ROLE OF REMOTE SENSING AND ITS APPLICATIONS IN DISASTER MANAGEMENT LIKE EARTHQUAKE, FLOOD AND TSUNAMIS.

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Abstract: This study highlights the use of remote sensing technologies in disaster management. Impact of natural disasters on life, property and ability to predict them would be one of the main contributions of remote sensing technology. Involving remote sensing with GIS and web technology makes it an extremely powerful tool to identify indicators of potential disasters. Information sharing through Internet reduces data acquisition time and thus providing efficient way to carry out real time disaster predictions (Earthquake, Tsunamis etc.). Changing land use and assessment of its impact on the system in general within reasonable time frame and with greater degree of accuracy becomes possible with new technology. A review of some recent applications of “hydrologically oriented” GIS in flood forecasting and related issues is presented. A regional approach to the assessment of flood hazard in oro graphically accentuated areas is also described on the basis of the supporting data handling capabilities of Geographical Information Systems. In particular, the development of operational methodologies aimed at the issuing of effective and timely warnings at the regional scale is presented both in a deterministic perspective by simple enumeration of a series of pre-defined targets and in a probabilistic one, based on the most recent advances in drainage geomorphology. The use of multisensory monitoring devices for the detection of extreme events, from the overall meteorological scenario down to the scale of the local variability of rainfall in space, is proposed on the basis of the experience of some international research projects recently activated in the field. The multi-faceted role of GIS in the collection of rainfall data from the whole set of available sensors, the identification of areas of potential occurrence of extreme meteorological events, the operational support to distributed rainfall-runoff models and the mapping of flood prone areas and landscape vulnerability is highlighted in the study.

***Index Terms* – :** Remote Sensing, Geographic Information System (GIS), Earthquake, Tsunami and Disaster Management , Flood.

I. INTRODUCTION

In the recent few years, large scale earthquakes and tsunamis brought tremendous damages to urban and rural areas across the world. It is also seen that rapid expansion of urban areas in developing countries has made the areas more vulnerable to various natural disasters. Recent advancements in remote sensing and its application technologies made it possible to use remotely sensed imagery data for assessing vulnerability of an area and for capturing the damage distribution due to disasters. To obtain pre and post-event information on built and natural environment several methods exist, such as field survey, airborne remote sensing, and satellite remote sensing.

Because of its capacity to cover a vast area in one acquisition time, satellite remote sensing has been a very powerful tool to monitor the condition of the earth surface. High resolution satellite imagery, which has become available in the last few years, made satellite remote sensing more useful in disaster management since even damage status of individual buildings can be identified without visiting the sites of disasters .

II. CONCEPT OF REMOTE SENSING

Remote Sensing: remote Sensing is defined as the science and technology by which the characteristics of object of interest can be identified, measured the characteristics without direct contact.

Electromagnetic radiation which is reflected or emitted from an object is the usual source of remote sensing data. However any media such as gravity or magnetic fields can be utilized in remote sensing.

A device to detect the electromagnetic radiation or emitted an object is called a "Remote sensor "or sensor". Cameras or scanners are example of remote sensors.

A Vehicle to carry sensor is called a "Platform". Aircraft or satellites are used as platforms.

The technical term "remote sensing "was first used in the United States in 1960's and encompassed photogrammetry, photo interpretation, photo-geology etc. Since Landsat-1, the First earth observation satellite was launched in 1972, remote sensing has become widely used.

The civilian application areas include Agriculture, Forestry, Oceans, the study of Biodiversity, monitoring urban growth, mapping of waste lands, Disaster management and managing water Resources. These studies are of very important, especially to the developing countries.

Space platforms or Satellite systems comprise of:

A. Space segments
B. Sensor systems &
C. Ground segments.

The Space segment consists of the satellite which is placed in the orbit and in which a sensor system is mounted on it, which in turn acts as the instrument that observes and transmits information to the earth receiving stations. In some

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cases provision exists in the form of a tape recorder which records the observed information, and transmits it to the earth receiving station located at a different place other than the place which is being observed. The process of observing and transmitting the information to the earth receiving station is a continuous process. Sensors are instruments which sense the objects on the surface of the earth and records them. Camera is also a form of sensor, which records the object it looks at and the light reflected reacts with the sensitized coating on the film which, when processed, reveals the object. Satellite mounted sensors sense the various objects in the form of digital format of the energy reflected. The data obtained in digital form can be converted to picture format by electro-optical conversion. Thus, we get a picture orimage of each scene covering on the earth's surface.
Different satellite systems may have different types of sensors, depending upon the design and specific needs. Remote sensing technology uses the visible, infrared and microwave regions of the solar radiation to collect information about the various objects on the earth's surface. The electromagnetic spectrum has a visible region, which we use to view an object with our eyes. The sun's energy, when it falls on the earth, gets reflected that we generally use in remote sensing.

III. DATA COLLECTION BY REMOTE SENSING

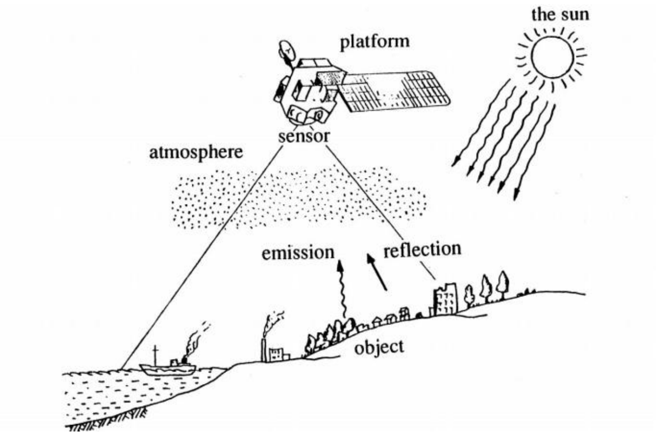

Figure 1

THE DISASTER MANAGEMENT CYCLE

Figure 2

Mitigation: Measure put in place to minimize the result from a disaster. Example: building codes and zoning, vulnerability analysis, public education.
Preparedness: Planning how to respond. Example: Preparedness plans, emergency exercises/training and warning system.
Response: Initial actions taken as the event takes place. it involve efforts to minimize the hazards created by a disaster. Example: evacuation, search , rescue and emergency relief.
Recovery: Returning the community to normal. Ideally, the affected area should be put in a condition equal to or better than it was before the disaster took place. Example: Temporary housing, grants and medical care.

IV. ADVANTAGES OF REMOTE SENSING

A. A large or wide area can be covered by a single image/Photo. Different Satellites with different sensor systems may cover different extent of areas.
B. We can get the data of any area repeatedly at regular intervals of time, enabling monitoring of changes.
C. Coverage of inaccessible or difficult terrain like mountains, thick forests etc are imaged.
D. Since data is obtained in digital form & in different channels, computer processing and analysis becomes possible.
E. Economic in cost and time.

V. DISASTER MANAGEMENT

The impact of natural disasters can be reduced through a proper disaster management, including disaster prevention, disaster preparedness (forecasts, warning, prediction), rapid and adequate disaster relief. Reduction of natural disasters can be successful only when adequate knowledge is obtained about the expected frequency and magnitude of hazardous events.
Some types of disasters, like, floods or earthquakes may originate very rapidly and may affect larger areas. The use of synoptic earth observation methods has proven to be especially suitable in the field of disaster management. In a

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number of countries, where warning systems and building codes are more advanced, remote sensing of the earth has been found successful to predict the occurrence of disastrous phenomena and to warn the people on time. Disaster management consists of two phases that take place before a disaster occurs, disaster prevention and disaster preparedness, and three phases that happen after the occurrence of a disaster, disaster relief, rehabilitation and reconstruction.

Disaster management is represented here as a cycle, since the occurrence of a disaster event will eventually influence the way society is preparing for the next one.

VI. REMOTE SENSING AND GIS TOOLS

Mitigation of natural disasters become successful only when we obtain the detailed information about the expected frequency and magnitude of hazardous events in an area. The information that are collected in natural disaster management contain spatial component. Spatial data is one which contain a geographic component, such as maps, satellite imagery, GPS data, aerial photography etc. All these data obtained will have a different projection and co-ordinate system, and need to be brought to a common map-basis, in order to superimpose them. After gathering the information, we can access organizing technologies like remote sensing and geographic information systems (GIS) in disaster management. Resulting from the technological progress made in the field of the management of the data banks and the computer aided cartography, the Geographical Information System (GIS) became today an ideal instrument of decision-making on territories as varied as a city, an agglomeration, an area or sometimes even the whole of a country.

A. Firstly the remote sensing and GIS provides a data base from which the evidence left behind the disasters that has been occurred before can be interpreted, and combined with other information to arrive at hazard maps, indicating which areas are more dangerous. 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.

B. 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.

C. 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 coverage.

D. 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 centers for emergency operations, and for integration of satellite data with other relevant data in the design of disaster warning systems

E. 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.

F. In the disaster rehabilitation phase GIS is used to organize the damage information and the post -disaster census information, and in the evaluation of sites for reconstruction. Remote sensing is used to map the new situation and update the databases used for the reconstruction of an area, and can help to prevent that disasters occurs again. The volume of data needed for disaster management, particularly in the context of integrated development planning, clearly is too much to be handled by manual methods in a timely and effective way.

G. For example, the post disaster damage reports on buildings in an earthquake stricken city, may be thousands. Each one will need to be evaluated separately in order to decide if the building has suffered irreparable damage or not. Afterthat all reports should be combined to derive at a reconstruction zoning within a relatively small period of time.

One of the main advantages of the use of the powerful combination techniques of a GIS, is the evaluation of several hazard and risk scenarios that can be used in the decision - making about the future development of an area, and the optimum way to protect it from natural disasters. Remote sensing data derived from satellites are excellent tools in the mapping of the spatial distribution of disaster related data within a relatively short period of time. Many different satellite based systems exist nowadays, with different characteristics related to their spatial, temporal and spectral resolution. Remote sensing data should generally be linked or calibrated with other types of data, derived from mapping, measurement networks or sampling points, to derive at parameters, which are useful in the study of disasters. The linkage is done in two ways, either via visual interpretation of the image or via classification. The data required for disaster management is coming from different scientific disciplines, and should be integrated. Data integration is one of the strongest points of GIS. In general the following types of data are required:

1. Data on the disastrous phenomena (e.g. landslides, floods, earthquakes), their location, frequency, magnitude etc.
2. Data on the environment in which the disastrous events might take place: topography, geology, geomorphology, soils, hydrology, land use, vegetation etc.
3. Data on the elements that might be destroyed if the event

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takes place: infrastructure, settlements, population, socioeconomic data etc.
4. Data on the emergency relief resources, such as hospitals, fire brigades, police stations, warehouses etc.

VII. EARTHQUAKES

Deformation at the Earth's surface, predominantly adjacent to tectonic plate boundaries, is the manifestation of forces acting deep within its interior. Geodetic and seismological measurements provide the principal data for understanding mantle dynamics, lithospheric processes and crustal response, and for improving numerical modeling for forecasting catastrophic events such as earthquakes and volcanic eruptions. Major advances have been made in earthquake research and risk mitigation. The areas affected by earthquakes are generally large, but they are restricted to well known regions (plate contacts). Typical recurrence periods vary from decades to centuries. Observable associated features include fault rupture, damage due to ground shaking, liquefaction, landslides, fires and floods.
The following aspects play an important role: distance from active faults, geological structure, soil types, depth of the water table, topography, and construction types of buildings. In earthquake hazard mapping two different approaches are to be distinguished, each with a characteristic order of magnitude of map scale , small scale (regional) *seismic macro zonation* at scales 1:5,000,000 to 1:50,000, and large scale (local) *seismic micro zonation* at scales of 1:50-25,000 to 1:10,000. The most important data for seismic hazard zonation is derived from seismic networks. In seismic micro zonation, the data is derived from accelerometers, geotechnical mapping, groundwater modeling, and topographic modeling, at large scales. Satellite remote sensing does not play a major important role in earthquake disaster management. In the phase of disaster prevention satellite remote sensing can play a role in the mapping of lineaments and faults, the study of the tectonic setting of an area, and geotectonic studies . Visible and infrared imagery with spatial resolutions of 5-20 meters is generally used. Satellite Laser Ranging (SLR) and Very Long Baseline Interferometry (VLBI) have been used for the monitoring of crustal movement near active faults. In the measurement of fault displacements Global Positioning System (GPS) will become very important. An increasingly popular remote sensing application is the mapping of earthquake deformation fields using SAR interferometery (In SAR) . It allows for a better understanding of fault mechanisms and strain. However, although some spectacular results have been reported, the technique still has a number of problems which does not make it possible to apply it on a routine basis. There are no generally accepted operational methods for predicting earthquakes. Although there is some mentioning of observable precursors for earthquakes in literature, such as variations in the electric field or thermal anomalies, they are heavily disputed. In the phase of disaster relief, satellite remote sensing can only play a role in the identification of large associated features (such as landslides), which can be mapped by medium detailed imagery (SPOT, IRS etc.). Structural damage to buildings cannot be observed with the poor resolution of the current systems. The Near Real Time capability for the assessment of damage and the location of possible victims has now become more possible with the availability of the first civilian optical Very High Resolution (VHR) mission, IKONOS-2, though this will only make a difference if adequate temporal resolution, swath-coverage and ready access to the data can be achieved .

Figure 3 Earthquake in Bhuj, India captured by IKONOS on February 2, 2001.

VIII. TSUNAMI

Tsunamis are water waves or seismic sea waves caused by large-scale sudden movement of the sea floor (due to earthquakes; landslides; volcanic eruptions or man-made explosions). With increasing population and development along most coastlines, there is a corresponding increase in tsunami disaster risk in recent years. Tsunamis differ from other earthquake hazards in that they can cause serious damage to thousands of kilometers from the causative faults. Once they are generated, they are nearly imperceptible in mid ocean, where their surface height is less than a meter. They travel at incredible speeds, as much as 900 km/hr, and the distance between wave crests can be as much as 500 km. As the waves approach shallow water, a tsunami's speed decreases and the energy is transformed into wave height, sometimes reaching as high as 25 m, but the interval of time between successive waves remains unchanged, usually between 20 and 40 minutes. When tsunamis near the coastline, the sea recedes, often to levels much lower than low tide, and then rises as a giant wave. The Pacific Tsunami Warning Center (PTWC) provides warnings for Pacific basin tele tsunamis (tsunamis that can cause damage far away from their source) to almost every country around the Pacific rim and to most of the Pacific island states. Satellite or aerial photography, especially when combined with a good GIS database of an area, can provide critical information for emergency

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managers, including damage to structures, transportation and communication links, and other "life- line" infrastructure components.

Figure 4 Aerial photo of before and after tsunami hit an area of Japan.

Satellite remote sensing can help us survey tsunami damage in many ways. In general, the application of remote sensing for tsunami disasters can be classified into three stages depending on time and disaster-related information.
In the first stage, general damage information, such as tsunami inundation limits, can be obtained promptly using an
analysis combined with ground truth information in GIS. The tsunami inundation area is one of the most important types of information in the immediate aftermath of a tsunami
because it helps estimate the scale of the tsunami's impact. Travel to a tsunami-affected area for field surveys takes a lot of time, given the presence of damaged roads and bridges, with much debris as obstacles.
In the second stage, detailed damage interpretation can be analyzed; i.e., classification of the building damage level. Recently, the quality of commercial satellite images has improved. These images help us clarify, i.e., whether a house
was washed away or survived; they can even classify more damage levels. The third stage combines the damage and hazard information obtained from a numerical simulation, such as the tsunami inundation depth. The damage data are compiled with the tsunami hazard data via GIS. Finally, a tsunami vulnerability function can be developed. This function is a necessary tool for assessing future tsunami risk. Recent advances in remote sensing technologies have expanded the capabilities of detecting the spatial extent of tsunami-affected areas and damage to structures. The highest spatial resolution of optical imageries from commercial satellites is up to 60–70 centimeters (Quick Bird owned by Digital Globe, Inc.) or 1 meter (IKONOS operated by Geo Eye). Since the 2004 Sumatra-Andaman earthquake tsunami, these satellites have captured images of tsunami affected areas, and the images have been used for disaster management activities, including emergency response and recovery.

IX. FUTURE ENHANCEMENT

Various satellites and sensors on-board provide with numerous possibilities of analyzing the data for disaster prediction and mitigation purposes. The nature of the natural
disasters determines the suitability of sensor types, spectral bands, active or passive radar data and their spectral, temporal and spatial resolutions. Impact of land use on natural disasters and ability to predict them would be one of the main contribution of remote sensing technology in this century. Integration of remote sensing with GIS and web technology makes it an extremely powerful tool to identify indicators of potential disasters. Information sharing through Internet reduces data acquisition time and thus providing efficient way to carry out real time disaster predictions (floods, forest fire, tsunami and hurricane etc.). Changing land use and assessment of its impact on the system in general within reasonable time frame and with greater degree of accuracy becomes possible with new technology. Over the last three decades urban development has taken place everywhere in general. From conservation point of view the planning for developments is vital. To update the database on land use in the watershed, all we would need to do is acquire more recent satellite imagery and carry out the land use classification. The beneficiaries of new technology are almost everyone, namely, the people, government, and private insurance industry. It is crucial to know which of the areas are at high risk and which ones are at relatively lower risk. Investment towards making use of the space technology is worth because improvement in instrumentation and real time prediction will bring about reduction in disaster damages; better prediction; accurate and timely damage estimation; and improved decision making in planning stages. Conventionally, flood emergency management, both public and private usually responds to crises rather than being concerned with the broader issues of vulnerability and its management. Its time this culture changed a little so other alternatives for mitigation of earthquakes, flood damages, landslides and soil erosion, such as, planned land use, should be explored, proposed and implemented. The future is promising with the new generation of very high-resolution satellites, like, IKONOS, TSINGHUA and QUICKBIRD and many more coming. They will provide the daily high resolution imaging of the world to track natural and human-made disasters.

X. CONCLUSIONS

Natural disasters cause damage to life and property all over the world in various forms. The pressure on the earth's resources caused by increased population has resulted in increased vulnerability of human and their infrastructure to the natural hazards, which have always existed. The result is

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a dynamic equilibrium between these forces in which scientific and technological development plays a major role. Recurring occurrences of earthquakes, floods, landslides and forest fires need to be studied using today's advanced technology to find effective preventive measures. Space technology can help the disaster mitigation process through better future scenario predictions, detection of disaster prone areas; location of protection measures and safe alternate routes etc. Post-disaster satellite data acquisition helps in disaster recovery, damage claim process and fast compensation settlement. Remote Sensing, GIS and GPS has proved a powerful tool for the disaster monitoring in many
cases. Satellite remote sensing showed monitoring capability not only at global scale but also at local scale.

- Present thinking on risk reduction, disaster management and climate change adaption would be better served if they were to harmonies more effectively.
- A Single institution is not enough to show the response against the disaster there should be all the institutions in that locality not only Government but also private show the response. Combined institutional effect is more effective than the single individual effect for example Government and NGO are the most extreme mitigative institutional effect against the disaster.

XI. REFERENCES

[1] Karen E. Joyce, Stella E. Belliss, Sergey V. Samsonov, Stephen J. McNeill and Phil J. Glassey, (2009) , "A review of the status of satellite remote sensing and image processing techniques for mapping natural hazards and disasters". *Progress in Physical Geography* pp. 183–207.

[2] Government of India. 2008. Common Guidelines for Watershed Development Projects. National Rain-fed Area Authority, Ministry of Land Resources, Government of Andhra Pradesh, India. 57 pp.

[3] Daniel N.M. Donoghue, (2002), "Remote sensing: environmental change", *Progress in Physical Geography* ,pp. 144–151.

[4] Engman E. T, Gurney R. J (1991) Remote Sensing in Hydrology, Chapman and Hall India.

[5] IMSD – Integrated Mission for Sustainable Development report, NRSA.

[6] David M. TralliT, Ronald G. Blom, Victor Zlotnicki, Andrea Donnellan, Diane L. Evans, (2005), " Satellite remotesensing of earthquake, volcano, flood, landslide and coastal inundation hazards," ISPRS Journal of Photogrammetry & Remote Sensing , pp. 185– 198.

[7] Rajeev,(2015), "Role of GIS in Utility Projects, 2015.", Unpublished scientific Project Report, Department of Science, Uttarakhand Open University, Haldwani, Uttarakhand.

[8] IRS-1D Handbook (1997). National Remote Sensing Agency, Dept. Space, Govt. India, India.

XII. INTERNET

- http://www.gsi.go.jp
- http://www.spaceimaging.com/carterra/applications/disaster/mozambique.htm
- http://www.pmel.noaa.gov/tsunami/aerial_photo_okushiri.html
- http://oar.icrisat.org/2001/1/Integrated-Watershed-Management-in-India.pdf

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