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Role of Remote Sensing and GIS in Natural Hazards Management

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Abstract:

Disasters are inevitable in nature, and recouping of damage is almost impossible. In recent years, Remote Sensing and Geographical Information System (GIS) technologies has been the object of considerable interest to all bodies concerned with space and in particular emergency services and disaster management. These systems generate data over a large area anywhere in the earth, irrespective of the nature of the locality and provide precise, regular and almost instantaneous information. Integration of GIS with Remote Sensing technology acts as a tool to solve complex planning and management problems and support decision making in disaster management cycle. In this paper we, address the issues regarding role of GIS in mitigating disaster risk. This paper is a review of some interesting and milestone research work carried out so far on the context of role of remote sensing and GIS in disaster management.

Introduction:

GIS, not surprisingly, has a very important role to play in natural disaster management. GIS is ideally suited as a tool for the presentation of data derived from distributed measurement stations. Unfortunately, however, most GIS have some severe shortcomings when it comes to dealing with the typical data obtained from such measurements, namely time series data. The techniques for dealing with time series data are covered more thoroughly elsewhere. In a nutshell, time series are long consecutive runs of data, such as the temperature measured every half hour at a certain point. Since most standard GIS software packages do not possess adequate tools for handling temporal data, they must be extended or auxiliary applications interfaced. The time series data routinely collected for natural hazards monitoring very often have two significant analytical and display problems. First, they typically relate to points, when data based on areal units would often be more useful. Second, the temporal sampling incidence is often too frequent, resulting in large volumes of ``data.

In particular, it should be noted how much of the system is actually dedicated to collecting, processing, and storing data rather than explicit spatial analysis and display operations.

Essentially GIS is only used at user workstations, whereas the major part of the system is dedicated to other tasks. This distribution is in most cases reflected in the corresponding implementation and running costs .As a rule at least 90 per cent of the cost involved in setting up an environmental hazards monitoring system is related to the measurement program. The quality and processing of data is only a minor part is related to the programming of GIS-based analysis. Often the simple data analysis functions provided by standard GIS software packages are insufficient for dealing with the data monitoring requirements of environmental hazards problems. The reasons for this are many, the most common being:

- The economic aspects of a project do not allow sufficient data to be collected to 'feed' the analysis tools;

- The characteristics of the data make simple extrapolation inappropriate;
- Several parameters are interconnected and the required data cannot be measured directly.

In such cases more complex techniques are needed to reflect the expected environmental situation. In such circumstances, the task of environmental monitoring goes much further than can realistically be achieved within a standard GIS.

1. **Objectives of the Study:**

The present study has following objectives:

- Role of GIS and Remote sensing in natural hazards management
- To study about the natural hazards in India.
- To discuss the types of natural disasters and its management in India in present time.

2. **Research Methodology:**

The present study is based completely on the secondary sources of data. The main secondary Source is the published government reports and various journals and other published works.

3. Classification of Disasters:

It is very essential to get insight knowledge on the differences between the terms disaster and hazard. Hazard is defined as a potentially damaging phenomenon. For example when earthquake occurs in abandoned places, it is not considered as a disaster. Instead if it occurs in a inhabited area and brings great loss, damage or destruction, then it is called a disaster. There are several ways used to classify the different types of disaster. One such possible classification is between **Natural Disasters** are the events which take place purely by natural phenomena and results in heavy loss to livelihoods and societies (example: earthquakes, hurricanes, tornadoes, volcanic eruptions, etc).

Man-made disasters are the events which occur due to human activities such as pollution, nuclear accidents, industrial chemical accidents, oil spills, major armed conflicts, etc.

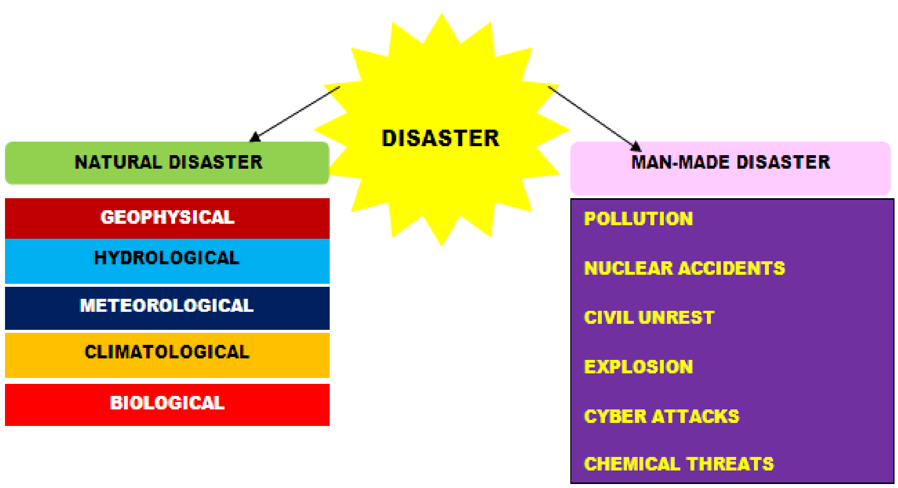

Figure 1. Classification of Disasters

4. Disasters Occurrence in Indian Scenario

India has been vulnerable, in varying degrees, to a large number of natural, as well as, human-made disasters on account of its unique geo-climatic and socio-economic conditions. It is highly vulnerable to floods, droughts, cyclones, earthquakes, landslides, avalanches and forest fires. Out of 35 states and union territories in the country, 27 of them are disaster prone. Almost 58.6 per cent of the landmass is prone to earthquakes of moderate to very high intensity; over 40 million hectares (12 per cent of land) are prone to floods and river erosion; of the 7,516 km long coastline, close to 5,700 km is prone to cyclones and tsunamis; 68 per cent of the cultivable area is vulnerable to drought and hilly areas are at risk from landslides and avalanches

Table: 1 Major Disasters in India

Sr. No.	Name of Event	Year	State & Area
1.	Drought	1972	Large part of the country
2.	Cyclone	1977	Andhra Pradesh
3.	Drought	1987	15 States
4.	Latur Earthquake	1993	Latur, Marathwada region of Maharashtra
5.	Orissa Super Cyclone	1999	Orissa
6.	Gujarat Earthquake	2001	Rapar, Bhuj, Bhachau, Anjar, Ahmedabad and Surat in Gujarat State
7.	Tsunami	2004	Coastline of Tamil Nadu, Kerala, Andhra Pradesh, Pondicherry and Andaman and Nicobar Islands of India
8.	Maharashtra Floods	2005	Maharashtra State
9.	Kashmir Earthquake	2005	Mostly Pakistan, Partially Kashmir
10.	Kosi Floods	2008	North Bihar
11.	Cyclone Nisha	2008	Tamil Nadu
12.	Drought	2009	252 districts in 10 states
13.	Leh Cloudburst	2010	Leh, Ladakh in Jammu & Kashmir
14.	Sikkim Earthquake	2011	North-eastern India with epicenter near Nepal Border and Sikkim
15.	Kedarnath Flood	2013	Uttrakhand
16.	Tamil Nadu Flood	2015	Tamil Nadu state

Source: Ministry of Home Affairs, Govt. of India, 2015

In the first decade of the 21st century, India faced devastating disasters like the Bhuj earthquake in 2001, the Indian Ocean Tsunami in 2004, the Kashmir earthquake in 2005, the Kosi floods in 2008, the Andhra Pradesh and Karnataka floods in 2009, the Leh cloudburst and the Uttarakhand floods in 2010 and the Sikkim earthquake in 2011. It is estimated that the cumulative losses from the Kosi floods in 2008, the Andhra Pradesh and Karnataka floods in 2009 and the Uttarakhand floods in 2010 as reported by the respective state governments amounted to about Rs. 80,000 crores. Given that the financial allocation made by the 12th Finance Commission for disaster management during the period 2005 to 2010 was only Rs. 21,333 Crores for the entire country, it is evident that the damages and economic losses caused by natural disasters are far exceeding acceptable levels and are wiping out the hard earned gains of development from the disaster affected areas. Further, the deployment of scarce resources for post-disaster relief, reconstruction and recovery are making a dent on resources which are required by sectors like health, education, social welfare, etc. It is in this context that an attempt is being made to analyse the issues and challenges in disaster management in India.

4. Role of GIS and remote sensing in disaster management

In the current scenario owing to the increasing efficient quality of the sensor technology and increase in number of operational satellites that are launched by many space research organizations and firms around the world, the field of remote sensing or earth observation has made a remarkable development and achievement in all fields of life. Technological innovations in the field of science and engineering in the last few years made it easier in reducing the disaster risks and helps in planning for the future. The combination of internet along with technologies such as Geographic Information system (GIS) renders possible knowledge in understanding and communicating the socio-economic and physical complexities of disasters.

GIS technology predicts disaster places which are vulnerable and most probable to occur. So by understanding and knowing the areas where the disaster happens, it is ease for the international organizations to develop a new, more effective and efficient methods to mitigate further risks. The extent of damage is dependent on the density of the population, physical infrastructure and means accessible for mitigation purposes such as evacuation site, flood control dams, etc. GIS synthesize information from a vast number of different data resources and helps in assessing disaster impact, plan response and relief strategies. Remote sensing and Geographic Information system plays a vital role to evolve suitable and sustainable strategies for assessing, managing and mitigating the disasters and also provides an occupational framework to indentify and fill the gaps.

Remote sensing data's helps rapidly in identifying hardest-hit areas, manipulates population density in disaster-prone areas, monitors rehabilitation or reconstruction after a major havoc. During a crisis, it facilitates plan for timely evacuation and recovery operations. Remote sensing is the only way to overview the disaster events happening on the earth's crust. Remote sensing plays a vital role in many aspects of disaster management, ranging from risk modeling and vulnerability analysis to early warning and damage assessment.

GIS can be loosely defined as a system of hardware and software used for storage, retrieval, mapping and analysis of geographic data. Spatial features are stored in a coordinate system (latitude, longitude, state, plane, etc.) that references a particular place on the earth. Descriptive attributes in tabular form are associated with spatial features. Spatial data and associated attributes in the same coordinate system can then be layered together for mapping and analysis. GIS can be used for scientific investigations, resource management and development planning. Remote sensing is the measurement or acquisition of information about an object or phenomenon by a recording device that is not in physical or intimate contact with the object. In practice, remote sensing is the remote utilization (as from aircraft, spacecraft, satellite or ship) of any device for gathering information about the environment. Thus, an aircraft taking photographs, earth observation and weather satellites, monitoring of a fetus in the womb via ultrasound, and space probes are all examples of remote sensing. In modern usage, the term generally refers to techniques involving the use of instruments aboard aircraft and spacecraft.

As disaster management work usually involves a large number of different agencies working in different areas, the need for detailed geographical information in order to make critical decisions is high. By utilizing a GIS, agencies involved in the response can share information through databases on computer-generated maps in one location. Without this capability, disaster management workers have to access a number of department managers, their unique maps and their unique data. Most disasters do not allow time to gather these resources. GIS thus provides a mechanism to centralize and visually display critical information during an emergency.

There is an obvious advantage to using a map with remote sensing or GIS inputs instead of a static geographical map. A static map is mostly analogous and is not interactive. On the other hand, a vulnerability map with GIS input provides dynamic information with cause and effect relationship.

Table: 2 Role of remote sensing in Disaster Management

Disaster	Response	Preparedness	Mitigation	Recovery
cyclone	Impact Assessment, identifying routes to escape, Crisis Mapping, Regular monitoring of cyclones and Storm surge predictions.	Early warning signs, long range climate modeling	Vulnerability Analysis and Risk Modeling	Damage assessment; spatial planning.
Drought	Assessing the extent of damage, monitoring vegetation	Weather forecasting; vegetation monitoring; crop water requirement mapping; early warning.	Risk modeling; vulnerability analysis; land and water management planning	Informing drought mitigation.

Earthquake	Identifying escape routes, planning routes for search and rescue	Measuring strain accumulation.	Hazard mapping and assessment of building stock	Damage assessment; Identifying sites for rehabilitation.
fire	Coordinating fire fighting efforts	Fire detection; predicting spread/direction of fire;	Identifying and mapping fire-prone areas, monitoring fuel load, risk modelling	Damage assessment.

Source: Ministry of Home Affairs, Govt. of India, 2015

5. National Disaster Management Act, 2005:

The parliament of India has enacted the National Disaster Management Act in November 2005, which brings about a paradigm shift in India's approach to disaster management. The centre of gravity stands visibly shifted to preparedness, prevention and planning from earlier response and relief centric approach. The proposed legislation is in the concurrent list of constitution thus having the advantage that it will permit the States also to enact their own legislation on disaster management. The new Act provides that:

- There shall be a National Disaster Management Authority (NDMA) of which the Prime Minister of India will be the Chairperson, helped by a Vice Chairperson
- The NDMA shall have the responsibility of laying down the policies, plans and guidelines for disaster management.
- There shall be created State Disaster Management Authorities (SDMAs), expected to be chaired by the Chief Minister of the State.
- There shall be created District Disaster Management Authority (DDMA) co-chaired by District Collector and President of the elected body of the district.
- The Central Government shall constitute the National Institute of Disaster Management (NIDM)
- NIDM shall plan and promote training and research in disaster management, documentation and development of national level information base relating to disaster management policies, prevention mechanism and mitigation measures.
- There shall be disaster management funds available to the Union, State and District Authorities to meet the immediate needs of providing rescue and relief to the victims of Disasters.

The Government of India has also constituted Cabinet Committee on Management of Natural Calamities and Cabinet committee on Security. Besides above there are High Level Cabinet Committee and Inter Ministerial Group in place. The training of eight battalions of Para-military forces has begun, to serve as Disaster Management Response Force (NDRF). It is proposed to establish four training centers in different parts of the country by respective paramilitary forces. A National Disaster Mitigation Fund and a National Disaster Response Fund are proposed to be created. A broad view of disaster administration in the country is depicted in the following figure.

5. National Disaster Management Authority

Emergence of an organization is always through an evolutionary process. Establishment of NDMA has also gone through same stage. Towards this aim, the Government of India (GOI), in recognition of the importance of Disaster Management as a national priority, has set up a High-Powered Committee (HPC) in August 1999 and also a nation committee after the Gujarat earthquake, for making recommendations on the preparation of Disaster Management plans and suggestion effective mitigation mechanisms. The Tenth Five-Year Plan Document also had, for the first time, a detailed chapter on Disaster Management. Similarly, the Twelfth Finance Commission was also mandated to review the financial arrangements for Disaster Management.

On 23 December 2005, the Government of India enacted the Disaster Management Act, which envisaged the creation of the National Disaster Management Authority (NDMA), headed by the Prime Minister, and State Disaster Management Authorities (SDMAs) headed by respective Chief Ministers, to spearhead and implement a holistic and integrated approach to Disaster Management in India. NDMA as the apex body is mandated to lay down the policies, plans and guidelines for Disaster Management to ensure timely and effective response to disasters. Towards this, it has the following responsibilities:-

- Lay down policies on disaster management;
- Approve the National Plan;
- Approve plans prepared by the Ministries or Departments of the Government of India in accordance with the National Plan;
- Lay down guidelines to be followed by the State Authorities in drawing up the State Plan;
- Lay down guidelines to be followed by the different Ministries or Departments of the Government of India for the Purpose of integrating the measures for prevention of disaster or the mitigation of its effects in their development plans and projects;
- Coordinate the enforcement and implementation of the policy and plan for disaster management;
- Recommend provision of funds for the purpose of mitigation;
- Provide such support to other countries affected by major disasters as may be determined by the Central Government;
- Take such other measures for the prevention of disaster, or the mitigation, or preparedness and capacity building for dealing with the threatening disaster situation or disaster as it may consider necessary;
- Lay down broad policies and guidelines for the functioning of the National Institute of Disaster Management.

National Disaster Management Authority has been constituted with the Prime Minister of India as its Chairman, a Vice Chairman with the status of Cabinet Minister, and eight members with the status of Ministers of State. Each of the members has a well defined functional domain covering various states as also disaster specific areas of focus and concern to carry out the mandated functions, NDMA has evolved a lean and professional organization which is IT-enabled and knowledge based. Skills and expertise of the specialists are extensively used to address all the disaster related issues. A functional and operational infrastructure has been built which is appropriate for disaster management involving uncertainties coupled with desired plans of action. The concept of the organization is based on a disaster divisions-cum-secretariat system. Each member of the Authority heads disaster-specific divisions for specific disaster and functional domains. Each member has also been given the responsibility of specified states and UTs for close interaction and coordination. The NDMA Secretariat, headed by a Secretary is responsible to provide secretarial support and continuity. It is proposed to have two Disaster Management Wings under the Secretariat. They are:

- ❖ DM I wing dealing with mitigation, preparedness, plans, reconstruction, community awareness and dealing with financial/administrative aspects.
- ❖ DM II wing is proposed to be composed of the National Disaster Management Operations Centre with the state-of-the-art multi-redundant communication systems, to carry out the tasks of capacity development, training and knowledge management.

6. Conclusion:

The increased availability of Remote Sensing data and GIS during recent decades has created opportunities for a more detailed and rapid analysis of natural hazards. Disaster Management can be very efficiently and cost effectively handled by using innovation in the technology. Highly sophisticated and effective Disaster Management systems can be developing accordingly which are basically GIS based. This can help us to reduce the casualties and damages caused by disasters.

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