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ENVIRONMENTAL RISK ASSESSMENT AND MITIGATION ANALYSIS: POLICY APPROACH TO NATURAL DISASTER REDUCTION

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Abstract *Combating natural disasters continues to absorb the efforts of people engaged in different branches of science and engineering in various institutions, both at national and international level. Policies need to be framed for disaster reduction through integrated approach. Emphasis of 'reduction' should be considered primarily on 'prevention' and then on 'impact minimisation' through preparedness of rescue, relief and rehabilitation.*

INTRODUCTION

Several parts of India are vulnerable to natural disasters of one kind or the other, viz. flood, heavy rainfall, cyclone, drought, strong wind, earthquake, avalanche, landslide, fire, volcanic eruptions, droughts etc. After analysis the occurrence and patterns of past events of natural hazards, it needs to be realised to a considerable extent and can be correlated with the biotic pressure on the ecosystems caused by population growth and ill-planned development.

Assessment of hazards, especially the ones based in nature has been a concern for the scientific community for long time. Better instrumentation, global networks, collaboration among the relevant institutions and agencies over the decades have resulted in improved hazard assessment techniques and data. There is still more to do in knowing the hazards, especially in relation to slow onset disasters or environmental hazards such as drought, flood, fire and ecological degradation (Aysan, 1993). However, understanding the vulnerability and damage risk is only part of the picture. The decade's aim, that is the reduction of natural disasters can not be achieved unless there is good understanding of what are the interactive influences and their root causes leading to the prevalence of natural hazard.

The distinction between natural hazards and their man-made (or technological) counterparts is often difficult to sustain. Nevertheless, in terms of the consequences there is a sizeable overlap (Alexander, 1993). Hence, much that is of benefit to the study of natural catastrophe can be learned from technological risks and disasters, and from the manner these interact with their natural counterparts. Man-made risks are important here as the technology has created new sources of risk, and increased old ones. It should also be considered that many aspects of disaster management and risk reduction, developed in response to technological impacts, are applicable to natural disasters.

NATURAL HAZARDS CHARACTERISTICS AND CAUSES

Natural hazards are defined as those events that occur in nature and are capable of producing injury or death to people and or damage to property. Human activities and ecological deterioration are likely to alter the frequency, increase or decrease their severity or intensity, alter the damage distance, influence the rate of exposure and vulnerability of hazard exposed persons and property (Petak and Atkisson, 1987). At the simplest level, humanity has the options either to live in harmony with the natural environment, by a symbiosis in which ecological life support systems are enhanced, or to exploit resources by a from of parasitism, in which hazards are ignored until they strike (Alexander, 1993). The former provides opportunities for sustainable development and protection against environmental extremes (natural disaster), while the later relies on careless exploitation of non-renewable resources, places little emphasis on hazard prevention and more on post-disaster relief, rescue and rehabilitation.

EARTHQUAKE

Severe shaking of the ground is known as strong motions and is characterized by its duration, present frequencies, maximum wave amplitude, attenuation with distance form the fault, the maximum velocity in meters per second and the maximum acceleration. The principal causes of strong motion are volcanic activity, ground subsidence and tectonic stress caused by the mobility of the earth's crust. Many small to moderate earthquakes have been provoked by the superpowers programmes on nuclear testing, and hence, the side of the interaction at seismic network also reflects investment in intelligence work designed to monitor such trials. Some induced seismicity is, however, inadvertent (Judd, 1974). The phenomenon was first noticed in Greece in 1929, and on the filling of the Hoover Dam on the Colorado river, which provoked about 600 earthquakes, the largest of which reached a magnitude of S.O. In 1967 in West Central India, the Koyna Reservoir, which had a capacity of 2,780 million meter cube of water, caused a magnitude 6.5 earthquake which killed 177 people, injured 2,200 and left thousands homeless (Gupta and Combs, 1976). Reservoir induced seismicity can be a problem when hydraulic conductivity is strong are the way down to highly fractured rocks situated deep beneath the impoundment, and where were pressure is high in the saturated clefts between rock blocks.

FLOOD

A flood is any overflow from a body of water that spreads out over adjacent land areas usually with the harmful inundation of property and lands utilize by man and often with the loss of life. Whether caused by the seasonal increase of inland rivers or the storm rise of coastal waters, flooding results from the inability of these soil, vegetation, or atmosphere to absorb the excess water. Adjustment to floods can broadly be classified into structural and non-structural, according to whether they use engineering or administrative methods (Thampapillai and Musgrave, 1985). Long-term measures of flood prevention are based on the management of catchment involving: (1) afforestation, (2) other vegetational changes, (3) agricultural measures, (4) management of snow-covered areas, (5) management of urban areas, and (6) implementation of efficient water resource conservation strategy.

Land use control combined with integrated water management programme, can be one of the most important activities in reducing flood hazards. Statutes, regulations and public motivation campaigns can be employed in this line. Clearly, flood mitigation involves some difficult dilemmas. For instance, using dams as a structural measure of flood control is problematic. It is difficult to decide between the parallel absence of a large number or head-water dams, which may exert a limited effect on a trunk river, or a measure downstream dam, which may be vulnerable to failure and collapse. In general, upstream dams are best at controlling erosion and sedimentation, while downstream ones act best to restrict flooding. The later may need to be kept half empty if they are to deduce high discharge rates, but this way limit their value for water supply, power generation or recreational uses. Perhaps for this reason, only 17 of India's 1,554 large dams were built with the objective of flood control.

DROUGHT

Drought can be defined as a condition of abnormal dry weather resulting in a serious hydrological imbalance, with consequences such as losses of standing crop and shortage of water (Alexander, 1993). In hydrological terms, a precipitation drought is caused by lack of rainfall, a runoff drought by lack of stream-flow and an aquifer drought by lack of ground water. Drought results from a prolonged period of moisture deficiency. One concept is of that particular use in the identification of drought condition is albedo. At the global scale albedo represents the total power of the earth's surface and its atmosphere to turn back incoming solar radiation. As moisture conditions can often be detected by remote sensing as an increase in surface reflectivity, caused by desiccation of the land surface and wilting or death of vegetation and crops (Idso et al., 1975).

Main drawback of the existing drought management practices is the non-consideration of long term key influences causing drought and the expansion of drought affected areas. Scientifically, it can be considered that floods are also one of the principle causes of drought. The existing systems involved only post-event relief or pre-disaster planning for emergencies, but no proper emphasis has been given on the strategies of water resources conservation practices to prevent these hazards.

TROPICAL CYCLONE

The tropical cyclones are the offspring of ocean and atmosphere, powered by the heat form the sea, driven by the easterly trades and temperate westerlies, the high planetary winds and their own fierce energy. In their cloudy arms and their traiquill core, winds blow with lethal velocity, and the ocean develops devastation surge, inundating vast coastline (Mandal, 1993). Because of very adverse impact of tropical cyclones on human activities, interest of mankind was drawn towards this problem from quite sometime. In fact, many nations established the meteorological services towards the end of the last century and in the beginning of this century for organising cyclone warning services for the marines and coastal population, the prevention of tropical cyclone formation is not within the realm of possibility. However, the loss of human lives and destruction of properties can be minimised by taking prescribed short and long term mitigation measures.

RELATIONSHIP BETWEEN NATURAL AND MAN-MADE HAZARDS

Natural hazards are known to be as old as nature but man-made hazards are of recent origin. Beginning with the industrial era man's activities started to cause considerable changes in the natural environment. Presently they have reached such a high that their physical, chemical or biological effects become sometimes similar to the effects of natural hazards and even to the natural phenomena causing disasters (Jovanovic, 1988). Table 1 reveals the interacting mixed influence on onset or severity of consequences between the natural and man-made hazards. Interactions between these two types of disasters, based on the effects are presented in Table 2. Aspects of these relationships are presented (modified after Jovanovic, 1988) in Table 3.

Table 1 Interacting influences on consequences between the natural and man-made hazards

Natural Hazards	Man-Made Hazards
Tsunami	• Coral reef destruction. • Destruction of beach forest and other protective features. • Low settlement location.
Natural forest fire Fires due to lightning Fire due to volcanic expansions	• Bad planning of long distance transport electric lines. • Poor management of forest areas. • Lack of protective corridors. • Negligence of fire sensitive areas.
Landslide Rock slides	• Bad road engineering. • Open mining. • Deforestation. • Poor drainage system.
Earthquake	• Underground nuclear testing. • Bad planning of water development projects. • Deep mining. • Sensitive material and construction design of buildings. • Dense settlement.
Floods	• Deforestation. • Expansion of denuded areas. • Destruction of vegetation cover. • Erosion of soil cover. • Environmental modifications. • Poor design of community infrastructure.
Drought	• Destruction of vegetation. • Environmental modifications. • Over exploitation of water resource. • Pollution/siltation oriented eutrophication leading to death of water body. • Alteration of evapotraspiration system.
Cyclones, Hurricanes, Typhoons Tornados	• Similar to hazards described under earthquakes, floods, tsunamis.
Modifications of temperature 'homeostasis' of planet earth	• Technological trace gases and biomass burning influences on formation of 'greenhouse' effect and climate change.
Ozone layer variations	• Technological influence on trace gases concentration leading to ozone layer depletion and UV-B increase and biological perturbation.
Soil carbon depletion	• Breaking of biogeochemical carbon cycle in agricultural areas. • Over removal of biomass resources and man-made fires.

Table 2 Classified relationship between man-made and natural hazards according to effect.

Man-made hazards		Natural phenomena
• Changes of location • Development Practice • Development Projects	Change caused in human activities, behaviour, or history due to	• Earthquake • Droughts • Volcanoes • Floods • Tsunamis
• Water, food supply difficulties	Severity of consequences increased by	• Epidemics • Fires • Pollution

Table 3 Aspects of relationship between man-made and natural hazards

Man-made hazards		Natural phenomena
Water pollution	Reversible	Sewage disposal river biota destruction
Air pollution	Irreversible	Acid rain

Arithmetic Effect : Man-made Event + Natural Event = Disaster
Resonance Effect: Small Explosion-Response-Earthquake

NATURAL HAZARD RISK ASSESSMENT AND MITIGATION

Appropriate evaluation of a hazard requires a determination of the occurrence of a natural event at its various intensity levels. To appropriately assess the levels of risk associated with natural hazard exposures in India, it is required to carry out following studies:

1. Identification and characterisation of natural hazard problems
2. Selection of potential hazards and past accident analysis
3. Study and formulation of cause-effect interactions and influence network modelling
4. Exposure-response assessment and vulnerability studies
5. Identification of the cost and characteristics of the appropriate technologies for preventing/mitigating the hazards
6. Assessment of associated public policies and improvements based on ecological / scientific and anthropological factors.

Following are the important aspects to be covered in environment risk analysis:

1. Identification of potential hazards
2. Probability of occurrence and prediction / warning
3. Maximum credible damage scenario
4. Damage distance analysis
5. Secondary hazards and
6. Environmental risk mapping

An assessment programme model presented in Fig. 1 reveals the guidelines for forming an effective disaster reduction plan by adopting policy goals.

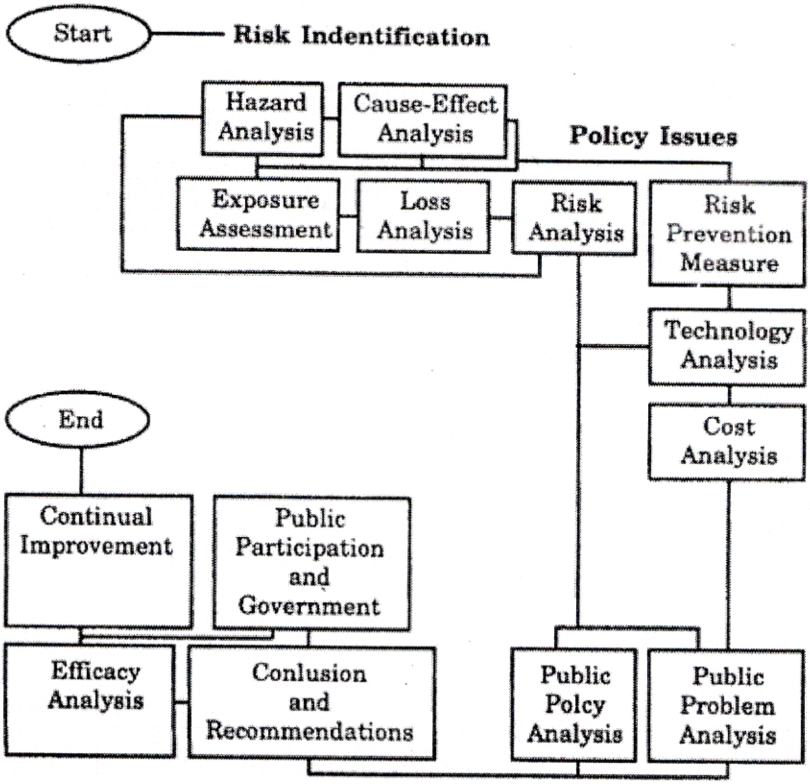

Fig. 1 Integrated environmental risk reduction programme for natural disaster management.

While mitigation is often taken to mean increasing structural strength, it is more useful to view it within a broader context. Mitigation is a management strategy that balances current actions and expenditures with potential losses from future hazard occurrences. More generally, mitigation objectives are those that eliminate or reduce the probability of occurrence of a hazard event, or those that reduce the impact of hazard occurrence. Preparedness activities are necessary to the extent that other mitigation measures cannot prevent disasters. In the preparedness phase, governments, organisations and individuals develop, test and maintain plans to save lives and minimise disaster danger (Petak and Atkisson, 1982).

Ecological risk assessment provides a methodology for evaluating the threats to ecosystem function associated with environmental perturbations or stressors and likely to cause a hazard or an increase in the probability (Lowrance and Vellidis, 1995). The objective of the regulatory development activities during the last two decades was to improve our nation's environmental quality. Environmental quality may be defined as a level of measurable ecosystem-health (Gupta, 1996) that is desired, which an organisation's activities and strategies are designed to achieve such with reduction in the risk of a natural hazard or preservation of a geographic area of significance. The scientific and technological information requirements may be classified as: (1) research and development activities aimed to improve the risk assessment process, and (2) innovative disaster prevention approaches and impact minimisation technologies (Rao, 1995).

DISASTER PREPAREDNESS AND ROLE OF DATA MANAGEMENT

Many people now accept that human activity itself has created the conditions for disaster events. This partly because of growing awareness that through negligence or inappropriate response, the working of social systems have made a disaster out a situation which otherwise might not have been so serious. There has also been a growth in understanding that it is hazard that are natural, but that for a hazard to become a disaster it has to affect vulnerable people (Cannon, 1993).

Aligning national and local efforts into the adoption of a preparedness and protection strategy may be no easy task. Such a strategy has to make its way into the face of the adopted 'relief management policy' and in the face of competing claims of national policies for poverty alleviation, integrated rural development, food security agriculture, economic structure adjustment and environmental protection (Oakely, 1993). Principal problem is that the 'relief-after-the-event' strategy is still being followed as the issue of natural disaster prevention and management which is dealt chiefly by the civil officers and the resource-scientist community is not appropriately made involved in planning better hazard reduction approach. In fact, it requires to establish a National Disaster Management Service. Ministry of Environment and Forests, Government of India has issued a notification (August, 1996) for the constitution of Central Crisis Group, State Crisis Group, District Crisis Group etc. However, it still lacks proper execution. In order to formulate an effective network these agencies may be given following responsibilities:

- Help define with communities the nature of their vulnerability
- Help ensure the most effective use of scarce resources
- To motivate the people on issues of hazard reduction strategy
- To advise on the undertaking of mitigating actions
- To offer training opportunities of Environmental Impact Assessment of development projects, and
- Help in introduction of Strategic Environment Assessment (of policies) and consequence modelling

To serve such plans, systems and procedures of disaster prevention and emergency management a comprehensive disaster information system is required. The identification and selection of data for disaster planning has to be based on the availability of reliable information on the range of topics. Existing risk assessment methods consider highly conservative exposure assumptions and toxicity/consequence estimates. By adopting conservations point estimates, the opportunity to qualitatives and more accurately address the input factors as a range estimates (Finkel, 1990). Risk estimates based on worst-case exposure scenario do not provide risk managers with lower risks of long term ecological hazards ultimately leading to environmental/natural disaster (Rao, 1995). The data on these aspects are likely to be well defined, and logically organised whilst other information may not exist, or where available may be both fragmentary and of dubious quality. These are the typical difficulties and discrepancies in a disaster planning system for an industrialising society, so within a developing country even wider gaps can easily be imagined in view if their limited professional resources to process and apply data.

CONCLUSION

Countering natural disasters continues to absorb the efforts of a number of branches of science and engineering and a wide range of institutions, both national and international. It has been estimated that, as a result of natural disasters, during 1970s and 1980s three million lives were lost worldwide, the number of disaster increased threefold, the economic losses per decade almost doubled and the insurance losses per decade quadrupled. In order to achieve the goal of United Nations proclamation of International Decade for Natural Disaster Reduction (IDNDR), nations are required to formulate their policies on disaster reduction through integrated approach. Emphasis of ‘reduction’ should be considered primarily on ‘prevention’ and then on ‘impact minimisation’ through preparedness of rescue, relief and rehabilitation. The issues of disaster reduction should be observed in this context with the objectives of efficient resource management, water conservation, poverty eradication and environmental protection through public motivation and statutory support.

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