Natural Disasters occur frequently around the world and their incidence and intensity seem to be increasing in recent years. The Disasters such as cyclones and floods often cause significant loss of life, large-scale economic, social impacts and environmental damages. India is one among the disaster prone geographical zones of the world and suffers losses huge money as a result of damages due to different types of disasters annually. Cyclone is a disaster resulting from nature's fury and is beyond human control. It causes damage to agriculture, human lives, livestock, infrastructure and communication facilities. The crucial part here is the information collection, mapping and its dissemination. The real-time operation of satellite remote sensing has demonstrated the translation of information derived from space technology to ground reality. Remote sensing techniques are invaluable for collecting the data rapidly and mapping the affected areas extensively, particularly in developing countries for which conventional resource mapping sources are limited. Mapping the disaster areas would help in the management of rescue and rehabilitation operations. The ancillary information has to be used alongwith remotely sensed data for better assessment. One direct method to estimate the damages is to procure satellite data before, during and after the event and analyze them together for change detection. From the satellite images prior to the cyclone and after cyclone, the situation can be mapped. The satellite images during event reveal the inundation extent. The post-cyclone satellite data shows the residual effects of the damaged area.

Cyclones

Among the coast based natural disasters, storm surges arising during cyclones, abnormal waves during tsunamis are the most prominent ones. The Bay of Bengal being a cyclogenetic area, generates cyclones every year. The cyclonic storms, which cross the coastal regions cause sudden abnormal rise of sea water, called surges and this is the primary cause for coastal flooding in the adjoining land. The Bay of Bengal is one of the ocean basins for the transformation of regions of low-pressure in the atmosphere into cyclonic storms. Between the years 1891 and 1977 the Bay of Bengal has generated about 400 cyclonic storms with different degrees of intensity. The effects of these storms are more pronounced in the states located on the East Coast of India, namely West Bengal, Odisha, Andhra Pradesh and Tamil Nadu. Sometimes, the surges along the coast accompanying these storms are abnormally high and form the most destructive component of this coupled ocean-atmosphere phenomenon. A Very Severe Cyclonic Storm (VSCS) PHAILIN originated from a remnant cyclonic circulation from the South China
Sea. The cyclonic circulation lay as a low pressure area over Tenasserim coast on 6th October 2013. It lay over north Andaman Sea as a well-marked low pressure area on 7th October. It concentrated into a depression over the same region on 8th October near latitude 12.00N and longitude 96.00E. Moving west-northwestwards, it intensified into a deep depression on 9th morning and further into cyclonic storm (CS), ‘PHAILIN’ in the same day evening. Moving northwestwards, it further intensified into a severe cyclonic storm (SCS) in the morning and into a VSCS in the forenoon of 10th Oct. 2013 over east central Bay of Bengal.

Role of GIS and Remote Sensing in Disaster Management

A Geographic information system (GIS) has a graphic database of geo-referenced information system, which is linked to the descriptive database. It uses high-powered graphic and processing tools that are equipped with procedures and applications for inputting, storing, analyzing and visualizing geo-referenced information. GIS and remote sensing (RS) are very useful and effective tools in disaster management. Various disasters like cyclones, floods, earthquakes, tsunamis and other natural hazards that kill lots of people and destroy property, infrastructures every year. Remotely sensed data can be used very efficiently to assess the severity and impact of damage due to these disasters. In the disaster relief part, GIS, grouped with global positioning system (GPS) is extremely useful in search and rescue operations in areas that have been devastated. Remote sensing is emerging as a popular means of map preparation while GIS can be used for storage, analysis and retrieval. Under remote sensing techniques, maps can be prepared using satellite data or aerial photographs and then digitized and stored on computers using GIS software. GIS and remote sensing technologies have been the object of substantial interest for all countries and bodies concerned with space and in exacting emergency services and disaster management. In disaster management, the objectives of the disaster experts are to monitor the situation, simulate the complicated disaster occurrence as accurately as possible so as to come up with better prediction models, suggest appropriate contingency plans and prepare spatial databases. Remotely sensed data can be used very effectively for quickly assessing severity and impact of damage due to cyclones and other disasters. Disaster maps generally show risk zones as well as disaster impact zones. These are marked areas that would be affected increasingly with the increase in the magnitude of the disaster.

During the disaster prevention stage, GIS is used in managing the huge levels of data required for vulnerability analysis and hazard assessment. It is useful mainly because of its capacity to build models or representations of the real world from information in databases. It is therefore important for aiding hazard prevention and for simulating the damage that would be caused in the event of a natural disaster. GIS can also be used to interpret information by creating thematic maps that show the spatial distribution of the information. These maps show spatial patterns, trends or relationships, making it easier to analyze the information. This is the case in the various successive stages of the process of assessing the damage caused by a disaster. In the disaster
preparedness stage, it is a tool for planning evacuation routes, designing emergency operations centres and for the integration of satellite data with other relevant data in the design of disaster warning systems. In the disaster rehabilitation stage, GIS is used to organise the damage information and post-disaster information and in the evaluation of sites for reconstruction. Natural hazard information should be included routinely in developmental planning and investment projects preparation. They should include cost/benefit analysis of investing in hazard mitigation measures and weigh them against the losses that are likely to occur if these measures are not taken. The application of remote sensing and GIS has become a well-developed and successful tool in disaster management. It allows for the combination of the different kinds of spatial data with non-spatial data, attribute data and use them as useful information in the various stages of disaster management.

**Disaster mapping**

Disaster mapping is a tool for assessing, storing and conveying information on the geographical location and spread of the effects or probable effects of disasters. It is the drawing of areas disturbed through excessive natural or manmade troubles resulting in loss of life, property and national infrastructures. The delineation can occur through the use of ground based observations and also using the remote sensing data. From the information gathered, it is possible to map the affected areas and provide information to the relief supplying groups. The difficulty with traditional manual maps is that they are tedious and time consuming to prepare, difficult to update and inconvenient to maintain.

**Cyclone Forecasting - The Early Warning System**

Tropical Cyclones are intense low pressure systems which develop over warm sea. They are capable of causing immense damage due to strong winds, heavy rains and storm surges. The frequency of the Tropical Cyclones in the Bay of Bengal is 4 to 5 times more than in the Arabian Sea. Indian Meteorological Department (IMD) is mandated to monitor and give warnings regarding Tropical Cyclone (TC). Data resources are crucial to early forecasting of cyclones. Satellite based observations are being extensively utilized. Satellite integrated automated weather stations have been installed on islands, oilrigs and exposed coastal sites. Buoys for supplementing the surface data network in the tropical ocean have been deployed. The Government has also started a National Data Buoy Programme. A set of 12 moored buoys have been deployed in the northern Indian Ocean to provide meteorological and oceanographic data. Dynamic forecasting of TCs requires knowledge of the vertical structure of both the Cyclone and the surrounding environment.

The goal of any warning system is to maximize the number of people who take appropriate and timely action for the safety of life and property. All warning systems start with detection of the event and with people getting out of harm’s way. Such warning systems encompass three equally important elements namely; Detection & Warning; Communication and Response.
The second stage of “Cyclone Alert” is sounded 48 hours in advance of the expected commencement of adverse weather over the coastal areas. Forecasts of commencement of strong winds, heavy precipitation along the coast in association with arrival of cyclone are issued at the alert stage. Landfall point is usually not identified at this stage.

The third stage warning known as “Cyclone Warning” is issued 24 hours in advance. Landfall point is forecast in this stage of cyclone warning. In addition to the forecasts for heavy rains and strong winds, the storm surge forecast is also issued. Since the storm surge is the biggest killer so far as the devastating attributes of a storm are concerned, information in this regard is most critical for taking follow up action for evacuation from the low lying areas likely to be affected by the storm.

**Search and rescue operation**

Search, rescue and evacuation procedures are carried out immediately after disaster strikes a certain area. These are major operations, usually performed by local volunteers, voluntary organizations and district and state agencies. The basic aim of all such operations is to ensure the survival of the maximum possible number of victims. A plan is worked out with the help of local people through aerial surveys and appropriate steps are then taken by the various teams involved to carry out the operations. Besides bringing material relief, the aim is also to control panic and confusion and to provide moral support.

**Assessment of Cyclone Damage (immediately during Cyclone)**

During cyclone, Remote sensing data provide timely and detailed information that are required by the authorities to locate and identify the affected areas and to implement corresponding damage mitigation. It is essential that information be accurate and timely, in order to address emergency situations i.e. dealing with diversion of inundated water, evacuation, rescue, resettlement, water pollution, health hazards and handling the interruption of utilities etc. Some important spatial outputs produced and analyzed in real time. The disaster extent maps, real time monitoring by remote sensing data and of damage to buildings and infrastructure maps were prepared. Moreover, meteorological reports based on real-time remote sensing data are required to show intensity/estimates, movement and expected duration of rainfall for the next 3 hours.

**Relief (after the Cyclone)**

In this stage, re-building of destroyed/damaged facilities and adjustments of the existing infrastructure will occur. The time factor is not as critical as in the last stage. Nevertheless, both medium and high-resolution remote sensing images, together with an operational geographic information system, can help to plan many tasks. The medium resolution data can establish the extent of the damages where as high-resolution data are suitable for pinpointing locations and the
degree of damages. They can also be used as reference maps to rebuild bridges, washed-out roads, homes and other facilities.

**Conclusion**

Disaster Management has to be a multidisciplinary and proactive approach. Besides various measures for putting in place institutional and policy framework, disaster prevention, mitigation and preparedness enunciated and initiatives being taken by the Central and State Governments and other organizations and media also have a key role to play in achieving our goal of moving together, towards a safer country. Remote sensing data and techniques alongwith GIS have proven their usefulness in disaster management plan especially in mapping the new situation after the disaster which help in updating the geographical database. This can be used for the reconstruction of the damaged area. GIS helped to interpret information by creating satellite based thematic maps that show the spatial dimension of the affected areas. It has become easier to carry out the disaster management operations efficiently. Studies have helped in making it possible to forecast and simulate disaster occurrences with regard to specific locations - helping in the initial stages of search and rescue operations. Techniques like satellite imagery and GIS help to identify areas that are disaster prone, zoning them according to risk magnitudes, inventory populations and assets at risk, and simulating damage scenarios. These tools are even useful in managing disasters as they provide instant access to information required in management decisions. Modern communication systems have also proved very useful, particularly in search and rescue operations. They not only help in providing warnings before the disaster, but also help in creating awareness which helps in reducing panic, confusion and mental stress. A communication network system helps in establishing contacts between relief teams which, with better central coordination, can work more efficiently.

**References**


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