ROLE OF GEO-INFORMATICS IN DISASTERS

Geo-informatics, which combines satellite geodesy, information technology and Geographical Information System (GIS), are comparatively new technologies which can assist in all phases of disaster and disaster management viz. (1) prediction, (2) prevention, monitoring and warning system (3) assessment of damages and (4) post-disaster management. These technologies may also be used for computer modeling for studying complex spatial patterns, distribution of and likelihood of integration of multiple data layers and cause and effect relationships. Deterministic models are capable of explaining the causes of such hazards[1].

Despite the tremendous potential of Geo-informatics applications in disaster management the technology is yet to be uses optimally by the decision makers. Ironically Geo-informatics is yet limited in our country as a research subject, where tremendous advancements were made. Training and capacity building of disaster managers in effectively utilizing Geo-informatics is an important area where focus is needed, besides the huge investments in achieving technological milestones[2].

Applications of Geo-Informatics in Different Disasters[3]

Role of Geo-informatics in Drought Mitigation

Remote sensing data provide major input to all the three types rainfall predictions; namely such as long-term seasonal predictions, medium range predictions and short-term predictions. Global and regional atmospheric, land and ocean parameters (temperature, pressure, wind, snow, El-Nino, etc.) required for long-term prediction, could be generated from observations made by geo-stationary and polar orbiting weather satellites such as INSAT and NOAA. In the medium range weather prediction, the National Centre Medium Range Weather Forecasting (NCMRWF) uses satellite-based sea surface temperature, normalized difference vegetation index, snow covered area and depth, surface temperature, altitude, roughness, soil moisture at surface level and vertical sounding and radiosonde data on water vapor, pressure and temperature, and vertical profile data in the T86/NMC model. In the short-range rainfall prediction also INSAT-based visible and thermal data are being used.

Role of Geo-informatics in Cyclone Warning and management

Meteorologists have been using satellite images for monitoring storms for about thirty years. One of the most important applications in this endeavor is to determine the strength and intensity of a storm. In the late 1960's, meteorologists began observing tropical cyclones at more frequent intervals. The infrared sensors aboard polar orbiting satellites began providing day-and-night observations while geo-stationary satellite provided the continuous coverage during daytime. There exists a very efficient cyclone warning system in India which is comparable to the best known in the world. The approach essentially involves the prediction of the track and intensity of the cyclone using conventional as well as satellite and radar-based techniques.

The most striking advantage of the earth observation satellite data has been demonstrated during the Orissa super-cyclone event. A severe cyclonic storm with a wind speed about 260 kmph hit the Orissa coast at Paradip on 29th October 1999 causing extensive damage to human life, property, live stock and public utilities. The National Remote Sensing Agency acted promptly and provided spatial extent of inundated areas using pre-cyclone IRS LISS-III data collected on 11th October, 1999 and Radarsat Synthetic Aperture Radar(SAR) data of 2nd November, 1999 since cloud -free optical sensor data over the cyclone-hit area were not available. The map showing inundated area as on 2nd Nov, 1999 was draped over topographical map, and was delivered to the Orissa Government on 3rd November, 1999. Information, thus generated, was effectively used by various departments of Orissa Government involved in relief operations. Subsequently, the recession of inundated areas was also studied using Radarsat and IRS data of 5th, 8th, 11th, 13t^{h} and 14th November, 1999. In addition, the crop damage assessment was also made and maps along with block-wise statistics derived using pre-and post-cyclone NDVI image from IRS WiFS data were also provided to Orissa Government.

Role of Geo-informatics in Flood Management and Mitigation

Optical and microwave data from IRS, Landsat ERS and Radarsat series of satellites have been used to map and monitor flood events in near real-time and operational mode. Information on inundation and damage due to floods is furnished to concerned departments so as to enable them organize necessary relief measures and to make a reliable assessment of flood damage. Owing to large swath and high repetivity, WiFS data from IRS-1C and -1D hold great promise in floods monitoring. Based on satellite data acquired during pre-flood, flood and post-flood along with ground information, flood damage assessment is being carried out by integrating the topographical, hydrological and flood plain land use/land cover information in a GIS environment. In addition, space borne multispectral data have been used for studying the post-flood river configuration, and existing flood control structures , and identification of bank erosion-prone areas and drainage congestion, and identification of flood risk zones. Incorporation of remote sensing inputs such as satellite-derived rainfall estimates, current hydrological land use / land cover, soil information, etc. in rainfall-runoff model subsequently improves the flood forecast.

Role of Geo-informatics in Earthquake Studies

Earthquakes are caused by the abrupt release of strain that has built up in the earth's crust. Most zones of maximum earthquake intensity and frequency occur at the boundaries between the moving plates that form the crust of the earth. Major earthquakes also occur within the interior of crustal plates such as those in China, Russia and the south-east United States. A considerable research has been carried out to predict earthquakes using conventional technologies, but the results to date are inconclusive. Seismic risk analysis based on historic earthquakes and the presence of active faults is an established method for locating and designing dams, power plants and other projects in seismically active areas. Landsat-TM and SPOT images, and Radar interferograms have been used to detect the active faults. Areas rocked by Landers earthquake (South California) of magnitude 7.3 were studied using ERS-1 SAR interferometry which matched extremely well with a model of the earth's motion as well as the local measurements. Active faults on the seafloor could also be detected by side-scan sonar system. Recently the space geodetic techniques and high resolution aerial and satellite data have been used for earthquake prediction. Space geodetic technique with Global Positioning System (GPS) provides an accuracy of a centimeter over 1000 km and thus, helps in measuring the surface deformations and monitoring accelerated crystal deformations prior to earthquakes with required accuracy. Satellite imagery can be used in delineating geotectonic structures and to clarify seismological conditions in earthquake risk zones. Accurate mapping of geomorphologic features adjoining lineaments reveals active movement or recent tectonic activity along faults. Space techniques have overcome the limitations of ground geodetic surveys/measurements and have become an essential tool to assess the movement/displacements along faults/plate boundaries to even millimeter level accuracy. Using Very Long Baseline Interferometry (VLBI), it has been possible to record accurately the plate movement of the order of centimeter along baseline of hundreds of kilometer. Similarly, satellite-based Global Positioning system (GPS) has emerged as a powerful geodetic tool for monitoring (geological) changes over time which is the key for understanding the long-term geo-dynamical phenomena. GPS has been particularly useful in measuring the more complex deformation patterns across plate boundaries where large and regional scale strain builds up. Plate movements, slips along faults etc. have been measured using differential GPS to an accuracy of sub-centimeter scale.

Geo-informatics in Monitoring of Volcanic Eruption

Many times precursors of volcanic eruptions have been observed in various areas of volcanic activity. Ground deformations, changes in the compositions of gases emitting from volcanic vents, changes in the temperatures of fumaroles, hot springs and crater lakes as well as earth tremors are preceding volcanic eruptions. Thermal infrared remote sensing has been applied for volcanic hazard assessment. However, deficiencies of equipment and coverage suggest that thermal infrared has not been adequately evaluated for surveillance of volcanoes. The National Remote Sensing Agency has demonstrated the potential of multi-temporal Landsat-TM thermal band data in the surveillance of active volcanoes over Barren island volcano which erupted during March 1991 to September 1991. In the last three decades, aircraft and satellite-based thermal infrared (TIR) data have been used extensively to detect and monitor many of the active volcanoes around the world.

Repetitive coverage, regional scale, and low cost of thermal infrared images from satellites make it an alternative tool for monitoring volcanoes. Although the spatial resolution of NOAA environment satellite is too coarse to record details of surface thermal patterns, the plumes of smoke and ash from volcanoes could be detected which is useful in planning the rehabilitation of affected areas. Studies have shown that the upward migration of magma from the earth's crust just before eruption inflates the volcanic cone. Such premonitory signs can easily and quickly be detected with the aid of differential SAR interferometry. Extensive calibrations in a variety of test areas have shown that by using this technique, changes on the earth's surface can be detected to centimeter scale accuracy.

Role of Geo-informatics in Landslide studies

Aerial photographs and large-scale satellite images have been used to locate the areas with the incidence of landslide. Higher spatial resolution and stereo imaging capability of IRS -IC and -1D enable further refining the location and monitoring of landslides. A number of studies have been carried out in India using satellite data and aerial photographs to develop appropriate methodologies for terrain classification and preparation of maps showing landslide hazards in the Garhwal Himalayan region, Nilgiri hills in south India and in Sikkim forest area. Such studies have been carried out using mostly aerial photographs because of their high resolution enabling contour mapping with intervals of better than 2m in height. The availability of 1m resolution data from the IRS missions may help generating contour maps at 2m intervals making thereby space remote sensing a highly cost effective tool in landslide zonation.

Geo-informatics in motoring of pest attacks

One of the successful programmes where space technology has been used in risk assessment from crop pests/diseases is the Desert Locust Satellite Applications project of the UN/FAO for the International Desert Locust Commission. Temporal and spatial distribution of desert vegetation and rainfall derived from NOAA-AVHRR data have been used to identify the potential Locust breeding grounds. It has also been utilized in some of the South Asian countries for effective pest control measures. For example, in India, the desert locust affects over 2 lakhs sq.km spread over Rajasthan, Gujarat and Haryana states. Improved desert locust forecasting system is being tried with the help of satellite data by the locust warning organizations by narrowing down the potential breeding areas to undertake aerial spraying for arresting further growth of locust.

Geo-informatics in Forest Fire

Several thousands of hectares of forests are burnt annually due to manmade forest fires causing extensive damage to forest wealth. The behavior of forest fire depends upon three parameters: fuel, weather, and topography. Each parameter has several characteristic parameters. The most important task in the preparedness phase is to assess the risk. For risk assessment variables such as land use/land cover, demography, infrastructure and urban interface are considered. Effective mitigation of forest fire involves fuel (land cover, weather, terrain, and vegetation type and moisture level) mapping, identification of fire risk areas, rapid detection, local and global fire monitoring and assessment of burnt areas. The analysis of near-real time low spatial resolution (1km) and high receptivity data from NOAA and high spatial resolution data with low receptivity from earth resources satellites could provide the information on areas under fire. The IRS satellite data have been used for monitoring forest fires over Nagarhole Wild Life Sanctuary of Southern India.

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