Natural Hazards-Disaster Management and Mitigation – A Review

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Summary

Asia and Pacific regions are more vulnerable to natural hazards like earthquakes, tsunamis, coastal or marine hazards, cyclones, storm surges, landslides, liquefaction, volcanic eruptions, droughts, floods, famines, sunstroke, cloud bursts, forest-fires, meteorological hazards, snow avalanches and epidemic disease etc. These hazards are associated with the various earth processes and also related to the strong coupling among the land, ocean and atmosphere. Hazards become disasters because of low awareness of the problems, low awareness of affordable solutions and perhaps, acceptance of higher risk in developing countries. The purpose of this paper is to increase awareness about the problems, affordable solutions and motivate the society for mitigation of disasters due to natural hazards. In this paper different natural hazards have been explained. This paper contains review study on natural hazard-disaster management and mitigation.

Introduction

It is important to assess hazards to ensure rapid development. Due to diverse geo-climatic conditions established in different parts of the globe, different types of natural disasters strikes according to the vulnerability of the area. India is considered as the world's most disaster prone country. It has witnessed devastating natural disasters in recent past like earthquakes, landslides, tsunami, floods, cloudburst, cyclones etc.

About 300 000 people have died due to the 26th December 2004 Tsunami alone making it the worst natural disaster in modern time. Damage due to devastation by recent flood in different parts of Tamilnadu, Maharastra and Gujarat states of India has caused heavy losses of human life and properties. Devastation due to recent Muzaffarabad (India-Pakistan border) earthquake of October 8, 2005 were more than 80,000 people died and more than 50,000 were seriously injured in the northern area of Pakistan, in the Pakistan Occupied Kashmir (POK), Jammu Kashmir and northern India. Thousands of houses were damaged. These are few examples of losses due to natural hazards. In recent years, the losses of human life and properties due to disasters have exponentially risen mainly because of lack of awareness, unplanned development and inadequate rehabilitation measures. Prediction and prevention of many natural hazards are yet not possible owing to high magnitude and complex nature of their occurrences. However, magnitude of their effects can be minimized to a certain extent through proper application of mitigation measures.

India faces most of the natural hazards on account of its geological position, climate and geographical setting. Cyclones, floods, droughts, earthquakes, landslides, cloudburst and forest fires are the frequent hazards. Himalaya faces maximum number of natural disasters requiring risk mapping & risk management. People living in mountainous terrains are at a greater risk from the natural disasters such as landslides, rock-fall, and cloudburst in summer and avalanches and crevasses in winter.

Various natural hazards

India is ranked 10th among the countries ravaged by earthquakes. About 60% of total area of the country is vulnerable to seismic activity of varying intensities. The earthquake hazard in India is high due to the possibility of great earthquakes in Himalaya and moderate but devastating earthquakes in Peninsular India. The impact of earthquakes is sudden with little or no warning, making it just impossible to predict or make preparations against damages and collapses of buildings and other man-made structures. Himalayan region is considered to be one of the seismically most active belts due to collision of Indian and Tibetan plates. Earthquakes of magnitude 8 or more occur once in every few decades in Himalayas. Seismicity in the Peninsular region is a result of compressive stress generated by the northward movement of the Indian Plate where once every twelve years or so a magnitude 6 or greater earthquake occurs. After the occurrence of Koyna, 1967, Latur, 1993, Jabalpur, 1997 and Bhuj, 2001 earthquakes, the peninsular region is also considered to have serious seismic hazard. Since these areas are highly populated even moderate earthquakes become highly destructive. Hence good knowledge of assessment of seismic hazard is required especially for the developing countries like India where destruction and deaths due to earthquakes are several orders

higher due to shoddy constructions and ever increasing population. Important aspects of earthquake hazard in India, cause and effects of earthquakes, the types of waves generated and their effect, seismic hazard assessment and microzonation as well as measures for preparedness are necessary to be study. As prediction of earthquakes is not possible it is recommended to have districtwise and citywise hazard assessment.

Tsunami is caused by vertical displacement of the water column of the sea floor triggered due to earthquakes, volcanic eruptions, submarine mudslides and bigger explosion into the sea. They are not detected in open sea due to their small amplitude and long wavelength; the tsunami waves can reach with high amplitude and small wavelength in the vicinity of a coast. It is identified that earthquakes along southern Sumatra, Makran coast, Indus Delta, Bangladesh and southern Myanmar in near future might cause tsunamis which can affect India. Northern Sumatra and Andaman regions are assessed to be probably free from great earthquakes for a few decades due to occurrence of 2004 Mw 9.3 and 2005 Mw 8.7 earthquakes. Southern Sumatra has potential for a great earthquake. However, the effect of tsunami due to it in India and Sri Lanka may be a limited one as the path of tsunami will be oblique to the rupture zone. The Makran subduction zone of southern Pakistan is seismically less active but has produced great earthquakes. The 28 Nov. 1945 (M_w 8.0) earthquake generated the last major tsunami in the Arabian Sea. More than 4000 people were killed on the Makran coast by both the earthquake and the tsunami. The tsunami caused damage in Bombay with 2 m run up and affected Karwar (Karnataka). This earthquake occurred in the central part of the Makran zone. Eastern and western parts of which remain potential zones for great earthquakes that can generate tsunami in future on Indian coasts. Indus delta and may be the Coasts of Kutch and Saurashtra are also potential zones for great earthquakes and tsunami. The Carlsberg ridge can give rise to local tsunami due to normal and thrust component of motion for major earthquakes as happened due to Mw 7.7 earthquake of 30 Nov. 1983 near Diego Garcia Island in Indian Ocean.

Monsoon rains are the nature's gift to the country. Yet major weather related and weather induced hazards occur during this season such as floods, droughts and landslides. About 11% land is prone to floods in India. On an average, floods affect 2% land and 3.7 crore people every year. Several major landslides have occurred during 2004, which brings to focus the risk of such hazards during the monsoon season. The events in the northern mountainous parts of the country are related to the systems producing heavy rain in these areas. These are (i) Break Monsoon conditions (ii) Movement of low-pressure areas or circulations from the monsoon trough and (iii) Eastward movement of troughs in the westerly airflow. On the other hand in the peninsular hills like the western and Eastern Ghats, landslides are associated with advance of monsoon and systems like west coast trough, mid tropospheric cyclone and off shore current 12.5 cm/day.

Drought is a permanent feature in some states of India. In fact drought is a significant environmental problem too as it is caused by less than average rainfall. In India about 68% of total area of the country is drought prone. Most of the drought prone areas identified by Govt. of India lie in the arid, semi arid and sub-humid areas of the country.

India has a very long cost line of 8041 km, which is exposed to tropical cyclone arising in the bay of the Bengal and Arabian Sea. About 8% of total area of the country is vulnerable to cyclone. The Indian Ocean is one of the six major cyclones –prone regions of the world. In India cyclones occur usually between April and May, and also between October and December. The eastern cost line is more prone on to cyclones as about 80% of the total cyclones generated in the region hit there.

Storms form over warm seas (sea surface temperature should exceed ~ 28°C in the Indian Ocean). The frequency of storms is highest in the Bay of Bengal. Though storms are tracked better today owing to satellite remote sensing, there is need for improvement in modelling of storm track and intensity because this is today one of the weakest links in storm-surge prediction. The impact of a storm as it crosses a coast is caused by the surge due to strong winds and low atmospheric pressure, and the high waves riding over the surge.

A cloudburst is extreme rainfall, sometimes mixed with hail and thunder, which normally no longer than a few minutes but is capable of creating minor flood conditions. Cloudbursts descend from very high clouds, sometimes with tops above 15 kilometers. The monsoon rains during July and August put a lot of water into the Himalayan soil; when there are instances of cloudbursts, the results can be disastrous. In the Indian subcontinent, a cloudburst usually occurs when a monsoon cloud drifts northwards, from the Bay of Bengal or Arabian sea across the plains, then onto the Himalaya and bursts, bringing rainfall as high as 75 millimeters per hour. An example was the sudden cloud burst over the Indian city of Mumbai and other regions of western

India, which occurred on the 26th of July, 2005. Approximately 950mm of rainfall was recorded in Mumbai over a span of eight to ten hours; the flood completely filled India's largest city and financial centre. Many time cloudburst had observed in Kullu Manali and Shimla (Himachal Pradesh) within a short span of time during July-Aug 2003. Uttarachal also experienced cloudburst during 2003.

An avalanche is caused when a build up of snow is released down a slope, and is one of the major dangers faced in the mountains in winter. An avalanche is an example of a gravity current consisting of granular material. In an avalanche, lots of material or mixtures of different types of material fall or slide rapidly under the force of gravity. Avalanches are often classified by what they are made of, for example snow, ice, rock or soil avalanches. A mixture of these would be called a debris avalanche. Indian himalaya witnessed for avlanches in past recent years.

In India landslides occur in Himalayas and Ghat regions. The Himalayan ranges are considered to be the world's youngest fold mountain ranges, which are geologically very active due to active continent-continent collision of Indian and Eurasian plates and most vulnerable to landslides and earthquakes. The Eastern and Western Ghats regions also experience several landslides every rainy season. Devastating landsides caused by exceptionally heavy rainfall. Earthquakes are known to have triggered a number of landslides.

If loose sand saturated with water is subjected to shear stress, the soil skeleton with tendency to contract transfers its load to water. The water pressure increases that reduce the confining stress to zero and the sand looses all its strength. The Bhuj earthquake of January 26, 2001 caused widespread liquefaction in the Great Rann saline-marshy lowlands to the north and the Little Rann to the southeast. As a result of soil liquefaction and subsidence, railway lines were heavily damaged, as were several small and medium sized dams.

Hyperthermia, also known as heat stroke or sunstroke, is an acute condition resulting from the body producing or absorbing more heat than it can dissipate, usually due to excessive exposure to heat. This is a serious medical emergency that requires immediate hospitalization. Body temperatures above 40 °C (104 °F) are life-threatening. At 41 °C (106 °F), brain death begins, and at 45 °C (113 °F) death is nearly certain. Internal temperatures above 50 °C (122 °F) will cause rigidity in the muscles and certain, immediate death. As Southern India and Orissa has experienced a large number of deaths due to sunstroke and lightning in recent years.

Disease becomes a disaster when it spreads in an epidemic as a massive outbreak of an infectious agent. Disease is historically the most dangerous of all natural disasters. Bubonic plague, Cholera, Black Death, Smallpox and Influenza often referred as Bird flu are the epidemic diseases caused so many human deaths in different parts of the world. From August 26, 1994, outbreaks of bubonic and pneumonic plague were reported in south central, southwestern, and northern India. Because most of the reports were unconfirmed, the extent of the outbreaks was unclear. However, a total of 693 suspected bubonic or pneumonic plague cases with positive test results for antibodies to Yersinia pestis were reported by India to the World Health Organization (WHO). Cases were reported from five states, Maharashtra (488 cases), Gujarat (77 cases), Karnataka (46 cases), Uttar Pradesh (10 cases), and Madhya Pradesh (4 cases) and from the federal district of New Delhi (68 cases). Some 156 critical plague cases were reported nationwide.

A famine is a phenomenon in which a large percentage of the population of a region or country are so undernourished that death by starvation becomes increasingly common. In spite of the much greater technological and economic resources of the modern world, famine still strikes many parts of the world, mostly in the developing nations. Famine is associated with naturally-occurring crop failure and pestilence and artificially with war and genocide. The flowering of bamboo forests in northeast India (Mizoram) could set off a trail of famine and ecological havoc during 1959. Bihar had also experienced famine in 1951 due to flooding and drought.

A wildfire, also known as a forest fire, vegetation fire, grass fire, brush fire is an uncontrolled fire often occurring in wildland areas, but which can also consume houses or agricultural resources. Common causes include lightning, human carelessness and arson. Drought and the prevention of small forest fires are major contributors to extreme forest fires. Across the southern and central India numerous fires were burning on March 15, 2004, captured by the Aqua satellite, NASA. The fires were predominantly located near rivers.

A volcano is a geological landform (usually a mountain) where a substance, usually magma (rock of the Earth's interior made molten or liquid by extremely high

temperatures along with a reduction in pressure and/or the introduction of water or other volatiles) erupts through the surface of a planet. Although there are numerous volcanoes (some very active) on the solar system's rocky planets and moons, on Earth at least, this phenomenon tends to occur near the boundaries of the continental plates, e.g. active volcano in Andaman & Nicobar Islands.

There are several considerations that contribute towards the vulnerability of the coastal areas:

(i) Coastal population density
(ii) Dependency on the sea
(iii) Quality of construction of buildings
(iv) Differences in Physical environment of coastal areas
(v) State of development
(vi) Location and type of hazard
(vii) Insurance cover

There are following different coastal hazards:

(i) Storm surges
(ii) Tsunamis
(iii) Submarine landslides/mudslides
(iv) Coastal erosion
(v) Harmful algal blooms (HAB)

Method

Flowcharts for natural hazards-disaster management and mitigation have been shown in Fig. 1, Fig. 2 and Fig. 3 at district, state and central government level respectively given by disaster management information centre. A natural disaster may become more severe because of human actions prior, during or after the disaster itself. Natural hazard disaster management and mitigation program consists of three components that are Preparedness, Rescue (Relief) and Rehabilitation as written below:

Preparedness: The preparedness phase involves the following aspects:

i) Hazards zoning map
ii) Hazards forecasting and warning
iii) Strengthening of existing structures
iv) Education & training
v) Insurance coverage for vulnerable people and houses
vi) Training for handling damaged buildings
vii) Putting up of new instruments e.g. tide gauge, seismograph, metrological instruments & others and up-gradation of existing ones

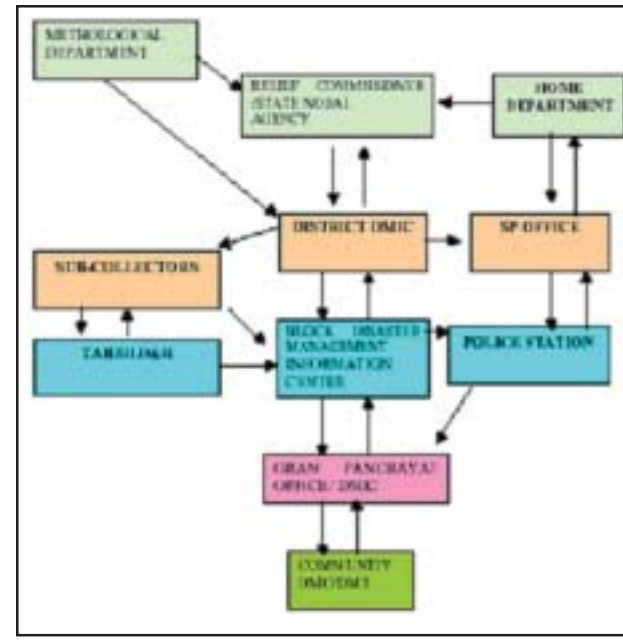

Fig. 1: Flowchart for disaster management at district level.

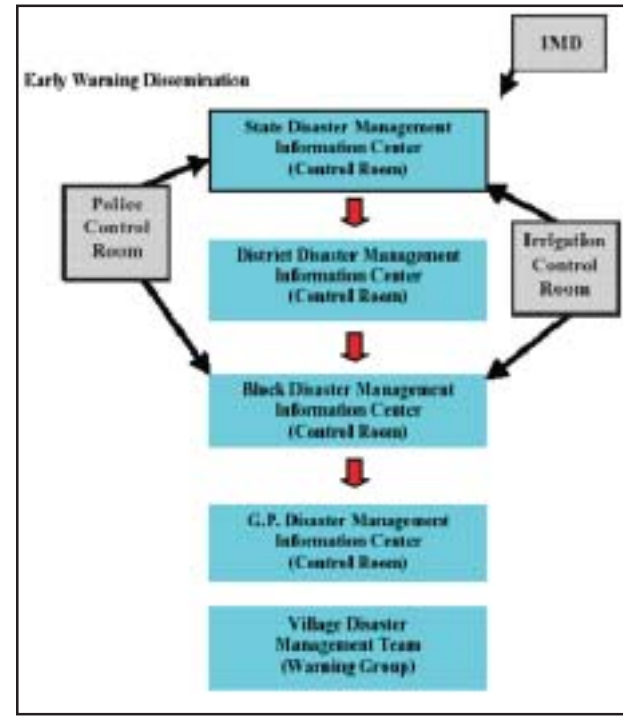

Fig. 2: Flowchart for disaster management at state level.

viii) Emergency preparedness

Rescue: Rescue at the time of emergency involves the following operations:

i) Maintenance of law and order; prevention of trespassing, looting. Keeping roads clear from sightseeing persons so that free movement of rescue vehicles is assured
ii) Evacuation of people
iii) Recovery of dead bodies and their disposal
iv) Medical care for the injured
v) Supply of food and water and restoration of water supply lines
vi) Erection of temporary shelters like tents, metal sheds
vii) Restoring lines of communications & information
viii) Restoring transport routes
ix) Quick assessment of damage and demarcation of damaged areas according to grade of damage
x) Cordoning off of severely damaged structures that are liable to collapse during aftershocks
xi) Temporary shoring of certain precariously standing buildings to avoid collapse and damage to other adjoining buildings

Rehabilitation: After the emergency, rehabilitation involves the following aspects:

i) Repair, restoration, strengthening or demolition of damaged buildings
ii) Selection of sites for new settlements, if necessary
iii) Adoption of strategies for new constructions (No cash compensation)
iv) Execution of the construction program
v) Preview/review of seismic codes & construction norms
vi) Training of personnel, engineers, builders and artisans
vii) Rehabilitation of destitute persons, orphans, widows, the aged and the handicapped

The function of control room starts from dissemination of message the flow chart given below gives us a clear picture of the flow of information from top to bottom and bottom to top in Fig. 1. Disaster Management Information Center plays a vital role in the disaster management activation. It coordinates the flow of information with respect to activities associated with relief operations, which is shown in Fig. 2.

Remote Sensing and GIS are playing vital role in mitigation of natural hazards viz. tsunamis, storm surges, cyclones, droughts, floods, cloudbursts and avalanches etc. It should also have pre-prepared plans and registers like

i) District and Block Disaster Mitigation Plan
ii) State Relief Code
iii) Disaster Mitigation Map
iv) Comparative Chart of previous disasters
v) Control Room Duty
vi) Register for in and out messages
vii) Gauge Reading Register
viii) Rainfall Register

There are following Mitigation Measures specified by Ministry of Home Affairs, Govt. of India:

i) Core Groups comprising eminent experts / administrators set up to guide and facilitate formulation of strategies and programmes for mitigation of earthquakes, cyclones and landslides.
ii) Emphasis on adherence to prescribed standards/codes for seismically resistant building designs and construction.
iii) Programmes for sensitization/training of Engineers, Architects and Masons in these aspects being implemented.
iv) Model building byelaws/regulations developed and interaction with State level authorities in progress to facilitate adoption and enforcement of appropriate techno-legal regime for hazard resistant.
v) Evaluation of existing building stock and infrastructure, particularly lifeline buildings and vital installations, for seismic safety, to carry out retrofitting/reconstruction.
vi) Sensitization and training of elected representatives, Civil servants/Police/Forest Service Officers and other public officials in disaster risk management.
vii) Awareness generation to inform and educate the general public on hazards, risks and vulnerability.
viii) Community level preparedness through Programmes involving preparation of village/Block/District level Disaster Management Plans, constitution and training of Disaster Management Committees/teams.
ix) Strengthening of disaster warning systems for cyclones, floods and landslides.
x) Drawing up project proposals for construction of multi-utility cyclone shelters, coastal shelterbelt plantations.
xi) Emphasis on drawing up and periodic rehearsing of on-site and off-site hazard management plans by industries- stocking /producing hazardous materials.
xii) Incorporating disaster management basics in school education.
xiii) Disaster management/mitigation aspects being incorporated in Engineering/Architecture/Medical Education curricula.

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Early warning would enable the administration and the community to be better prepared in case of natural

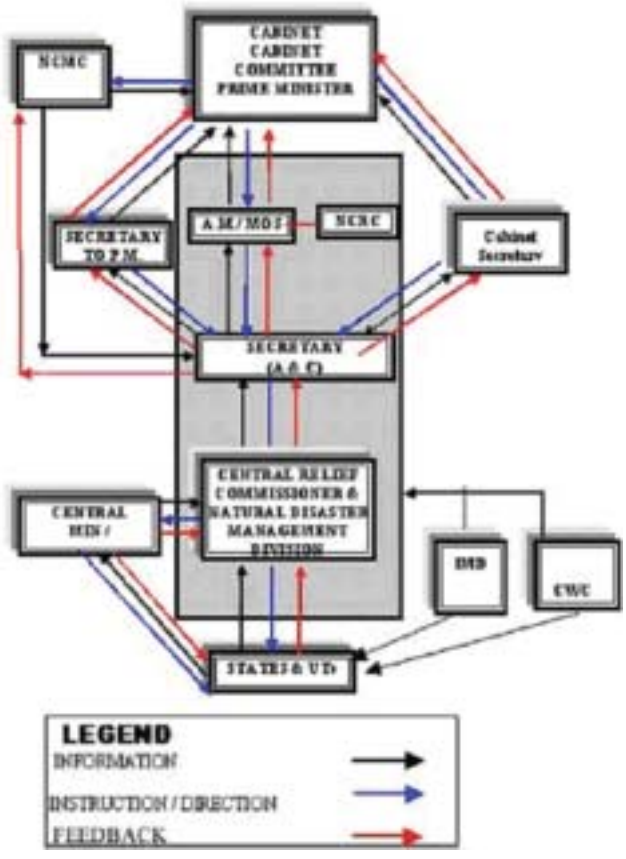

Fig. 3: Natural Hazards - The Interaction Pattern in the Government.

hazards. More importantly information about the vulnerabilities and impact would be required to reduce on the actions required to mitigate the effect of disasters. This would be supplemented with disaster risk management tools such as Early Warning Systems (EMS), which can play a vital role in saving lives and protecting livelihoods.

Conclusions

Ministry of Home Affairs, Government of India is responsible for providing help at the time of emergency. Disaster management is through the National Disaster Management Authority. The government acts as the biggest insurer to help the population in distress due to any natural calamity through relief and rehabilitation programs and loans and subsidies. During emergency a number of voluntary agencies come forward in a big way. The district collector has to coordinate their efforts. Contingency plans are normally available with the District Administration & Civil Defense authorities for use after every disaster. This should be periodically checked and updated. IMD, Delhi is responsible to give the proper warning to mitigate for the different meteorological hazards in India.

The disaster management plan should include the Preparedness program besides the plans for Rescue (Relief) and Rehabilitation and efficiently followed up at community, local, state and national level to minimize the losses from the disasters through institutional mechanism like the National Disaster Management Authority. Disaster Management Information Centers are responsible for minimize the disaster at various levels - District, Block and Gram Panchayat level in normal, pre, during and post disaster situation.

An ideal Disaster Management System needs to support the activities related to preparedness, prediction, damage assessment and rehabilitation. In recent years, the focus of disaster management community is increasingly moving on to more effective utilization of emerging technologies such as Remote Sensing, Geographic Information System, and Satellite Communication, enabling to prepare for mitigates potential impacts.

Haresh Shah, a noted risk management authority from Stanford University mentioned in one seminar that society will achieve to what it is motivated. Unless the society is motivated to check the disasters, disasters will keep striking us. It has often been said that the best preparedness of a natural hazard to face a natural hazard is derived from education of the community.

Therefore the disaster education is one of the most important so that citizen's evacuation is encouraged and it is necessary to invent the education's tools to understand damages by the natural hazard. Because the natural hazard is an uncommon event, it is difficult for most citizens to image it.

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