' 5 DISASTER PREVENTION

Structure

5.1 INTRODUCTION

The United Nations International Strategy for Disaster Reduction (ISDR) defines disaster prevention as "activities to provide outright avoidance of the adverse impacts of hazards and means to minimise related environmental, technological, and biological disasters. Depending on social and technical feasibility and cost/benefit considerations, investing in preventive measures is justified, particularly in areas frequently affected by disasters. In the context of public awareness and education, related to disaster risk reduction, changing attitudes and behaviour contribute to creating a "culture of prevention."

Preparedness includes measures taken to ensure *readiness* of the administrative apparatus to respond quickly and efficiently to a disaster in order to minimise the loss to life and property. Disaster preparedness and prevention require policy and resources for the purpose. Pertinent questions to be asked in this regard include:

What is disaster prevention? What does it *mean* to us and should we *invest* effort in its application? If the answer is "yes", then *what* needs to be done, and *how* is it to be translated into policy and action? In order to address these questions, the government would need to allocate resources for disaster management, which would envelop the aforesaid concerns.

5.2 SIGNIFICANCE OF DISASTER PREVENTION

The continued effects of disasters (man-made and natural) are all too evident to be overlooked. Recent events alone include the devastating effects of Hurricane Katrina in America, Tsunami destruction in South Asia and the recent Earthquake in Pakistan and India, as well as the so-called complex political emergencies (CPE) in Iraq, Afghanistan and Sudan. Such incidences command large- scale emergency response, the arena in which humanitarian agencies have the highest profile. Such events also raise retrospective questions, such as, whether anything could have been done to prevent or reduce the scale of such disasters. In the case of CPE, prevention requires the political will of all those directly involved and able to influence the course of events. For natural disasters, efforts can be directed at reducing the scale of lives lost and property destroyed.

In the last two decades, reducing risk through the implementation of disaster preparedness and prevention measures has been gaining ground. The UN named the decade of the 90's as the "International Decade for Natural Disaster Reduction (IDNDR)." Whilst the success of the IDNDR is believed by many to have been muted through lack of interest and limited funds, organisations including the European Union, World Bank, DFID, UN and USAID (OFDA) are all investing resources in disaster prevention. Regarding International NGOs; IFRC leads, assigning disaster preparedness delegates to several country teams. Several NGO networks also exist, including the La Red in Latin America, ADRRN in Asia and a new network funded by DFID in sub-saharan Africa. In addition, local NGOs and specialist centers such as SEEDS and ADRC are known for implementing DPP (Disaster Prevention Planning) training and research.

The message inherent in these initiatives is the growing acceptance and action towards the same by many key players in the international aid business that more can and must be done to prevent and/or mitigate the impact of disasters to reduce the risks to vulnerable communities.

To foster a common understanding of the concept of DPP, it is worth looking briefly at what disaster mitigation and preparedness are. A ***disaster*** happens when a "**hazard**" (earthquake, flood, drought, fighting, etc) coincides with a "**vulnerable**" situation (cities or villages in earthquake/flood prone zones, impoverished people, etc). This is often written as:

Disaster = Hazard + Vulnerability.

Without the coincidence of both these conditions, a disaster would not occur (a hurricane at sea affects nobody, volcanic activity in Hawaii is a tourist spectacle). What this means therefore, is that development actions need to be targeted at reducing vulnerabilities, which are social, physical and economic in nature, incident amongst the most vulnerable, which are the poorest communities in society.

Disaster prevention is analogous to preventive health care. Whilst most efforts are directed towards post -disaster relief, reconstruction and rehabilitation (where the need is all too visible), prevention is often the ignored stage of the cycle of disaster (the 'invisible' side to disaster). There is often little interest or political will to take measures for preparation for a disaster that hasn't happened yet. Yet of course failures to address this can result in enormous losses of life and livelihoods.

5.3 ISSUES INVOLVED IN DISASTER PREVENTION

Disaster Prevention therefore implies the protective and preventive actions taken prior to a disaster, directed towards the reduction of risk and the effects of the hazard, that is, the actions that impede the occurrence of a disaster event and prevent and reduce the harmful effects of the event on communities and key installations. Constructing a *dam* or a *levee* (embankment) to control floods is an example of a preventive measure. Preventive Measures may include:

- *Structural Measures:* Engineering or Technical Inputs
- *Non- Structural Measures:* Administrative and Managerial Inputs

According to Udono (2002), five types of information are necessary for any/both of the above-mentioned categories of disaster prevention:

What: What occurs, what kind of phenomenon occurs? For example, a heavy rain causes a flood, a landslide or a debris flow. A volcanic eruption ejects a pyroclastic flow.

Where: Where does such a phenomenon appear? How extensive is the range of damage?

How: How large is the scale of phenomenon? How intense is it? For example, there is a heavy rain of 500mm in one day, or lava flow of 3000 m.

How does the phenomenon develop or spread? How does it come up? For example, there is a scenario of volcanic eruption such as Earthquake → Ash → Pyroclastic flow → Lava flow.

When: When does a phenomenon occur or when is it likely to occur? What is the frequency or probability of occurrence? For example, there is a heavy rain that occurs once in 30 years, or a great volcanic eruption that occurs once in 200 years.

Who: Who suffers from a disaster? How high is the grade of disaster? How many deaths, building damage or collapse? How much is the total loss?

5.4 HAZARD MAPPING FOR DISASTER PREVENTION

Hazard mapping is explained as "the process of establishing geographically, where and to what extent, particular phenomena are likely to pose a threat to people, property, infrastructure, and economic activities. Hazard mapping represents the result of hazard assessment on a map, showing the frequency or probability of occurrences of various magnitudes or occurrences"(DMTP, 1994).

Two parameters are used in hazard maps, *event parameter (*intensity of the hazard*)*, and *site parameter (*physical characteristics of the area), since the physical characteristics of the area with respect to that particular hazard determine the extent of losses that would be suffered in the event of an actual disaster. Event parameters give the *nature* of the hazard and site parameters give the *impact* that is likely in the event of a disaster.

As per Coburn Sspence and Pomonis in DMTP, 1994, *event* and *site* parameters for prominent natural hazards are:

Natural Hazards	**Event Parameters**	**Site Parameters**
Flood	Area Flooded (Km^2) Volume of Water (m^3)	Depth of Water (meters)
Earthquake	Energy Release (Magnitude)	Intensity of Ground Shaking (modified Mercalli /MSK intensity) Peak Ground Acceleration.
Volcano	Eruption size and duration	Potential to be affected by ash coverage (m); lava; dust fallout; debris flow
Strong Winds	Wind velocity (Km/h) Area	Wind velocity (km/hr)
Landslide	Volume of material dislodged	Potential for ground failure; ground displacement (meters)
Tsunami	Height of wave crest	Depth of flood water (meters)
Drought	Area affected (Km^2)	Rainfall deficit (mm)

A flood hazard map will show the maximum impact of floods with *different return periods* superimposed on each other. This would give the probability of occurrence along with the likely impact in different geographical settings.

A volcanic hazard map will give areas of variable risk, though it is comparatively difficult to quantify volcanic hazard than other hazards. Areas closest to the summit are permanently prohibited for habitation. Areas around a certain diameter, for example, 20 km. are subject to *pyroclastic* (airborne volcanic debris) surges and *lahars* (lava flows), which are subject to evacuation during eruptions. Parts of lower slopes, which are possible mud flow paths; since satellite imagery has made it possible to trace mud- flow paths based on observation through remote sensing and past data analysis, are second danger areas.

The critical factor in the preparation of maps is availability of data pertaining to past events with a view to preparing databases. Knowledge regarding spatial distribution of some natural hazards, namely, earthquakes, floods and droughts is now so advanced that it has been possible to account for minor variations in involved variables like area or population 'at risk'. Hence, it has been possible to prepare micro-zonation maps, which give detailed information about the susceptibility of different areas at risk from these hazards, even in case of multi-hazard vulnerability of a given area.

According to Odaka (2002), the objective of a hazard map is to provide residents with information about the range of possible damage and the disaster prevention activities. It is important to provide residents with understandable, clear information. There are two types of hazard maps:

Resident Education type: This type of map has the main objective to inform the residents living within the damage forecast area of the risk of danger. The information on areas of danger or places of safety and the basic knowledge on disaster prevention are given to residents. Therefore, it is important that such information is presented in an understandable form.

Administrative Information type: This type of map is used to provide residents with information about the basic materials that the administrative agencies utilise to provide disaster prevention services. These hazard maps can be used to establish a warning system and the evacuation system as well as evidence for land use regulations. They may be used in preventive works also.

There are certain constraints however in hazard mapping. *One* is security. Detailed mapping with regard to information on transportation routes etc. are not considered feasible from the security point of view. *Second,* following information regarding vulnerability, there would be more pressure incident on administrative authorities regarding preventive measures.

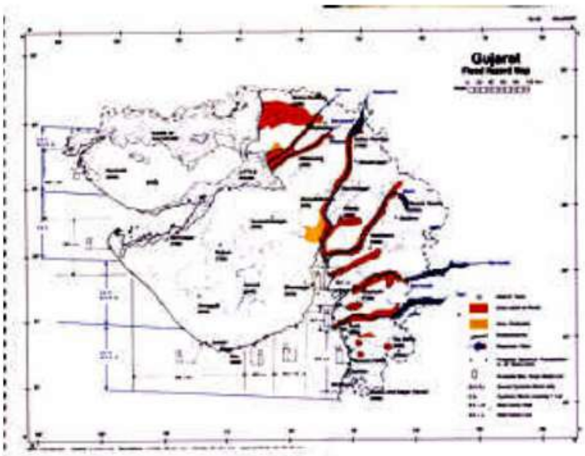
Post-Yokohama, India is committed to policy towards disaster prevention. The Ministry of Urban Development and Poverty Alleviation, Government of India (1994) constituted an Expert Group to study the following issues related to impact of natural hazards particularly with respect to housing and infrastructure:

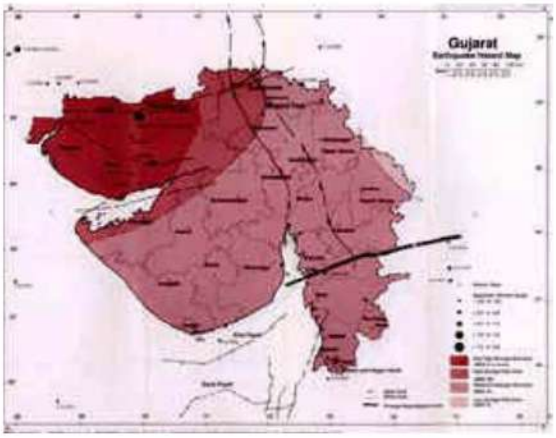
- Need to identify vulnerable areas with reference to natural hazards such as earthquakes, cyclones, floods, etc., having a potential of damaging housing stock and related infrastructure.
- Preparation of a Vulnerability Atlas showing areas vulnerable to natural disasters and determination of risk levels of houses.
- Formulation of a strategy for setting up Techno-legal regimes for enforcing disaster resistant construction and planning practices in natural hazard prone human settlements.

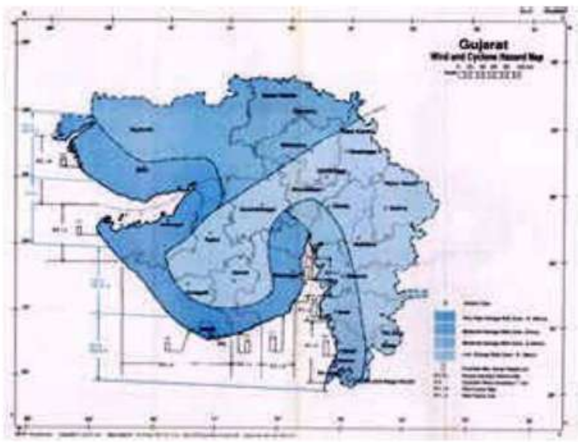
Accordingly, a National Policy was chalked out declaring the following objectives:

- Creating Public Awareness about safety from Disasters
- Amending/Enacting legislation for safety from Hazards
- Planning development areas with safety from Hazards
- Protection of habitations from adverse hazard impacts
- Constructing new buildings safe from Hazards
- Retrofitting existing buildings for improving hazard resistance

Apart from a multi- hazard vulnerability map, detailed hazard maps for flood, cyclone and wind hazards have been prepared. State wise hazard maps have been prepared, which vividly describe the particular states' vulnerability to a hazard. For purpose of illustration, the following maps drawn from the Vulnerability Atlas (BMTPC, 1994) give the vulnerability of the state of Gujarat, to floods, earthquakes and cyclone hazards *in that order.*







5.4.1 Information Technology For Disaster Prevention

Apart from hazard mapping, science and technology has greatly facilitated disaster prevention planning. Information technology (IT) has revolutionized communication, which has significant implications for disaster management.

A. Decision Support and Public Awareness

The World Wide Web and the Internet have opened up possibilities of department specific web sites, which provide information in specialised branches of disaster management. Some of these web sites are openly accessible to people which disseminate valuable information for interest articulation and academic deliberation which lead to fruitful policy. There are specialised web sites on natural hazards such as earthquakes and cyclones that provide comprehensive information regarding specific natural hazards. Such web sites also form 'knowledge bases' in that a web site on earthquakes would present all information on the hazard and ways to deal with it. These serve as important decision support tools that facilitate *real time* knowledge transfer from the emergency site.

B. Information Sharing

The Information Communication Revolution has made possible the setting up of local area and wide area networks known as INTRANETS and EXTRANETS that link up institutions over distant regions and facilitate information sharing even on a global basis. The integration of information technology (IT) with telecommunication interface modalities have made possible facilities like *video teleconferencing*, which provide for direct interface between aid givers and official agencies at the emergency site during real time emergencies. These also provide for 'knowledge networking' across institutions, especially research institutions that facilitates building data base for disaster prevention for different regions during 'peace times'.

Another significant development has been the Geographical Information System (GIS), by which detailed spatial analysis of 'at risk' area is accomplished through satellite imagery. Comprehensive information is collected about the area, which can be displayed graphically, on a map. This helps in highlighting critical facilities and communities at risk, available communication infrastructure for aid provision etc. which guides immediate disaster response in the short run, and facilitates risk mapping, risk assessment, dissemination of information, public awareness etc. over the long run, which aid long term policy planning for disaster mitigation. The GIS has greatly facilitated response effort as strategies can be devised on the basis of scientific simulation studies and scenario analysis using information through remote sensing. The India Meteorological Department (IMD) has commissioned a satellite based communication system called Cyclone Warning Dissemination System for quick dissemination of cyclone warning in coastal areas in local languages.

C. Policy Planning

Information Technology has greatly aided planning for disaster response and preparedness. Information technology has made policy for disaster risk reduction more fact based and less judgemental /'*a priori*'. Even generally, policy making for traffic, transport, forest conservation, urban congestion etc is facilitated by spatial imagery through remote sensing.

5.5 PLANNING FOR DISASTER PREVENTION

There is increasing understanding of the fact that disasters may not be unforeseen events, as has been assumed until now. Advancements in technology now enable authorities to identify the hazards that threaten a community and to estimate the areas and the settlements that will be affected. One can then take steps to *prevent the disaster*, or prepare for the disaster and substantially reduce, or mitigate, its impact. These actions are known as pre-disaster planning.

As read in Lesson 1 of the University of Wisconsin course on Disaster Prevention, Frederick Krimgold pioneered the early conceptualization of pre-disaster planning, which he describes as follows:

"Planning may be defined as the process of preparing a set of decisions for action in the future directed at achieving goals by optimal means. The stated goals of disaster relief are the reduction of human suffering, the improvement of material well- being, and the increase of personal security. It goes without saying that these goals are best served if disaster, in the first place, can be avoided or reduced. Thus, the primary goal of pre- disaster planning may be seen as the prevention or mitigation of disaster. If we refer to the definition of disaster in terms of the need for outside help, we may describe the goal of pre- disaster planning as the creation of self-sufficiency in dealing with natural phenomena. In those cases where prevention is not possible, the goal must be to plan for the effective application of aid…"

Planning follows *risk identification to secure a facility/area from likely risks.* A disaster plan is the result of a wide range of preliminary activities. Disaster planning is conducted both at the micro (at the level of an institution, involving instituting fire protection systems, electrical systems, plumbing, and protection against environmental hazards etc.) and the macro levels, the objectives of which are outlined as follows by Anil Sinha (2002):

- Forecasting, forewarning of disaster threat and providing the institutional and organisational setup and logistics, personnel, inventory, finances, etc., to achieve desired level of preparedness.
- Mobilisation of resources from internal and external sources.
- Taking organisational and administrative steps, including disaster action plans, regular and periodic updating of plans and projects securing institutional wherewithal to implement it, providing for a horizontal and vertical coordination through a network of official and non official agencies involved viz. government departments, civil defence military and paramilitary organisations running through the central, state and field levels.
- Placing on ground, well equipped modern forecasting and warning system and reliable fast communication system.
- Generating capabilities for prompt and rapid rescue, relief and rehabilitation work on the other.
- Proper planning for medical assistance and health cover would be a critical requirement.
- Providing for other miscellaneous needs like stocking and distribution, food, medicines, shelter, clothing, evacuation, transportation and long term resettlement and rehabilitation of affected communities.
- Securing water management practices since provision of clean water is often a problem and a necessity, post disasters.
- Government initiatives implying long term measures identified by the central government, instituting intensive Training programmes,

building data based on documentation of disasters and lessons to be learnt there from, and, dissemination of information.

- Integration of disaster management with overall development planning.
- Improving public awareness.
- Investment in R&D, use of modern technology, particularly information and remote sensing technologies.

Interventions Needed

- Evolve model integrated district/ institution wide disaster action plans that include all types of disasters, natural and man made, viz. land slides, accidents, earthquakes, etc., and cover all steps, namely preparedness, mitigation, risk mapping, relief and rehabilitation;
- Evolve a model state plan to ensure a degree of uniformity of approaches, actions and systems and their periodic updating, and,
- Training covering local industries and businesses to ensure better implementation through cooperation of the private corporate sector and the voluntary sector.

5.6 PREVENTION GUIDELINES IN CASE OF SELECTED HAZARDS

A. Landslides

According to R.S. Tolia, Rakesh Sharma, R.K. Pande, and J.K Pathak (2001), apart from natural causes like excessive rainfall, earthquakes, and changes in soil slope composition, in structure, hydrology or vegetation, *anthropogenic interferences* with the environment are also responsible for causing landslides. For example in Uttarakhand, major landslides occur because of blasting carried out for road cuttings. Other man- made factors are; construction of dams or reservoirs, housing schemes, roads, agricultural practices on steep slopes etc., implemented without proper *environmental impact assessments*. Deforestation also contributes to soil erosion. Even natural causes are not altogether beyond control, if right impetus is given to research and requisite authority and say granted to specialists. Preventive and remedial measures are studied within the purview of *environmental geomorphology*. To prevent water-induced land instability, the following measures are recommended (ESCAP IDNDR, 1999) as per the Bangkok Meeting of the ESCAP:

- Preventing or diverting runoff flows around critical sites;
- De-watering sites using drainage systems;
- Planting trees or shrubs which remove sub-surface water by transpiration;
- Planting deep-rooted vegetation to bind sub-soil material;
- Underpinning foundations to stable rock;
- Battering slopes to stable grades;
- Constructing retaining walls along the toes of critical slopes.

B. Cyclones

As per IDNDR ESCAP regional meeting (1999), the principal preventive measures employed to mitigate the destructive and injurious effects of tropical cyclones include the introduction of building design and construction standards aimed at improved resistance to the damaging effects of wind and water.

Preventive measures include both *structural measures* such as channel modifications, flood detention storages and levees or embankments which are designed to reduce the incidence or extent of flooding, and *non-structural measures* such as flood insurance, flood zoning restrictions, land-use management, economic incentives, public information and community education. To protect low-lying coastal areas, against damage from tidal inundation, principal structural measures involve the construction of embankments strong enough to withstand the anticipated storm surge heights and forces. Non-structural measures employ land-use zoning and controls over occupation in high hazard areas. Building controls are also imposed to restrict building on vulnerable areas. These controls require that flood heights be set at a safe elevation above a given datum.

Apart from warning systems, which are absolutely imperative, there is need for second line unconventional communication infrastructure, since mainline infrastructure is the first casualty in cyclones. Such facility is known as *Amateur Radio, which* has emerged as one of the most important second line communication systems during disasters. Though the facility as yet is not as commonly applied in India as it is in Japan and other western developed nations, the Andhra Pradesh government has taken considerable initiative in this regard. The National Institute of Amateur Radio (NIAR) has established HAM radio networks along the coastal belt of Andhra Pradesh. Other measures include providing cyclone shelters at regular distances to help save lives, natural coastal shelter belts like mangroves, trees like casuarinas, eucalyptus, tamarind, neem, etc., which act as natural buffers, building concrete houses to withstand strong winds and tidal waves, grains that do not shred easily in the face of strong winds, and securing cooperation of local folks like fishermen providing training and cooperation of community action groups, which is held imminent now for the success of any measure. The Andhra Pradesh government has implemented all these measures successfully. (Naidu, 2001)

C. Droughts

As per IDNDR ESCAP (1999), drought management measures can be considered in two categories: large-scale measures and small scale or on-farm measures. Large-scale surface-water conservation measures revolve around the provision of large water storage reservoirs for the regulation of natural stream-flow and the delivery of this water to critical areas, sometimes over considerable distances, through irrigation, stock or domestic water supply systems. Experience with large dam sites has not been particularly happy, especially in tropical countries, where adverse environmental and socio- economic consequences have resulted, such as waterlogging and salinity and large-scale displacement and loss of livelihoods for the poor. The recommendation emanating from the conference in this regard was that, where possible, large water storages should be designed and operated as multi-purpose structures, incorporating where possible and appropriate, irrigation, flood mitigation, power generation and recreational functions. These may not be mutually consistent, so that multi-purpose design requires a compromise solution based on the best overall net benefits to all potential users. Irrigation, stock and domestic water supply delivery and distribution systems should also be consistent with ecological and cultural considerations in that proposed channel or pipeline routes may traverse areas of natural significance, wildlife habitat or historical or cultural value. Large agricultural tracts in the ESCAP region, in Australia, China, India, Pakistan and Thailand have been degraded because of water logging and salinity due to large irrigation projects. Hence, new irrigation areas need to be carefully sited and selected keeping in consideration factors such as soil type, nature of the underlying strata, quality of irrigation water to be used and provision for proper drainage and disposal system. Good drainage takes care of the problem of water logging and salinity. Drainage water may be too high in salinity for safe disposal into a major watercourse, in which case an effective disposal process, such as transpiration from an irrigated salt-tolerant woodland or evaporation from an evaporation basin, could provide an effective solution. Besides, efficient groundwater management is an urgent necessity. Problem of losses through seepage and evaporation can be taken care of by structural measures like proper control valves at vantage points, good pipeline delivery, temporary storage arrangement at the delivery end, recharge arrangements of excess surface water during floods etc. through permeable seepage arrangements.

Drought is a slow onset disaster. It can be controlled through timely action and proper monitoring of the drought prone area through remote sensing. Citing the report of the Central Soil and Water Conservation Research and Training Institute, Dehradun, Alka Dhameja (2001) feels that topsoil erosion and rapid deforestation is shrinking the supply of groundwater, leading to *hydrocide* or death of rivers. Soil erosion is part of a wider environmental problem of *desertification* which is explained as a " a process of environmental degradation that leads to the abandonment of irrigated fields and pasture lands because of salinisation, water-logging or other forms of soil erosion. Dhameja recommends revival of traditional water storage and harvesting systems such as the *Kundis (saucer* shaped concrete structures used to store rainwater) of Rajasthan and the *Virdas* (shallow wells dug in low depressions or *jheels* to collect water) and the system of temple tanks, as was practiced widely in ancient times in South India and even now exists in many places there.

Other recommended measures include, planting drought resistant seed varieties, educating farmers in drought management and powers to the district magistrate (DM) to intervene at the right time to relieve distress of farmers. It is also felt that employment generation schemes should be formulated and run at the state level instead of being dictated and controlled by the Centre, such as the State Employment Guarantee Scheme in Maharashtra, since it would make timely intervention on the part of the District Collector possible. The said scheme has run successfully in Maharashtra.

D. Earthquakes

Though earthquakes cannot yet be predicted, drafting seismic codes, building regulations to ensure adoption of earthquake resistant technology, retrofitting of old structures that do not satisfactorily comply with safety regulations and regulation of informal settlements like 'jhuggis' in hazard prone areas are some of the preventive/mitigation measures that can be attempted. Proper town planning and effective enforcement of legislation and codes for mitigation can effectively prevent loss of life from earthquakes. For administrative preparedness for quick response, regular drills of paramilitary forces, simulation studies, data collection across quake-hit regions of the world with a view to diagnosing vulnerability can minimize losses during earthquakes. Manpower planning would be required to create specialist manpower to plan for and implement safe building measures.

E. Floods

Structural measures for flood prevention include construction of levees and floodwalls. However, they create problems of drainage and seepage of water and are also susceptible to breaches. Hence, structural safeguards, such as periodic maintenance of levees, proper side slopes to minimise slumping, ample freeboard to reduce overtopping of levees are required for desired protection. Other structural measures are channel modifications to divert excess flow, permeable groynes and revetments, constructed of piling, rock, concrete, fencing materials, vegetation or other materials etc.

It is being realised that structural protection measures have unviable side effects and limited utility. Hence, undesirable side effects of *dams* and *embankments* have shifted focus to non-structural mitigation measures to prevent losses from disasters. While dams result in large-scale displacement of populations and environmental degradation of surrounding areas, embankments cause siltation and water logging problems, creating fresh opportunities of floods rather than preventing their occurrence. Floodwaters carry a heavy load of sediments, which rise the riverbed overtime, making it necessary to raise the embankments to contain the waters. Rainwater is also blocked from flowing into rivers naturally because of embankments. Seepage of water underneath creates water logging in adjoining areas (Kulshrestha, 2001). Experts now feel that total flood disaster prevention is almost impossible in case of floods since costs involved are prohibitive and information of all possible consequences difficult since engineering know how is limited. Hence the focus is now on non -structural measures which aim to reduce susceptibilities such as rehabilitation safeguarding public health, better crop planning to derive maximum benefit from fertile flood zones, regulation of construction in flood prone areas as per hazard assessment and feasibility studies, disaster resistant communication infrastructure, proper drainage in urban areas for flood mitigation, provision of flood insurance etc. (Rangachari, 2001).

In case of structural mitigation measures, the emphasis is now on inter-regional cooperation (for areas such as the Ganga –Brahmaputra- Meghna (GBM) Basin covers India, Nepal, Bhutan and Bangladesh which are low income countries and cannot afford disaster losses) in instituting early warning systems, sharing of hydro-meteorological data, especially in downstream areas regarding upstream water levels for better forecast of floods, warning, provision of drainage facilities for easy discharge of excess water from dams and reservoirs, water harvesting for dry seasons, water management through water storage in common river upstream areas, regular monitoring of dams for regulating water storage and periodic release of excess water; and statistical analysis for risk assessment and estimation of the intensity and hazard occurrence probability with respect to common hazard threats. To clarify further, as per Rangachari, the terrain of Nepal and Bhutan, as well as the upper reaches of the GBM basin in India offer excellent sites for possible storage of water. Bangladesh and the plains of India offer no such facilities. Similarly, when the rivers emerge into the terrain/plains from the hills, they spread out, spill and meander. Construction of embankments could create political controversy. From an engineering perspective as well, cooperation would be necessary between neighbouring countries for better dam and embankment facilities and their maintenance.

Some Problems

Some problem areas in prevention arise from the traditional outlooks towards natural disasters. There may be longstanding acceptance of hazards by governments and communities. For instance a nation may have lived for centuries with a recurring major flood problem. Therefore, the need for preventive measures is not recognised. Also cost of some of the preventive measures can be very high and thus these initiatives are completely ruled out. In addition there are other national priorities, which are given more attention. Thus Disaster Prevention may not receive importance in National Planning. Problems like political issues and no public pressure on the government to take preventive measures add to the lack of initiative at the national level in this regard.

Towards Prevention

The problem areas in disaster prevention tend to require various forms of counter measures. However, the nature of disaster prevention is such that the measures involved usually need to be implemented from the senior levels of government. The population of a single community or area is unlikely to be able to institute, for example, a, major flood prevention project (though such populations can produce pressure through action groups and other means). The possible approaches towards this therefore have to have these constraints in mind. Some of the approaches may be:

- *National Policy*: There is need for a clear and comprehensive national disaster policy, which addresses the total disaster management spectrum, including consideration of all aspects of prevention. Within this policy there must be willingness on the part of government to institute preventive measures regardless of their popularity or interest articulation in this regard.
- *Legislation:* If necessary, there should be resort to legislation to implement measures for prevention; for example, mandatory building codes.
- *Assessment and Monitoring:* There should be adequate assessment and monitoring of disaster hazards and vulnerability, so that the need for prevention is accurately identified and defined. This should lead to accurate evaluation of all reasonable disaster prevention projects. In this regard, it is especially important that sensible cost benefit comparisons are worked out; to know whether, by instituting preventive measures, the nation and community is going to gain more (bearing in mind project costs), as against the losses which may arise if nothing is done.

  In this context, the establishment and maintenance of a permanent disaster prevention section or centre can play a vitally important part because on behalf of the government, the section/centre should keep a constant watch on disaster management. Thus, it is able to identify the need for preventive measures, whenever such need arises. It is then the responsibility of the section/centre to advise the government with regard to needs in the disaster prevention field, and the priorities, which should apply.

  Furthermore, there should be insistence by the disaster prevention section/center (on behalf of the government) that an effective post- disaster review is undertaken after all major disaster events. This review must include advice to government on whether, as a result of the particular disaster, further preventive measures are warranted.

- *Public Awareness and Education:* Public Awareness and Education Programmes should ensure, among other things, that disaster-prone communities are kept aware of risks and vulnerabilities, which may apply to them. In this way, communities are likely to support the need for sensible disaster prevention, if this becomes necessary.
- *International Assistance:* The maintenance of a continuous dialogue with international assistance agencies can also be of use. Such a dialogue helps to ensure that any proposals concerning disaster prevention can be evaluated and submitted to appropriate assistance agencies.

5.7 CHALLENGES FOR SOUTH ASIA

For long, the link between disasters and development had been overlooked. The consequence has been a spate of uncontrolled disasters worldwide. Disaster Prevention seeks to stress the significance of inbuilt strategies for disaster risk reduction in everyday planning for development, such as construction technology in hazard prone areas. Sahni and Ariyabandu (2003) outline the challenges in this regard especially for the South Asian Community, which is among the more vulnerable areas because of coupling of odds; physical vulnerability to natural hazards and widespread poverty of the masses and lack of disaster awareness among policy makers. There is a need to gradually integrate disaster risk analysis into development plans. The process should desirably be bottom up by way of infrastructure provision at the grass roots level such as water harvesting structures in drought prone areas, reviving traditional methods of water preservation, merging water shed management with forestry programmes, locally appropriate early warning systems, shelters, etc. with active involvement of local community based organisations coupled with generation of heightened awareness among communities to utilising the same as an active policy measure. The International Strategy for Disaster Reduction (ISDR) programme/ document entails the following stipulates by way of internationally agreed goals and objectives:

Goals

- Increase public awareness of the risks that natural, technological and environmental hazards pose to modern societies.
- Obtain commitment by public authorities to reduce risks to people, their livelihoods, and social and economic infrastructure and environmental resources.
- Engage public participation at all levels of implementation to create disaster resistant communities through increased partnership and expanded risk reduction networks at all levels.
- Reduce the economic and social losses of disasters as measured, for example, by Gross Domestic Product.

Objectives

- Stimulate research and application, provide knowledge, convey experience, build capabilities and allocate necessary resources for reducing or preventing severe and recurrent impacts of hazards, for those people who are most vulnerable.
- Increase opportunities for organisations and multi-disciplinary relationships to foster more scientific and technical contributions to the public decision-making process in matters of hazard, risk and disaster prevention.
- Develop a more proactive interface between management of natural resources and risk reduction practices.
- Form a global community dedicated to making risk and disaster prevention a public value.
- Link risk prevention and economic competitiveness issues to enhance opportunities for greater economic partnerships.
- Complete comprehensive risk assessments and integrate them with development plans.
- Develop and apply risk reduction strategies and mitigation measures with supporting arrangements and resources for disaster prevention at all levels of activity.
- Identify and engage designated authorities, professionals drawn from the widest possible range of expertise and community leaders to develop increased partnership activities.
- Establish risk monitoring capabilities, and early warning systems as integrated processes, with particular attention to emerging hazards with global implications such as those related to climate variation and change, at all levels of responsibility.
- Develop sustained programmes of public information and institutionalised educational components pertaining to hazards and their effects, risk management practices and disaster prevention activities for all ages.
- Establish internationally and professionally agreed standards/methodologies for the analysis and expression of the socio-economic impacts of disasters on societies.
- Seek innovative funding mechanisms dedicated to sustained risk and disaster prevention activities.

In this regard, controlling corruption in the implementation of well- meaning schemes is the key factor in controlling vulnerabilities through well-intentioned policy intervention on the part of the government. For instance as brought out by Janki Andharia (2003), in India vulnerability to disasters is high, especially as people, lack basic facilities like safe/clean drinking water, adequate housing/shelter, schools, hospitals, roads et al. Existing vulnerability is exacerbated/turned to active risk by improprieties like illegally tapping electricity, which crates conditions for fire outbreaks, dumping radioactive and other hazardous waste in rivers against regulations, which creates active threat to peoples' lives and well being, and other such willful omissions and commissions on the part of people with or without connivance of official functionaries which result in malpractices potently threatening life and property over the impacted area/populace. Curbing malpractices would require proactive policy in this regard with active cooperation of the people. Citing Cernea (1992), Janki Andharia (2003) brings out the constraints in articulating the possibility. People centered development and top-down planning are mutually contradictory, in that they offer two opposing paradigms and hence, difficult choices. The paradox is explained by the following three factors or constraints in desired reconciliation between the government centered and people centered approaches as articulated by Andharia:

- The expanding role of the public sector in launching programmes which discourages popular participation since there is no commensurate effort to evolve mechanisms to involve people.
- The growth of international aid, which amplifies government programmes, while "increasing the distance between the progamme's center and periphery";
- The recurrent failure in public programmes due to alienation of intended beneficiaries.

The challenge is to institutionalise people centered approaches in the 'monopolistic environment' where the government is the sole provider of public services generally, also, specifically for those related to disaster relief /mitigation. There is need for peoples' involvement in disaster prevention activities, specifically, since people need to be aware of the vulnerabilities and also of what is being/needs to be done to ameliorate the situation with regard to susceptibilities, physical, economic and social to natural or man-made or any other hazard(s). To that end, right to information and social activism on the part of people or 'organised volunteerism' with regard to specific issues/concerns. For example, the foundations of buildings need to be elevated as a general rule in flood prone zones, and likewise, as per requirements with regard to other hazards in different areas. There has to be intense articulation in this regard and sufficient pressure/lobbying for concrete policy, which is unfortunately lacking in third world countries where people are found to be largely passive with regard to their rights and there is not enough activism on their behalf on the part of civil society since level of political development is low. Hence, active institutionalisation of social capital inherent in communities on the part of government can empower communities and give them the channel for articulating their grievances. There have been encouraging beginnings however, as, following the Latur Earthquake, the Government of Maharashtra launched the Maharashtra Emergency Earthquake Rehabilitation Programme (MEERP) in which one of the most progressive features was the importance given to community participation (MEERP Information Brochure, 1998).

Participation is desired, as per Cohen and Uphoff (1977) read in Andharia (2003), with regard to/ in:

- *Decision-making*, since policy has to ideally respond to articulated concerns, which involves, identifying problems, formulating alternatives, planning activities, allocating resources, etc.

- *Implementation* of programmes, carrying out activities with catalytic assistance from the state, managing and operating programmes, partaking of services etc.
- *Procuring/Deriving* benefits, individually and/or collectively.
- *Evaluating* the activity and its outcomes with bearing on the above stated preceding activities, viz. planning, implementation and availing benefits.

Hence project planning for rehabilitation and development must have the aforesaid built- in features and the onus for the same lies on the project planners and the politicians since political will to empower passive communities is a major factor/constraint as has been brought out in researches. Onus for the same is on project planners who are sometimes reluctant at delegating responsibility or parting with authority, more pertinently, and on politicians who are diffident for their own reasons about empowering people.

5.8 IMPLICATIONS FOR HUMANITARIAN & DEVELOPMENT AGENCIES

Five key reasons why disaster prevention and preparedness (DPP) is important for humanitarian and development agencies to address are:

1. Disaster risk reduction is one of the biggest neglected *development* issues. Since it falls between "emergency" and the "development", it is ignored on both counts and misunderstand in both respects. Yet it serves both purposes, and can provide a powerful force for good governance.

2. Undertaking large development programmes without consideration of disasters is bad practice. In Bangladesh, reportedly, recent floods have destroyed ten years of development. The same holds true of the recent cyclone in Honduras. Smaller everyday disasters, example. fires in markets also contribute to mounting losses.

3. Humanitarian agencies and their donors have invested huge resources in emergency response and reconstruction. Why not invest more in prevention?

4. DPP provides a 'bridge' between relief and development. Probably the strongest argument for addressing DPP lies in this. The language of vulnerability and capacity is the same language of disaster as it is of development

5. New tools for existing problems. If the argument against DPP is that it is being done under other names, then the counter argument is that by focusing interventions according to DPP, new solutions may occur. For example, community interventions addressing a hazard, for example, a flood or fire, can provide a perceived *neutral* threat that all stakeholders mobilise around, which can lead to other development related spin offs.

5.9 CONCLUSION

Disaster Prevention and Preparedness is an *integrated approach*, which requires planned commitment on the part of governments. Prevention means measures designed to prevent natural phenomenon from causing or resulting in disaster or other related emergency situations. It concerns the formulation and implementation of long-range policies and programmes to prevent and eliminate the occurrence of disasters. On the basis of vulnerability analysis of all risks, prevention includes legislation and regulatory measures, principally in the fields of physical and urban planning, public works and building. Preparedness on the other hand means actions designed to minimize loss of life and damage to property, and to organize and facilitate timely and effectively rescue, relief and rehabilitation in case of an event. A well-planned, well-implemented and well-coordinated Disaster Prevention and Preparedness Plan can considerably reduce the damage and destruction due to disasters

5.10 KEY CONCEPTS

Disaster: Disaster is defined as "a serious disruption of the functioning of a society causing widespread human, material, or environmental losses which exceed the ability of the affected society to cope using its own resources" (ISDR).

Disaster Prevention: Disaster Prevention is understood as the process of surveying the work place, identifying areas or situations which might cause or contribute to a disaster, and taking action to eliminate or minimize the areas or situations (www.epa.gov/records/tools/toolkits/vital/b.htm).

Groynes: Groynes protrude into the channel and are designed to divert flow away from the bank, whilst at the same time causing an accumulation of sediment along the toe of the bank and on the downstream side of the groyne structure (ESCAP IDNDR, 1999).

Hazard: Hazard is "a phenomenon that poses a threat to people, structures or economic assets and which may cause a disaster. It could be either manmade or naturally occurring in our environment" (ISDR).

Preparedness: The United Nations Disaster Relief Office (UNDRO) uses the following definition for Disaster Preparedness:

"Disaster Preparedness may be described as (a series of) measures designed to organise and facilitate timely and effective rescue, relief and rehabilitation operations in cases of disaster…Measures of Preparedness include, among others, setting up disaster relief machinery, formulation of emergency relief plans, 5 training of specific groups (and vulnerable communities) to undertake rescue and earmarking funds for relief operation" It therefore concerns immediate measures to reduce risk just before, during and after a disaster, and is defined as *"measures, which enable governments, organisations, communities and individuals to respond rapidly and effectively to disaster situations."*

Revetments: Revetments, on the other hand, are constructed along or parallel to the bank, where they serve to reduce the velocity of flow along the bank, thus reducing bank erosion and allowing the riverbank to stabilise (ESCAP IDNDR, 1999).

Risk Reduction: Disaster Management Training Programme (DMTP, 1994) defines risk reduction as "long-term measures to reduce the scale and/or the duration of eventual adverse effects of unavoidable or unpreventable disaster hazards on a society which is 'at- risk' by reducing the vulnerability of its people, structures, and economic activities to the impact of known disaster hazards. Typical risk reduction measures include improved building standards, flood plain zoning and land use planning, crop diversification and planning windbreaks. The measures are frequently subdivided into structural and "non- structural," active and passive measures". Disaster Mitigation, Prevention and Risk Reduction have been used interchangeably, more or less to refer to similar activities.

Vulnerability: Vulnerability is defined as "the extent to which a community, structure, service, or geographic area is likely to be damaged or disrupted by the impact of a particular hazard, on account of its nature, construction and proximity to hazardous terrain or a disaster prone area." (ISDR).

6 VULNERABILITY ANALYSIS AND RISK ASSESSMENT

Structure

6.1 INTRODUCTION

Vulnerability is the extent to which people or buildings are likely to suffer harm from a disaster, while risk is the likely quantified losses that would result considering the probability and intensity of a hazard. As such, risk also includes an element of hazard, the natural or man-made event that can lead to a disaster if there is high vulnerability. In order to initiate programmes for reducing risk in any community, it is necessary to understand specific vulnerabilities and to weigh the resilience against the threats present in the area. This involves a series of steps, the major ones being the assessment and analysis of vulnerability and risk. This should influence public policy for immediate and long-term preparedness, mitigation and vulnerability reduction. Vulnerability and risk assessments are both *science* and *art* since quantitative assessments of probability of risks and likely damage are attempted using mathematical techniques. Socio-economic study with a view to studying communities and specific factors that make them vulnerable, is attempted using the insights provided by such assessments and effective transformation attempted through policy. It is especially important to recognise that this social vulnerability is much more than the likelihood of buildings collapsing or infrastructure getting damaged. It is about the characteristics of people, and the differential impacts of a disaster on people.

6.2 UNDERSTANDING VULNERABILITY

To conduct vulnerability analysis, we need a clear idea about what Vulnerability is. *Vulnerability* is defined in the United Nations Disaster Management Training Programme (1994) as the "degree of loss to a given element at risk (or set of elements) resulting from a given hazard and a given severity level." The concept of vulnerability can be assessed at various levels and from diverse perspectives. Both physical scientists and social scientists are involved in conceptualising vulnerability. There has also been growing specialisation in the respective fields of *hazard* and *vulnerability* assessment. While specialisation is welcome, there is an inherent danger of increased isolation among respective specialists in physical science and social science streams and even across the two broad categorizations in that even within the broad specialisation of physical sciences and social sciences, perspectives are likely to differ with respect to emphasis areas as per super/sub specialisations. Hence an engineer or a scientist/researcher in related fields is likely to perceive vulnerability more in terms of Risk, while a climate scientist, in terms of the likelihood of occurrence and impacts of weather and climate related events. The *biophysical* concept of vulnerability is akin to the concept of 'Risk' while the *social science perspective* defines it more in terms of socio economic parameters. Experts from the following fields are involved in study and analyses of vulnerability; *climate science, policy development studies, economics, disaster management, health, and social sciences along with others.* According to Nick Brooks (2003), each of these relates only themselves to a partial understanding of vulnerability. There is a need to rise above specialisations and take an across- the- board, interdisciplinary and cross-cultural view of the issue of vulnerability to present a more complete and holistic analysis of vulnerability for meaningful interest articulation and policy formulation in the area. Physical vulnerability has also to be understood in the context of political conflict, issues of class struggle, unequal access to power and social backwardness to formulate comprehensive vulnerability reduction approach. The same should be attempted by integrating, through a conceptual model, through research, these different and diverse "traditions in a coherent yet flexible fashion."

The attempt on the part of all involved specialists/academics is to get closer to the root causes of vulnerability. The closer the analysis gets to the fundamental causes rather than the symptomatic aspects of vulnerability, the more difficult and complex vulnerabilities get/are in fact to address. However, the more fundamental the vulnerability addressed, the more hazard-resistant the vulnerable group is likely to become as a result.

As per Terry Cannon (2000), Social vulnerability is the complex set of characteristics that include a person's:

- *initial well-being* (nutritional status, physical and mental health, morale),
- *livelihood and resilience* (asset pattern and capitals, income and exchange options, qualifications,

- *self-protection* (the degree of protection afforded by capability and willingness to build safe home, use safe site),
- *social protection* (forms of hazard preparedness provided by society more generally, for example, building codes, mitigation measures, shelters, preparedness), and
- *social and political networks and institutions* (social capital, but also role of institutional environment in setting good conditions for hazard precautions, peoples' rights to express needs and of access to preparedness).

In most vulnerability analysis methods, there is a clear sense of *comparability* and *convergence* in the analysis of vulnerability factors (encompassing the different components of vulnerability discussed above). There is also a vivid realisation that vulnerability conditions are themselves determined by *processes* and *factors* that are apparently quite different from a hazard, which is mistakenly held singularly responsible for losses. These root causes, or institutional factors, or more general, political, economic and social processes and priorities are highlighted in much of the vulnerability analysis work that has been done. As peoples' livelihood and wider political and economic processes determine opportunities and their patterns of assets and incomes, vulnerability to disasters is also a function of this wider environment. All the vulnerability variables are inherently connected with peoples' livelihoods (lower vulnerability is likely when livelihoods are adequate and sustainable), and their innate resilience related with issues such as poverty (in most disasters) since, it is mostly the poor who are disproportionately more at risk than other groups, and much less capable of recovering easily.

Related concepts are *sensitivity*, *resilience* and *adaptive capacity*. Sensitivity refers to the degree of proneness of a particular 'element at risk' to a particular threat, such as climate risk, land degradation etc. Sensitivity would refer to the degree of change that would be brought about as response in one variable that is *correlated* to the other. Assessing *Sensitivity* would involve working out the correlation. Resilience is explained as fortitude in the face of a potential threat. In one word, it means resistance. Adaptive capacity refers to preparedness through an ancillary way in that it means how much *absorption* capacity is here or is needed by policy intervention in this regard, specifically what, in order to withstand natural changes and how to adapt to them. For example, retreat of glaciers in the Himalayas due to global warming, or changes in harvest seasons that could be possible (grain suffers due to early summer) would need to be tackled through adaptation measures such as resistant varieties of seeds, manures, innovative irrigation techniques, etc.

To understand *differential vulnerability* of different segments of population in a given area exposed in the same measure to a given hazard, it is important to inquire into the differential causes of vulnerability. It encompasses poverty, marginalisation, or other deprivations that accentuate the vulnerability to climate risks or specific biological hazards that affect particularly the sections of the population who are disadvantaged, 'at risk', or in other ways in need. Vulnerability involves a *predictive quality* since it is a way of conceptualising what may happen to an identifiable population under conditions of particular hazards. Precisely, because it should be predictive, vulnerability analysis (VA) should be capable of directing development aid interventions, as also public policy interventions on the part of governments seeking ways to protect and enhance peoples' livelihoods, assist vulnerable people in their own attempts at self-protection, and support institutions in their role of disaster prevention.

6.3 VULNERABILITY AND CAPACITY

There appears to be two separate approaches to Vulnerability Analysis. The first conceives of them being the two ends of a spectrum, so that people who have a high degree of vulnerability are low in capacity and vice versa. In this approach, there is no 'separate set of factors' that should be considered as vulnerability factors or capacities or capabilities; there are simply scales on which high levels of capacity axiomatically indicate low level of vulnerability. The second perceives them as two distinct or only partly inter-related sets of factors since capacity might include institutional membership, group cohesion, or even literacy, which positions people better to cope with adverse conditions, in relation to others, vulnerabilities notwithstanding. The implication is that some capacities may not always be the opposite of vulnerabilities, in that being part of a particular network may be a capacity, or a denial of capacity to others, as is the case with cohesion norms based on caste behaviour in India. This is not to construe that the term vulnerability cannot imply capacities as scalar 'opposites'. Different conception is simply purported to facilitate conceptual understanding of vulnerability, not to confuse it in any way.

The use of the concept of *capabilities* emerged in response to the supposedly negative connotation of the term vulnerability, and has been especially stressed in the World Disasters Report, 2004. Instead of Vulnerability and Capacity Analysis, or VCAs, the term employed now is CVA or Capacity and Vulnerability Analysis, signifying the change in approach from vulnerability reduction to capacity enhancement, as policy focus/emphasis. It has been realised that a lot more effectiveness in disaster response and mitigation could be achieved if the emphasis shifted from tackling vulnerabilities singly, to reinforcing capacities that enable communities to fight disasters and recover after suffering losses from any such event. It was suggested that to speak of people as being vulnerable was to treat them as passive victims and ignore the many capacities that make them competent to resist hazards through self-help.

If we accept that measuring vulnerability includes any factor or process that can alter the 'exposure' of a person or household to risk, then capacities can also be considered as factors that lead to greater danger (vulnerability) when they are low, and reduced danger when they are high. As per Palakudiyil and Todd (2003), Vulnerability/Capacity could be physical/material, social/organisational/ or motivational/attitudinal.

Physical/Material Vulnerability and Capacity: The most visible area of vulnerability is physical/material deprivation. Variables include land, climate, environment, health, skills and labour, infrastructure, housing, finance and technologies to which the poor are denied access. Poor people suffer from crises more often than the rich because they have little or no savings, few income or production options, and limited resources. They are more vulnerable and also recover more slowly. To understand physical/material vulnerability, one has to ask what made the people affected by the disaster physically vulnerable, in that was it their economic activities (for example, farmers cannot plant because of floods), or geographic location (for example. homes built in cyclone-prone areas) or lack of access to relief resources that made them suffer particularly.

Social/Organisational Vulnerability and Capacity: How society is organised, its internal conflicts and how it manages them are just as important as the physical/material aspects of vulnerability, though less visible and less well understood. This includes 'formal political structures' and the 'informal systems' through which people get politically empowered/ socially networked which is a capacity/vulnerability, however the case, which determines access to relief in disaster times and to livelihood means in general. For example, during the recent tsunami, it was realised that aid did not reach many because of caste seclusion. Hence, constitutional provisions/guarantees provided in the Constitution under articles, 14, 15, 16, 17, 21, that safeguard the rights of the socially marginalised would need to be invoked in future in such possibilities.

Poor societies that are well- organised and cohesive can withstand or recover from disasters better than those that are ill- organised or lacking in cohesion on some irrational principle as divisiveness on race, religion, and class or caste lines. To explore this aspect in depth with a view to inquiring into the causes of vulnerability, one has to ask what the social structure was before the disaster struck and how well it served the people in relief and recovery; one can also ask what *apocalyptic* impact disasters had on social organisation, since there has been evidence of attitudes changing or even new 'permutations and combinations' emerging in social alignments in post-disaster situations. This underscores the significance of research into social networks/attitudes and how improvements could be affected, possibly through policy interventions to reinforce/discourage behaviour as aforestated

Motivational/Attitudinal Vulnerability and Capacity: This implies how people in society view themselves and their ability to protect themselves in the event of disasters. Groups that share strong ideologies or belief systems, or have experience in cooperating successfully, may be better able to help each other at times of disaster than groups without such shared beliefs or those who feel *fatalistic* or *dependent*. Crises can stimulate communities to make extraordinary efforts. Questions to be asked include; what people's beliefs and motivations are how they affect their behaviour during disasters. The more pertinent question would be: what is the *general worldview*, implying culture, in that whether communities place reliance on some metaphysical regulation of life or believe in human action. Public policy intervention in this case would need to aim at changing attitudes within communities, since such attitudes could be counter-productive. Long-term measures in this respect would be education of the masses, through which cognitive development could be achieved.

6.4 VULNERABILITY ANALYSIS

Once knowledge is gained of the *threats* in existence, their expected severity and locations at risk, an understanding of what can be affected by these threats and to what degree, is required for ameliorative policy in this regard. This activity is termed vulnerability assessment and is defined as:

"The analysis of the vulnerability of various sectors that are exposed to the natural hazards identified in the hazard analysis exercises. The sectors include social, livelihoods, economic, physical assets, agriculture, political and administration." (DMTP, 1994).

Vulnerability, as has been explained earlier, is the extent to which a community, structure, service or region is likely to be damaged or disrupted by the impact of a particular hazard. People's lives and health are directly at risk from the destructive effects of hazards. Their incomes and livelihoods are at risk because of the destruction of buildings, crops, livestock or equipment, which they depend on. Even if physical loss is avoided, the effects on livelihood, etc. can last a long time, and often, previous levels of existence are not re-attained; for example, fire in an informal market may not kill anybody, yet may destroy goods and therefore livelihoods of market traders. Thus vulnerability assessment aims not just to recognise who is immediately affected but also who is most or least able to recover from disasters.

The objective of vulnerability assessment is in particular, to identify who is most /more vulnerable and why.

Vulnerability Analysis implies/reinforces the *political economy approach* to disaster management in that on the state is enjoined the responsibility to undertake as a vanguard, mobilising efforts for structural mitigation measures for hazard prevention and create the environment for non-structural mitigation measures through actions such as institutionalising/strengthening social capital to foster community self help etc. Tokyo, Japan, and Managua, Nicaragua, are prone to earthquakes. But the people of Tokyo are far less vulnerable to injury by earthquakes because Tokyo has strictly enforced building codes, zoning regulations and earthquake training and communications systems. In Managua, there are still many people living in top-heavy mud houses on hillsides. They are vulnerable.

Landslides or flooding disasters are closely linked to rapid and unchecked urbanisation that forces low-income families to settle on the slopes of steep hillsides or ravines, or along the banks of flood-prone rivers.

Famines can be closely linked to shortages of purchasing power caused by rural unemployment or a sudden influx of refugees into a country from a strife-torn neighbouring country.

High numbers of deaths accompanying earthquakes almost always result from structural collapse of poor, low-cost houses.

In other disasters, such as cyclones and tsunamis, humans can increase their vulnerability by removing bits of their natural environment that may act as buffers to these extreme natural forces. Such acts include destroying reefs, cutting natural windbreaks and clearing inland forests.

The poor countries that suffer the worst disasters are those in which environmental degradation is proceeding most rapidly. Countries with severe deforestation, erosion, over cultivation and overgrazing tend to be hardest hit by disasters.

Natural hazards are agents or trigger mechanisms that can come into contact with a vulnerable human condition to result in a disaster.

Process of Vulnerability Analysis

Each type of hazard puts a different/specific set of 'elements' at risk. Most of disaster mitigation work is focused on reducing vulnerability, and in order to do so, development planners need an understanding and indication of which elements are most at risk from the principal hazards, which have been identified. Vulnerability assessment to hazards usually takes place in the following two-stage sequence:

1. *Making an inventory of what is at risk:* Once the possibility of hazards in any location or area is known, it is necessary to find out what may be affected by them. Thus base line data is required on the following:

- Population; age, gender, health
- Livelihoods; types, locations
- Local economies
- Agriculture and fisheries
- Buildings
- Infrastructure
- Cultural assets (that is, libraries, museums, historic buildings etc.)
- Local institutions

2. *Assessing the vulnerability of elements at risk*: After an inventory has been prepared of the elements at risk, further examination is required as to how they will be affected by hazards to make accurate assessment of the risk. It should be noted that whilst a quantification of the elements existing in any location is relatively straightforward, an assessment of how they will be affected in a hazard event is harder to assess. It is important to note that it is often the case that the 'intangible' aspects of vulnerability will be as important as the quantifiable aspects. These should include the evaluation of socio-economic vulnerability and individual or societal "coping mechanisms" as well as support systems, which allow some people to cope with the impact of a hazard and recover from them comparatively faster.

Tangible and Intangible Vulnerable Elements

PRINCIPAL VULNERABLE ELEMENTS		
	Tangible	**Intangible**
Floods	Everything located in flood plains or tsunami areas. Crops, livestock, machinery, equipment, infrastructure Weak buildings	Social cohesion, community structures cohesion, cultural artifacts

Earthquakes	Weak buildings and occupants. Machinery and their equipment, infrastructure. Livestock. Contents of weak buildings	Social cohesion, community structures cohesion, cultural artifacts
Landslides	Anything located on or at base of steep slopes or cliff tops, roads and infrastructure, buildings on shallow foundations	Social cohesion, community structures cohesion, cultural artifacts
Strong winds	Lightweight buildings and roofs. Fences, trees, signs; fishing boats and coastal industries, Crops and livestock.	Community structures, social cohesion, cultural artifacts
Technological disasters	Lives and health of those involved or near the vicinity. Building, equipment, infrastructure, crops and livestock	Destruction of the environment. Cultural losses. Possible population disruption.

(Adapted from Primer on Natural Hazard Management, OFDA, 1991)

The most difficult vulnerabilities to address are based on exclusion from social, economic and political systems, which often decisively determine capacities/vulnerabilities of people, since these are rooted in the history and culture of the people. These vulnerabilities may reflect characteristics such as prejudices based on race, gender, religion, ethnicity, social class, age, etc. These most fundamental vulnerabilities limit people's access to resources, opportunities, services, information and ultimately deny people choice in control over their lives.

Vulnerability assessment is therefore another complex data collection process to determine what 'elements' are 'at risk'. These include social, economic and natural and physical factors. It is always a 'site-specific' process with a concern for unique characteristics of a local situation and will always require local expertise and experience.

6.5 RISK ASSESSMENT

The term 'risk' refers to the expected losses from a given hazard to a given element at risk, over a specified time period. Difference between the understanding of 'Risk' and 'Vulnerability' as explained in DMTP (1994) needs to be noted. Risk combines the *expected losses from all levels of hazard severity*, taking account also of their occurrence probability. Vulnerability is the loss to a given 'element at risk' resulting from a given hazard at a given severity level expressed as a percentage expressed as a percentage loss (or as value, 0 to 1) for a given hazard severity level. Expression would depend on the element at risk; accordingly, repair cost for physical infrastructure damaged, ratio in case of number killed to total 'at risk' population, or degree of physical damage on some appropriate scale. For example, *average repair cost of 5% experiencing 130km/hr winds.*

Risk presentation is done in aggregate terms as, for example, 75% *probability of economic losses to property experiencing heavy damage or destruction in the particular town within the next ten years.*

Risk assessment is defined as:

"A process of analysis to identify and measure risks from natural hazards that affect people, property and the environment. This process can also encompass the assessment of available resources to address the risks."

(Vulnerability and Risk Assessment, DMTP, UNDP, 1994)

Risk assessment forms a crucial early phase in the *disaster management planning cycle* and is essential in determining what disaster mitigation measures should be undertaken to reduce potential future losses. Any attempt to reduce the impact of a disaster requires an analysis that indicates what 'threats' exist, their expected severity, who, or what they may affect, and why. Knowledge of what makes a person or a community more vulnerable than another, added to the resources and capacities available, determine the steps we can take to reduce risk they are exposed to. Recognition of the need for this diagnostic process is contained in the first principle from the IDNDR, 1994 Yokohama "World Conference on Natural Disaster Reduction" which states:

"Risk assessment is a required step for the adoption of adequate and successful disaster reduction policies and measures" *(Outcome of the Conference, Document A/Conf.172/L.2, page 3, 1994).*

Risk assessment is carried out as a series of related activities, which builds up a picture of the hazards and vulnerabilities, which explain disaster losses. Information is first collected on the specific location, severity, duration and frequency of threats that are faced by a society. This is followed by an assessment of potential hazard impacts on the society's livelihoods, economy, infrastructure and key facilities, etc. The scale of these impacts will always be conditioned by those processes, which either increase or decrease vulnerability, which may be economic, social, political or environmental.

Risk assessment has two central components:

1) **Hazard Analysis**: understanding the scale, nature and characteristics of a hazard; and

2) **Vulnerability Analysis**: the measuring of the extent to which people or buildings are likely to suffer from a hazard occurrence.

Any change in either of these two components will correspondingly affect a change in the nature or size of the risk faced. Once data has been collected and analysed on both the 'threat' and what is/are 'at risk' to it, the information has to be passed on in an appropriate format to decision makers to determine the levels of 'acceptable risk' and what actions should be taken to reduce the risk(s). Decisions will then be made as to whether risk reduction measures should be initiated, implying, timing, what level of protection is required and whether there are other more pressing risks to address with the finite resources at hand. Understanding risk and taking decisions is therefore a two- part process, involving both risk evaluation and risk assessment.

- **Risk Assessment** refers to the scientific quantification of risk from data of past precedents regarding nature of hazards, intensity at which incident, degree of damage, likely changes if any in any of the factors involved/mentioned which gives complete understanding of hazard proneness of the region and the vulnerability of elements, identified as part of the exercise, to it.

- **Risk Evaluation** is the social and political judgment about the importance of various risks faced by individuals and communities, *as they perceive it.* It involves prioritising between risks, which are often political, since choices are involved between competing interests for resource allocation. It involves weighing risks and benefits in each case, which involves scientific judgments as also other factors and beliefs.

Risk assessment is therefore mainly a *scientific* and *quantitative* process, which provides input for/impacts public policy for risk mitigation and preparedness. The data is incorporated in disaster reduction policy/programmes, which depend on risk evaluation, which is the appraisal or perception of the risk in the context of other priorities, whether anything can be done to reduce that threat and qualitative assessment of disaster preparedness to combat the threat. It is therefore logical that the more accurate the diagnosis of the problem, more successful would be the strategy, and also cost- effective since resources available to meet it are limited, even in developed countries.

6.6 CONDUCTING RISK ASSESSMENT

In order to understand and to compare different risks, scientists and economists usually try to quantify them in terms of their probability of occurrence and the potential damage/ losses they might cause. This is done by using statistical analysis to predict the probability of future events by gathering data on the effects of various hazards in the past that have caused/exacerbated the particular risk. This identification of effects and the understanding of the processes of disaster occurrence constitute the first steps in establishing a relationship between hazard and vulnerability in order to specifically identify the risk.

By using past historical records and an analysis of scientific data estimates can be made of the likelihood of hazard occurrence and expected severity. When allied to estimates of what is vulnerable to various hazards, risk can be defined in terms of the *probability*, that is, the likelihood of losses and *estimation* of the proportion of the population or property, which will be affected.

The purpose of statistical analysis is to arrive at an appropriate statistical model that relates risk posed by a natural disaster to socio economic parameters. UNDP carried out an exercise to relate the risk posed by natural disasters such as earthquakes, tropical cyclones, floods and drought etc. to specific socio economic factors like HDI (Human Development Index), rate of urban growth etc. that create losses. The study was carried out under the aegis of the United Nations Development Programme (UNDP) using data for more than 90 countries over a period of 20 years.

Statistical analysis is based on two major assumptions; *one,* that risk can be measured in terms of the number of victims of past hazardous events, and second that the equation of risk follows a 'multiplicative model,' in that following risk identification in each case (taking into account the number of people killed) is arrived at by taking into account the relevant 'factor' values in each case, for example, rate of urban growth was taken as the factor that would determine loss of life from earthquakes, and access to water supply in case of droughts, etc.

Methodology

The exercise has two key assumptions.

- The number of people killed by a natural disaster is a measure of Risk (physical exposure or PhExp)
- The equation of risk follows a multiplicative model where the number of people killed is related to socio economic factors and number of people exposed to the risk by the following equation

$$K = C. (PhExp)^{\alpha}. V_1^{\alpha 1} .V_2^{\alpha 2} \ldots V_N^{\alpha N}$$

Where,

K is the number of people killed by the disaster

C is a multiplicative constant

$V_{1-N,}$ are socio economic parameters

α_{1-N} is the exponent of V_{1-N}

{Note: Taking logarithm of both sides transforms this into a linear equation. Empirical data of natural disasters is taken and relevant socio economic parameters and their exponents are estimated using linear regression (difference between actual and desired states)}

For example in case of earthquakes, the socio economic parameter is urban growth, in case of cyclones, percentage of arable land and human development index; in case of floods, local population density and gross domestic product; in case of droughts, percentage of population with access to improved water supply *{further read at,* http://www.undp.org/bcpr/disred/documents/publications/rdr/english/ta/t5.pdf.}

The process of risk assessment is usually conducted in the following sequence:

1. Hazard Analysis: Hazard information is needed on such matters as location, frequency, duration and severity of each hazard type. Risk assessment should be carried out, where possible, in relation to all the hazards in a given location. As explained in the Disaster Management Training Programme, (1994), like risk, hazard occurrence is expressed in terms of average expected rate of occurrence of the (specified type of) event or on a probabilistic basis regarding occurrence probability/possibility. Hazard maps present graphically, the annual probability and magnitude of the event following intensive geological analysis of the area, along with a study of past records, sometimes dating a century back or more, as in case of dormant volcanoes. Other corroborative evidence such as soil composition analysis to predict landslides or the NDVI (normalised drought vegetation index) to predict droughts may be used in case of inadequacy of temporal data to predict the recurrence of an event. Information gathered is collated and depicted on a hazard map for necessary correlations tracing causes and effects for the purpose of objective derivations of variables (independent and dependant) involved in the phenomena and their analysis (statistical methods discussed above). Information collation is relatively easier for events with relatively regular periodicity. Corroborative evidence can be gathered from geological 'hints' such as silt deposit, high water marks, deposits in case of floods, and past fault lines in case of earthquakes, and, human records as the main source evidence regarding hazard probability in all cases. The latter are considered more important and are being stressed more as compared to geological records by scientists.

The level of severity of natural hazards can be quantified in terms of the magnitude of occurrence as a whole (event parameter) or in terms of the effect the occurrence would have at a particular location site (site parameter).

Like risk, hazard occurrence may be expressed in terms of average expected rate of occurrence of the specified type of event, or on a probabilistic basis. In either case, the annual occurrence rates are usually used. The inverse of an annual recurrence rate is a return period. Coburn, Sspence and Pomonis, (1994) state that:

"There is an annual probability of .08 of an earthquake with a magnitude exceeding 7.0 in Eastern Turkey. "This is effectively the same thing as saying, "the average return period of an earthquake of M=7.0 in eastern Turkey is 12.5 years."

Rare events like volcanoes are hard to predict since adequate historical data is not available. It may be possible for geologists to analyse old lava flows and try to date the eruption frequency from that.

Smaller more frequent events can also be studied for indications of severity of future large-scale events.

Knowledge of the consequences of events will be helpful in planning for control of hazards during the design and operation of the facility by taking proper action to reduce hazard rate or minimise the consequences, as the case may be, or else the assessed risk may just be ignored. By evaluating the risk of various hazards to which the country is liable or potentially liable, it becomes practicable to formulate strategies to mitigate the impact of hazards in a cost-effective way. If a community is especially vulnerable to a particular type of disaster, severe risk treatment measures may be required to reduce the disaster risk to 'acceptable levels'.

The other important function of risk analysis is to develop a comprehensive disaster preparedness plan by providing a clear understanding as to what hazards exist and what risk(s) they pose to the vulnerable neighboring communities.

2. **Vulnerability Analysis:** Vulnerability analysis, as has been explained earlier, starts with creating an inventory of all elements that are 'at risk' to the identified hazards such as social groups, buildings, infrastructure, economic assets, agriculture etc. This is followed by an assessment of their susceptibility and an estimation of damage and losses. Vulnerability analysis includes an assessment of resources or capacities to meet and recover from hazardous events.

Risk Evaluation and determining levels of Acceptable Risk

Once data on the nature of the hazards and vulnerability have been collected, synthesised and analysed in the categories noted above, it ideally has to be passed in an appropriate format to decision makers to enable them to determine levels of acceptable risk leading to levels of protection. These decisions will be made according to risk perception, knowledge of possibilities to reduce the threat and other priorities. High level of risk perception determines the amount of money that would be spent for a flood dyke project or retrofitting of buildings, for example. If the risk is extreme something has to be done promptly. Acceptable risk implies the best that can be managed within constraints to protect lives and property to the maximum extent possible. For example, buildings could be hazard proof to the extent that they allow enough time for the occupants to escape. They might not be fully hazard resistant in that they may suffer damage but not totally give way under pressure. There are resource constraints, which are compelling. Hence, depending on the level of risk perception and acceptable risk among communities and policy makers, hazard proofing is attempted.

Following the exercise, **Risk Determination** involves:

- *Hazard occurrence probability*, which is the likelihood of a hazard striking an area;
- *Elements at risk*, that means the lives and property at risk, and,
- *Vulnerability of elements at risk*, that is the extent of damage estimated to be suffered.

Disaster preparedness follows risk determination, since in view of limited resources only targeted risk reduction has to be attempted. There are subparts of this exercise of determining risk. For example vulnerability of different elements at risk would depend on hazard intensity. Hence, preparedness has to take cognizance of differing levels of vulnerability to varying intensity of hazard. A windstorm would strike with varying intensity in different time periods. Risk estimation has to factor that.

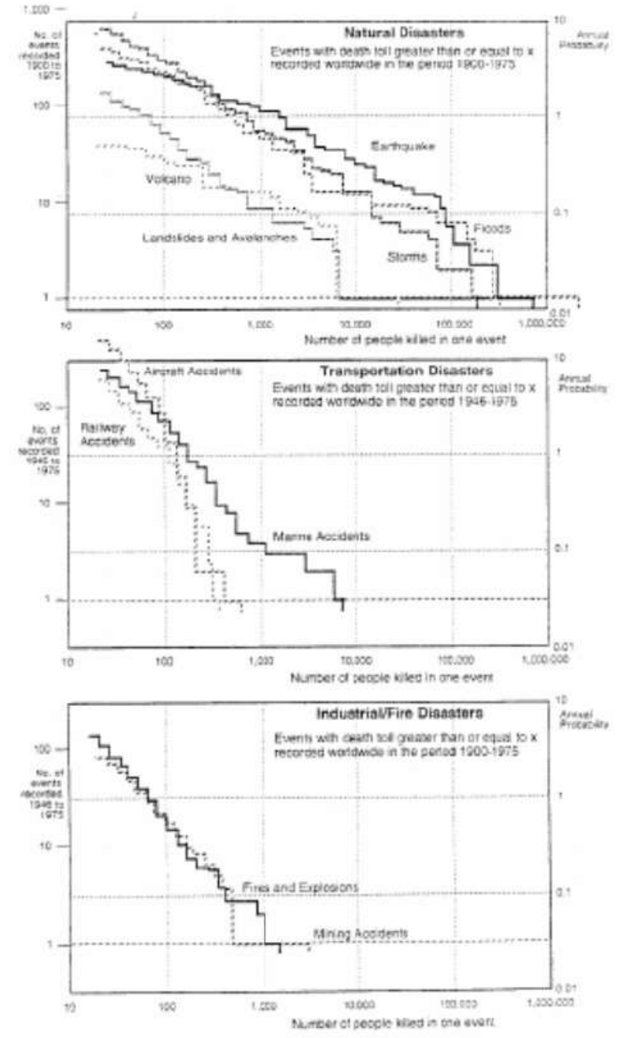
6.7 RISK MAPPING

Risks can be vividly depicted through maps. Methods developed for near accurate estimations include f: N curves, scenario mapping, potential loss studies as explained by Coburn, Sspence and Pomonis (1994) in the Disaster Management Training Programme, UNDP.

(a) **f:N Curves:** Here "f" stands for frequency of disaster event and "N" denotes the number of casualties. Data on the size and frequency of disaster occurrences for a particular country can be plotted as f: N curves. These involve plotting the frequency of events causing greater than a certain number of fatalities. Different numbers of casualties (or magnitude of losses expressed in some other way) are plotted for different frequency of occurrence on *x* and *y-axis* on a graph respectively. However such relationships always show aggregated losses for a large region over a period of time. They do not help identify the geographical distribution of damage, for which risk mapping is needed. In the diagram given below the first block gives disaster losses due to various natural disasters in the period 1900- 1975 the second block gives losses due to transportation disasters; the third block gives losses due to accidents like industrial fires. It is clear that losses from natural disasters far outnumber those due to man made calamities like transportation or fires.

Figure 4

f-N curves for various disaster types (worldwide)



It is clear that natural disasters greatly exceed technological disasters caused by industry or transportation in their capability to cause massive loss of life

ANSWER (from page 20)

The communities' resources and exposure to the risk are greater than that of the individual. Therefore both motivation and resources for mitigation activities are higher for the community.

(b) **Scenario Mapping:** In scenario mapping, the presentation of the impact of a single hazard is attempted. Circles and shaded regions on a map are used to depict settlements and building types, low density and high-density areas etc. to assess damage likely in particular locations, based on past experience and development since the last event for proper assessment in the changed scenario. Hence a scenario map can identify 'communities at risk' and regions at risk. Hot spots thus located are the foci of restorative and regenerative activities post disaster. Scenario mapping is used to estimate the resources likely to be needed to handle an emergency. The number of people killed and injured and the losses likely with respect to other 'elements' are estimated. From these can be assessed the resources needed for medical attention, accommodating the homeless and other measures to minimise the recovery period. For example assessing the state of the present infrastructure can aid damage assessment in the event of an earthquake. The diagram given below, adapted from DMTP (1994), describes a scenario of an earthquake of 7.2 magnitude hitting the Bursa Province in Turkey. It is not claimed to be predictive. The authors only claim to describe a situation in case of an earthquake.

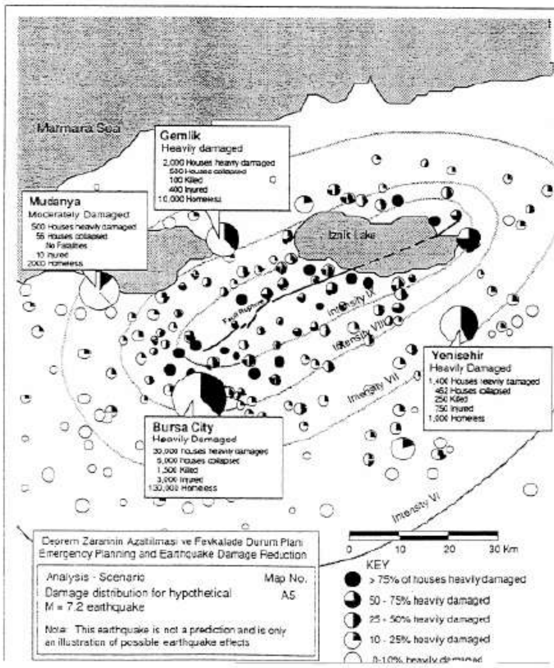
This kind of exercise helps preparedness planning when an earthquake strikes. The top block, aside the Mamara Sea gives the Gemlik area (heavy damage), the left block gives the Mudanya area (moderate damage), the central block is the Bursa province (heavy damage) and the right block gives the Yenisihir area of heavy damage.

The following table accompanies the map.

VILLAGES TOWNS BURSA CITY TOTAL

	Villages	Towns	Bursa City	Total
Houses lightly damaged	34,000	21,000	50,000	105,000
Houses heavily damaged	15,000	9,000	30,000	54,000
Houses collapsed	4,000	2,000	6,000	12,000
People killed	2,000	800	1,500	4,300
People injured	6,000	2,500	4,500	13,000
People Homeless	73,000	36,000	13,000	122,000

A scenario event



ANSWER
(from page 20)

Risk mapping presents risk in a geographical way that shows the risk trends over an area and allows comparison of risk levels in different geographic areas. The f/N curves, on the other hand, show aggregated losses for a large region over a given time period.

Key: *Complete Dark Circle: >75% of houses heavily damaged*

Three-fourth Dark Circle: 50-75% heavily damaged

Half Dark Circle: 25-50% Heavily Damaged

Quarter Dark Circle: 10-25% Heavily Damaged

Empty Circle: 0-10% Heavily Damaged

(c) **Potential Loss Studies:** Mapping the impact of expected hazard occurrence probability across a region or country shows the location of communities likely to suffer heavy losses. The effect of the hazard of each area is calculated for each of the communities within those areas to identify the communities most at risk. This shows for example which towns or villages likely to suffer heaviest losses, which should be priorities for loss reduction programs, and which are likely to suffer heaviest losses, which should be priorities for loss reduction programme and which are likely to need most aid or rescue assistance in the event of disaster of differing magnitudes.

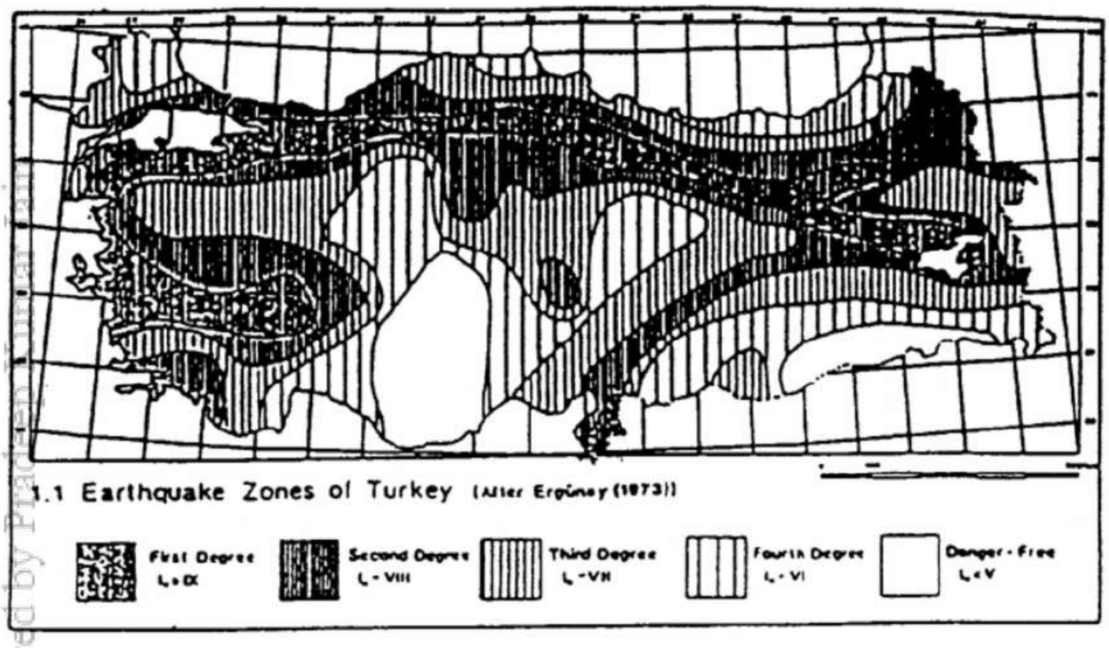
MAP 1 has been published by the Earthquake Research Institute of Turkey. It gives the degree of risk in different areas from differing intensity of earthquake.

MAP 2 gives the differential vulnerability of big and small towns. Big towns (over 25,000 population) are shown by circles surrounding dots and small towns (2000-25000) by simply depicting population density.

MAP 3 shows the physical vulnerability of buildings in the hazard prone zone. Towards the West are relatively safer concrete structures (complete dark circles) which is the affluent part of the region. The South East has weak structures (partly empty circles), which is inhabited by poor people.

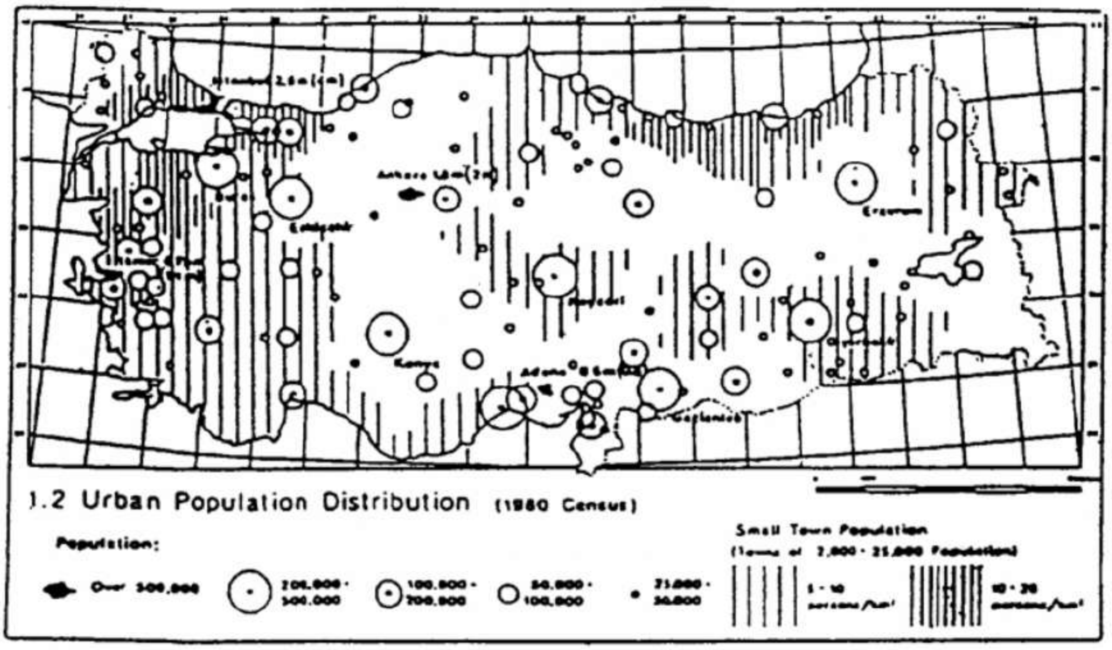
MAP 4 gives complete analysis of three preceding maps. Combining information from map 2 and 3, we get the number of people living in each building type, which helps us determine exposure to risk, or likely casualties if an earthquake of a high enough magnitude were to strike.

MAP 1-HAZARD

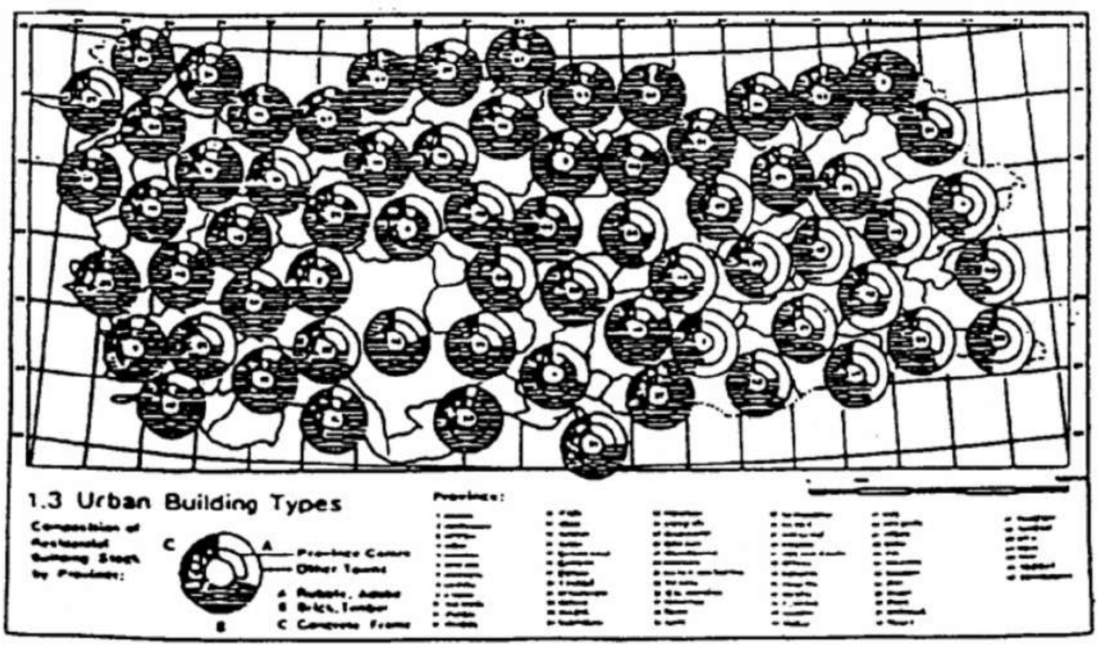


1.1 Earthquake Zones of Turkey (After Ergünay (1973))

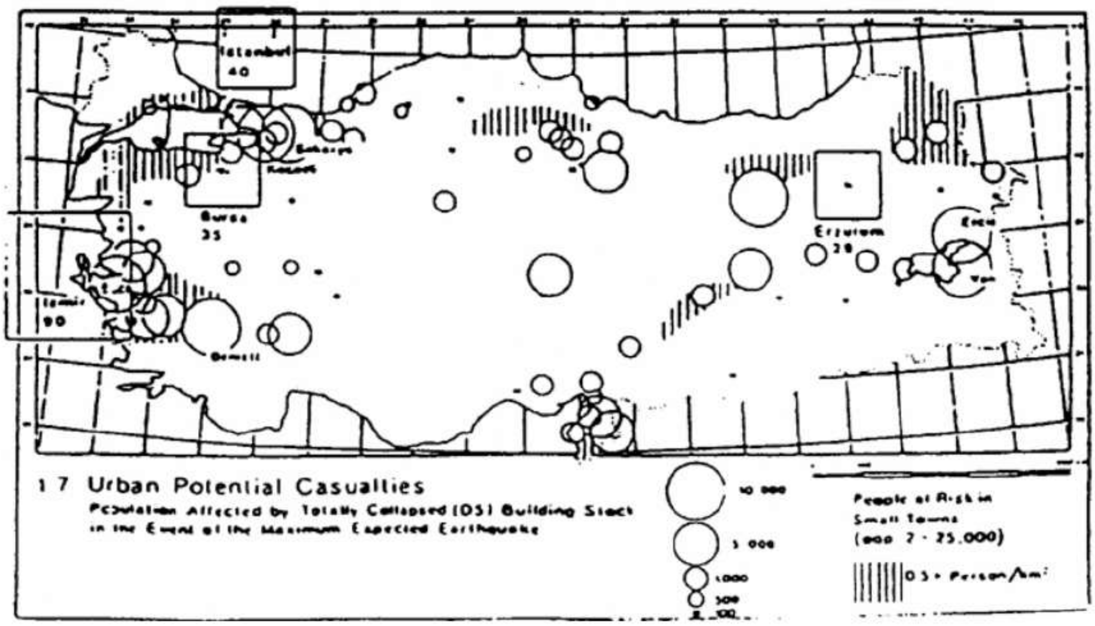
MAP 2 -ELEMENTS AT RISK



MAP 3- VULNERABILITY

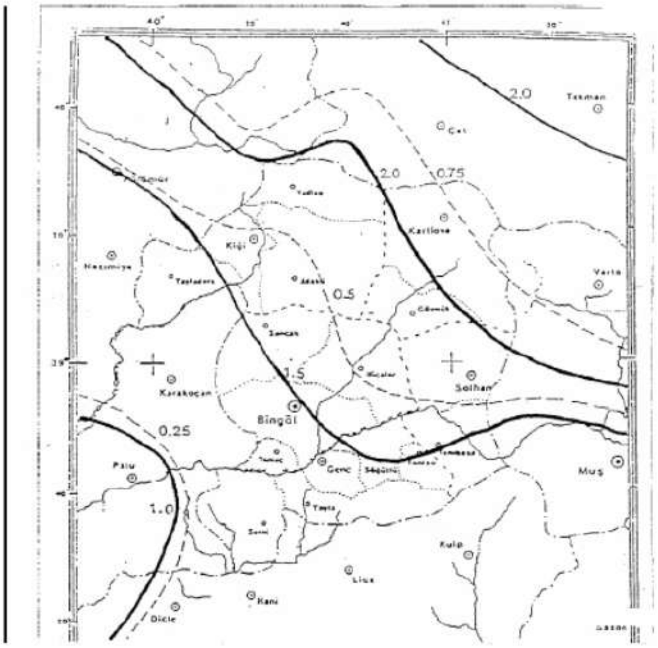


MAP-4- CASUALTY RISK



(d) Annualised Risk Mapping: The annualised specific risk from any hazard at any location is the average expected total losses from all events over a time period. The probability of each level of hazard occurring within a unit time period is combined with the consequence of that level of hazard to generate the expected losses probable/expected in that time. Summing up the losses from all levels of hazards gives the total losses likely over a time period. Hence an annualised risk map gives the total losses over both time and space. Areas of concentration of damage over a year in a given area are depicted on the map. It is expressed as a proportion of the total value (or number) of the total population at risk. This could be better understood with reference to the following map, derived and adapted for this work from the UNDP Disaster Management Training Programme, 1994.

Example 3—
Annualized risk —
% housing los per year
Bingöl Province,
Turkey



Earthquake Risk: *The Dark lines give specific risk (% annual housing loss based on mean village performance): Dotted lines give specific risk exceeded by 75% of villages.*

As per DMTP (1994), tangible and intangible losses or *loss parameters* in disasters is represented in a tabular form as follows:

LOSS PARAMETERS FOR RISK ANALYSIS

Losses			
Consequences	*Measure*	*Tangible*	*Intangible*
Deaths	*Number of People*	*Loss of economically active individuals*	*Social and psychological consequences*
Injuries	*Number and injury severity*	*Medical treatment needs, temporary loss of employment activity by productive individuals*	*Social and psychological pain and recovery*
Physical damage	*Inventory of damage elements by number and damage level*	*Replacement and repair cost*	*Cultural losses*
Emergency operations	*Volume of manpower, man days employed, equipment and resources expended for relief*	*Mobilisation costs, investment and preparedness capability*	*Stress and overwork on relief participants*
Disruption to economy	*Number of working days lost, volume of production lost*	*Value of lost production*	*Opportunities, competitiveness reputation,*
Social disruption	*Number of displaced persons, homeless*	*Temporary housing relief, economic production*	*Psychological social contacts, cohesion, community morale*
Environmental impact	*Scale and severity*	*Clean-up costs, repair costs*	*Consequences of poorer* *Environment, health risks, risk of future disaster*

Adapted from Coburn Sspence, and Pomonis in Disaster Management Training Programme (1994)

6.8 CONCLUSION

Almost all communities live in situations that expose them to some hazard or the other. These hazards include natural ones such as earthquakes and cyclones, as well as man-made ones such as industrial accidents and pollution. Disadvantaged sections of communities are more vulnerable to the hazards. Vulnerability can be in terms of poverty, low financial resources, poorly built houses and so on. At the same time communities also have some inherent capacities, which could be in the form of strong social grouping, and local infrastructure such as strong buildings of religious or community places. Vulnerability analysis informs us of the extent and impact of vulnerability while risk assessment goes a step further to look at the net probability of a disaster occurrence, given the status of hazards, vulnerability and capacity.

6.9 KEY CONCEPTS

Capacity: The ISDR, UN, defines Capacity "as a combination of all the strengths and resources available within a community, society or organisation that can reduce the level of risk, or the effects of a disaster. *In general this involves managing resources, both in normal times as well as during crisis or adverse conditions. The strengthening of coping capacities usually builds resilience to withstand the effects of natural and induced hazards."*

Coping Capacity: As per ISDR, in general this involves "managing resources, both in normal times as well as during crises or adverse conditions. The strengthening of coping capacities usually builds resilience to withstand the effects of natural and human induced hazards."

Capacity and Vulnerability Analysis (CVA): Lately, the emphasis has been on capacities of people for self-help during disasters and strengthening of the same through policy in this regard. Earlier the emphasis had been on studying vulnerabilities and amelioration of the same through external measures like aid et al. It has been experienced that measures that strengthen innate capabilities of people to fight disasters and rebuild lives is better disaster response than humanitarian aid.

Elements at Risk: Elements at risk refers to tangible and intangible targets such as people, structures, health, and livelihoods, likely to suffer harm from a hazard.

Resilience/Resilient: The ISDR explains it as the capacity of a system, community or a society potentially exposed to hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure. This is determined by the degree to which the social system is capable of organising itself to increase its capacity for learning from past disasters for better future protection and to improve risk reduction measures.

Risk Assessment: Risk assessment is a technical exercise to estimate the hazard potential of facility/project with a view to in-built provisioning of safeguard/protective measures. Risk assessment is a quantitative measure of likely losses in the eventuality of a disaster or if the apprehended catastrophe in case of any individual facility takes place such as nuclear plant.

Threat: Threat is different from Risk. Threat is a more general concept, while Risk is specific in that a threat, such as terrorism, has to be broken down into specific risks and communicated to policy makers for policy in this regard, mitigation or preparedness. Threat is simply an apprehension, which will not give policy guidelines.

Vulnerability:

Vulnerability is susceptibility to suffer losses; in other words, weakened resilience to face the onslaught of a disaster. Socio economic vulnerability is owing to adverse social positioning due to poverty unemployment, living in hazard prone zones, or dilapidated structures. Physical vulnerability refers to engineering weaknesses which causes structures to give in easily to pressures during earthquakes, cyclones et al, causing heavy casualties.

Vulnerability Analysis:

As explained in the Disaster Management Training Programme, (1994), "in engineering terms, vulnerability is a *mathematical function* defined as the degree of loss to a given element at risk, or set of such elements, expected to result from the impact of a disaster hazard of a given magnitude. It is specific to a particular type of structure, and expressed on a scale of *no damage* to *total damage*. For more general socio-economic purposes and macro level analysis, vulnerability is a less-strictly defined concept. It incorporates considerations of both the intrinsic value of the elements concerned and their functional value in contributing to communal well being in general and to emergency response and post-disaster recovery in particular. In many cases, it is necessary to settle for a qualitative classification in terms of *high*, *medium* and *low* or explicit statements concerning the disruption likely to be suffered."

disasters. Relate the three lists to each other, and write a risk statement for your community.