Maps and Disaster Management

(invited paper)

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The Kutch earthquake of 26 January 2001 was, as it is well known, a massive one - one of the most severe earthquakes in many decades. Thousands of people lost their lives and over a million homes were damaged and destroyed. There was widespread destruction of physical and social infrastructure. Though the vastness and severity of destruction could be felt and realized in the immediate aftermath of the earthquake, it took some time for a clear and concrete picture to emerge. Within minutes of the earthquake it was known that Bhuj and surrounding areas were severely affected. However, it took many hours to realize that Bhachau town and surrounding villages were flattened. In retrospect, one feels that had we had a comprehensive and on-line geographical information system, it would have been much easier and quicker to comprehend the magnitude and severity of the earthquake. Of course, maps and database were used right from the morning of 27 January 2001.

People came forward to help the victims of the earthquake. The response was overwhelming not only from various parts of Gujarat but also from other States and even other countries. They came with relief materials, expertise and equipment. People from outside were not familiar with the geography and the terrain. RESECO and other agencies did an excellent work in providing road maps and village maps of affected areas. Such maps were extremely useful particularly for smooth and quick movement of the relief personnel and material. Yet one feels that if one had readily available maps and updated database, the performance would have been much better.

Within hours of the earthquake, senior officers of the State Government reached Bhuj. They saw the death and destruction all around. They could realize that the devastation was widespread. Communication had broken down. In order to have a quick assessment of the situation hundreds of revenue and panchayat officials were deputed to villages - some of them remote - to assess the magnitude of damage and death. The officials worked round the clock, visited villages under difficult circumstances, as there was no electricity, no water supply and communication had been disrupted. They made quick assessment in the first few days. Again one feels that with detailed, accurate and updated maps - and of course if one had access to GIS -one could have assessed the spread and magnitude of the damage and destruction much faster than it was actually done. This would have helped in better allocation of human and material resources.

The Kandla cyclone of 1998 had caused widespread destruction particularly in remote areas. Salt workers and salt pans were severely affected. It was feasible to assess the adverse effects within a short time with the help of satellite imageries and photographs before and after the cyclone.

The above examples illustrate the role, relevance and utility of maps and imageries in disaster management. These are real-life situations which show how critical the role of mapping is in disaster management.

Maps are essential at all stages of the disaster management cycle: prevention, mitigation, preparedness, response and recovery. It is important to undertake a range of activities such as: risk assessment; scenario analysis or analysis of consequences; forecast and projection; dissemination of information; allocation of personnel, equipment and other resources; reaching various affected areas by relief personnel; damage assessment and so on. Maps play a critical role in all these activities.

Maps have been used for centuries. Village maps based on land survey and road maps are there since ages. In recent times, availability of powerful computers, digitized maps and development of GIS have transformed the design, quality and utility of maps. GIS can help us in organizing, analyzing, displaying and verifying enormous data that help decision making.

The role of mapping for disaster management can be analyzed with reference to the following phases:

(i) Hazard assessment and vulnerability analysis

(ii) Mitigation and preparedness

(iii) Pre-disaster phase

(iv) Response

(v) Loss and damage assessment

(vi) Rehabilitation and reconstruction

Hazard assessment and vulnerability analysis are fundamental to disaster management planning. It is necessary to identify geographical areas that are likely to be affected by hazards such as earthquakes, cyclones and floods. Vulnerable and risky areas in the context of various types of disasters need to be identified and mapped with a view to planning of prevention, mitigation and emergency response measures. Maps will show areas having different degrees of vulnerability and those

prone to multiple disasters that will help the disaster managers prioritize the response mechanism.

If we had geographical information systems, which link maps with database, it would be possible to have simulation models that can be useful at various stages. With the help of GIS, one can analyze disasters over time and space. Based on such an analysis, one can assess the likelihood of such phenomena at different locations and over time. This can help prevent certain occurrences and mitigate the effects of such phenomena if they occur. Mitigation measures will have to be taken in areas that are more prone to hazards like earthquake, cyclone, flood and drought. Maps and GIS can facilitate such activities. With the help of GIS, one can have a dynamic system of mapping. In other words, maps can be updated as soon as the linked database is updated.

Based on the above analysis mitigation and preparedness activities can be planned. For example, enforcement of the earthquake resistant design of buildings is essential, as a mitigation measure, for areas with higher probability of earthquake or seismic zones IV and V, and also other zones. Resource mapping at the local level will be an important ingredient of preparedness.

For our present discussion, the pre-disaster phase is defined in a limited sense. It is the period after a warning or an early warning of a disaster and before the actual occurrence of a disaster. For example, cyclone alert messages may be given 48 to 72 hours prior to the landfall. There is always uncertainty about the landfall point and its timing. During this period, with the help of maps and GIS, scenarios can be analyzed and response measures can be planned. Evacuation routes can be planned and displayed for use by emergency managers. Another example is when we have a system of early warning of a drought. During the monsoon season, the rainfall situation is monitored closely. With the help of maps and GIS, it is possible to have a detailed assessment of areas with excess, normal and deficient rainfall.

Action during the response phase can be a continuation of that during the alert period. Once we know that a cyclone has crossed the coast, the response, for example search and rescue activities, can be planned and organized with the help of maps which show urban settlements, vital installations, houses, population and so on.

An interesting development in the USA and some developed countries is the introduction of “ShakeMaps” which can be prepared in a few minutes after an earthquake and sent to the emergency response agency. “ShakeMaps” show the extent of the potential damage due to shaking following an earthquake. Such maps can be used for emergency response, loss assessment and for public information through emergency response network. Preparation of such maps will of course need elaborate instrumentation and telecommunication network. The data necessary to produce “ShakeMaps” are automatically collected from hundreds of seismological instruments and received at a central processing site.

In the event of an earthquake, one needs to know the epicentre at the earliest possible time. With reference to the epicentre a circle can be drawn with a radius that corresponds the points where the earthquake is known to have an impact with the intensity of V or more on the Mercalli scale. Similar circles can be drawn with reference to varying intensity on the Mercalli scale. If we already had maps which were accurate and had the relevant details, it would be possible to quickly estimate the impact of an earthquake.

The role of maps in loss and damage assessment does not need any emphasis. In the event of a disaster, the assessment of damage may have to be done in phases. Immediately after the disaster, questions are asked regarding the number of deaths, the number of injured persons, loss of property etc. With the help of GIS one can have broad and quick estimates of area, population and the vital installations affected. At a later stage when a detailed survey and damage assessment are carried out, the consistency and reliability of the data can be checked with the help of GIS based analysis.

Mapping is essential even during relief, rehabilitation and recovery phases after a disaster. In the event of a major disaster affecting vast areas and a large population, it is necessary to plan relief and rehabilitation activities with the help of maps. The task becomes easier and more systematic if maps are linked to database.

In Gujarat attempts have been made in recent times to use maps, imageries and information in an integrated fashion. Some of the examples are as follows:

- Simple maps of India and Gujarat were used during cyclones of 1998, 1999 and later in order to track the movement of cyclones and plan for response activities. The position of the eye of the cyclone was plotted on a map from time to time so as to get an idea about its movement, direction and likely landfall.
- Satellite imageries before and after the Kandla cyclone were used in order to show the spread of the affected areas in the memorandum to the Government of India.
- During the monsoon season the Revenue Department collects data on rainfall on a daily basis. Talukas with shortfall in rains are identified and analyzed. During the last four years digitized maps are used to analyze crop and weather situations. Areas with deficient, normal and excess rain are shown in a map which provide the basis of an early warning system for taking timely and precautionary measures. This helps the decision-

makers to take appropriate policy decisions.

- The vulnerability atlas of India prepared by the Government of India has been extremely useful in identifying areas prone to different types of disasters and taking mitigation and preparedness measures. The Gujarat State Disaster Management Authority proposes to prepare such maps at a more desegregate level, i.e. the district and taluka level.
- Immediately after the earthquake of 26 January, 2001 GIS work stations were installed in the State Disaster Control Room. Maps with different types of data were generated for use of various Government departments. Maps showing areas severely affected and moderately affected were developed which were very useful in the relief and rehabilitation work. Various relief agencies were given village maps and road maps, which were necessary for expediting their work.
- Maps of earthquake affected villages showing villagewise population, households, deaths and injuries, collapse of houses, health centres, drinking water facilities etc. provided valuable data for planning relief and reconstruction work.

GSDMA has made an arrangement with the Remote Sensing and Communication Centre (RESECO) for developing GIS based decision support systems for disaster management and GIS mapping. RESECO will provide the technical inputs and map data while GSDMA will identify output data. Progress has been made in the following aspects:

- Digital data based on the 2001 census of all districts and talukas of Gujarat have been mapped.
- A unique code is given to each village so as to link it to the respective taluka and district.
- Data relating to damage is linked with the GIS database. GIS mapping of village amenities has also been done.
- An attempt has been made to have scenario analysis for disaster management with reference to the Surat district. For different water levels, areas have been classified into four categories: areas under alert, areas ready to shift, areas requiring immediate shift, areas that are safe.

It is proposed to undertake the following activities:

- Resource mapping: hospitals, police stations, transport services, HAMs, blood banks, medicine shops, doctors, cranes, tent suppliers, water suppliers, ST depots, NGOs, fire stations etc.
- Scenario building: Based on the Surat experience, other districts will be covered. Other disasters will also be addressed.
- Mapping for different types of disasters: areas within 5 km of the war zone, vital installations, highways, dam failures, cyclones etc.

Mapping has become an integral part of a modern decision support system. Disaster management involves complex issues of decision making, because most of the decisions are taken under an uncertain environment. In this context convergence of imagery, information and maps has immense potential. It can facilitate better policy analysis, preparedness and quicker response that can help us save life and property.