GIS and Remote Sensing for Natural Disaster Prevention

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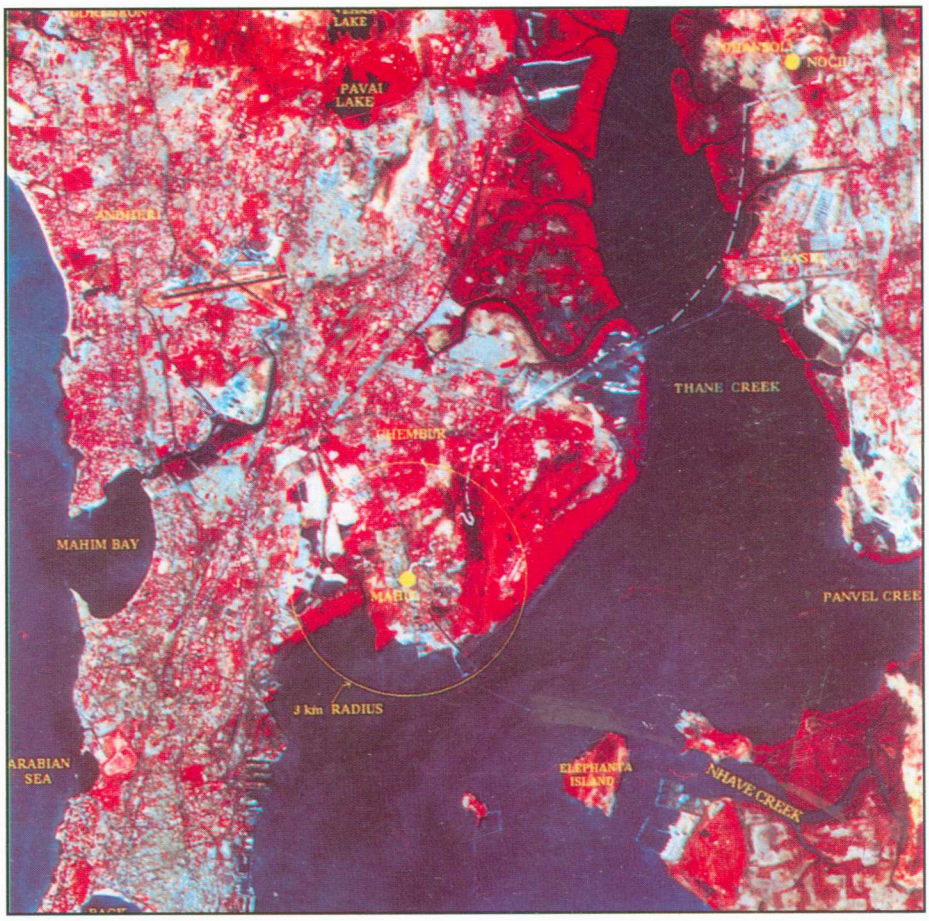
Abstract

Disasters are usually geographic events (floods, earthquakes, cyclones, wildfires, drought, and so forth). Mapping and information acquisition is vital for disaster management. Geographic Information technology tools like Geographic Information Systems (GIS) and Remote Sensing (RS) support all aspects of disaster management. Disaster planning, response, mitigation, and recovery all become more efficient through the use of GIS and remote Sensing (RS).

Disaster Preparedness

Disaster planning involves predicting the risk of an event (flood, earthquake, cyclone, etc.) and possible impacts of the event to human life, property, and the environment. Once these factors are determined, effective planning can begin. Response requirements, protection needs (removing vegetation in the face of a wildfire, hardening bridge supports in the event of an earthquake, evacuation centre developments) can be determined for areas at highest risk. This planning can be done effectively and quickly with GIS and Remote Sensing (RS).

Disaster planning can be very powerful when modelling is incorporated into GIS. Most potential disasters can be modelled. Modelling allows disaster managers to view the spatial characteristics of the impacts of disasters i.e. location, type of buildings and people,and required resources and their availability. Immediately following a large-scale event, one of the first tasks performed is locating disaster assistance centres based on the number of people affected and the availability of shelter facilities. GIS plays a natural role in this exercise.



Pipeline from BPCL refinery, Mahul (Chembur) to NOCIL (Ghansoli), Mumbai as seen by IRS-1C LISS-III camera.
Source : NRSA Data Centre, Hyderabad

GIS and RS are essential to effective preparedness, communication, and training tool for disaster management.

GIS as Tool in Risk Assessment

GIS in conjunction with remote sensing and photogrammetry, can be used to identify hazards. Seismic faults and flood prone areas can be identified by scientists using GIS to analyse satellite image, aerial photos and field survey data.

Once the hazards have been identified, their representation can be stored conveniently in GIS databases. The information required for earthquake risk assesment includes the location and properties of seismic faults, surface geology, terrain slope, water table levels and inventories of epicentres and landslide occurrences. For hurricane risk, information on landuse, land cover, coastline and distance from coast are important. Similarly topology data are required for flood assessment and storm surge analysis.

In addition, new hazard layers can be generated within a GIS by combining hazard layers. For example, a landslide hazard layer can be generated in a GIS by overlaying elevation, surface geology, water table level and landslide inventory data, and liquefaction hazard can be generated in a GIS by overlaying geology with water table level data. Inventory data can also be stored easily in a GIS database. Data on building stock, liveliness, utilities, etc. can be aggregated into geographic regions such as census wards, pin codes or larger administrative regions such as villages, talukas, and even districts. Using statistical functions available in GIS systems, the average value various properties of different building classes can be computed (e.g. average monetary value of residential value dwellings in particular village) and stored with their geographic regions in the GIS database.

The information retrieved by querying the GIS database serves as inputs for the risk assessment models. These

risk assessment models can run both deterministic as well as probabilistic risk assessment Deterministic risk assessment involves defining a disaster event and computing the damage associated with that event, whereas probabilistic risk assessment computes damages for the probability for each event. Deterministic events could be defined using a GIS front-end system.

The resulting loss patterns over regions and their associated uncertainties that are computed through this risk assessment can be mapped and again used for querying information through GIS application. GIS technology provides a powerful tool for displaying outputs and permits user to "see" the geographic distribution of impacts from different peril scenarios and assumptions and allows the users to perform a quick graphical sensitivity analysis of the factors affecting the risk potential A GIS based software system creates the ideal framework to integrate the various components of the model.

The specific GIS applications in the field of Risk Assessment are:

Hazard Mapping

A very common use of GIS in risk assessment is in the preparation of hazard maps. Hazard maps could be created to show earthquake hazard, landslide hazard, flood hazard or fire hazard. These maps could be created for cities, districts or even for the entire country.

GIS can be used for the analysis to determine hazard zones in the map, as well as in the output and printing of such maps. These hazard maps serve as risk zone identifiers for the general population since they are easy to understand and interpret, but they area also of use to the planner, developers and insurance companies, since they serve as quick identifier of risk prone areas

Threat Maps

Tropical cyclone threat maps are used by meteorological departments to improve the quality of their tropical storm warning services. The purpose of these maps is to quickly communicate the risks to the people likely to get effected by the cyclones. GIS is used effectively to display the position and likely movement of the winds and the vulnerability for the identified zones. These maps are very helpful for administrative agencies involved in risk assessment and disaster mitigation. The threat maps can be suitably overlapped with population and landuse maps to arrive at meaningful conclusions. These maps can also be provided to the media for effective communication. Considering the quick turn-around time for generation of these maps, threat maps can be used for real time simulation of wind velocities, cyclone tracks and identification of potential high-risk zones.

Disaster Management

Emergency disaster management requires response, incident mapping, establishing priorities, developing action plans, and implementing the plan to protect lives, property, and the environment. GIS and RS allow disaster managers to quickly access and visually display critical information by location. This information facilitates the development of action plans that are printed or transmitted to disaster response personnel for the co-ordination and implementation of emergency efforts.

Some examples of GIS and remote sensing applications in various disasters are discussed below:

Drought

GIS and remote sensing can be used in drought relief management. For example, early warnings of drought conditions will help to plan out the strategies to organise relief work. Satellite data may be used for to target potential ground water sites for taking up well-digging programme The first phase of National Drinking Water Mission consisted of district-wise groundwater potential maps by using high-resolution Landsat / IRS data. An integrated study to combat drought was taken up by Department of Space, Government of India in collaboration with concerned state governments in 21 districts in different states of the country to ensure action plan packages for combating drought in drought prone districts. This covered management of water resources, fodder resources, and integrates natural resource physical database and socio-economic and demographic database. Data from IRS satellite on 1:50,000 scale was used to generate resource data

Earthquake

GIS and remote sensing can be used for preparing seismic hazard maps. In order to assess the exact nature of the

Thematic Map and their Relevance to Natural Disasters

Thematic Data	Relevance to
NATURAL RESOURCES	
Slope	Landslides, flood proneness, industrial hazards, drought
Soils	Landslides, mass washing, floods, floods earthquakes, droughts, soil borne diseases, green house effects.
Geology	Earthquakes, floods, droughts, fire.
Land use / land cover	Flood cyclones, droughts, damages, assessment of industrial hazard, greenhouse effects.
Drainage network	Floods, earthquakes.
Surface Reservoirs	Floods, earthquakes, industrial hazards, fire.
Hydrogeomorphology	Industrial hazards, earthquakes, drought, hazard preparedness and monitoring.
NATURAL RESOURCES	
Rainfall Pattern	Floods, droughts, landslides, epidemics, crop pests and diseases.
Temperature	Cyclones, droughts, epidemics.
Wind	Cyclones, droughts, epidemics, fire.
Humidity	Epidemics, industries.
ADMINISTRATIVE SETUP	
District Boundary	Relevant to planning disaster preparedness, relief measures, mitigation.
Tahsil Boundary	Revenue circle / Mandal.
Cadastral boundary	Regulation Zone–coastal, chemical, industrial, etc.

risks several factors such as gravity, magnetic, geodetic, electrical data need to be analysed along with geological factors

Flood

Satellite data can be effectively used for mapping and monitoring the flood inundated areas, flood damage assessment, flood hazard zoning and post-flood survey of river configuration and protection works. During 1986, real time mapping was done over Godavari basin and parts of Ganga basin lying in Bihar and Uttar Pradesh. This was continued during the flood period of 1987 in respect of various rivers such as Ganga, Ghaghra, Kosi, Gandhak, Mahananda, Brahmputra, Teesta, Jhelum, etc. in different parts of the country. The cyclone of May 1990 over Andhra Pradesh coast and resulting flood was mapped using satellite data. Floods in Jhelum and Brahmputra rivers and in Orissa state were mapped during 1992.

Landslide

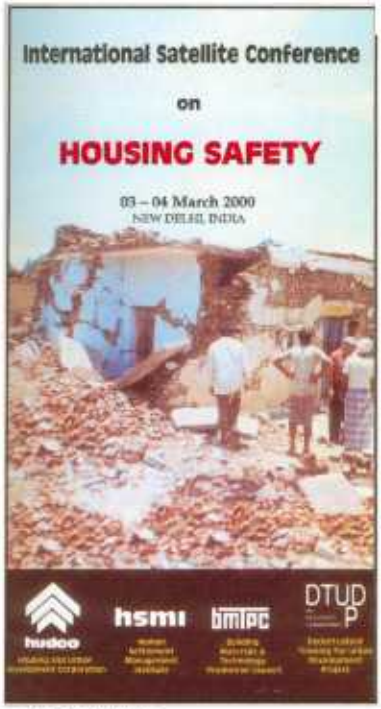
Preparation of comprenensive landslide zonation map requires intensive and sustained efforts. The problem is highly interdisciplinary in nature A large amount of data concerning many variables, covering large scope areas has to be collected, stored, sorted and evaluated. The use of aerial photographs and adoption of remote sensing techniques helps in the collection of data. One of the early projects on zonation was carried out by Central Road Research Institute in 1984, in which hazard zonation techniques were used to choose a most suitable alignment from the possible alternative assignments on landslide affected stretches in Sikkim area. During 1989, a hazard zonation map was prepared for a part of Kathgodam-Nanital highway.

Search and Rescue

GIS can be used in carrying out Search and Rescue operations in a more effective manner by identifying areas that are disaster prone, zoning them accordingly to risk magnitudes, inventorying populations and assets at risk and simulating damage scenarios.

Records Management

Record keeping is the most critical task for disaster management. Claims, status of repairs, required repair work, personnel, and so forth, can be difficult to maintain and account for. GIS facilitates record keeping and status of ongoing work. As work is completed and identified, GIS can visually display current project status. For example, damaged structures deemed unsafe for occupancy or those requiring minimal work can be appropriately coded and displayed in GIS. As status changes, information can be quickly updated and reports generated. Current status can be easily viewed and accessed through a centralised GIS and RS interface.



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BACKGROUND

In recent years, there has been a growing concern for the safety of the built environment. Rising incidence of natural disasters and crime graphs have brought into focus the issue of housing safety with multiple dimensions of physical and social aspects. Environmental safety to promote health and well being to create a conducive living environment for growing populations is another important dimension. In recognition of this, the Housing and Urban Development Corporation, (HUDCO), is organizing a two day Conference on the subject of Housing Safety in conjunction with the 5th World Conference on Injury Prevention and Control from 5th to 8th March 2000.

OBJECTIVES

The conference is expected to provide a forum for interaction to professionals from different disciplines and other concerned groups to discuss issues with a focus on the following concerns.

- experience sharing to blend perspectives on the issue of housing safety; bringing out innovations in institutional frame work for housing safety;
- in the context of developing economies, highlighting the concerns of poor and informal groups with respect to housing safety; in particular, the house as a production and work centre.

FOCUS

Three major themes proposed for experience sharing are:

1. **Physical/Structural Safety:** Design and structural preparedness for resistance to natural disasters; design of cyclone shelters, earthquake resistant housing units, retrofitting of damaged units, designing for resistance to high wind velocities, designing for flood protection etc. etc.
2. **Environmental Safety:** Safety in the provision of services, i.e. safe water, safe sanitation, safe power supply and safe access.
3. **Socially Secure Environment:** Design aspects of housing layouts, dwelling units, community spaces and infrastructure from the point of view of social acceptability and safety of use particularly for special groups such as women and children, and security from theft & crime.