive. Most of the flood prone rivers in India change their course after every flood wave eroding river banks. Satellite remote sensing based morphological studies are quite useful in following areas:

- To identify the changes in river course over a time period.
- To identify the erosion prone areas along the river course.
- To study the efficacy of flood management structures

The river configuration and flood control works maps can be effectively used to identify the vulnerable river reaches and status of the flood control embankments/spurs so that necessary measures can be taken accordingly to avoid breaches. The bank erosion maps can be used for planning bank protection works. The study of river configuration will be useful to understand the behavior of the river and can be used for laying physical models.

XIV.CONCLUSION

Floods are a recurrent phenomenon, which cause huge loss of lives and damage to livelihood systems, property, infrastructure and public utilities. In India, out of the total geographical area of 329 million hectares (mha), more than 40 mha is flood prone. The Central Water Commission (CWC) has given detailed estimates of economic loss and loss of human and cattle lives due to floods from 1953-2016. This data reveales that the decade of the 1970s was the worst in terms of loss of human and cattle lives due to floods in India. It is also apparent that flood related damages show an increasing trend – the average annual flood damage in the last 10 years period from 1996 to 2005 was Rs. 4745 crore as compared to an average of Rs. 1805 per annum for the previous 53 years. This increase can be attributed to many reasons – a steep rise in population, rapid urbanization, growing developmental and economic activities in flood plains coupled with global warming.

Urban flooding can occur on account of several reasons including heavy rainfall, sudden release of water from a bund or dam, tidal waves, etc. However, the main underlying cause is usually the slow absorption of water by the land. The 2016 flooding of Chennai and the 2017 flood in Mumbai were examples of urban flooding. Satellite Remote Sensing and GIS techniques have emerged as a powerful tool to deal with various aspects of urban flood management in prevention, preparedness and relief management of flood disaster. They have greater role to play as an improvement over the existing methodologies. GIS is ideally suited for various floodplain management activities such as, base mapping, topographic mapping, and post-disaster verification of mapped floodplain extents and depths. Remote sensing and GIS techniques can replace, supplement or complement the existing flood management system. Extensive use of these technologies have great prospect in creating long-term database on urban flood proneness, risk assessment and relief management.

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