UNIT 6 VULNERABILITY ANALYSIS AND RISK ASSESSMENT

Structure

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6.0 LEARNING OUTCOME

After studying this Unit, you should be able to:

- Discuss the concepts of vulnerability and risk;
- Examine the principles of vulnerability analysis and risk assessment processes;
- Discuss the need and the means for carrying out rapid assessments; and
- Understand the processes from the point of view of development

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

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

Where,

K is the number of people killed by the disaster

C is a multiplicative constant

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

$\alpha_{1\text{-}N}$ is the exponent of $V_{1\text{-}N}$

{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

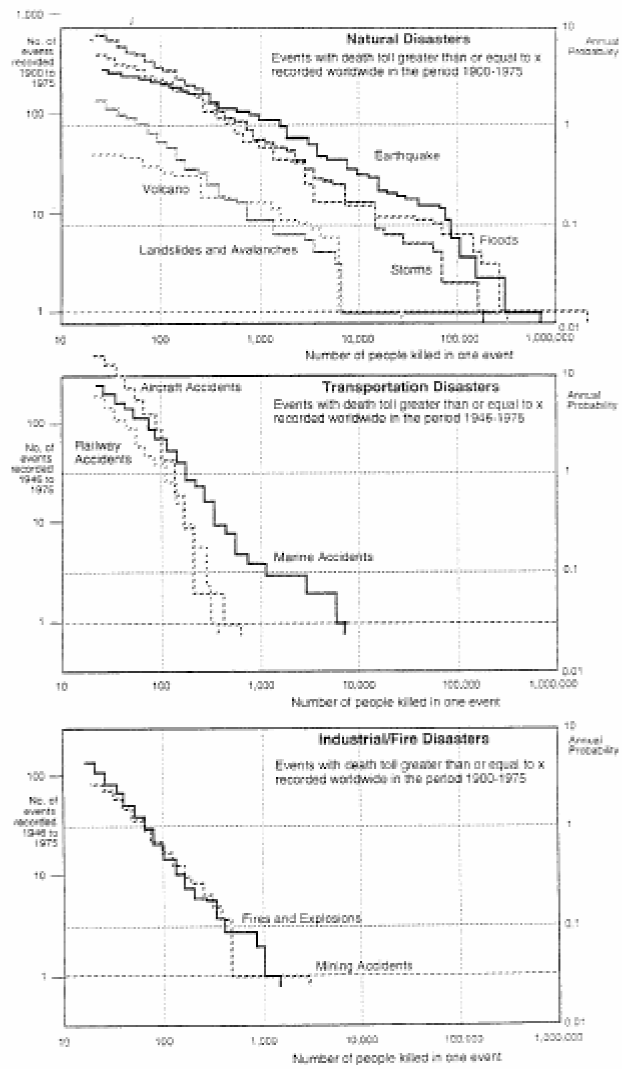
Risks can be vividly depicted through maps. Methods developed for near accurate estimations include f: N curves, scenario mapping, potential loss studies as explained by Coburn, Sspence and Pomonis (1994) in the Disaster Management Training Programme, UNDP.

(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 (worldwie)

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.

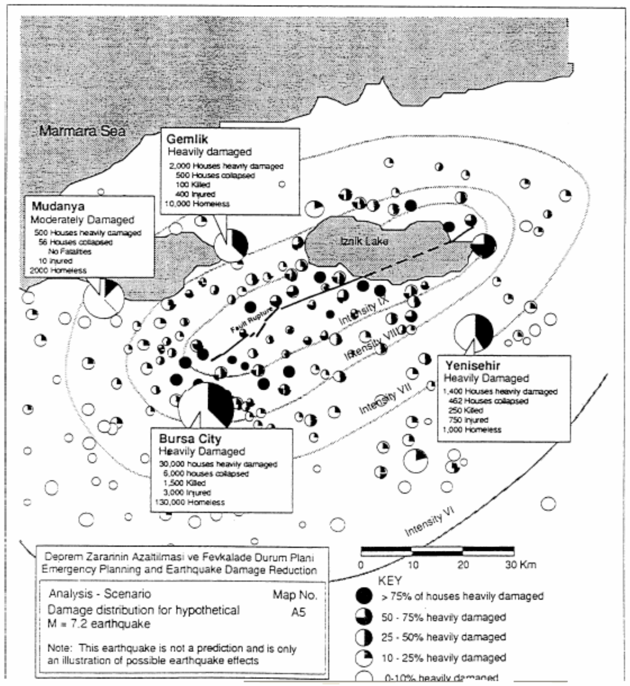
This kind of exercise helps preparedness planning when an earthquake strikes. The top block, aside the Mamara Sea gives the Gemlik area (heavy damage), the left block gives the Mudanya area (moderate damage), the central block is the Bursa province (heavy damage) and the right block gives the Yenisihir 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 29)

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: *<u>Complete Dark Circle</u>: >75% of houses heavily damaged*

<u>Three-fourth Dark Circle:</u> 50-75% heavily damaged

<u>Half Dark Circle:</u> 25-50% Heavily Damaged

<u>Quarter Dark Circle</u>: 10-25% Heavily Damaged

<u>Empty Circle:</u> 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.

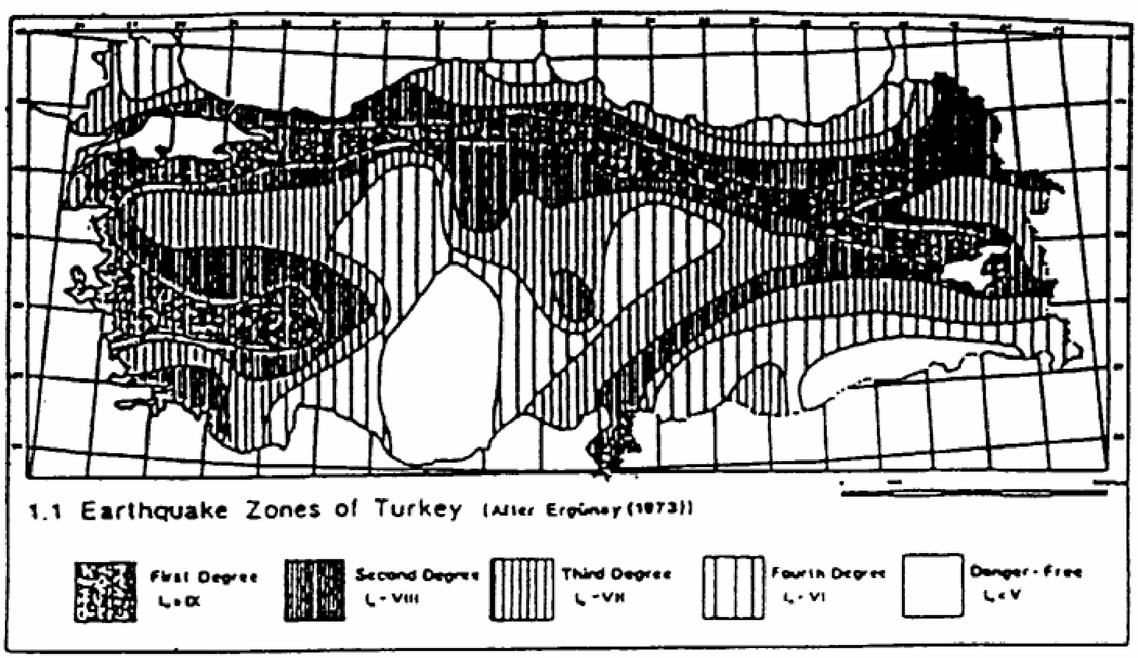
MAP 1 has been published by the Earthquake Research Institute of Turkey. It gives the degree of risk in different areas from differing intensity of earthquake.

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.

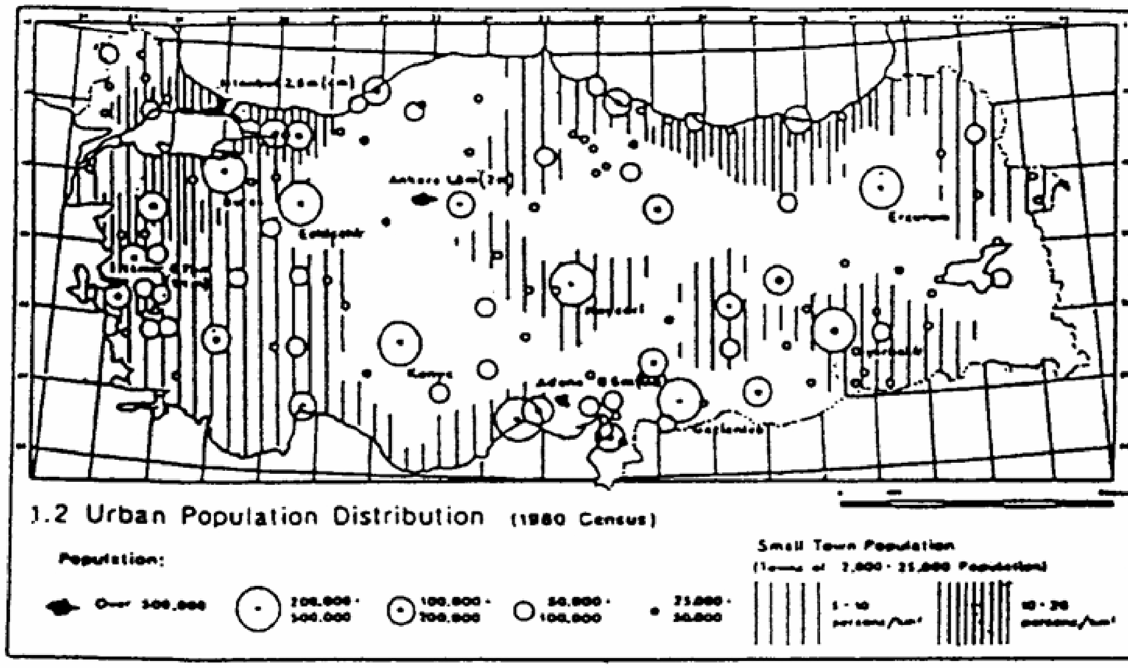
MAP 4 gives complete analysis of three preceding maps. Combining information from map 2 and 3, we get the number of people living in each building type, which helps us determine exposure to risk, or likely casualties if an earthquake of a high enough magnitude were to strike.

MAP 1-HAZARD



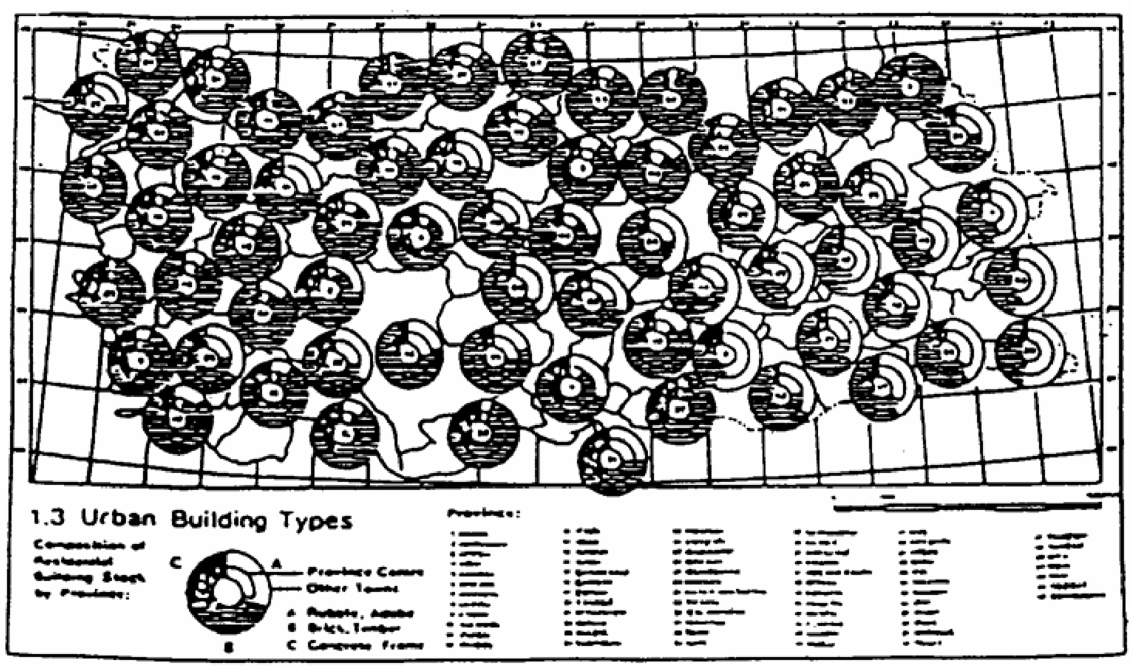
1.1 Earthquake Zones of Turkey (After Ergünay (1973))

MAP 2 -ELEMENTS AT RISK



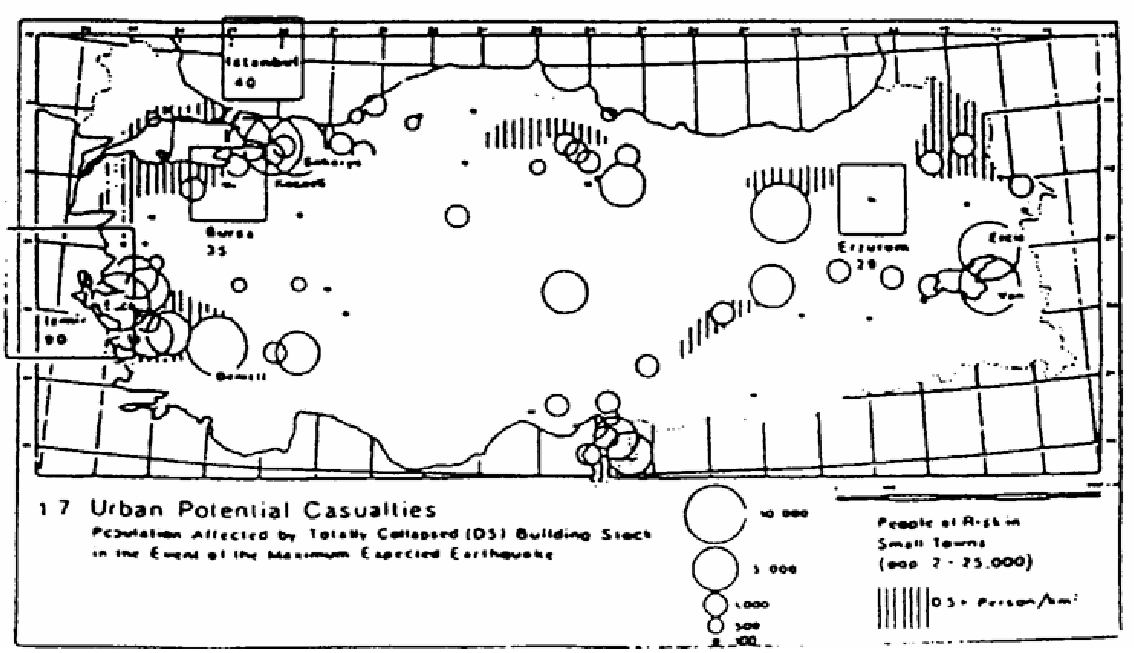
1.2 Urban Population Distribution (1980 Census)

MAP 3- VULNERABILITY



1.3 Urban Building Types

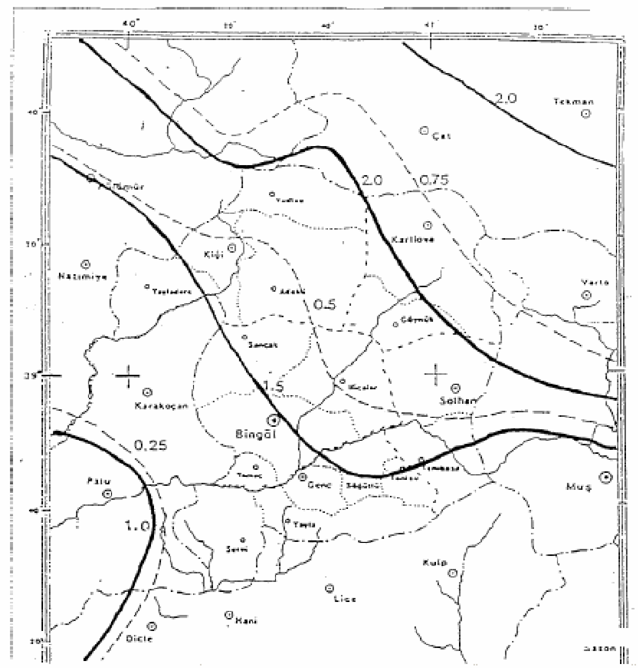
MAP-4- CASUALTY RISK



1 7 Urban Potential Casualties
Population Affected by Totally Collapsed (D5) Building Stock in the Event of the Maximum Expected Earthquake

(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 **t**he 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."

6.10 REFERENCES AND FURTHER READING

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6.11 ACTIVITIES

1) List the hazards that can affect your neighbourhood or village, and identify those facilities and people who are most likely to get affected. Explain why these are mostly likely to get affected, and thereby understand their vulnerability.

2) Create three lists – hazards that affect your locality, characteristics of local people and buildings that make them vulnerable, and qualities of local people and institutions that will be their capacities in dealing with

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