



THE INSTITUTION OF
CIVIL ENGINEERS

Megacities

*reducing vulnerability to
natural disasters*

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Megacities: reducing vulnerability to natural disasters

Institution of Civil Engineers

Megacities: reducing vulnerability to natural disasters

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Executive summary

As the human and economic assets at risk grow in the megacities of the developing world, so there is increasing responsibility for city government to protect those assets from hazard by developing strategies of mitigation. The increasing recognition of the importance of mitigation measures, within the United Nations (UN) and international funding agencies, provides the conditions for significant progress to be made.

Earthquakes, extreme winds, storm surges, flash floods, tsunamis, landslides and volcanic eruptions can in some cases be predicted, but can rarely be influenced by human endeavour (Chapter 1).

The 'megacities' of the developing world, in which the combined forces of population growth and industrialization are at their greatest, can be at significant risk from natural hazards. It is the impact of natural hazards on cities that creates disaster (Chapter 2)

Many megacities of the developing world are situated in hazard zones (Chapter 2).

Mitigation, the process of taking action in advance to minimize the effects of future hazards, is a long-term investment in the welfare of all. There is a growing need to emphasize mitigation rather than response (Chapter 3).

National and city governments are therefore under an increasing obligation to assess risk and to ensure that a mitigation strategy features prominently in the development agenda (Chapter 3)

Funding for development projects should be conditional on the quality of a city's overall mitigation strategy. International funding agencies are increasingly conscious of the benefits of mitigation, and can help to promote it through their funding policies (Chapters 3 and 9).

The UN should now ensure full coordination between the existing UN agencies to create an effective overarching structure with the capacity to:

- synthesize and promote the most effective systems for hazard prediction, utilizing technological advances
- synthesize and promote best practice in mitigation techniques
- assist and enable national, regional and city governments to meet the criteria of funding agencies and to achieve efficient use of resources (Chapter 9).

To implement a mitigation strategy, city governments should pursue two types of activities: redirecting routine tasks of administration and maintenance to mitigate exposure to identified risks, and creating new programmes and projects which incorporate features that will mitigate damage (Chapter 7).

The potential effects of hazard events on each element of a city's infrastructure should be studied in detail. Hazard zonation maps should be used to identify areas suitable for development (Chapter 5).

City government's first requirement is to carry out a preliminary risk assessment. An implementing agency should be selected, and a task force appointed to utilize all sources of data and expertise within the city and externally to carry out such an assessment (Chapter 4).

The risk assessment should be scrutinized by city government in order to establish the nature of mitigation measures required, on the basis of long-term cost-benefit analysis. A task force with appropriate management and powers should be established to formulate a detailed mitigation strategy and action plan (Chapter 9).

Scientific and technical information on natural hazards should be presented to the task force in an accessible format. Information should include: estimates of probability, level of risk, and hazard zonation maps (Chapter 4).

Resources should be concentrated on reducing the vulnerability of key components of the infrastructure, particularly those of post-disaster significance. The planning, design and construction of new infrastructure should incorporate disaster mitigation principles. Infrastructure networks should incorporate duplication and redundancy to allow operations to continue if individual sections are damaged (Chapter 5).

Settlement should be directed towards less hazard-prone areas by land-use planning, and by applying regulations, incentives and penalties (Chapter 5).

City government should provide local communities, including those in the informal sector, with support to enable them to install, operate and maintain infrastructure and other services within their own area. Support should include technical assistance, and the provision of subsidized materials. The coping mechanisms of local communities should be enhanced (Chapters 5 and 6).

Secure tenure, land rights and other incentives which encourage residents to improve their own environment will be the key to ensuring fundamental and sustained improvement in informal communities of the city (Chapter 5).

In devising a mitigation strategy, full regard must be given to factors such as the income, gender, age and level of education of different sectors of the city, and the ethnic, religious and cultural background (Chapter 6).

Plans for disaster response should be designed to answer the immediate human needs of rescue, shelter, first aid and clean water. Rescue of victims is most effectively done by local people and organizations because they are able to carry this out more quickly than outside agencies (Chapter 6).

In terms of external support, the greater benefits accrue from the provision of, for example, water-supply equipment and a small number of specialist experts, rather than from extended multidisciplinary groups arriving after a disaster without careful preparation (Chapter 6).

Public education programmes should be devolved to local communities, businesses and other organizations to enable individuals to reduce risks and prepare for hazards. These programmes should be supported by information collated and distributed by the city government. (Chapter 8).

Procedures for disseminating warnings of imminent hazards should be agreed in advance between the government, scientific agencies and the media (Chapter 8).

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Foreword

The earthquake that struck Kobe, Japan on 17 January 1995 brought home forcefully the risk faced by modern cities from natural hazards, even where there is substantial commitment to preparedness and response at national level and extensive awareness at local and community level. As the size and number of large cities around the world grows, local, municipal and national governments face an increasing risk of similar catastrophe. The United Nations' International Decade for Natural Disaster Reduction (IDNDR) provides an opportunity for all nations to develop their understanding of the risk from natural hazards and to take steps to reduce that risk.

This book is concerned with the effects of natural hazards on the urban environment and the steps which can be taken by governments, other organizations and individuals, particularly of the world's great conurbations, or megacities, to mitigate those effects. Although concerned primarily with natural hazards of sudden onset (such as earthquakes, severe winds, floods, volcanic eruptions and landslides) some aspects of this book are also relevant to concerns arising from other natural processes such as drought and desertification, and hazards of a biological or technological origin.

This book identifies ways in which urban developments are vulnerable to the effects of natural hazards and illustrates the strategies by which these effects can be mitigated. The aim is to provide an overview, practical guidance and an *aide memoire* for public administrators, staff of agencies involved in development programmes, managers of public utilities and of commercial and industrial enterprises, educators, community and voluntary workers in non-governmental organizations, members of professional groups, property developers, owners and occupiers. The commitment and contribution of these groups is crucial to successful implementation of a mitigation strategy.

The risk of natural disaster is one of many pressures facing metropolitan governments. In some areas of the world, where awareness of the hazard is high, steps have been taken to enforce better planning and building codes, to develop disaster management strategies and to educate and train the population. However where there is no recent memory of natural disaster there is often no such preparation. Many cities have grown rapidly over recent years, and attention has been focused on infrastructure development and social and economic programmes. The Great Hanshin (Kobe) earthquake showed clearly the cost of disaster even in a country whose building codes and disaster-prevention programmes are among the most advanced in the world. Many urban areas have been devastated by floods and high winds, and to a lesser extent by landslides, volcanic eruptions and tsunamis, throughout this century. This book is intended as a reference for the people of those cities, concerned about natural disaster, who strive to build for the future.



Preface

The years 1990–2000 have been designated by the United Nations (UN) as the International Decade for Natural Disaster Reduction (IDNDR). In response, many countries have established national IDNDR committees, in order to raise interest, develop research projects and promote international cooperation. The UN's Scientific and Technical Committee has also endorsed a range of international demonstration projects. One such project, entrusted to the World Federation of Engineering Organizations (WFEO) and the Union des Associations Techniques Internationales (UATI), is 'Urban developments and their vulnerability to natural disasters, with particular reference to "megacities"'. The Institution of Civil Engineers (ICE) has undertaken the project on their behalf, with the considerable support of the Overseas Development Administration (ODA).

This book has been produced as a result of that project, and is intended for use in all large urban areas. In preparation, case study visits were made to three cities: Karachi in Pakistan, Jakarta in Indonesia, and Metro Manila in the Philippines.

Part 1 provides an overview of natural hazards and their effects, and of the characteristics of urban developments and their vulnerability. A rationale for mitigation is presented.

Part 2 discusses the issues and strategies involved in mitigation, and provides practical guidance and examples of good practice, in terms of the contribution of science, the protection of physical infrastructure and the human dimensions.

Part 3 discusses the role of city management and public awareness in reducing risk, outlines a strategy for mitigation and offers guidance on its implementation.

This project was coordinated by a working group chaired by Mr Stuart Mustow (1994 President, ICE) and consisting of Mr Jolyon Dromgoole, Mr Peter Guthrie (RedR), Mr Michael Leonard (WFEO), Mr Bernard Newman, Mr Nick Paul, Dr Scott Steedman (Vice-Chairman), and Dr John Whittow.

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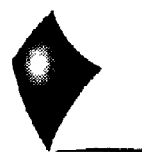
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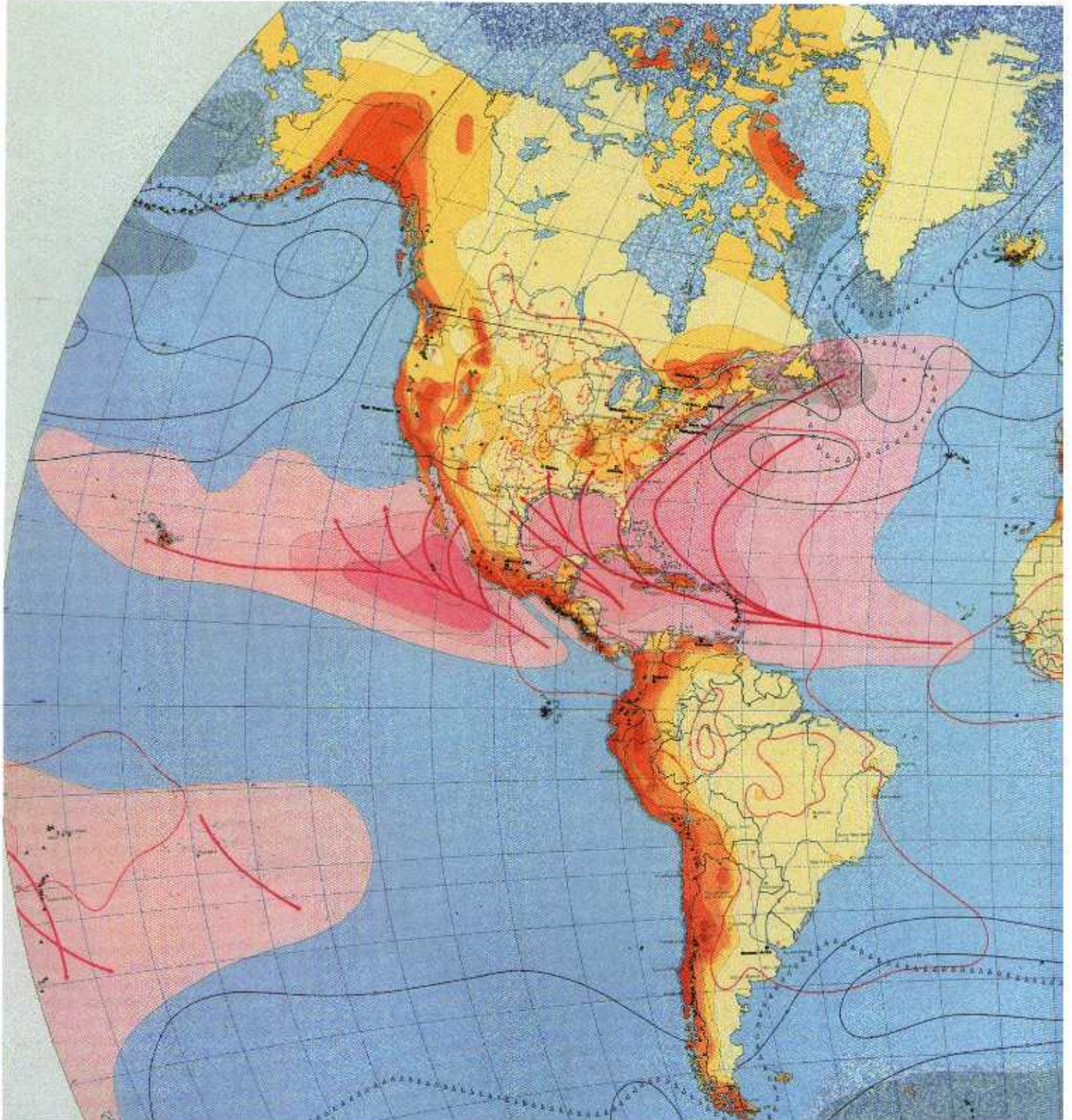
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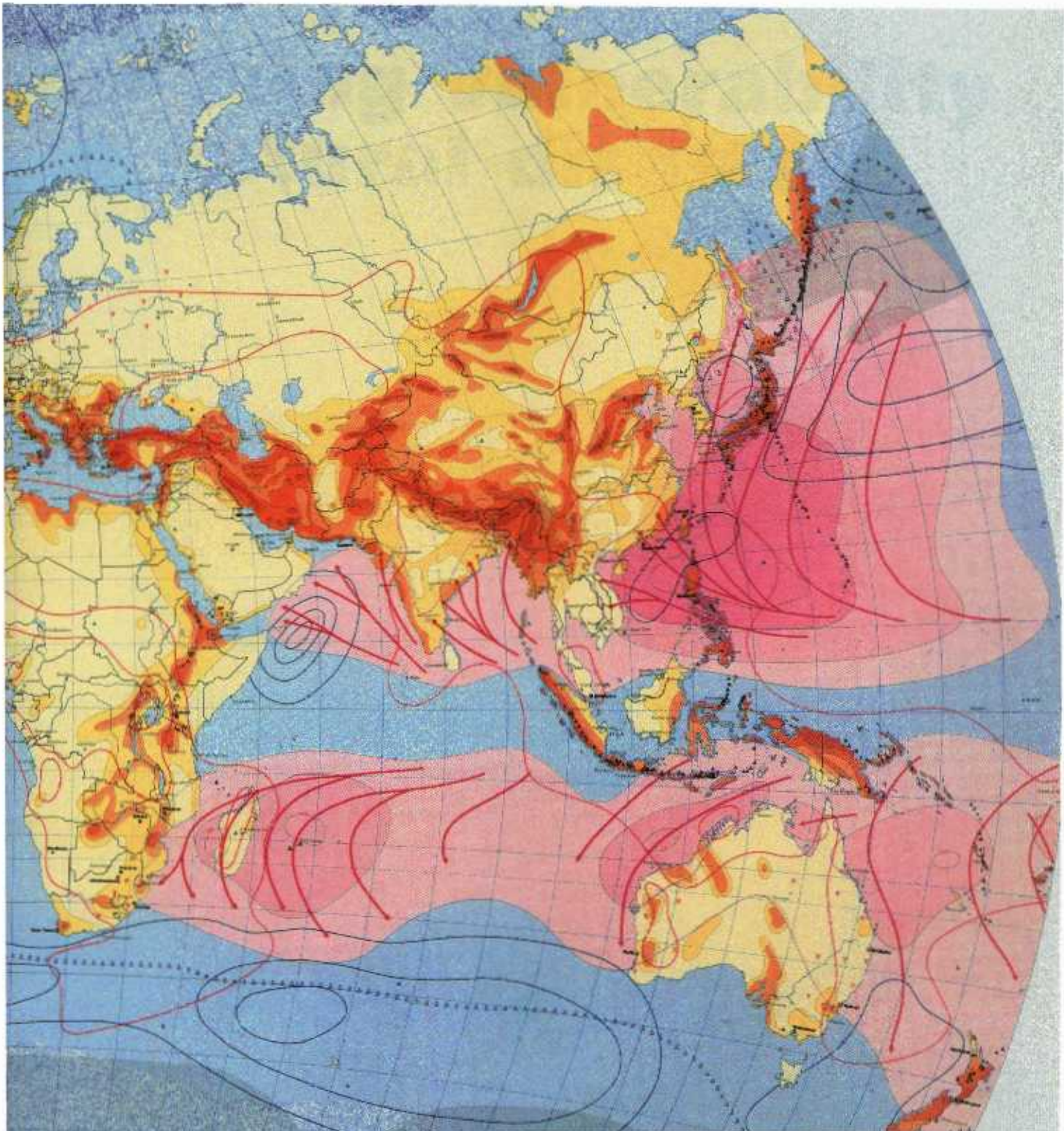
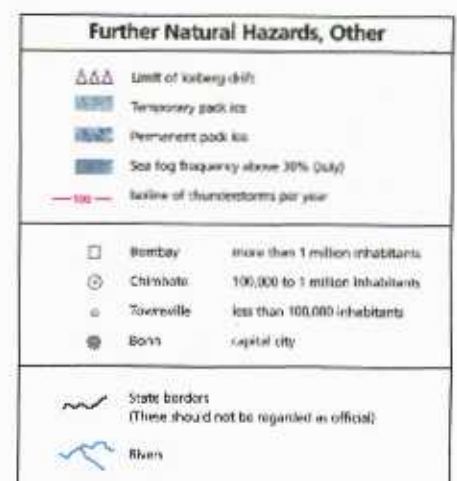
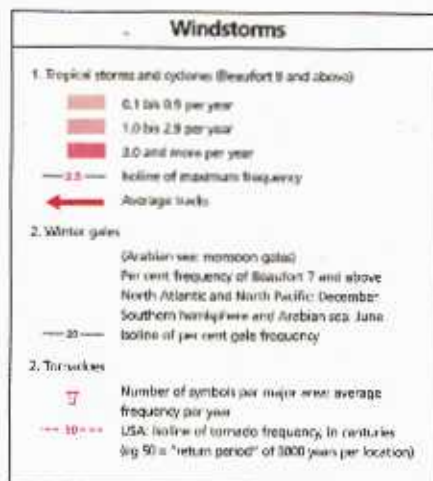
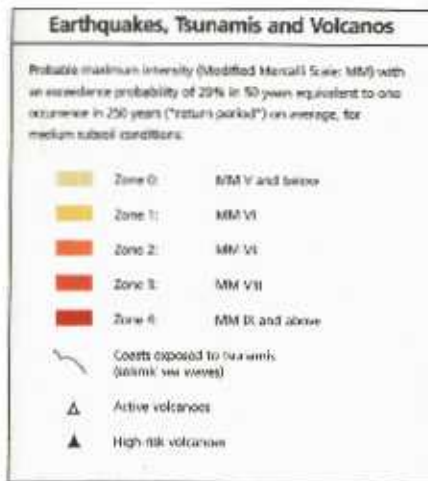
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World Map of Natural Hazards





Part 1

Background

Natural hazards (phenomena and effects)

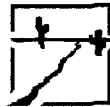
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An understanding of the characteristics of natural hazards and of how they release energy is an essential precursor to an analysis of the mitigation of their effects. With limited exceptions, it is not yet possible to prevent the onset of natural hazards because of the enormous energies released (the main exception is in the area of ground stabilization, used to prevent or reduce ground movement and, particularly, to stop or reduce the possibility of some landslides).

The natural hazards considered in this chapter are:



tropical cyclones
(including hurricanes
and typhoons)



earthquakes



floods (rain and sea-
surge generated)



landslides



tsunamis



volcanic activity

(A summary is given in Table 1.1)

Each hazard has characteristic features – probability, frequency, intensity, coverage and duration – and effects. Their impact also depends on factors such as location, topography, geology and soil characteristics. The probability of natural hazard events occurring in a particular region can be estimated with varying degrees of accuracy. The formation and track of tropical cyclones and floods can be forecast, and it is possible to predict the onset of some types of landslides, volcanic eruptions and tsunamis, using sophisticated monitoring techniques. Predictions, warnings and the collection of scientific data are discussed in Chapter 4.

Table 1.1 Summary of primary and secondary effects of natural hazards

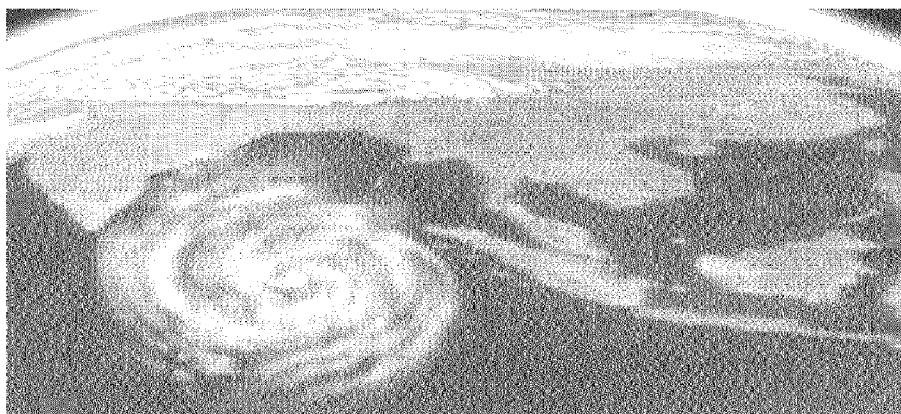
Natural hazards	Primary phenomena	Secondary phenomena
Cyclone	Strong winds Heavy rains	Flood and sea surge Landslide Water pollution
Flood	Flooding	Water pollution Landslide Erosion
Tsunami	Flooding	Water pollution Landslide Erosion Deposition
Earthquake	Violent ground motion Fault rupture	Soil liquefaction Fire Flood Landslide Tsunami Water pollution
Landslide	Ground failure	Flooding via river damming Water pollution Debris flows
Volcano	Lava flow Pyroclastic flow/surge Ash fall Volcanic gases	Fire Air pollution Tsunami Lahar flows Water pollution Ground subsidence

Tropical cyclones (including hurricanes and typhoons)

Causal phenomena



Tropical cyclones are spawned in the tropics from atmospheric disturbances which develop steep barometric pressure gradients. These induce high winds which rotate about a centre, or eye. They may or may not be accompanied by precipitation. Such storms are known as cyclones in the Indian Ocean and South Pacific, hurricanes in the Western Atlantic and Eastern Pacific, and typhoons in the Western Pacific.



When a cyclone strikes land, high winds, often accompanied by exceptional rainfall and storm surges, can cause damage to buildings and other structures. It can also cause the occurrence of secondary flooding, landslides and mudflows.

Tropical cyclones can be tracked from their initial stages; however, as unpredictable changes in course can occur, accurate landfall forecasts are usually possible only a few hours in advance.

Cyclones are known as tropical cyclones if they originate in the tropics, or extra-tropical if they result from a cold and warm front. They develop as a result of high energy build-up from continuous solar radiation over the ocean, and provide a means of releasing this accumulated energy. A mixture of heat and moisture forms a low-pressure centre over oceans in tropical latitudes where water temperatures exceed 26°C. Wind currents spin and organize around deepening low pressure, accelerating toward the centre and moving along a track pushed by trade winds. A depression is defined as a tropical cyclone when winds reach gale force (120 km/h).

The central area, or eye of the storm, around which the air circulates has a diameter of 20–40 km, and atmospheric pressure within it is extremely low (well below 1000 millibars). Weather conditions are relatively quiet with light winds and small amounts of cloud. From the perimeter of the eye to the storm's outer boundary (or wall), violent winds and torrential rains occur, which may persist for many hours. The diameter of this area ranges from 100 to 300 km, and gale or storm force winds may occur within a diameter of 600 km or more. The depth of a cyclone from its top to sea-level ranges from 10 to 20 km. When the eye of a storm passes over an area, strong winds from one direction are followed by the quiet conditions of the central area, and then by strong winds from another direction.

Most tropical cyclones originate between 5° and 30° latitude north and south of the equator. Once formed, the cyclone will move within the zone of the trade winds at speeds of 10–50 km/h. In a first phase, it will run along the latitude but will later take a more longitudinal direction. The course that the cyclone follows is determined by the distribution of the ocean water temperature, and accordingly of the lower atmospheric strata, and is also influenced by pressure distribution in higher atmospheric strata. In general, the direction will be to regions where a maximum of energy is available. The average duration of a cyclone is nine days, during which period it may travel over a distance of 10,000 km. Due to much lower energy supplies, it will subside over land. Friction on the Earth's surface will also destroy the cyclone gradually by allowing more air to penetrate its eye.

The damaging effects of the winds are produced by a combination of their strength, gustiness and persistence. Tropical cyclone is often described as the most devastating of all natural phenomena, because it usually affects a very large area and often has disastrous secondary effects such as river flooding, flash floods, storm surges, landslides and mudflows. When it approaches land, risk of serious loss or damage arises from winds, rainfall and surges. Although intense rainfall can occur over a lengthy period, wind produces the most damaging effects. Wind speeds exceeding 120 km/h are referred to as destructive winds, and the destructive power of wind increases with the square of its speed: a ten-fold increase in wind speed increases its force 100 times.

General characteristics



Predictability

General description

Tornadoes occur rapidly, have a smaller diameter than cyclones and a relatively short life and span, but can cause almost total destruction along their paths

Several scales are used to indicate wind forces, including the Beaufort scale and the Saffir-Simpson scale, the latter of which classifies hurricanes from 1 to 5 (representing wind speeds of 120 to 150 km/h). However, there are no scales which adequately represent the force of gusts of wind in urban areas.

Floods (rain and sea-surge generated)



Causal phenomena
General characteristics

Inland flooding, as distinct from coastal flooding, is generally caused by the overflow of water courses as a result of intense rainfall or of a reduction in waterway area by landslide or debris damming (which themselves may be triggered by natural events such as earthquakes). Coastal inundation may be the result of storm surge, tsunamis or the subsidence of coastal land. Human manipulation of watersheds, drainage basins, floodplains and the effects of deforestation, soil erosion, silt carriage have increased volume and speed of runoff.

Flash floods. Floods of short duration with relatively high peak discharge caused by accelerated runoff from localized storms, dam failure, or break-up of ice jams.

River floods. Relatively slow build up, usually seasonal in river systems.

Coastal floods. Associated with tropical cyclones, tsunami waves, and storm surges, which cause a rise in sea-level and inundation of coastal and inland areas. The degree of hazard depends on: depth of water, duration, velocity, rate of rise, frequency of occurrence, seasonality.

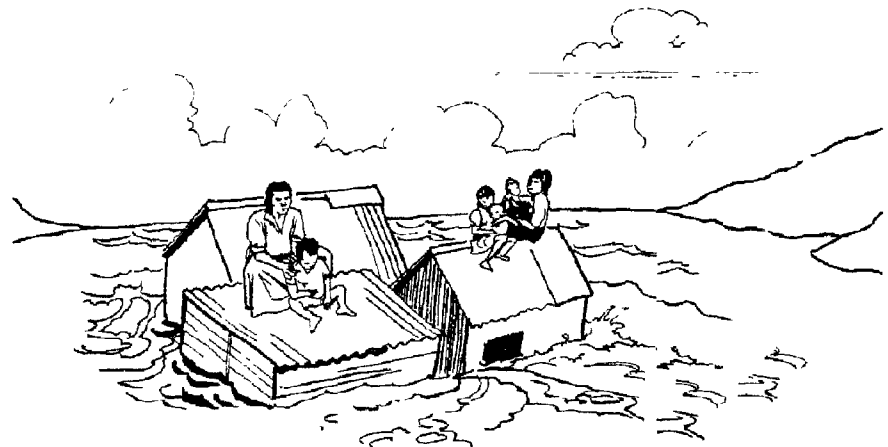
Predictability

Flood forecasting is based on seasonal patterns, capacity of the drainage basin, floodplain mapping, and surveys by air and land. Warnings can be issued far in advance for seasonal floods, but only shortly before onset in cases of storm surge, flash floods and tsunamis. Numerical models are used to predict storm surges in tropical cyclone conditions

General description



Flash floods. Flash floods are generally associated with isolated and localized intense rainfall. In some regions, severe and destructive flash floods occur very infrequently in any one of a large number of small catchments within a given



region. Efficient surveillance, warning and protection against the hazard is therefore difficult. In other regions, flash floods occur annually on the same river; warning in these cases is more a matter of timeliness.



River floods. The magnitude and extent of a river flood depends upon the size of the catchment area of the river, the topography, soil conditions and vegetation, and the weather conditions involved. For instance, river flow on very large rivers (such as the Nile and the Mekong) is relatively slow to change in the downstream reaches; flood waters will generally be a combination of many rainfall events occurring over a wide area, sometimes augmented by melted snow. In large river basins flooding is usually seasonal and peak discharges can be reached and maintained over days or weeks.

River floods can also be caused by rainfall of extra-tropical or frontal character, as experienced in temperate latitudes, and by large tropical atmospheric depressions with moisture-laden winds, moving from a maritime environment onto and across a land mass (for instance, seasonal monsoons in Asia and line squalls on the west coast of Africa). Rainfall in these events is generally widespread and can be heavy. The level of flooding can be high, and is influenced by topographic features

Coastal floods. Devastating floods can occur as a result of extreme wind storms (typhoons, hurricanes or tropical cyclones). The Indian sub-continent (Bay of Bengal), and countries in Asia and the Pacific are all typically subject to such events. Catastrophic flooding from rainfall is often aggravated by wind-induced surge and low atmospheric pressure along the coastline. Rainfall intensities are high and the area of the storm is wide; the combination of these factors can produce extreme flood discharge in both small and large river basins, which can be maintained at high levels by a coastal discharge.

Tsunamis, or long period gravity waves, are generated by disturbances of the ocean floor resulting from earthquakes, landslides or volcanic activity.

Tsunamis are very long waves of low amplitude, and are barely perceptible in deep water. They may measure 160 km between wave crests. The waves cannot be sensed aboard ships nor seen from the air in the open ocean, but can be considerably amplified when they reach land by shoaling, diffraction and resonance; heights of 40 m have been recorded. They can move at speeds of up to 800 km/h in the deep water of the ocean, diminishing in speed as the wave

Tsunamis

Causal phenomena

General characteristics





approaches the shore. They may strike the shore in a series of crashing waves, inundating the land. The extent of flooding depends on the shape of shoreline and the tides.

Predictability

The Pacific Tsunami Warning System monitors seismic activity and declares warnings. However, waves generated by local earthquakes may strike nearby shores within minutes; warnings are not possible in such cases.

General description

When a tsunami reaches shallower coastal waters, wave heights can increase rapidly from a few centimetres to many metres. Coastal waters may be drawn into the ocean just before the tsunami strikes. When this occurs the sea bed may be exposed below the level of the lowest tide.

The advancing wave front of a tsunami may surge inland, causing severe damage for up to 300–400 m (much further if it travels up river estuaries). The first wave may not be the largest; successive wave crests, each typically arriving at 10–45-min intervals, may continue to pound the coast for several hours.

Tsunamis can be generated in any deep sea or ocean, but occur most frequently in the Pacific Ocean, related to the intensive number of earthquakes generated by the continuing movement of the Earth's surface in this area.

Earthquakes

Causal phenomena

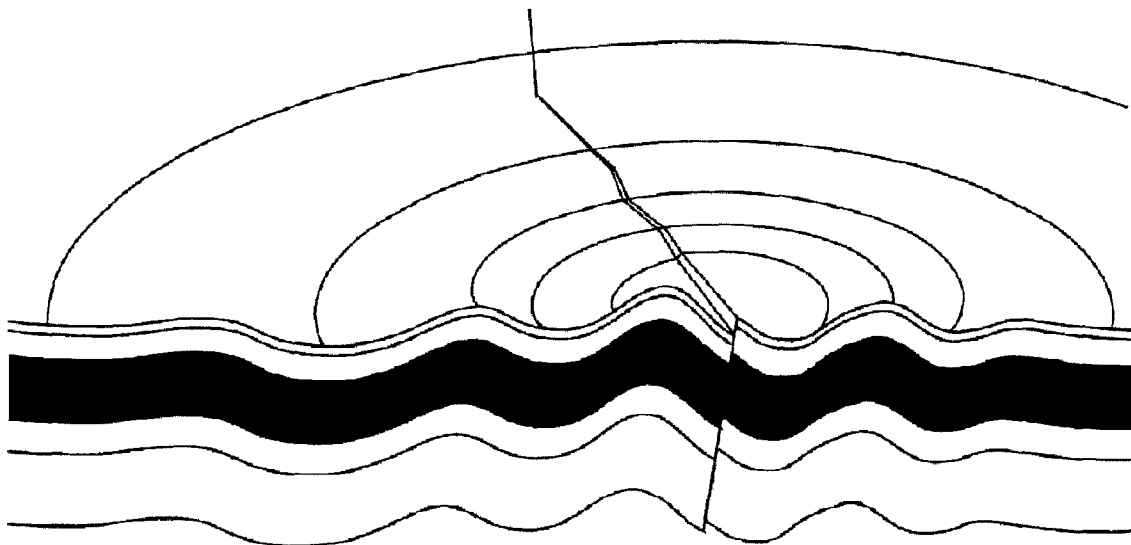
Earthquakes are caused by sudden slippages of crustal rock along a fault or an area of strain, thereby causing rebound to new alignment. They are releases of strain energy related to sudden fault movements.

General characteristics and effects



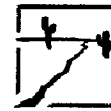
An earthquake shock causes vibrations, or seismic waves, on and below the Earth's surface causing:

- ground rupture
- ground shaking
- aftershocks
- liquefaction
- tsunamis
- landslides.



The probability of an earthquake occurring in a particular place can be determined, although its exact timing cannot be predicted. Probability estimates are based on the monitoring of seismic activity, on detailed geological knowledge and on historical incidence.

Predictability



General description

Ground rupture. An earthquake is produced by abrupt displacement of rock masses, usually within the upper 15–50 km of the Earth's crust. Earthquakes may be generated either as deep focus or shallow focus. Most earthquakes result from the movement of one rock mass past another in response to tectonic forces. Rock is elastic and can accumulate strain where adjacent areas of rock are subjected to forces pushing or pulling them. However, when the stress exceeds frictional resistance or the strength of the rock, the rock slides along a pre-existing or new fracture plane known as a fault.

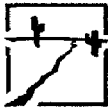
The resulting rock displacement extends outwards along the fault plane from its point of origin, or focus. The epicentre of an earthquake is the point on the Earth's surface that is directly above the focus. Rupturing usually does not proceed uniformly: its progress is typically jerky and irregular. Variations in rock properties and overburden pressures can bring the rupture almost to a stop; then, due to a rearrangement of elastic forces, the rupture may suddenly break free and swiftly propagate. The rupture will continue until it reaches places at which the rock is not sufficiently strained to permit it to propagate further. If the rupture reaches the surface, it produces a visible surface break.

During the rupture the sides of the fault grind and scrape against one another; considerable energy is expended by frictional forces and in the crushing rock, and the surfaces are heated locally. Earthquake waves are generated at the same time by the rebounding of the adjacent sides of the fault at the rupture surfaces, as well as by grinding and crushing.

Seismic waves Energy is emitted from the rupture as vibrations, or seismic waves, the speed of which depends on depth and type of rock/soil. The fastest are known as primary or compressional waves, which travel in average crustal rocks at between 5 and 8 km/s. The secondary, slower or shear waves travel at a speed of 3–4.6 km/s. Surface waves, known as Rayleigh and Love waves, travel more slowly (2.7–4 km/s) near the surface of the Earth; their depths of penetration depend on their wavelengths.

Seismic waves propagate outwards in all directions from the focus when a fault rupture causes the ground to vibrate at frequencies ranging from about 0.1 to 30 Hz (cycles per second). This shaking causes buildings to vibrate primarily in a vertical direction: damage occurs if the building cannot withstand these vibrations. Compressional or primary waves and shear or secondary waves mainly cause high-frequency vibrations (greater than 1 Hz), which are more efficient than low-frequency waves in causing low-rise buildings to vibrate. Primary waves are the first to cause vibration of a building or structure.

Secondary waves cause a structure to sway from side to side. These are the most damaging, as buildings are more susceptible to damage from horizontal motion than from vertical motion. Rayleigh and Love waves mainly cause low-frequency vibrations, which are more likely to cause tall buildings to vibrate. Amplitudes of low-frequency vibrations decay less rapidly than those of high-frequency vibrations as distance from the epicentre increases; tall buildings located at relatively large distances from a fault are therefore susceptible to damage (as in the 1985 Mexico earthquake).



Surface faulting. Surface faulting is the offset or tearing of the Earth's surface by differential movement (either vertical or horizontal) on opposing sides of a fault. Fault displacement is usually confined to zones ranging from a few centimetres to a few hundred metres in width, subsidiary branch faults can extend as far as 8 km from the main fault, and secondary faulting as far as 30 km or more from the main fault. The length of the rupture can range from 100 m to about 400 km. Tectonic deformation of the Earth's surface usually accompanies surface faulting. As well as lateral rupture, the depth of the earthquake below the Earth's surface is a major element, affecting deformation. Deformation may be local, affecting narrow zones near a fault break, or may involve major differential vertical and horizontal movements over wide areas of the Earth's crust. Surface faulting is usually accompanied by horizontal or vertical distortion of the Earth's surface within 100 m from the fault. The distortion can result from drag (bending), rebound or concealed closely spaced fractures. Distortion is greatest at the fault and decreases as distance from the fault increases.

Ground displacement. Regional uplift and subsidence may accompany earthquakes caused by larger displacements on shallow buried faults, particularly reverse or thrust faults. Regional tectonic deformation constitutes a hazard to shoreline facilities and extensive hydraulic systems where broad-scale changes in land elevation occur relative to water level. Such changes, either uplift or subsidence, can affect many hundreds of square kilometres of the Earth's surface.

Secondary effects. Secondary effects include rock falls, avalanches, and landslides triggered by ground motion dislodging rock and debris on steep slopes, and ground failure caused by extensive loss of shear strength in quick or sensitive clays or silty soils.

Strong ground shaking can also cause areas of clay-free sands and silts to temporarily lose strength and behave as viscous fluids, if groundwater is within 10 m of the surface. This process of liquefaction takes place when seismic shear waves pass through the saturated granular soil layer, distort its granular structure, and cause some of the void spaces to collapse.

Earthquakes are described in terms of:

- Magnitude (M), a measure of the strength of an earthquake, or the strain energy released at its source, denoted by a number on a logarithmic scale. The severity of ground shaking generally increases with magnitude.
- Intensity (I), a measure of the observed effects of the earthquake on people, buildings and the Earth's surface at a particular place, denoted by numbered grades on a scale. In general, areas near the epicentre have higher intensity than those located further away.

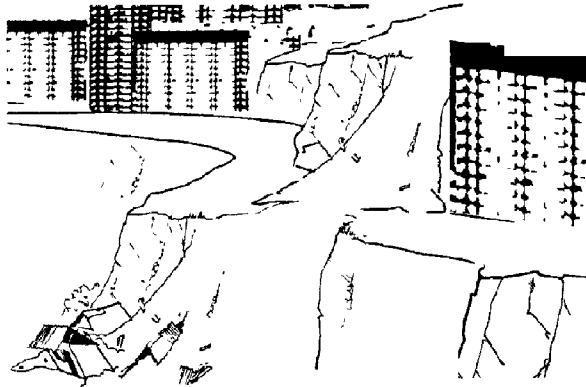
A commonly used scale to compare the total energy of seismic waves radiated from an epicentre is the Richter scale or local magnitude (ML). Intensity scales in most common use are the Modified Mercalli (MM) and the Medvedev, Sponheuer and Karnik (MSK), each having 12 categories.

Landslides

Causal phenomena

Factors that may initiate the downward movement of soil, rock or other surface material include shocks and vibrations (from earthquakes), changes in water content or the effects of groundwater, a change in slope gradient (by human manipulation), excess loading, weathering and erosion interference with water courses.

Landslides vary in types of movement (falls, slides, topples, lateral spread, flows),



and may be the secondary effects of heavy storms, earthquakes, or volcanic eruptions. Landslides are more widespread than any other geological event.

General characteristics

The frequency of occurrence, extent and consequences of landslides may be estimated, and areas of high risk determined, using information on local geology, local seismicity, geomorphology, hydrology, climatology, vegetation and land-use practices.

Predictability

Landslides can move at different speeds. Rapidly moving landslides pose a greater hazard to life, as they can cause damage with little warning. Although slower landslides will gradually cause increasing amounts of damage, their movements can be monitored and predicted.

General description

There are several types of downward movement of soils, all commonly known as landslides. They include the slow creep of soils and bedrock, the sudden fall of rock (rockfalls), a large movement of external material along a slip surface, and a flow-slide (mudslide) caused by liquefaction. Landslides can be initiated by different influences: see 'Causal phenomena'

Shear stress Landslides will occur after sudden or gradual changes in the shear stress and strength condition. The most important factors are the water content of the geologic mass and vibrations (by earthquakes).

Volcanoes are formed when magma is propelled through weak or fractured points in the Earth's crust by the pressure and effervescence of dissolved gases

Volcanic activity

Causal phenomena

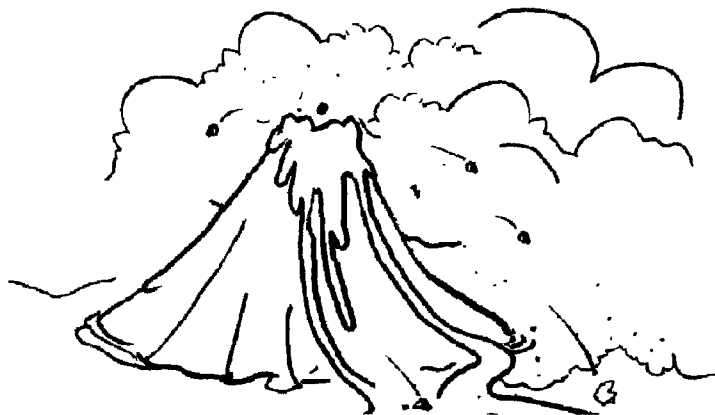
Volcanoes can be classified as cinder cones, shield volcanoes, composite volcanoes and lava domes. Magma flowing out onto the surface is known as lava; all solid particles ejected are known as tephra. The type of damage depends on the material ejected. ash, pyroclastic flows (blasts of gas containing ash and fragments), mud (lahar), debris and lava flows.



General characteristics

Volcanoes are mainly located in a clearly defined volcanic belt. The study of their geological history, seismic activity, ground deformation, sulphur dioxide emissions and other observations, may indicate an impending volcanic eruption. There is not yet a reliable method of forecasting, and precursory signs do not always occur, although a number of classified 'active' volcanoes are monitored for connected

Predictability



seismic activity and hazard maps, based on historical evidence, have been constructed for certain regions.

General description

More than 500 volcanoes have been active in historical times; hundreds of others, now dormant, show evidence of eruptive activity in recent prehistory. Eruptions have occurred at volcanoes previously thought to be extinct, and some of these will erupt again. Entirely new volcanoes, many under the ocean, are formed from time to time within volcanic zones.

Molten material within the Earth's crust, known as magma, is a complex mixture of silicates, containing dissolved gases and sometimes crystallized minerals in suspension. As it rises, the pressure decreases, enabling the dissolved gases to effervesce and expand, and driving magma upwards through the volcanic vent. The degree of violence of the eruption depends mainly on the amount and rate of effervescence of the gases, and on the geochemistry and viscosity of the magma.

Eruptions vary widely in magnitude, duration and frequency; some volcanoes erupt almost continuously, others at intervals of hundreds or thousands of years.

The volcanoes of the major rift systems (including the mid-Atlantic and East African rifts) or mid-oceanic upwellings (such as Hawaii) produce lava of a low viscosity, which flows easily and may spread over large areas. The volcanoes of the great subduction zones around many ocean margins usually emit lava of high viscosity, which tends to build up into cones or to form relatively short, thick flows. The high viscosity of magma within these volcanoes allows high gas pressures to build up; when the gas is released its expansion is explosive, and it carries with it large amounts of solid or molten lava in suspension. All varieties of eruptive behaviour can be observed, from the quietly effusive to the violently explosive, depending on the composition and gas content of the magma.

The primary volcanic effects posing sudden and urgent threats to life or property include ash flows, pyroclastic flows, mudflows, lava flows and volcanic gases. Volcanic dust suspended in the atmosphere can also affect the world climate, communications and air transport. Eruptions can cause secondary hazardous phenomena, such as ground failure, ground subsidence (sudden or gradual), debris avalanches, mudflows (lahars), glacier bursts, volcanic earthquakes and tsunamis. Volcanic earthquakes frequently precede or accompany eruptions, but are rarely of sufficient magnitude or intensity to cause severe damage.

Megacities: from hazards to disasters

2

The natural hazards outlined in the previous chapter unleash tremendous energy and can be catastrophic in their impact upon society. It is the presence within hazardous areas of society – people, physical structures and economic activities – that creates the possibility of disaster

This chapter examines the growth of urbanization, and the relationship between that growth and the on-going incidence of natural hazards. The significance of hazards upon urban developments is described with specific reference to the 'megacity'. (The United Nations (UN) defines a 'megacity' as a city with a population of over eight million.) The vulnerability of assets at risk – human, physical and economic – is considered.

The process of urbanization has been a common feature in the development of civilizations throughout history, as communities have chosen to settle in favourable locations and to focus their commercial, political and cultural activities around central points. Settlements have developed around areas offering commercial and societal benefits, undeterred by the fact that those same areas may be at risk from natural hazards.

Urbanization and the growth of cities

In choosing the valley of Mexico as the centre of their empire, the Aztecs probably also considered the specific risks in the world around them, such as invasions by hostile neighbours. But their decision .. was certainly not very fortunate in terms of the earthquake risk. They were obviously frequently intimidated by earthquakes and volcanic eruptions (*Earthquake Mexico* '85, Munich Reinsurance Company).

In the developing world, in the past 50 years, technical advances associated with industrialization and economic development have stimulated a high rate of growth of urban areas. Opportunities for employment in industrial and manufacturing sectors have multiplied, and this factor has been complemented by the provision of education, health and other social services. In some parts of the world, the modernization of agricultural processes has reduced the need for rural labour, and increased demand for 'urban' supporting services such as food processing. In other areas drought and desertification have led to the loss of agriculturally productive land and a resulting migration to urban areas. In summary, people are attracted by employment prospects, which at their worst are likely to be more rewarding than those of rural economies, where land ownership is often confined to a minority. In China, for example, some 30% of the agricultural land has been abandoned in the last decade or so.

This urban migration has been magnified by an increased rate of population growth in the developing world, which impacts with greatest intensity in cities. UN sources predict that, between 1990 and 2020, the urban population of those parts of the world currently defined as developing will increase by 160%, a total increase of 2200 million people. Currently 34% of people in the developing world live in urban areas, by 2020 this proportion is projected to be 57% of a greatly increased total. The increase in the population and geographical area of many cities places more people at risk from natural hazards.

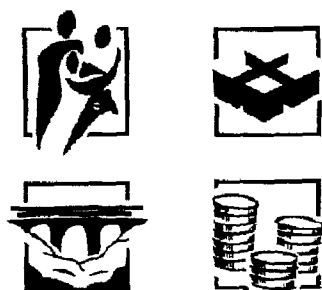
Figure 2.1 gives a clear idea that many megacities will appear in developing countries. These countries are often situated in zones historically prone to one or more types of natural hazard.

... the likelihood of metropolitan disasters, and the enormity of their consequences, are rising. More people in larger areas are facing increasing, and unprecedented, risk. Failure to acknowledge and analyze the special conditions of disaster vulnerability that exist in today's metropolitan areas will be costly both in terms of human suffering and in terms of the consequences for economic and social development in poor societies (*Metropolitan Areas and Disaster Vulnerability* by Mary B. Anderson, World Bank Discussion Paper No. 168, edited by Kreimer and Munasinghe).

Effects of natural hazards on cities

Natural hazard events have both immediate and longer term effects upon people, physical structures and economic activities. These effects are 'generic' to all natural hazards considered in this chapter, although their extent and nature will vary according to the particular hazard and the particular physical characteristics of the city (see Table 2.1).

Vulnerability and risk



Assessment of the potential severity of these effects within a particular situation involves an assessment of vulnerability and of risk. In this chapter, vulnerability and risk refer to specific concepts within the study of disaster mitigation.

The vulnerability of a particular element of society is defined as the degree of loss which it would suffer as a result of a specific hazard event. The nature of

Figure 2.1
Growth in the number of large cities and megacities in low, medium and high income countries. Note. Large cities have between 3 and 8 million inhabitants. Megacities have over 8 million inhabitants.

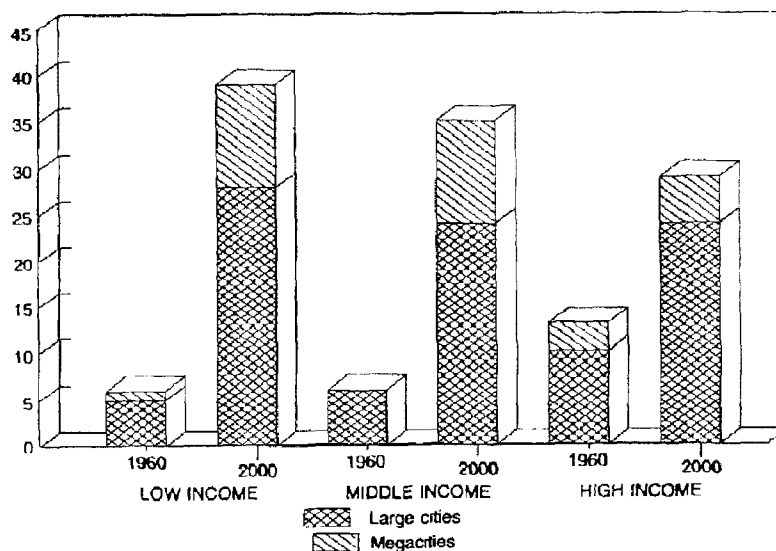


Table 2.1 Potential effects of natural hazards

	Social or human effects	Physical effects	Economic effects
Primary effects	Fatalities Injuries Loss of income or employment opportunities Homelessness	Ground deformation and loss of ground quality Collapse of and structural damage to buildings and infrastructure Non-structural damage to buildings and infrastructure (e.g. component damage)	Disruption of business due to damage to buildings Damage to industrial plants and equipment Loss of productive work force, through fatalities, injuries, and relief efforts Disruption of communications networks Costs of response and relief
Secondary effects	Disease or permanent disability Psychological impact of injury, bereavement, shock Loss of social cohesion due to disruption of community Political unrest where government response is perceived as inadequate	Progressive deterioration of damaged buildings and infrastructure which are not repaired	Losses borne by the insurance industry, weakening the insurance market and increasing premiums Loss of markets and trade opportunities, through short-term business interruption Loss of confidence by investors, withdrawal of investment Costs of repair, rehabilitation, medical and welfare assistance

vulnerability and its assessment vary according to whether the element involved represents people and social structures, physical structures, or economic assets and activities.

The vulnerability of an area is determined by the capacity of its social, physical and economic structures to withstand and respond to natural hazard events. Certain groups of people, types of physical assets and economic activities can be particularly vulnerable or susceptible to damage.

Risk has been defined by the UN as a measure of the expected losses due to a hazard event of a particular magnitude occurring in a given area over a specific time period. The level of risk depends not only upon the nature of the hazard and the vulnerability of the elements which it affects, but also upon the economic value of those elements. As communities grow larger, more established and more complex, experience has shown that the level of risk which they face increases.

Factors influencing vulnerability will vary from one area to another. However, it is possible to identify fundamental causes of vulnerability common to different areas as discussed in Chapter 6. Some factors influencing the vulnerability of people and social structures are suggested below

*Vulnerability
of people*



Fundamental causes of human vulnerability.

- Lack of access to resources (material/economic vulnerability).
- Disintegration of social patterns (social vulnerability)
- Degradation of the environment and inability to protect it (ecological vulnerability).
- Lack of strong national and local institutional structures (organizational vulnerability).
- Lack of access to information and knowledge (educational vulnerability)
- Lack of public awareness (attitudinal and motivational vulnerability)
- Limited access to political power and representation (political vulnerability)
- Certain beliefs and customs (cultural vulnerability).
- Weak buildings or weak individuals (physical vulnerability)

Taken from *Natural Disasters: Protecting Vulnerable Communities* by Y F Aysan.

The impact of an event will depend partly upon random factors, such as the time of day or night and day of week when the event occurs, it also depends upon the vulnerability of those affected. For example, individual households may not take protective or preventive measures due to lack of resources or lack of awareness; or the ability of a community to protect itself may be weakened by a lack of social cohesion or inadequate institutional structures.

The vulnerability of people to hazard events is often assessed in terms of the number of potential casualties which would result from a specific event; however this quantitative approach does not take into account the full effects on the population, including injury, damage to physical and psychological health and social disruption.

Particular vulnerability of megacity populations

Certain characteristics of large cities exacerbate human vulnerability. The larger the city and the greater its rate of growth, the more intractable are the problems of managing and controlling development. Demand for land in and around the city results in geographical expansion. A large proportion of the city's population may live in unplanned informal settlements in marginal areas which are often particularly prone to natural hazards. Those who live in the informal sector are often in generally poor health, with very low incomes and no personal food stocks. Local administrative organizations are likely to be rudimentary and overstretched.

The high rate of unplanned development and the pressure on resources means that the provision of water, shelter, health services and transport is often inadequate, particularly in the informal sector. Even in established and relatively wealthy areas, supplies of water and electricity are often restricted on a routine basis. Natural disasters can deprive entire sectors of the population of water, electricity supply and sewage facilities for prolonged periods.

When disaster strikes, the larger and more unplanned the city, the more difficult it is to organize rescue and respond to disaster.

Vulnerability of buildings and physical infrastructure

The vulnerability of city dwellers to natural hazards is fundamentally dependent upon the nature of the buildings and infrastructure surrounding them. Different types of dwellings are vulnerable to different hazards. For example, houses built from cane, thatch and corrugated iron are more vulnerable to extreme winds, while brick buildings are more likely to disintegrate with the violent ground surge of an earthquake, than are lighter structures or those with strong reinforced concrete frames. Assessment of the vulnerability of different types of buildings is

often used to predict the potential numbers of casualties in a specific event, as there is a strong correlation between the two (Figs 2.2 and 2.3)



Buildings and physical infrastructure which may be particularly vulnerable to the effects of natural hazard events include:

- Older residential buildings in densely populated areas (such as inner-city 'slums'), built to standards which are now considered inadequate, which have been poorly maintained, or have been illegally altered or extended, or are substantially overcrowded.
- A large number of buildings will have been erected prior to the existence of building control specifications; more recent buildings may have been constructed with little regard to specifications.
- Unplanned 'informal' settlements located in marginal and possibly hazardous areas (such as steep slopes and floodplains), in which dwellings are built without technical advice on safe construction methods.
- Modern buildings of poor design or construction quality (such as low-cost housing developments).
- Communication and control centres which are concentrated in one area.
- Hospital facilities which are insufficient for large numbers of casualties and may become inaccessible.
- Schools and other community buildings which have been built to low construction standards and may be vulnerable to collapse, or which do not have the capacity to provide emergency shelter.
- Bridges and viaducts, embankments and culverts which are of poor design and liable to collapse, preventing casualty evacuation and the movement of emergency supplies; narrow streets which become blocked with debris and stalled traffic will have the same effect
- Potable water mains which are liable to rupture, resulting in pollution and disease.
- Sewerage systems which are liable to flood, spreading disease.
- Electrical supply lines and systems which are liable to failure.
- Gas mains which are liable to rupture, fuelling fires.

Damage to buildings and infrastructure results in both immediate and long-term effects on people. Immediate effects include loss of life and injury from collapsing

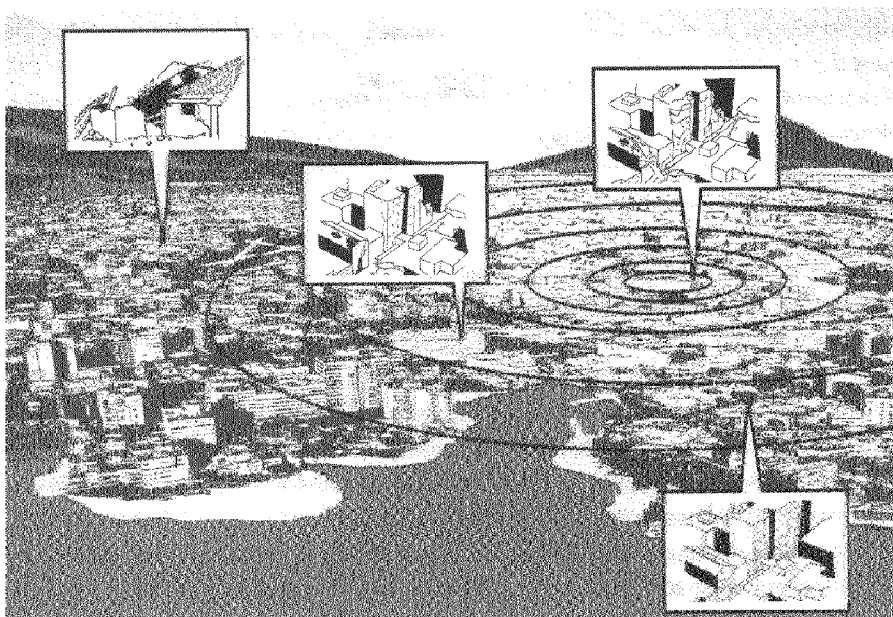
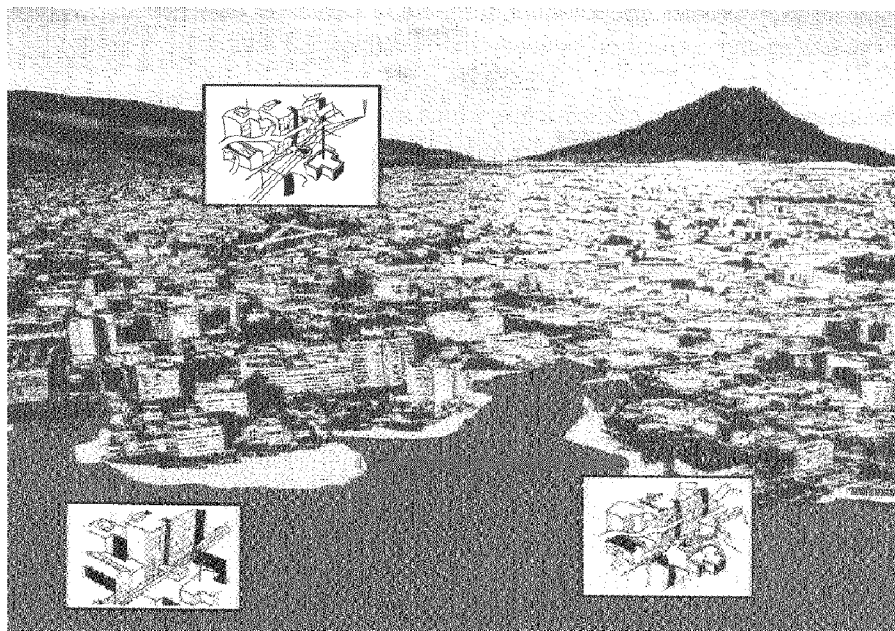


Figure 2.2

The effects of earthquake upon a city are selective and variable.

Figure 2.3

The effects of extreme winds upon a city are arbitrary and variable.



structures, burial, drowning or fire. Long-term effects include sickness, disablement and loss of life through lack of medical care, inefficient casualty evacuation, lack of shelter and shortages of potable water, food, electricity and fuels, and disease from water pollution and malnutrition.

Increasing risk of damage to industrial facilities



Industrial complexes are increasingly prevalent in most developing cities. In the event of a natural disaster, they may release hazardous waste carrying considerable secondary risks. Liquid and vapour releases are common, and people nearby can be seriously affected by toxic, inflammable and radioactive substances.

Release of inflammable materials at the time of a disaster can also create secondary hazards. Spillage of petroleum products can result in a localized fire hazard, while burning fuel entering drainage systems may cause widespread fires. If propane or natural gases are released, the effects can be widespread, as was tragically demonstrated at Kobe. Large amounts of flammable gases can quickly become airborne and, on ignition, may explode or become a fireball. Many people would be killed, unless sheltered within a sound structure.

Release of ionizing radiation could result from damage to a nuclear installation, although these should be designed and constructed to international standards, and situated far from centres of population. In the event of major damage, radiation would be released as airborne dust.

Casualties from these industrial risks could impose considerable additional burdens on crowded casualty evacuation and medical systems.

Vulnerability of economic assets



The relationship between a natural disaster in a major city and the nation's economy is complex. On one hand, disasters can generate a subsequent boom in construction work, with beneficial effects upon the labour market and on national gross domestic product (GDP). On the other hand, disasters devastate the industrial and commercial activities concentrated in major cities by disrupting energy supplies and production, communication and transport networks. This disruption would impact upon national economic indicators such as the rate of

economic growth, rate of inflation, productivity measures and international trade balances



Poorer countries may not have the resources to repair damaged infrastructure; this would result in further losses in production time and industrial earnings. Losses suffered by workers with specialist skills will delay industrial recovery. The prospect of civil unrest after the event may lead to further economic deterioration. In less developed countries, these negative impacts are unlikely to be offset by aid revenue or increased construction activity.

At the other end of the economic spectrum, the impact of a major earthquake striking a city such as Tokyo would affect commercial activity world-wide. The country's asset base would dwindle, due to the vanishing confidence of banks and investors, and its overseas investments would have to be withdrawn in order to support the domestic economy and to provide funds for recovery and rehabilitation. A recent analysis of the Kobe earthquake forecast that Japan, a traditional saver which provides the basis for a number of 'spending' economies, will need to refocus resources in future towards infrastructure strengthening. This could create long-term disturbances within the global economy. In view of the increasing interdependence within the global market, this is a significant model.

International investment in the emerging markets of cities in the developing world is increasing considerably, a trend which is likely to continue as their economic significance grows. The economic impacts of natural disaster in these cities would carry increasing implications for the international financial markets.

Direct economic effects. Direct economic effects result from damage to physical infrastructure networks, and damage to or loss of other physical assets, and are relatively simple to calculate for hazard events of different magnitudes.

As urban settlements grow, industrial and production assets increase. The risk of direct damage is correspondingly greater. Industrial plant and import and export facilities for raw materials and finished products are concentrated in cities, where they are supported by extensive production, communication and transport services and energy supplies.

Indirect economic effects. Indirect economic effects result from lost industrial production time and capacity (through the loss of productive workers and disruption of infrastructure and service networks), disruption of commercial and financial activities, and reduced personal expenditure. These factors could combine to produce a chain reaction of reduced profits and increased unemployment. The loss of export markets and overseas trade, the decline of tourism and the deterrent to businesses which had previously planned to establish themselves in a particular city, are other significant indirect effects.

Even a minor event which causes the failure of one or two bridges or rail tracks could cause lengthy delays on the transport network. Potential economic losses resulting from delays or failure of transport systems can be assessed on the basis of lost daily values in trade and commerce.

Indirect effects will multiply as trade slows, and could ultimately lead to an economic depression. It is possible to attempt theoretical assessments for all indirect losses from natural hazards. For example, a study carried out by Pannell Kerr Forster for the Los Angeles Visitors' Bureau indicated an overall decline in spending by visitors during 1994, as a result of the January 1994 Northridge



earthquake; lost income is estimated as being of the order of \$308 million with a predicted loss of 9240 jobs as a result of the decline in tourism.

Secondary economic effects Secondary economic effects arise as a consequence of other effects of the event itself, and may include.

- failure of potable water supplies or of public health facilities, leading to risk of epidemic diseases
- a shortage of food and other commodities, leading to increased prices, and therefore increased interest rates and possibly inflation
- reduced funding for social, educational and economic activities, due to reduced tax income and the need to fund rehabilitation and reconstruction
- falling property values, restricting the scope to raise capital for repairs
- increased costs due to high demand for building materials and skilled labour (particularly as large projects attracting overseas aid can be more attractive to the construction industry).

Long-term economic effects. The most significant long-term economic effects are likely to be loss of international investment and foreign markets, the collapse of particular industries, increased budget deficits and a fall in national GDP. Long-term economic effects can be best demonstrated in terms of the amount of time needed for a city's economy to return to the pre-disaster level.

National and city governments will be judged by their degree of preparation for and reactions to hazard events. It is therefore necessary to study the effects of past events, in order to estimate the potential long-term effects of a major disaster. The negative impact on economic growth of indirect damage and secondary effects is illustrated in the following example from R. Jovel, 'Natural disasters and their economic and social impact in Latin America and the Caribbean', *CEPAL Review* No. 38, August, 1989.

In 1974, hurricane Fifi swept through the mainland of central America, causing severe damage to houses in urban areas, transportation and other social infrastructure, and crop production, and resulting in high levels of unemployment and countless injuries. In Honduras alone, the effects were catastrophic: 7000 people killed, nearly 15,000 rendered homeless; indirect losses estimated at U.S.\$588 million, a massive balance of payments deficit due to the loss of agricultural exports and increased imports of equipment and materials for reconstruction; rehabilitation, reconstruction, and a fall in export tax revenues costing U.S.\$244 million; and a fall in GDP growth in the following years.

Disasters also have social costs. Some of these, such as the loss of social infrastructure – schools, health, religious, cultural and recreational centres, and the loss of the family income earner, home, furniture, clothing and household utensils, have a direct economic impact. These societal costs are dealt with more fully in Chapter 6. Others, which also have a long-term effect on the social well-being of individuals and families cannot be directly valued in economic terms but, nevertheless, have indirect economic costs, relating to the loss of relatives and social support networks and to personal trauma.

The issue of relief aid provided by governments and international agencies, and its contribution to the effective long-term mitigation of disaster, is considered in Chapter 3.

- Disasters occur when major natural hazard events impact upon people, physical structures and economic activities.
- An increasing proportion of the population of the developing world live in urban areas. By the year 2020, 57% of the greatly increased total population, in developing countries, will be city dwellers.
- Many megacities exist in hazardous zones, prone to natural disaster.
- Particularly vulnerable to disaster are those living in unplanned, informal settlements in marginal areas, where standards of construction and infrastructure provision are low
- The vulnerability of city dwellers depends upon the quality of the buildings and infrastructure surrounding them. Buildings in old inner city areas may be constructed to poor standards, and those in the informal settlements may be basic and insubstantial.
- Transport infrastructure, water and fuel supplies are often insufficient, liable to blockage or rupture
- The risk of toxic substances being released from damaged industrial facilities increases with the growth of industrialization, greatly increasing the risk of casualties.
- Natural disasters have both immediate and longer term economic effects. The disruption of commerce will affect the rate of economic growth, inflation, productivity and trade balance. This could lead, in extreme cases, to an economic depression.

Summary of main points

The rationale for mitigation

3

The rapidly increasing scale of human and economic assets in huge cities at risk from natural disaster gives unprecedented weight to the need to invest in a strategy of mitigation before an event, rather than response and recovery after an event.

In this chapter, activities relating to disaster management are reviewed, and the rationale for a mitigation strategy proposed. The scope of typical mitigation measures is introduced.

Disaster management is a cycle of interlinked activity, encompassing mitigation, preparedness, the disaster event, response, recovery and reconstruction (see Fig. 3.1). Activities within each phase are necessary for effective disaster management (see Table 3.1)

The onset of a major disaster attracts national and international attention, with considerable emphasis upon the phases of response, recovery and reconstruction. International, national and local resources are concentrated in an effort to alleviate loss of human life and suffering, to restore the basic requirements of human existence, the means of livelihood and commercial activity. The competence of national and local government is judged by their ability to react to major disasters, which provide news material for the world's media.

Principal phases of activity



Characteristics of phases within the cycle

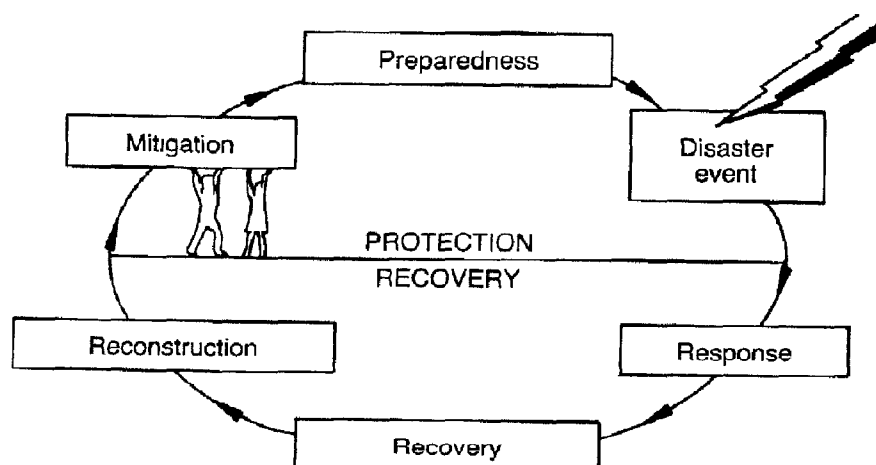


Figure 3.1
The cycle of disaster management

**Table 3.1** The main activities of the cycle of disaster management

<i>Mitigation</i> – measures that reduce or minimize the effects of disasters on a community	<i>Activities include</i> an initial assessment of hazard, vulnerability and risk. The production of a detailed long-term strategy and plan, in which some elements can be swiftly implemented and others would require lead time and resources. These elements include engineering and construction of hazard-resistant and protective structures and infrastructure, land-use planning, economic measures to ensure diversification, and encouragement of widespread insurance, institutional measures to engender the political will and expertise to ensure mitigation and measures to establish a 'safety culture' through public awareness of risk.
<i>Preparedness</i> – plans for response by national, regional and municipal governments, organizations, communities and individuals	<i>Activities include</i> designating key individuals to act as focal points for the formulation and implementation of preparedness activities including 'emergency officers' in government institutions and the community; formulating up-to-date plans for rapid response; special provisions for emergency action such as evacuation to safe areas; providing warning systems and emergency communications; instituting public education and training programmes; cataloguing and upgrading facilities and equipment for search, rescue and emergency treatment of victims
<i>Disaster event</i> →	
<i>Response</i> – saving life, protecting property and dealing with immediate damage and disruption	<i>Activities include:</i> implementing disaster reaction plans; activating the counter-disaster system, search and rescue, providing emergency food, shelter, medical assistance; survey and assessment; evacuation measures, protection of property against looting.
<i>Recovery</i> – assisting communities' return to normal level of functioning. Includes restoration and rehabilitation	<i>Activities include:</i> restoring essential services; restoring repairable buildings and installations; providing temporary housing; assisting the physical and psychological rehabilitation of sufferers.
<i>Reconstruction</i> – long-term replacement of destroyed buildings and infrastructure	<i>Activities include:</i> introducing improved building systems and programmes, utilizing international disaster assistance to optimum effect; applying disaster experience in future research and development programmes; ensuring that development is planned to ameliorate the impact of subsequent disasters

From *Handbook of Disaster Management* (ADB, 1991)

By comparison, the extent of mitigation and preparedness for an event which may occur at some time in the future will only be as great as the perception of the risk; the resources required will be subject to competing priorities. The governance of cities imposes great demands upon those in responsibility, and expanding cities of the developing world present a immense step in the scale of problems. City administrations are never relieved from this continuing demand.

The additional tasks of undertaking long-term analysis and committing resources to mitigation for an unspecified future hazard should not be underestimated, but the necessity must be faced



The rationale for a mitigation strategy

The principal reason for cities to implement a mitigation strategy is to minimize the potential harm to city populations and economic assets, which are constantly increasing in the cities of the developing world (Fig. 3.2). This presents city government with the urgent need to act to protect assets from natural hazards, rather than to accept and subsequently react to disaster.

This new emphasis upon mitigation was clearly spelt out in the final declaration of the United Nations (UN) Conference on Natural Disaster Reduction (1994).

The impact of natural disaster in terms of human and economic losses has risen in recent years and society in general has become more vulnerable to natural disasters. Those usually most affected by natural and other disaster are the poor and socially disadvantaged groups in developing countries as they are least equipped to cope with them.

Disaster prevention, mitigation, preparedness and relief are four elements which contribute to, and gain from, the implementation of sustainable development policies. These elements, along with environmental protection and sustainable development, are closely interrelated. Therefore, nations should incorporate them in their development plans and ensure efficient follow-up measures at community, national, subregional, regional and international level.

Disaster prevention, mitigation and preparedness are better than disaster response in achieving the goals and objectives of the decade. Disaster response alone is not sufficient, as it yields only temporary results at very high cost. We have followed this limited approach for too long.

The extent of economic disruption caused by a natural disaster is described in Chapter 2 in terms of direct and indirect impact, secondary and long-term effects. The cost of responding to natural disasters adds to public expenditure and, hence, to budget deficits. Overseas financial assistance may be required, with current account deficits having to be funded by capital inflows. The net impact can be a raised level of government indebtedness; both domestic and foreign.

Mitigation of economic impacts

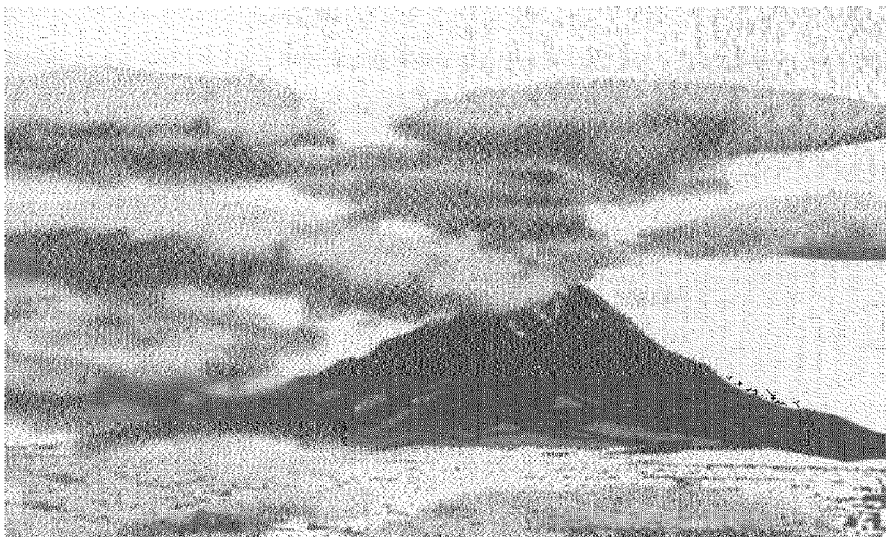


Figure 3.2
A volcanic eruption can cover the entire city in dust and fumes.



With the trend towards financial market liberalization, international capital flows are increasingly fluid. Inward investment is frequently determined by the country's perceived long-term security. Perception of that long-term security is an essential element in an investment decision. It is of growing importance to the perceived security of assets that a strategy that mitigates natural hazards is seen to be in existence and is in course of being implemented

The total economic impact of natural disasters is often larger than their specific effect on gross domestic product (GDP) (many losses either cannot be costed or do not contribute to GDP). All losses from natural disaster represent a major resource cost to society.

Expenditure on mitigation measures is likely to have a positive effect on growth and employment, as the increased demand generated raises the output of economies operating at less than full capacity. A analogy can be drawn with expenditure on environmental measures over the past 25 years, which has been shown in general to produce benefits significantly greater than the costs invested.

The UN Development Programme, in its 1994 Human Development Report, identified projects and priorities particularly relevant to urban areas in developing countries. The report indicated how the costs could be met through the restructuring of national budget priorities and readjustment of bilateral aid. Mitigation of the effect of natural hazards is not to be seen as an alternative investment to these human development programmes, but as an integral part of protecting and ensuring their long-term results.

Mitigation of human impact



The vulnerability of city dwellers has been described in Chapter 2, and the impact on human society is further expanded in Chapter 6. The increased density of populations in cities means that many more are at risk from disaster than 10 or 20 years ago. The trend intensifies. The scale of potential human suffering is much greater in terms of deaths, injuries, incidence of shock and bereavement, subsequent disease and long-term illness and trauma. Impoverished and poorly housed people, who constitute a high and growing percentage of city dwellers, are much more vulnerable to damage

Damage carries with it considerable costs for the cohesion of society, including loss of leadership and direction, the break-up of families, the increase in numbers of orphaned children, the increase in dependence and overcrowding, and the loss of corporate morale and sense of purpose.

Mitigation of such potential suffering is the hallmark of responsible government. It is also consistent with the principle of sustainable development, which requires a particular emphasis on the need to provide for the least advantaged in society. It further requires recognition of the needs of future generations, who would be more adversely affected by a disaster if the present generation fails to take effective mitigation measures.

Circumstances that promote mitigation

A number of circumstances underline the increasing emphasis upon mitigation:

- perception of increasing vulnerability; defined in Chapter 2
- the opportunities and obligations of city development
- increased accessibility of knowledge and technology
- increased international support for the concept of mitigation
- conditions attached to international funding.

Economies of many developing nations are growing faster than at any time in history, and city growth an inevitable result of that development. This process presents a continuous series of opportunities to mitigate the damaging effects of disaster, through infrastructure projects, land-use planning and institutional development. The concept of development also encompasses informal developments, whereby immigrants to the city establish themselves around the periphery. As will be noted below in this chapter and in Chapter 5, there are many low-cost opportunities to incorporate simple design enhancements into new housing which improve damage mitigation.

The opportunities and obligations of development

Although the science of disaster management is relatively young, significant advances in knowledge, understanding and technology are being made. For example, it is now possible to track storms accurately using satellite photography and to record earthquakes with strong motion instruments. Engineers and risk specialists have developed an improved understanding of the effects of natural hazards on structures and the built environment (see Fig. 3.3). Understanding of the consequences of failures of social organization and regional economies has also improved.

Increasing access to knowledge and technology

However, this knowledge is currently not well distributed and access to much of it is difficult to obtain: a primary objective for the international community should be to improve access to knowledge

Declarations from major events such as the UN Conferences on Environment and Development (Rio, 1991) and Natural Disaster Reduction (Yokohama, 1994) have given considerable status and emphasis to the subject of disaster mitigation. These are signs of the growing international concern to reduce the impact of natural disasters, the aim of the International Decade for Natural Disaster Reduction. Relevant excerpts from the Rio declaration are given in Table 3.2 for reference.

International consensus on the benefits of mitigation

Post-disaster relief aid, wrongly targeted, can distort local markets. Aid may be focused to too great an extent on swift rehabilitation and construction, whereby damaged buildings are rapidly replaced by new construction of precisely the same

International funding

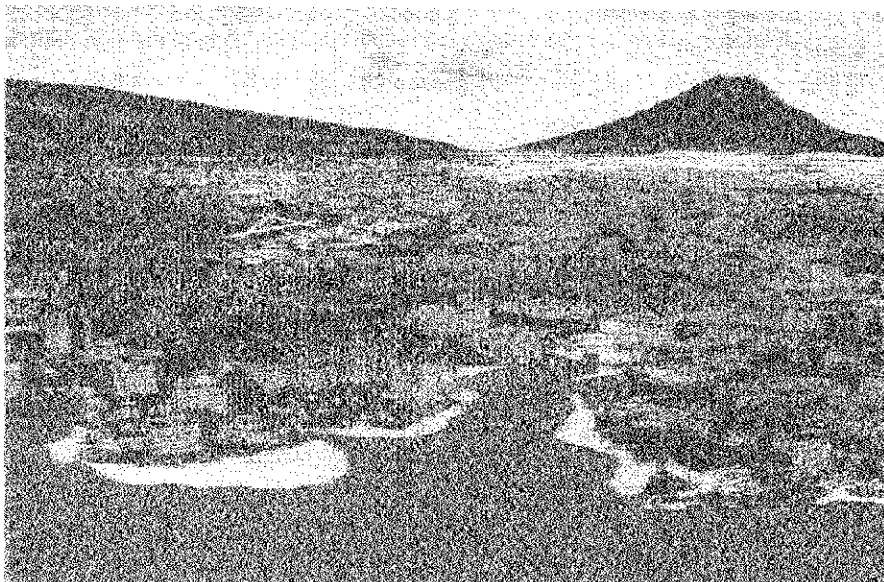


Figure 3.3
The extent of flooding within the city can be predicted

Table 3.2 Excerpts from the UN Conference on the Environment and Development, Rio de Janeiro, 1991

One objective of Agenda 21, the main output from the conference, is to enable all countries, in particular those which are disaster prone, to 'mitigate the negative impacts of natural disaster on human settlements'.

Within this programme, three distinct areas of activity are foreseen: developing a culture of safety, developing pre-disaster planning and initiating post-disaster reconstruction and rehabilitation planning.

Cities are tasked to:

- Undertake complete multi-hazard research into risk and vulnerability of human settlement infrastructure, including water and sewerage, communications, and transport.
- Develop methodologies determining risk and vulnerability with specific human settlements, and incorporating risk and vulnerability reduction into the human settlement planning and management process.

Cities emerging into post-disaster recovery and reconstruction phases are urged to

- Undertake research on past experience of the social and economic aspects of post-disaster reconstruction.
- Adopt effective strategies and guidelines for post-disaster reconstruction, with particular focus on development strategies in the allocation of scarce reconstruction resources, and on the opportunities that post-disaster reconstruction provides to introduce sustainable settlement patterns.

type in the same location. This forfeits the opportunity to construct safer buildings and infrastructure networks to improved specifications and to a well-conceived master plan.

In line with thinking within the UN, major international funding agencies increasingly recognize the benefits of funding longer term mitigation projects that are based upon objective risk assessment. Projects are particularly attractive to funding agencies when they are incorporated into an overall mitigation strategy, as part of long-term development plans. Proposals are subjected to sophisticated and systematic appraisal by agencies, based on the net rate of return which seeks to quantify social and economic returns from investment. The appraisal is likely to include an examination of fiscal propriety, audit methods, financial controls and social impacts. The role of international funding agencies is discussed further in Chapter 9.

Scope of mitigation measures



Having examined the case for mitigation it is appropriate to introduce briefly the scope of mitigation measures, which are fully expanded in subsequent chapters. As has been noted above, these mitigation measures are components of an overall strategy, based on an initial risk analysis, and subsequent detailed plans

The scale of resources involved varies according to the type of mitigation measure proposed. New programmes of infrastructure provision will require substantial investment. However, the process of incorporating mitigation principles into planning processes, design techniques and construction methods for existing schemes need not be costly. All will be of fundamental benefit. The principal message is that it need not demand too great a degree of resource to make a start on the development of a mitigation strategy, which should be progressed on the basis of a long-term programme.



Engineering and construction measures

The effects of floods can be alleviated by such works as sea walls, breakwaters, river-retaining walls, levees, dredging, foundation adaptation, and regulation of and enhanced drainage for water discharge. Levees may be appropriate in some areas and the provision of flood plains in others.

The effects of earthquakes can be mitigated by engineering of structures to withstand vibration, enforcement of adequate building codes and standards, and strengthening of key infrastructure (such as transport, water and power).

Measures against landslide or avalanche include the engineering of resistant structures and land-use planning. Measures against strong winds, often accompanied by heavy rainfall, include adequate construction standards, appropriate siting, the provision of windbreaks, and measures to counter the effects of floods and landslides as above.

Land-use planning in the cities of the developing world is difficult to implement, where often the pace of growth swamps the ability of local authorities to control settlements and provide even the most basic facilities. Where possible, land-use planning must take account of natural hazards and risk in the normal process of development control. Some natural hazards are localized, with effects confined to specific known areas. Their impact can be considerably reduced by discouraging settlements and construction of key installations in hazard-prone areas such as flood plains or steep and unstable slopes.

Land-use planning measures



Land-use planning can also help to mitigate hazards by the reduction of population density, the location of public sector facilities with redundancy of service lines where appropriate, and the design of service networks and replication of routes in transport, power, water and sewerage systems.

Developments in safer locations can be encouraged by the provision of acceptable service systems, and conversely deterred in hazardous areas by the denial of facilities and by mapping and publicizing hazard-risk zones. Nevertheless, closeness to employment opportunities is often the governing criteria for location, those living in poverty are rarely able to choose their location. Rather, they are forced into available 'free' land, even when it lacks infrastructure, and many thus live in hazardous areas. Notification which makes 'hazardous' land unattractive will at the same time make it more 'affordable' to the impoverished. Efforts to limit development on hazardous areas must therefore, if they are to be successful, provide other equally 'free' sites to the impoverished. Experience shows that, with better housing policies, better tenure rights and acceptance of informal housing, standards improve over time.

Economic development is vital to disaster mitigation. A strong economy provides the resources to undertake the physical measures required, and allows for financial reserves to be built up to meet losses.

Economic measures



Economic planning can assist the reduction of disaster risk by diversification of economic activity (as multiple activities are less vulnerable than single industry economies). Infrastructure linkages may be more vulnerable than the assets of the industrial sector; analysis of the relative risks is needed.

Economic incentives and penalties, such as grants, loans and taxes can be used to encourage mitigation measures including relocation of industries and workforces, and improvements in the quality of structures and buildings. A significant economic protection device is insurance, whereby losses are dispersed because the risks are spread over many premium payers. The more widespread the insurance system, the lower the premium. In areas of high or frequent risk, commercial insurance is not always obtainable. However, the majority of residents in developing countries will be too poor to pay for either personal or property

insurance, even if insurance companies were prepared to extend cover on their property. The role of insurance is considered in Chapter 8.

Institutional measures



To bring about any change, political will is required, together with staff and structural resources, and professional expertise. An examination of existing machinery is a pre-requisite to assessing the feasibility of mitigation. In the long term, a culture of safety needs to be developed, mitigation principles need to be incorporated into planning procedures, and adequate design and construction standards need to be implemented.

If the required institutional changes are to be achieved it will be necessary for governments to allocate resources, arrange for specialist training and establish an appropriate information base. At national and municipal government level, there is a need to establish a mitigation committee of stakeholders, and an implementing agency (see Chapters 7 and 9) for disaster mitigation.

At the local community level, a participatory approach to understanding the need for and the nature of mitigation measures is essential. A type of intervention is required which encourages the people's 'coping' mechanisms. The participation of the local community can be achieved by working with community-based organizations, enlisting the support of community leaders, and by training programmes for local builders. Simple enhancements, such as the incorporation of lighter roofs, the tying of timber to earth and stone walls, and the firm attachment of roofs to walls may dramatically reduce (by as much as 80% in a region) the number of casualties.

The 'self-help' approach has the advantage of drawing not only on professional expertise and resources of government, but also on local knowledge, skills and commitment. This leads to 'sustainable' mitigation.

Public awareness



A successful public awareness campaign might include a high-profile effort on a 'national awareness day', involving media broadcasts and rehearsed drills. This could be combined with long-term campaigns to familiarize the public with the effects of hazards and to promote confidence, thus ensuring that households are able to take precautions. Hazard awareness should be included as an element of the school curriculum, and households should be encouraged to apply simple mitigation measures such as positioning of furniture, practice of emergency drills, and storage of emergency food and water supplies. Impoverished households, who cannot afford to buy and store water and food, should be made aware through community leaders and a variety of appropriate community groups such as women's cooperatives, of the nearest safe location and public food. The contribution of public awareness to the mitigation strategy is discussed in Chapter 8.

Summary of main points

- Disaster management is a cycle of interlinked activity encompassing mitigation, preparedness, the disaster event, response, recovery and reconstruction.
- The principal reason for cities to consider a mitigation strategy is to minimize the potential harm to city populations and economic assets that are constantly increasing in the cities of the developing world.
- This is underlined in the final declaration of the UN Conference on Natural Disaster Reduction (1994), which stated that 'Disaster prevention, mitigation and preparedness are better than disaster response ..'.
- There is a need to mitigate economic impacts and human impacts. The vulnerability of both has been outlined in Chapter 2.

- Certain circumstances underline the emphasis on mitigation, including the opportunity presented by city development, the increased availability of knowledge and technology, increased international support for the concept of mitigation, and the conditions attached to international funding.
- The scale of resources required varies considerably according to the mitigation measure proposed. The principal message is that it need not demand too great a degree of resource to make a start with the development of a mitigation strategy.
- The scope of mitigation is introduced and includes: engineering and construction measures, land-use planning measures, economic measures, institutional measures, and public awareness.

Part 2

Understanding the risk

The contribution of science

4

This chapter considers the type of scientific and technical information required by planning authorities, and the format in which this information should be presented. It aims to encourage cooperation and greater understanding between scientists and administrators. It outlines the potential and limitations of the scientific study of hazards and vulnerability.

A distinction should be made between data and information. In the context of this chapter, data can be defined as the objective facts and figures which are collected through scientific activities such as monitoring and surveys. Data collected for scientific purposes will often be incomprehensible to the administrator or other non-specialists. To provide information which will be of use to the administrator, data need to be presented in an accessible format which summarizes, explains and interprets the most relevant facts.

The reliability and accuracy of data are also of concern, as they affect the reliability and accuracy of the information derived from them. Scientific agencies should specify the level of accuracy of data which they collect (for example, within a margin of error of $\pm 5\%$) and any conditions or assumptions which may affect the reliability of the data. Factors involved in the collection of data should also be specified, as these will determine whether it is possible to compare one set of data with another.

The role of the city's administrative authority is primarily to define its requirements for information, to identify those agencies which possess relevant data, and to obtain information in an accessible form.

Detailed scientific and technical references are included in the Bibliography, and specialist research centres are listed in Appendix 4.

High professional standards and adequate resources are essential for the production of accurate and reliable scientific information. Extensive collections of data are often readily available, either from established scientific agencies within the country or from other sources internationally. For example, extensive meteorological and hydrological records are held in most countries, as such information is required by airports and airline services and other transport agencies. Geological and geotechnical records are often retained in archives, and historical data on earthquakes are collated by specialist centres in several countries (including Japan, U.S.A., U.K. and Switzerland).

Information base
General information

One of the first tasks in formulating a disaster mitigation strategy is to quantify the natural hazards which could affect the city, in terms of return periods for events of different intensities. Frequent events, such as those with return periods of a few years, are likely to include heavy rainfall or tropical storms; it is unusual for such events to be classed as disasters. Extreme events, which recur once every several tens, hundreds or even thousands of years, might include a tropical cyclone of hurricane strength passing close by, or strong earthquake shaking, or nearby volcanic eruption. A regional hazard study should then be conducted, to predict the extent to which specific locations in the area would be affected by each hazard, preparing intensity maps for shaking, flood levels, wind speeds or mud flow, for example.

Instruments installed around a city can provide an important source of 'real-time' data on rainfall, wind speeds and possibly seismic shaking. These data can form an important component of the hazard assessment and can also provide the opportunity (for some hazards) to develop advance warnings. Historical or geological research will usually be required to fully understand the nature of the extreme events which could affect the city of today.

In parallel to hazard assessments, social and land-use surveys will provide a starting point for the assessment of human and physical vulnerability. The process of obtaining this information could be described as an 'audit' of the city. A classification of building types in the city (in terms of their age, height and form of construction) and of lifeline networks (including energy, water, communications, transport and medical services) will be needed to reduce the amount of data to a manageable level.

The scientific information required for preparation of spatial development plans, design codes and building regulations, and the form in which this information should be provided, are described in the following sections. Reliable, manipulable and accessible data is the basic requirement to provide useful scientific information as the degree of reliability is a frequent issue in disaster mitigation risk assessment.

Information on floods



An assessment of the risk from flooding requires a knowledge of a number of key parameters including ground configuration, depth of water, duration, velocity of flow, rate of rise and frequency of occurrence. It also requires interpretative skills.

In its simplest form, flood hazard is depicted in plan by contours which represent the areal extent of the predicted water surface of a flood of specific return period (e.g. 50 years). Longitudinal profiles of water surface are also often shown. These profiles are determined both for floods of a specified frequency of occurrence and for historically recorded or estimated events of catastrophic magnitude. With sufficient and appropriate annotation, flood hazard plans will indicate to planning agencies the potential severity of inundation for floods of specific return periods.

An important issue to address in the assessment of flood hazard is the effectiveness and quality of dykes or coastal protection systems. Breaching or overtopping of dykes may dramatically increase the flooded area. Areas susceptible to sea surge and tsunami should also be covered under this heading.



Information on cyclones

The impact of these hazards is not restricted by topographical or geological features to specific areas. If a city is located within a region in which they occur,

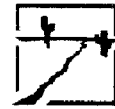
every square metre may be exposed to the maximum impact (although some buildings may be shielded by others). Strong winds are often accompanied by heavy rainfall and hence there may be a combined risk of flooding and windstorm



Information will be required on the frequencies of wind strengths, recorded and predicted storm tracks, and rainfall intensities and frequency of occurrence. Historical research is needed to quantify the nature of extreme storm events. Wind speeds associated with gusts during a cyclone cannot readily be predicted by extrapolation from smaller storms for which more extensive instrumental data will be available. The effectiveness of warning systems will be of interest to those involved in preparedness planning, as the period of warning may influence the planning of evacuation routes and the number and location of protective shelters provided

Geological data can be used to prepare specialized maps of isoacceleration, landslide potential, and microzoning for liquefaction. Geotechnical maps should include the definition of ground soil types and their characteristics, the thickness of each unit, the depth to bedrock where relevant, and the ground-water levels.

Information
on
earthquake
hazard



Records of seismic intensity provide information on maximum intensities which have occurred in urban areas during previous earthquakes. Figure 4.1 shows the epicentres of earthquakes which have occurred near Karachi. For relatively small

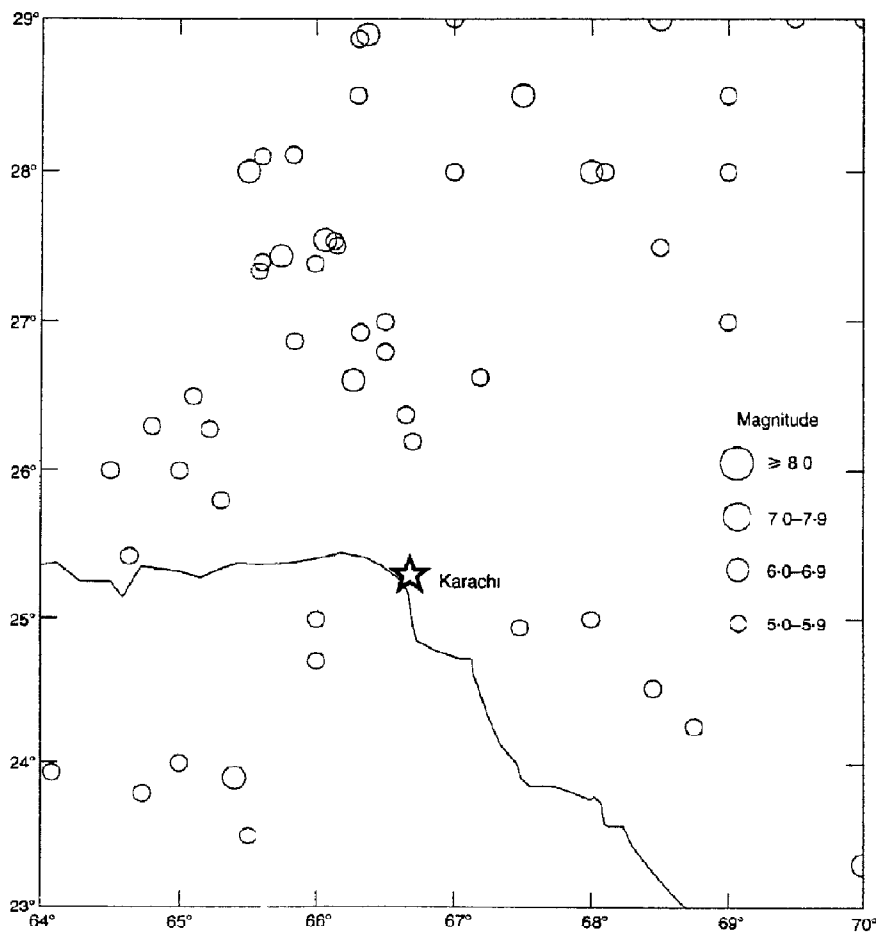


Figure 4.1
An example of scientific
information: earthquakes greater
than magnitude 5.0 occurring
within 300 km of Karachi
(1900-90). Source: British
Geological Survey, Edinburgh.

urban areas, maximum intensities can be represented by a single value. However, for major urban areas, information on variations in the degree of damage, and on possible correlations between intensity and the degree of damage incurred during previous events, should be related to ground conditions within each zone.

Maximum intensities and estimated maximum ground acceleration should be shown on a map of isoacceleration and seismic intensity. Isoacceleration maps can be used to show maximum (or peak) ground acceleration for return periods typically of 50, 200 and 500 years in different urban areas; these are usually based on three general categories of subsurface conditions: loose soils; consolidated soils; and bedrock or very firm ground. Response spectra can also be estimated for each urban zone, for the three return periods and for the same ground types as those used to create isoacceleration maps.

Areas which might suffer surface fault ruptures, landslides or liquefaction should be recorded on separate hazard maps; landslide potential and liquefaction potential are evaluated by geotechnical engineers. The secondary effect of flooding from tectonic deformations and landslides which block water flows should be evaluated, and recorded on maps indicating potential floods and debris flows linked to earthquakes.

The information detailed above should be combined into summary maps and microzoning maps for the use of planning authorities. Summary maps show combinations of hazards in specific zones, while microzoning defines zones which are subject to the same level of hazard. Each map should make recommendations concerning the depth of geotechnical study required in relation to the overall hazard in each zone. This information will be required by planning authorities and building control officers, for the purposes of development planning and building regulations.

Information on active volcanoes and volcanic hazards



Geological studies of the history of local volcanoes can be used to ascertain the frequency and character of previous eruptions and the areas affected (it is reasonable to assume that future eruptions will be of the same category). Hazard maps can then be prepared, identifying hazardous zones, and an assessment made of the probability of a specific area being affected in a given period of time. Input will be required from meteorologists to assist in predicting the likely distribution of wind-blown tephra or toxic gases.

Information on landslides



Information will be required on the locations (both within the city and in the vicinity of nearby infrastructure) and magnitude of potential landslides, the trigger mechanism (i.e. earthquake, water or slow creep) and whether measures can be taken to improve the situation. Planning authorities should also have an adequate understanding of the potential impact of landslides on structures and infrastructure, and of which urban uses the land is suitable for.

This information is usually presented on a landslide hazard zoning map, which planning authorities should use to determine suitable land uses. Zoning maps, particularly at scales of 1:25,000 or larger, generally include detailed scientific and geological information, but these must be translated into explicit conclusions and recommendations for the use of planning authorities.

Classification of data

Scientific and engineering data used for hazard assessment is of three main types:

- meteorological, geological and hydrological information, obtained from

studies of the city's geography, climate, hydrology, geology, tectonic setting and soil distribution

- historical information, obtained from studies of the built environment, social surveys and historical research
- instrumental data (real-time) used to understand the background hazard level and to predict events, using monitoring instruments.

As comprehensive scientific studies often take many years to complete, preliminary hazard assessments should be based on information currently available and on rapid appraisal audits, supplemented by information from international sources. With an understanding of the vulnerability of the city, a risk assessment should then be undertaken before any major investment is made in mitigation measures.

An audit of the city should be organized into discrete tasks. Data are potentially available from many sources, although some will need to be acquired by new studies. The main sources of data are:

- surveys of the natural environment
- historical research
- classification of physical infrastructure
- economic surveys
- social surveys, medical research and veterinary public health
- population and urbanisation surveys, and census reports.

Topographical, pedological, geological, hydrological, bathymetric, hydrographic and meteorological maps for all cities should be readily available; however, in some countries this is military classified information. To assess secondary seismic effects and landslide potential, knowledge of the soil is required; planning and building control departments should possess records of ground investigations carried out for new construction

Geological zonation maps can be prepared using existing data on geology, geomorphology and hydrogeology. These maps should define areas susceptible to ground motion, amplification, surface rupture, soil liquefaction, earthquake-induced landslides and tsunami inundation. They will provide an input to planning guidelines (indicating areas unsuitable for particular types of construction) and design guidelines (indicating areas in which existing construction requires strengthening).

Flood hazard zonation maps can be prepared using topographical maps, data on river flows through the city and rainfall statistics. Cyclone hazard zonation maps, including the risk of storm surge, can also be prepared. Volcanic hazard maps are available for certain areas, and can be prepared for vulnerable urban areas elsewhere. The degree of accuracy needs to be defined as insurance claims may depend on these maps

These hazard zonation maps can be combined into a composite map providing guidance for planning authorities. Geographical information systems (GIS) provide a useful technological tool for preparing composite maps with zone areas in terms of type and degree of risk (see Fig. 4.3).

Historical records and physical evidence of previous events can be used to provide additional data or information. Although cyclones, wind storms and heavy rainfall often do not leave permanent visible evidence, national and international meteorological agencies should have records of more recent events.

Surveys and audits

Scope of the audit

Surveys of the natural environment

Historical research

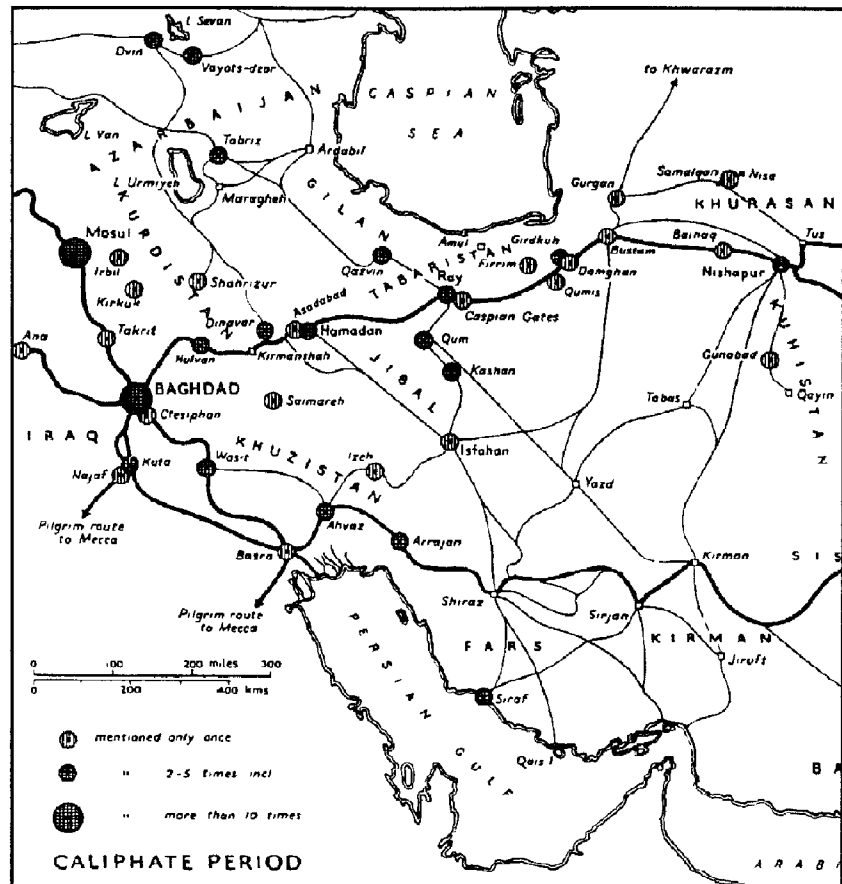


Figure 4.2

Historical incidence of earthquakes in Iran.

Source: Ambraseys and Melville (1982).

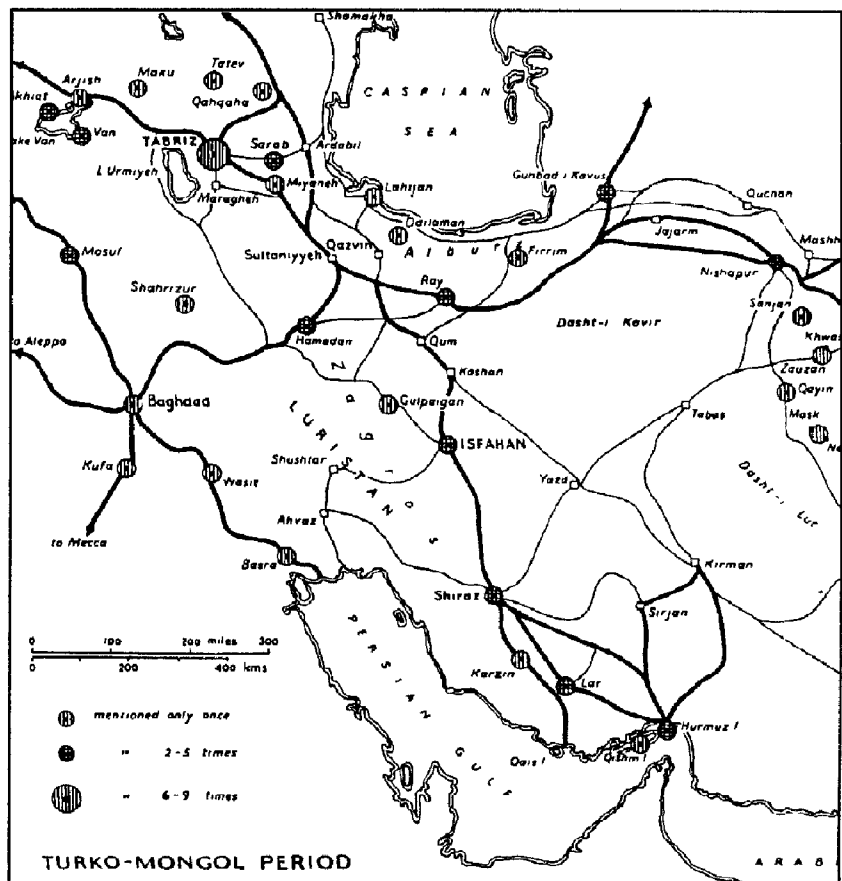


Figure 4.2

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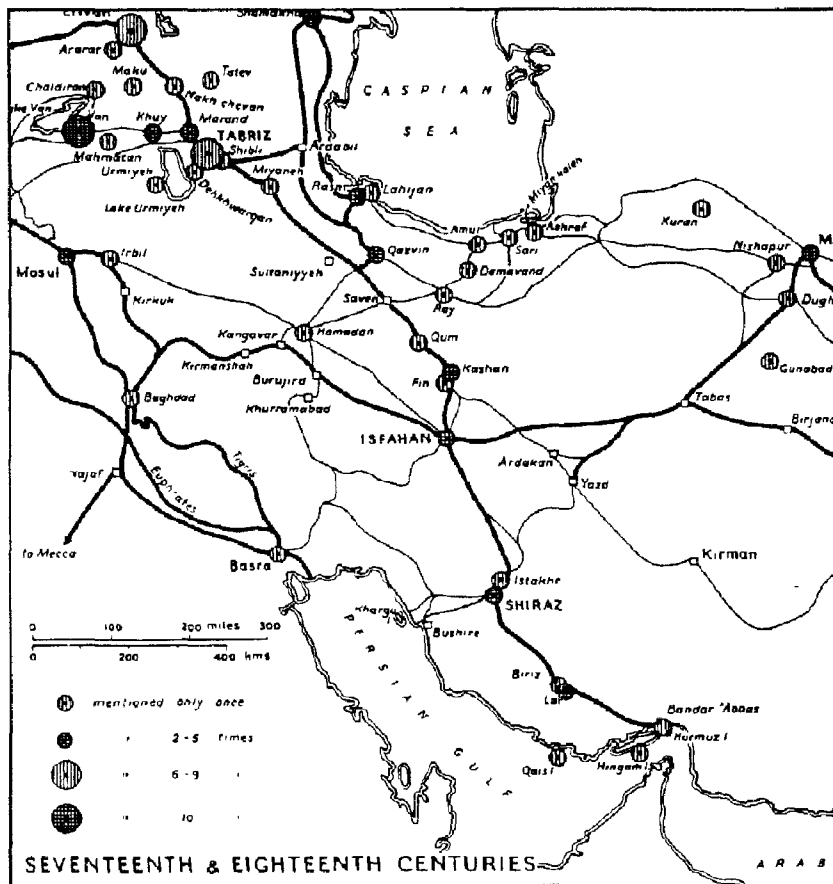


Figure 4.2
Continued.

These data can be used to assess wind strengths and rainfall probability.

Evidence of previous volcanic eruptions is often extensive. For example, previous eruptions in Iceland have been reconstructed after studying the lava and ash deposits. In the Philippines, during studies of the eruption of Mount Pinatubo in 1991, it was discovered that a greater eruption had occurred some 35,000 years ago. Evidence of climatic change and air pollution caused by volcanic eruptions is also present in Greenland and the polar ice cap.

Evidence of previous earthquakes includes surface and subsurface features, written historical records, instrumentation records from specialist centres, and scientific investigations. The study of plate movements, and the trenching of faults and carbon dating of their activity enable accurate assessments of past events and consequently improved assessments of the probability of future events.

Historical evidence must be interpreted with great care: although it can provide useful data, it is often distorted in various ways. For example, Ambraseys and Melville (N. N. Ambraseys and C. P. Melville, 1982 *A History of Persian Earthquakes*. CUP, Cambridge) found that the level of information available on previous earthquakes in Persia was determined largely by the political and social significance of the area in which they occurred (see Fig. 4.2).

Further, scientists will disagree about the probability, magnitude, timing and location of a future event. The interpretation of evidence must take account of a number of opinions.

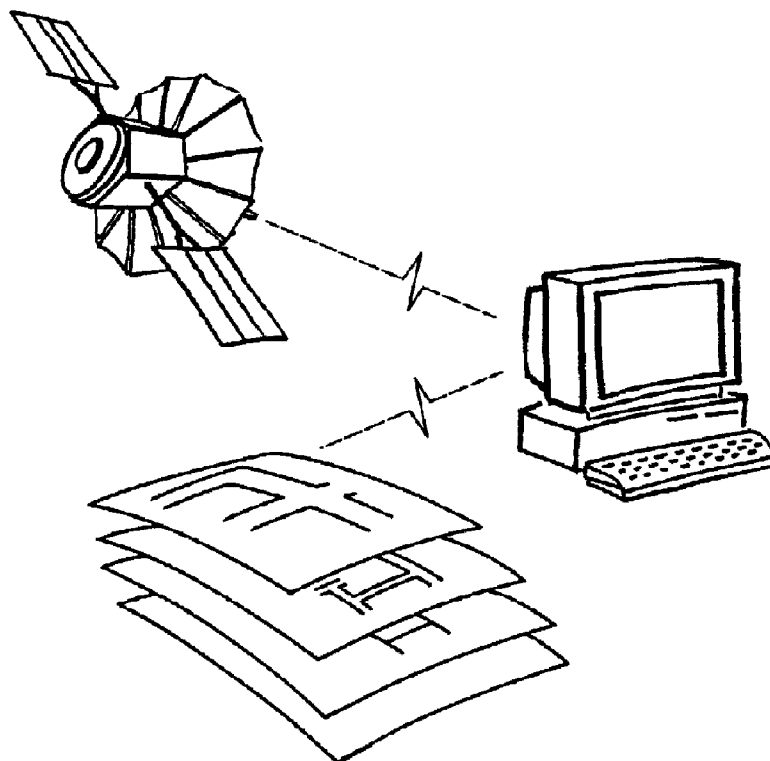


Figure 4.3
Satellites and geographical information systems can be used for compiling data for a city audit.

Classification of physical infrastructure



In order to define the vulnerability of the physical infrastructure, it is necessary to classify it into distinct categories (Figs 4.3 and 4.4). The following categories are suggested:

- buildings – including residential, medical, commercial, industrial, leisure and community facilities
- structures – including bridges, industrial complexes (such as refineries and similar plants), towers and advertisement hoardings
- transport facilities – ports (including berthing and cargo-handling facilities, breakwaters and warehouses), roads, railway lines and airports
- utilities – gas and oil, electricity, telecommunications
- water and public health facilities – clean water supply and distribution, waste water collection and disposal, solid waste collection and disposal, surface water drainage.

Classification should take account of the age of the component, its design, the construction materials used, its location and prevailing ground conditions. Buildings should also be classified in terms of the ratio of their height to minimum width and their occupancy. Many other factors could be included, although these are not necessary for initial assessments. Once the classification has been made, it can be refined and updated at intervals of, perhaps, three years.

Infrastructure facilities which are of strategic importance in post-disaster response, including hospitals, schools, major transport links and bridges, should be given particular attention. These facilities should receive priority when implementing measures for mitigation.

Economic surveys



An assessment of the vulnerability of the physical infrastructure can be used to estimate the direct economic effects of an event. Estimates of indirect, secondary and long-term economic effects should be based on an assessment of the vulnerability of the economy in general, which can be derived from an analysis of the city's economic resources and characteristics.

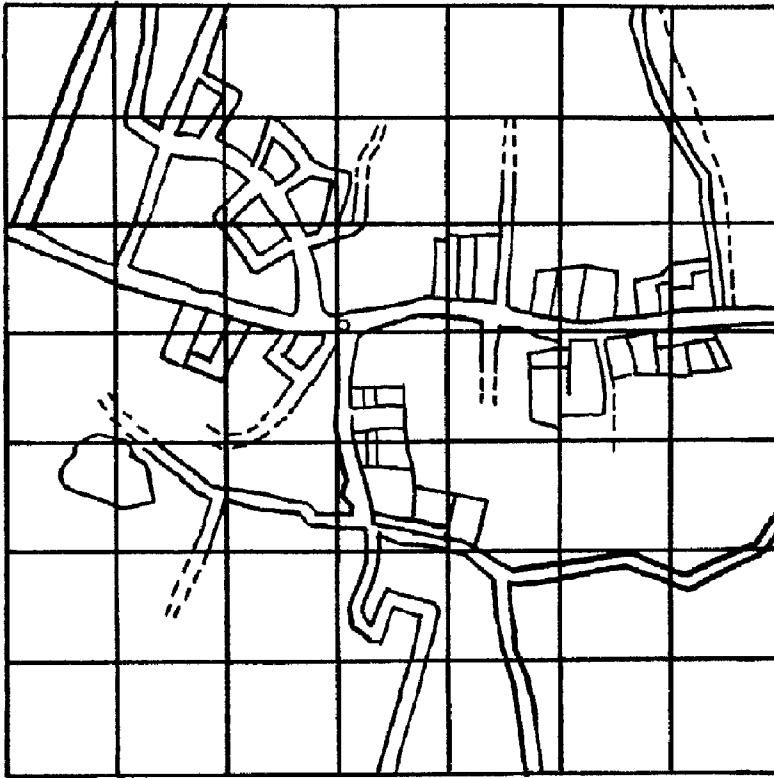


Figure 4.4
Classification of physical infrastructure can be based upon postal districts or a grid system.

Social surveys should compile data on population distribution and density, family structures, living conditions and travel patterns. Relevant data may be readily available as they are normally used by the city authority to assist routine strategic planning. Supplementary data may also be available from universities or other research institutes. Some rapid appraisal techniques are described in Chapter 9.

Social surveys



Detailed research may be needed to:

- survey the attitudes of different social groups towards investment in mitigation measures
- document the experiences of survivors of previous events
- study levels of awareness and behaviour patterns amongst hazard-prone communities.

Disaster epidemiology is the study of the medical effects of natural disasters, including those effects which are a result of secondary hazards and other circumstances. It can make significant contributions to emergency response plans, to the planning and design of the physical infrastructure, and to raising public awareness of the risks of natural hazards. International guidelines for ethical review of epidemiological studies were issued by the Council for International Organizations of Medical Science (CIOMS) in 1991

Medical research



Although few cities will have access to specialist knowledge in disaster epidemiology, a study of the effects of previous events occurring locally and nationally could form the basis of developing such expertise within the city. The consequences of other hazards, such as drought, desertification, civil war and famine can often be defined as 'disastrous' and, because of their gradual onset, such hazards offer considerable opportunities for studies in disaster epidemiology. Sharing information and knowledge with other regions can be helpful although data obtained in other regions will not necessarily be directly comparable.



Routine data collected to assist in the planning of health service provision, and other data collected in the course of health care and environmental improvement projects, can also be useful. Studies in this area, which link data collection and analysis to an immediate decision-making process, can provide valuable input to basic training in standard emergency procedures for medical professionals responding to accidents.

Casualty models should be formulated, in order to predict fatality and injury rates for specific scenarios. This work will necessarily involve collaboration between relevant disciplines, such as engineers with a knowledge of the mechanisms of building failure, and physicians.

Previous studies have identified fire as a primary concern of those at risk from natural hazards. Fires are often the most destructive secondary effect of natural hazard events. The control of fire and of its effects is an area in which epidemiologists, civil engineers, architects, planners, sociologists, fire protection engineers and fire-fighters could work in collaboration to effect gradual improvements such as fire breaks, access lanes for fire-fighting equipment and community measures.

Epidemiological research should also aim to identify potential secondary health effects. These should be shown on risk maps which identify potential sources of risk. For example, a natural hazard event could damage industrial plant and cause a release of toxic substances. The potential medical effects of such incidents, and the scope for mitigation and preparedness measures, should be considered.

Veterinary public health

The routine monitoring of disease carriers is usually the duty either of the health service or of the veterinary services, and their work should involve the collection of basic data with the following objectives:

- to provide an understanding of human/animal/environment relationships, in order to discriminate between the 'normal' and the 'abnormal'
- to identify problems which may occur as a result of hazard events
- to identify mitigation and preparedness measures which should be taken
- to facilitate the provision of external help
- to monitor emergency situations.

It may be advisable to classify data in relation to separate areas of the city, because some essential factors, such as the presence of animals, may differ from one area to another.

Instrumental data Technological development



Data-processing techniques, satellite and computer technologies are of increasing significance in the monitoring of natural hazards and their effects. Accurate predictions and warnings are now possible for some hazard events and as the quality of data improves, these should become more accurate and reliable. This section discusses some major technical developments and their applications.

United Nations International Emergency Network (UNIENET). The International Decade for Natural Disaster Reduction (IDNDR) has encouraged increased activity in the study of all aspects of disaster management, and UNIENET provides a valuable source of information on this activity. Its members can access information on organizations involved in disaster mitigation, international meetings and activities, historical data on previous disasters, training facilities and possible sources of related funding support, directories of specialist organizations, and 'state of the art' and 'appropriate' technology. As greater numbers of urban authorities join the network, relevant data will become more accessible.

Contact details are included in Appendix 3.

Geographical information systems. GIS can be used to produce a detailed assessment of the risks affecting a particular city, which can be continually refined and modified as further information becomes available. GIS is a technique for computer storage and display of base geographical information, with additional information – such as soils and hazard zones, land-use types, building types, lifeline networks, population density and dwelling types – shown on higher levels or overlays. GIS is similar to the technique of using a base map and acetate overlays, but enables the storage, amendment and retrieval of substantial quantities of data. With sufficient data, GIS can also be used to show trends and simulated effects of hazard events



An assessment of the vulnerability of a city (as described in Chapter 9) involves collating information on the topography, geology, tectonic setting, hydrology, soil composition, land use and infrastructure of the area. Topographical information at a scale of 1:10,000 or larger may already be available in digital form, and could be used as a base on which other information can be superimposed. Further applications of the system could include the preparation of localized risk assessment maps for specific communities.

The application of GIS should be a high priority for public authorities concerned with disaster management, and could be developed by an existing agency involved in the planning of land use or of public infrastructure provision

Remote sensing. The use of remote sensing techniques for operational, commercial and experimental applications is increasing world-wide. In hazard assessment and disaster mitigation, they are used to monitor flooding and associated effects such as erosion, for land use and vulnerability mapping, and for meteorological measurements and severe storm warnings.

In the Philippines a comprehensive range of hardware and software is available for satellite image processing and analysis, and remote sensing applications include weather monitoring and forecasting, natural resources monitoring, soil and water management, education, aerial photography, surveying, planning, and volcanology. The University of the Philippines Training Centre for Applied Geodesy and Photogrammetry supports master's degrees and diploma programmes in both remote sensing and GIS

Essential components in any disaster mitigation strategy are.

- identification of hazards which involve a high risk
- assessment of risks and delineation of the areas likely to be affected
- where possible monitoring and predicting of hazards
- adoption of measures to reduce potential losses.

The first three stages mainly involve scientific activities, while the fourth involves policy making and implementation. Scientific findings therefore need to be disseminated effectively in order to formulate policies and strategies which are practical and appropriate. However action as a result of this process is often ineffective, due to

- inadequate identification and prediction of hazards (i.e. a failure to locate the hazardous event in space and time, and to measure the uncertainties involved), or
- inadequate formulation of warning messages, or
- inadequate transmission of warning messages to intended recipients, or

Networking information

- inadequate understanding of warnings by recipients, and consequently a lack of suitable action, or a combination of these.

Each stage is equally important, and any weakness in one stage could render the entire process ineffective. The response of the community as a whole is a vital component, but human reactions are often not helpful. Experience from the United States shows that people retain a strong attachment to their homes and locations after disaster, and are unwilling to evacuate for longer than three weeks when disasters are predicted.

It is essential to maintain a high standard of prediction and warnings, of communication between scientific and political agents, and of public education. Effective forecasting requires continuous data exchange between countries. Studies have identified religious, social and ethnic groupings as factors which influence responses to warnings; the response of poor communities, minority groups and women is often the most restricted. Disaster management must therefore include the following preparedness objectives:

- improve the accuracy of forecasts
- increase duration of advance warnings
- reduce time taken to evacuate
- minimize the number of authorities responsible for processing data and issuing warnings
- improve communications between scientific agencies, urban development authorities and the public
- adopt international standards for warnings
- ensure that funds are allocated for the monitoring of all relevant hazards
- encourage scientific research in disaster mitigation.

The following subsections describe the availability and use of warnings for each hazard.

Cyclone warning



Tropical storms can be tracked and their future progress predicted with some confidence. In Hong Kong, for example, the Royal Observatory tracks cyclones from satellite pictures taken in both infrared and visible spectra and, within about 500 km of the territory, by weather radar. Forecasters apply experience and synoptic reasoning to the particular meteorological situation, in order to forecast the future movement of a storm, assistance being provided by a range of statistical-dynamical objective forecast schemes. Figure 4.5 shows the cyclone warning signals currently in use in Hong Kong.

In addition to other meteorological and geophysical information, the Hong Kong Royal Observatory provides cyclone warning services for the public, for sea traffic, for aviation and for specialist users such as building contractors, wharfing companies, public utilities, public transport operators and other commercial enterprises. Warnings relate to the risk faced by the territory and to expected wind conditions. When a warning signal is hoisted, bulletins are disseminated to the public, the media and other users. Similar information is provided through an automatic telephone answering service and the Hong Kong Telephone Company provides a service for those who wish to be notified by telephone of the hoisting and lowering of signals.

Weather prediction requires the constant exchange of meteorological data between countries. As part of a regional cooperation programme under the World Meteorological Organization, warnings and prognoses are exchanged among meteorological services throughout east Asia.

Signal		Display		Meaning of the signal
		Symbol	Lights	
Stand By	1	T	White White White	A tropical cyclone is centred within about 800 kilometres of Hong Kong and may later affect Hong Kong.
Strong Wind	3	L	Green White Green	Strong wind expected or blowing, with a sustained speed of 41–62 km/h and gusts which may exceed 110 km/h.
NW^{LY} Gale or Storm	8 NW	▲	White Green Green	Gale or storm expected or blowing, with a sustained wind speed of 63–117 km/h from the quarter indicated and gusts which may exceed 180 km/h
SW^{LY} Gale or Storm	8 SW	▼	Green White White	
NE^{LY} Gale or Storm	8 NE	▲	Green Green White	
SE^{LY} Gale or Storm	8 SE	▼	White White Green	
Increasing Gale or Storm	9	⋈	Green Green Green	Gale or storm is increasing or expected to increase significantly in strength.
Hurricane	10	+	Red Green Red	Hurricane force wind expected or blowing, with sustained speed reaching upwards from 118 km/h and with gusts that may exceed 220 km/h.

Figure 4.5
Cyclone warning signals used in Hong Kong. By courtesy of the Hong Kong Government.

Flooding resulting from sea surge, storm surge or heavy rainfall can be predicted and warnings issued. Continuous monitoring of water levels and of rainfall in river catchment areas provides information on which flood warnings can be issued. Numerical models can simulate river basin and urban area floods and, together with tide level records, are used to predict the likelihood of storm surges in tropical cyclone conditions. Embankment failure is more difficult to predict, and often occurs before the design return period is experienced, due to poor maintenance or sediment and bank erosion. Failure of dams can be determined by site geology or caused by forest removal.

Flood protection work in the form of embankments (levees) or walls in urban areas can reduce the extent and impact of floods. For example, levees have been constructed in Budapest, as protection against flooding of the River Danube with a return period of 1 in 1000 years.

Jakarta covers an area of 24,000 hectares, of which 15,000 are less than 2 m above sea-level and sinking. Flood hazard maps have been prepared, the Public Works Department (PWD) operates a flood warning system in the areas at risk, and 'flood gangs' are on standby to assist in problem areas. The work of the PWD has been complicated by the presence of illegal residents in areas at risk.

Prediction and warnings for small catchments are difficult, due to the short time

Flood warning



scale involved. For example, the Malir and Lyari rivers passing through the city of Karachi have caused many instances of flooding in the past, leading to substantial loss of life and property in the city. Flooding of the Malir has been controlled with embankments, and the effect of flooding of the Lyari has been mitigated, partly by construction of embankments and partly by provision of monitoring stations and adoption of a rain flood emergency plan. In the longer term, when flood ways are cleared and embankments constructed, the emergency plan may be unnecessary; at present, authorities annually persuade illegal settlers encroaching on flood plains to leave their dwellings, only to see them return and rebuild their damaged homes after the flood has passed.

Tsunami warning



Although tsunamis cannot be prevented, their effects can be mitigated, both in the long term by planning to minimize any damage, and in the short term by issuing warnings. Long-term mitigation is desirable, but may not be cost-effective if it involves the construction of major wave-breaking barriers which may only be needed occasionally. Due to the potential force of a tsunami, a warning system giving several hours of advance notice is likely to be the primary strategy for reducing loss. Timely warnings can be very effective in avoiding loss of life and minimizing damage, for example, by shuttering windows or opening those on the ground floor to let the flood pass through, by moving vehicles and mobile equipment to higher ground, and by protecting critical facilities.

The Pacific Tsunami Warning Centre (PTWC) in Hawaii acts as an international warning centre for tsunamis which pose a Pacific-wide threat. An international warning system was formalized in 1965, when PTWC assumed the responsibilities of the Pacific Tsunami Warning System (PTWS), to which 26 countries belong.

The objective of PTWS is to detect, locate and determine the magnitude of potentially tsunamigenic earthquakes in the Pacific basin or its immediate margins. Earthquake monitoring services, such as that of the US Geological Survey, provide basic data. If the location and magnitude of an earthquake meets the known criteria for tsunami generation, a warning of the imminent hazard is issued. The warning includes predicted arrival times of the tsunami at selected coastal communities, within an area defined by the maximum distance the tsunami could travel in a given time period. If a significant tsunami is detected by sea-level monitoring instrumentation, the warning is extended throughout the Pacific basin.

Tsunami watches, warnings and information bulletins are disseminated to appropriate officials and the general public by various methods including radio, television and marine radios.

Earthquake prediction



There is not yet a reliable method of predicting the occurrence of an earthquake. However, seismological research can estimate the magnitude and frequency of earthquakes which may occur within the vicinity of a city, by predicting the probability that an earthquake of a certain magnitude will occur in a given area during a specified period.

Seismic monitoring in Karachi and Jakarta There are no seismic measuring instruments in Karachi, nor in any other part of the province of Sindh, despite the presence of faults suspected of being active crossing parts of the urban area. In 1994 the Geological Survey Office began to prepare zonal geological maps of the city in a four-sheet 1:25,000 scale coverage. Due to financial restraints this work has had to be based on information readily available with no additional surveys.

Data collection to detect seismic forces is not given a high priority in Jakarta. Long-period motion instruments are located in the meteorological and geophysical agency compound but these now have very low sensitivity due to the proximity of highways and the effect of traffic vibrations. In the private sector, strong motions instruments were installed in high rise buildings over 10 years ago but none are known to be still working and providing results.

It should not be assumed that if a geological fault passes through a city, the city will be susceptible to major movement along the fault line, nor that no ground movement will occur where there is no fault line. The 1985 Mexico City earthquake is a dramatic example of substantial movement occurring although no fault lines pass through the city; conversely, the 1994 Los Angeles Northridge earthquake was generated by movement on an underground and unknown fault line, rather than on the many surface fault lines

Fault lines and earthquake generators across the world are well defined; historically, most major earthquakes have occurred along these lines. However, it is believed that almost any area could experience an event of magnitude 4.5, and that events of greater magnitude are possible in many areas distant from major fault lines. From 1900 to 1989, the following events were recorded within a 300 km radius of major cities:

City	Magnitude
Bangalore	>5.0
Bangkok	>6.0
Jakarta	>8.0
Karachi	>6.0
Lagos	>5.0
London	>5.0
Moscow	>5.0
New York	>5.0
Paris	>5.0
Seoul	>6.0

False predictions can create unnecessary alarm, and consequently have indirect social and economic effects. For example, in 1981, a catastrophic earthquake was predicted to occur in Lima, Peru and, although the event did not occur, those who were aware of the predictions and who were able to leave, did so. The task of administrative authorities is to make effective use of information available. If, for example, information indicated that an earthquake of magnitude 7 could occur in the city within 250 years, appropriate action could be planned. However, predictions that a similar event may occur within a year would allow little scope for action, particularly if long-term mitigation measures were not already in place.

Unusual or abnormal animal behavior is the oldest and most consistently reported earthquake precursor. Yet, even the recent scientific literature is fraught with contradictory evidence related to this phenomenon. We recently completed studies of eight earthquakes in North, Central and South America, none of which were known to have had foreshocks. Our data indicates that unusual animal behavior occurs a few hours before some, but not most, such earthquakes. Studies of earthquake folklore support the same conclusion. Animal behavior seems unlikely to be of much direct value in earthquake prediction, but it is possible that analysis of some animal reactions could point the way to identification of physical precursors common

to at least some earthquakes (*Animal Behavior and Earthquake Prediction*, edited by Benjamin L. Hart, School of Veterinary Medicine, University of California)

Landslide potential



Geological, seismological, meteorological and topographical studies can identify the location of potential landslides, but not their timing. Landslides are generated primarily by vibrations, erosion, and lubrication caused by earthquakes and water, sometimes aggravated by changes in the vegetation of hillsides. Where rainfall has caused initial movement, it can be reasonably expected that further movement will occur during the next rainy season.

Although attempts to manage the effects of a large landslide may not be cost-effective, some potential landslides can be prevented by engineering measures, such as slope stabilisation to reduce the likelihood of liquefaction and flow-slide. Evacuation to protect life may be the only other mitigation measure available. For example, close monitoring of the Randa rockslide, begun after an initial event in 1991, identified the possibility of further movement; tremors were registered shortly afterwards, followed by a second large rockfall causing property damage, but no casualties. However, the monitoring process proved very expensive.

Volcanic eruption warning



Although major urban developments have rarely been established in volcanic areas, eruptions often affect towns, villages and agricultural areas which have developed in order to benefit from the rich soils of the area

For example, Metro Manila is situated within 100 km of three major volcanoes, Taal, Banahaw and Pinatubo. Of the 45 nominally active volcanoes (known to have erupted within historical time or known to have records of eruption dating back to the last 10,000 years) within the Philippines only six were monitored between 1980 and 1990. This monitoring did not include Pinatubo, which was not classified as a high risk. One challenge facing volcanology is to distinguish a dormant volcano from one which is extinct.

The Philippine Institute of Volcanology and Seismology (PHIVOLCS) has had extensive experience of monitoring and of issuing warnings of volcanic activity. The summary of the major eruption of Mount Pinatubo in June 1991 given in Tables 4.1 and 4.2 shows the process of alerting and warning which evolved during this event.

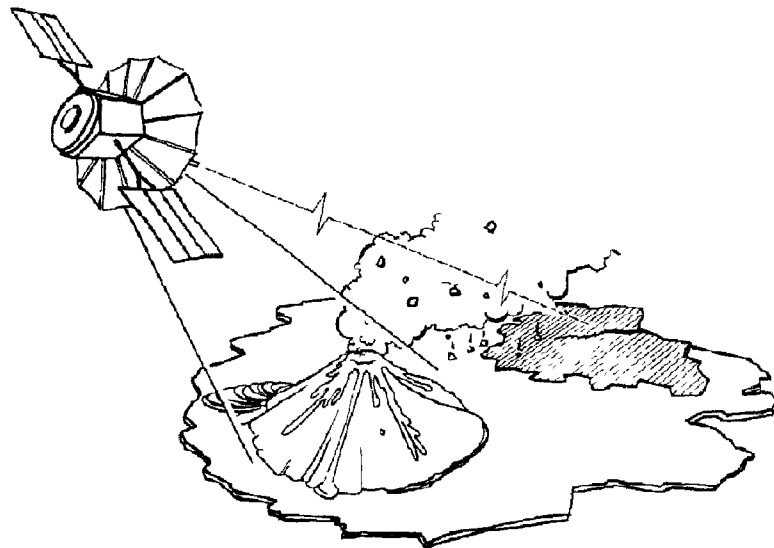


Figure 4.6
Monitoring volcanic activity

Table 4.1 Eruption of Mount Pinatubo*July–August 1990*

Local people living on the mountain report audible rumbling sounds, ground cracking and increased steaming from the pre-existing thermal area

April 1991

An explosion at the crater, rumbling sounds and intense steaming from several vents prompted further warnings by residents.

A quick response team conducted ocular and aerial observations, finding fissure and new craters at the north-east end of the line of steaming vents.

A temporary seismic station was installed, recording hundreds of high frequency volcanic earthquakes within 24 h. A permanent danger zone was declared and residents advised to evacuate. Regular bulletins provided earthquake counts, visual observations and assessments of the volcano's condition.

Seismograph units, electronic distance meter stations, and a telemetered seismic network were installed; sulphur dioxide emissions were measured. A central station (now the Pinatubo Volcano Observatory) was established.

Monitoring confirmed that magma was rising beneath the volcano.

May 1991

An alert scheme was adopted in place of the bulletins, which had become inadequate for disseminating information, alert level 2 was declared.

Sufficient data were now available to conclude that an eruption was entirely plausible. Topographic maps, air photographic analysis and field verification identified the size and extent of the pyroclastic flows, ashfall and lahars that could result from an eruption, given prevailing wind patterns. The maps included circular zones of increasing radius centred on the volcano to delineate evacuation zones.

There was concern that officials, community leaders and endangered inhabitants would fail to recognise the potential danger and take appropriate action. The people at risk and their leaders were understandably sceptical, as the volcano had been dormant for generations; consequently, an intensive education campaign was launched among relevant officials and endangered inhabitants.

To expand coverage of the campaign, representatives of national and local media were invited to the main office and field stations. There is no doubt that media involvement was a key factor in the rapid and widespread dissemination of information. The education and media campaigns convinced many people to prepare for a possible eruption.

June 1991

Shallow seismicity and the amount of ash in the steam plume gradually increased. The characteristics of the earthquakes were also changing. A sudden decrease in sulphur dioxide values indicated that new material from below was plugging the path of the gases. Some steaming vents had stopped and ash emissions had increased. The alert level was raised to 3.

Due to further changes in earthquake activity and progressive tilting, the alert level was raised to 4. A small lava dome was sighted near the most active steam vent, giving positive evidence of rising magma. Alert level 5 was declared, with the danger zone increased to 20 km after the sighting of a pyroclastic flow; the closest residents began to evacuate.

A large explosive eruption began shortly afterwards; due to fears of a large caldera eruption, the danger zone was increased to 40 km. Monitoring operations were re-established at about 25 km from the centre of the volcano; on 16 June it was reported that the eruption had created a 2-km diameter summit caldera and that the worst had probably passed.

A typhoon passed over the area on the same day, its winds carrying ash from the eruption to wider areas, school classes in Metro Manila were suspended and the Ninoy Aquino International Airport closed. The typhoon brought rains, wetting the ash accumulated on roofs, causing roof collapse, injury and death. It also triggered lahars, claiming more lives. However, due to the effectiveness of monitoring and warnings, the number of fatalities was limited to about 300, 200 due to collapsed roofs from ash fall.

**Table 4.2** Alert levels/signals for Pinatubo region, adapted starting 13 May 1991

Alert level	Criteria	Interpretation
No alert	Background, quiet	No eruption in foreseeable future
1	Low-level seismicity, other unrest	Magmatic, tectonic or hydrothermal disturbance; no eruption imminent
2	Moderate level of seismicity, other unrest, with positive evidence for involvement of magma	Probable magmatic intrusion, could eventually lead to an eruption
3	Relatively high and increasing unrest, including numerous b-type earthquakes; accelerating ground deformation, increased vigour of fumaroles, gas emissions	If trend of increasing unrest continues, eruption possible within two weeks
4	Intense unrest, including harmonic tremor and/or many 'long period' (=low frequency) earthquakes	Eruption possible within 24 h
5	Eruption in progress	Eruption in progress

Stand-down procedures: in order to protect against 'lull before the storm' phenomena, alert levels will be maintained for the following periods *after* activity decreases to the next lower level: from alert level 4 to 3, wait one week; from alert level 3 to 2, wait 72 h.

Source: R. S. Punongbayan, 'A warning system for active volcanoes and response to warnings', *World Conference for Natural Disaster Reduction*, Technical Committee F, 1994, WMO/UNESCO.

Assessment of vulnerability



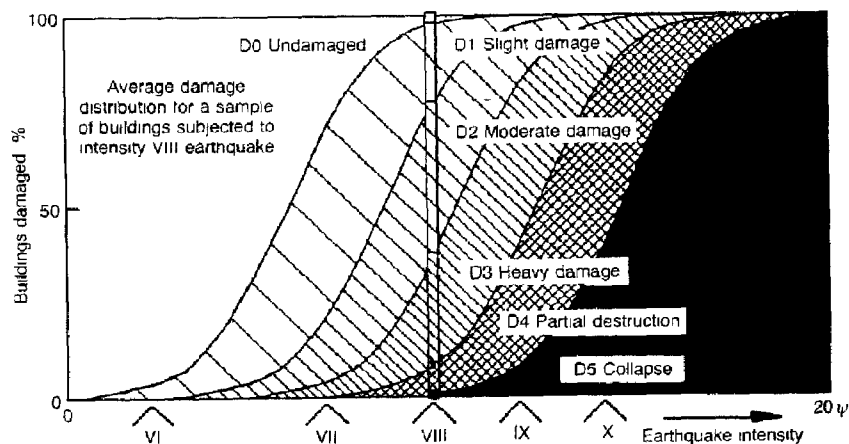
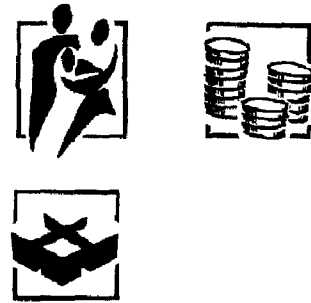
The vulnerability of people to natural hazards can be assessed in terms of social aspects, economic performance or physical loss. Extensive research into the vulnerability of physical infrastructure has been carried out by engineers and architects, based partly on observations of failure in previous disasters and partly on theoretical or experimental evaluation of the critical loads which structures can withstand. However the great variety of structural forms, together with local variations in building details, can have a major impact on their resulting vulnerability. Experience of the behaviour of similar structures is a valuable input in the assessment of vulnerability. For example, investigations in Kobe, following the earthquake of 17 January 1995 will provide extensive data on the performance of timber-framed buildings.

Some elements at risk can be identified visually (e.g. lightweight dwellings in cyclone-prone areas, structures built in flood plains, buildings with heavy balconies or soft storeys in earthquake-prone areas). A comprehensive analysis would be costly, time consuming and unnecessary, as effective classification of the physical infrastructure can limit the number of actual assessments required.

Socio-economic vulnerability can be identified more easily, although it is more difficult to quantify; qualitative classifications (such as high, medium and low) are sometimes used.

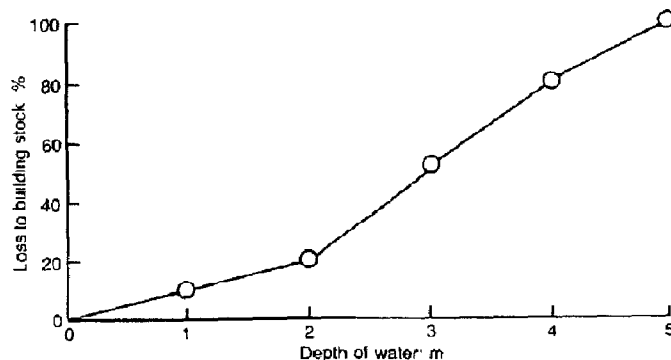
There are a number of sources of 'vulnerability functions' in the literature for

different classes of structure. Care must be taken in combining different datasets because of the differences in building construction, even for apparently similar building forms; brick masonry buildings in California are built in a different manner to brick masonry buildings in Australia (as illustrated by building performance in the Newcastle earthquake, for example). However, such vulnerability functions enable a quantitative assessment of risk to be made by linking damage levels (and hence cost) to intensity of hazard in the vicinity of the structure. Examples are given for the performance of brick masonry buildings under earthquake loading (Fig. 4.7) and for floods (Fig. 4.8). It would also be possible to calculate vulnerability functions for secondary losses, such as economic costs, or for reconstruction or recovery time or other parameters. Further information on the vulnerability of structures can be found in the companion volume *Structures to Withstand Disaster* (Thomas Telford, 1995).



Damage is almost zero below intensity V, but reaches 100% by intensity IX, at which intensity no buildings would remain undamaged. The curve D5 has a similar shape but shows that the proportion of collapsed buildings is nearly zero up to intensity VIII, but will reach about 50% at intensity X. The value of plotting in this way is that by drawing a vertical line at any level of ground shaking, the intersections with the five curves show the expected distribution of a sample of buildings among the five levels of damage. The vertical loss scale can also be interpreted as the probability of a given damage level for a single unreinforced masonry building at any particular level of ground shaking.

Figure 4.7
Earthquake vulnerability functions for brick masonry buildings.
Source: UNDP/UNDRO, *Vulnerability and risk assessment*, 1991.



For many purposes it is not necessary (or possible with the available data) to determine the damage distribution at each level of hazard and only the total proportional loss is needed. The example of the vulnerability function for floods shows the expected losses to buildings caused by inundation by high-velocity water, expressed as a proportion of the total replacement cost of the buildings. Such loss curves are useful for economic planning but less valuable for assessing probable numbers of casualties or homeless people.

Figure 4.8
Vulnerability function for buildings affected by floods
Source: UNDP/UNDRO, *Vulnerability and risk assessment*, 1991.

Summary of main points

- Hazardous phenomena should be monitored continuously and timely forecasts of hazardous events disseminated clearly and comprehensively.
- Scientific and technical information on natural hazards should be presented to administrators in an accessible format which summarizes and interprets the most relevant facts.
- This information should include: estimates of the probability of the occurrence of hazard events of various magnitudes, hazard zonation maps showing the geographical areas of the city likely to be affected; and the level of risk associated with each hazard.
- A rapid initial classification of the physical, social and economic infrastructure of the city should be carried out, using existing data. This should be updated regularly
- An audit of the city should then be carried out, using existing data supported by new studies as appropriate, to assess the vulnerability of its physical, social and economic infrastructure.

Vulnerability of the physical infrastructure

5

Infrastructure is the physical fabric of the nation. It is the basic framework necessary for the well being and productive development of a modern industrial society (*First Report of the Infrastructure Policy Group*, Institution of Civil Engineers, 1984.)

Infrastructure plays a vital role in economic and social development, and ultimately in providing improved standards of living for the population. The approach to infrastructure provision adopted by the developed world, which emphasizes sophisticated technology, may not be the most appropriate nor the most cost-effective in other situations. Overall, all approaches to infrastructure provision should be based on the common objective of improving living standards

The various elements of the physical infrastructure are often described as lifelines, because they are so essential to all human activities. This description is particularly appropriate in the context of disaster mitigation; in the aftermath of disaster, infrastructure plays a crucial role in emergency operations, and in sustaining the functions of any city

Reducing the vulnerability of the physical infrastructure network will therefore effect a reduction in social and economic vulnerabilities within the city. This chapter discusses ways in which the physical infrastructure network may be at risk from natural hazards, and suggests priority actions in reducing these risks. The various elements of infrastructure are discussed in turn, according to the logic of development:

- infrastructure constraints: planning and land use, interdependence of lifelines
- transportation: surface transport, ports, airports
- water and public health: water supply, waste water, solid waste, storm water
- utilities: gas and oil, electricity, telecommunications
- buildings and structures.

Many mitigation measures are generic, in that they apply to physical infrastructure in general, and an understanding of the principles involved will enable specific measures to be adapted to local circumstances (see Table 5.1 and Figs 5.1 and 5.2). Within this chapter specific measures are recommended within the following categories:

- preventative measures, which aim to minimize the physical damage created by hazard events
- spreading the risk, which aims to reduce the effects of physical damage by ensuring a range of alternative facilities
- spreading the responsibility, which aims to provide an incentive for different agents to implement mitigation measures
- covering or minimizing the impact, which aims to manage potential effects
- planning disaster management, which aims at long-term resilience.

Table 5.1 Examples of generic mitigation measures

Preventive measures	Using city hazard zonation maps, carry out an audit of all infrastructure to identify elements at risk. Identify key components of each system, particularly in installations and buildings of post disaster significance and infrastructure linking them. Nominate strategic components for upgrading or re-routing away from vulnerable areas Upgrade all vulnerable strategic structures Where it is impossible to avoid hazard-prone areas design, detail or retrofit systems to minimize the effects of hazards and enable a rapid return to normal operation. Review design standards, specifications and good practice guides, and revise them according to the priority of the component and the level of finance available. Provide protection for sensitive plant and equipment. For example, raise items above flood or surge level, fix and brace free-standing equipment in earthquake areas. insulate computer hardware and control equipment from the effects of volcanic dust. Keep records on a database secure from damage, and ensure that maps of primary systems and district by district records of secondary systems are retained and accessible to users.
Spread the risk	Avoid dependence on single facilities and transport routes. Introduce redundancy or reinforcement into the distribution system for re-routing operations (advisable to safeguard supply during major repairs) Provide alternative sources of electricity supply.
Spread the responsibility	Widen ownership of the system, particularly for maintenance and operation, under regulatory control Help informal communities to install and manage local systems, subject to regulations on minimum standards for security and quality of supply Encourage user participation by promoting public/private partnership in community-based projects utilizing forms of concession such as BOT (build/operate/transfer) or BOOT (build/own/operate/transfer).
Cover or minimize the impact	Provide insurance for physical losses particularly for mechanical and electrical plant, to facilitate rapid recommissioning of the system Encourage strategic users to install and regularly test standby power-generation equipment and ensure that there is adequate fuel for, for example, 30 days continuous operation. Hold spares to replace critical items Establish procedures for system failure and minimizing the effect of pollution.
Plan disaster management	Plan to minimize the time taken to return to normality Arrange regular workshops and training programmes for the continuing education of staff in hazard preparedness and mitigation Promote hazard awareness and the planning of facilities away from vulnerable areas.

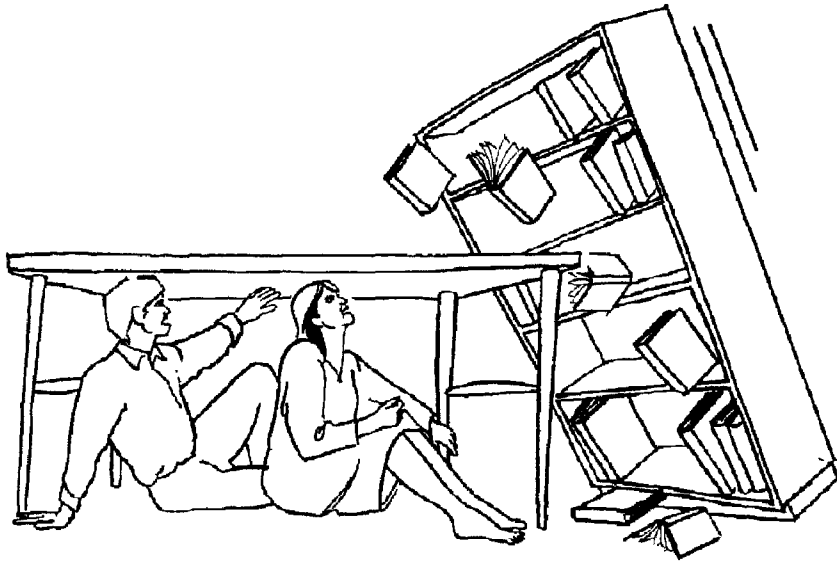


Figure 5.1

Preventative measures fix and brace free-standing equipment.

Competent, central planning by a city's administration has the following advantages in relation to mitigation

- development can be confined to land which is suited to that use and which is not at serious risk from natural hazards
- physical infrastructure and basic services can be provided before the construction and use of buildings
- development can support the economic, social and environmental objectives of the region

Infrastructure constraints

Planning and land use



In many cities development mechanisms do not function effectively and cannot keep pace with the rate of growth. This leads to

- development occurring on unsuitable land which is often hazard prone, such as flood plains, watershed areas, and unstable slopes
- buildings being constructed and occupied with little or no supporting physical infrastructure or services
- inadequate economic opportunities and social facilities for the population.

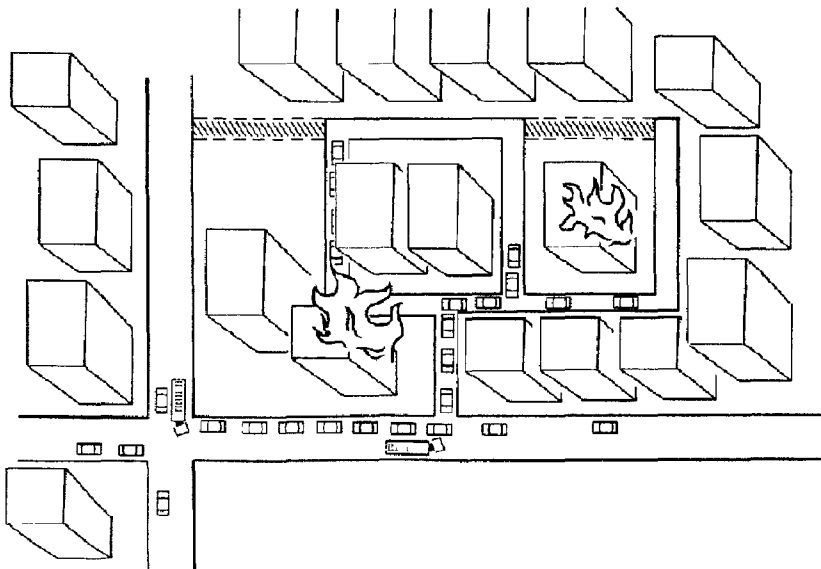


Figure 5.2

Cover or minimize the impact: plan evacuation routes and emergency vehicle access routes



These deficiencies are exemplified by informal or illegal settlements which, by definition, exist without the approval of the planning authorities. Some strategies, such as clearing and relocating informal settlements, have proved largely unsuccessful (with the notable exception of Hong Kong). Strategies which provide legal tenure and facilitate improvements in such settlements are now being explored more widely. If coupled with policies to control migration into a city, this approach may be more beneficial.

In general, inadequacies in physical infrastructure are often a major concern of city and national governments, and therefore attract substantial investment which often involves funding by international development agencies. The solutions to inappropriate land use are perhaps more complex; effecting fundamental change in land use patterns is an extremely slow process. Long-term change in both areas will become possible with continued economic growth and with reforms in planning procedures (see Table 5.2)

For effective infrastructure development, the separate functions of spatial and physical planning, project identification and development programming, and financing need to be coordinated within a single organization with responsibility for city management. The same organization should also be responsible for achieving wider economic and social objectives, including sustainable development and disaster mitigation. Within such a structure, it is possible to ensure that the principles of disaster mitigation form an integral part of the city management function.

The role of metropolitan authorities in reducing vulnerability is discussed in Chapter 7.

Interdependence of lifelines

The elements of the infrastructure network, or lifelines, depend on each other in varying ways and to varying extents; failure of one element may lead to failure or disruption of others. This interdependence is illustrated in Table 5.3, specific examples relating to each lifeline are given in subsequent chapters

Table 5.2 Mitigation measures in land use and planning

Preventive measures	Ensure that plans and designs for new development take account of any hazardous characteristics of the area Implement preventive or protective measures where practicable. Discourage development in hazard-prone areas where possible, and provide protection for vulnerable locations and facilities
Spread the risk	Encourage decentralization of commercial and industrial sectors, while acknowledging transport implications Develop alternative power supplies. Ensure a range of suppliers and routes for delivery of natural resources and raw materials
Spread the responsibility	Encourage political decentralization. Encourage local communities within the city to manage the provision of infrastructure and services within their area
Cover or minimize the impact	Plan evacuation routes and emergency vehicle access routes Identify buildings for designation as emergency shelters such as schools and gymnasia.
Plan disaster management	Minimize the time taken to return to normality, and plan evacuation procedures

Table 5.3 Interdependence of lifelines
(adapted from *Lifelines in Earthquakes*, CAE, University of Canterbury, New Zealand)

Dependent lifeline	Support lifeline																	
	Water supply	Gas and oil supply	Sanitary drainage	Storm drainage	Electricity supply	Telecom services	Highways	Railways	Ports	Airports	Media	Fuel supply	Fire-fighting	Buildings	Building services	Health	Food supply	Total dependence
Water supply	•	•	5	3	5	5	3	•	•	•	•	5	•	•	•	5	5	36
Gas and oil supply	5	•	•	•	5	5	3	3	3	•	•	3	5	•	•	5	5	42
Sanitary drainage	5	•	•	5	5	3	3	•	•	•	•	5	•	•	•	5	5	36
Storm drainage	5	•	5	•	3	•	3	•	•	•	•	3	•	•	•	1	1	21
Electricity supply	5	•	•	•	•	5	5	5	5	•	3	5	•	•	•	5	5	43
Telecom services	5	•	•	1	5	•	5	•	•	•	•	5	•	•	•	5	5	31
Highways	5	•	•	5	3	3	•	•	•	•	3	3	•	•	•	5	5	32
Railways	5	•	•	3	5	5	5	•	3	•	3	5	•	•	•	5	5	44
Ports	3	•	3	3	3	5	5	5	•	•	•	5	5	5	•	3	3	48
Airports	3	•	3	5	3	5	5	3	•	•	5	5	5	5	5	3	3	58
Media	5	•	•	•	5	5	3	3	•	5	•	5	•	5	5	5	5	51
Fuel supply	5	•	•	•	5	5	5	5	5	•	•	•	•	•	•	5	5	40
Fire-fighting	5	•	•	1	1	3	5	•	3	•	3	5	•	•	3	5	5	39
Buildings	•	•	•	5	5	5	5	•	•	•	•	3	5	•	5	5	5	43
Building services	5	5	5	•	5	•	1	•	•	•	3	•	•	•	•	•	•	24
Health	5	•	5	3	5	5	5	•	•	3	5	5	3	5	5	•	5	59
Food supply	5	5	5	3	5	3	5	5	5	3	3	5	3	5	5	5	•	70
Total importance	71	10	31	37	68	62	66	29	24	11	25	70	26	25	28	67	67	

5 = High; 3 = moderate, 1 = low • = none

Table 5.3 shows that it is vital to restore electricity supplies, telecommunications, transport and fuel supplies after a hazard event. Similar analyses should be conducted by each utility provider, which should then be coordinated, in order to identify areas of interdependence.

As it would be neither economical nor practicable to protect every item of infrastructure against extremely rare events, preparedness and response plans should be formulated by each agency involved. Following a hazard event, the objective of all agencies should be to restore full services in the shortest possible time. However, Table 5.3 shows that, for example, restoring water supplies will be ineffective without also restoring electricity supplies; a coordinated plan for restoration of all services is required.

Table 5.4 shows the results of an exercise in which representatives of each utility provider in the city of Wellington, New Zealand, estimated the time needed to restore normal service if a major earthquake were to strike the city. Although its results have been subject to debate, participants found the exercise of value in assessing vulnerability and ease of recovery, and in emphasizing the relative importance of each utility.

Characteristics Ports handle a large proportion of a nation's trade and, as a city will often have access to only one port, its significance to the local economy is particularly critical.

The components of a port include breakwaters, quays, cargo sheds, cold stores, fuel storage, open storage areas, cranes, infrastructure, offices, passenger terminals, roll-on-roll-off facilities, material handling equipment, mobile plant, highway and rail links to the city and region. Historically, ports have often provided a focal point for the city's development; they are generally surrounded

Transport

Ports



Table 5.4 Recovery of service – a preliminary assessment of the time to recover following a major event (adapted from *Lifelines in Earthquakes*, CAE, University of Canterbury, New Zealand)

Utility	Recovery of basic service or control	Provision of 50% service	Provision of full service	Comment
Water	Up to 2 days	2 weeks	12 months	Access and equipment. Pipe structures. Treatment plant. Radio communications.
Drainage: Sewerage	Up to 2 weeks for control	12 weeks minimum	24 months minimum	As for water 6 months minimum for inspection (CCTV)
Stormwater	2–3 days	12 weeks	12 months	Important for early sewerage control
Gas: Welgas	Up to 3 days	3 weeks	6–2 months depending on sleeving prog.	Local shutdowns only as necessary. Inspection needed to reinstate service
HVEB	Less than 3 days	3 weeks	6 months	As for water
Electricity: Regional	Up to 3 days	2 weeks	9–12 months	Radio communication. Access and equipment
District	Up to 3 days for control, 1 week for service	4 weeks	12 months	Transmission towers. Substations. Cable structures
Telecom: VHF mobile	Up to 4 hours	2–3 days	2–6 months	Access and equipment. Standby fuel.
Local telephone	Up to 2 days	3–6 weeks	12 months	Buildings. Line structures.
Tolls	Up to 5 days	4 weeks	12 months	Transmission towers
Cellular	Up to 5 days	4 weeks	2 months	Switching units.
Broadcasting	Up to 6 hours	2–3 days	2–6 months	Transmission towers. Access and tower requirements. telephone links. Standby power.
Roads	3–5 days – some access to most areas Two weeks – access to region	3–4 weeks	18–4 months	
Rail Wellington	2–3 months	2–3 months	12 months	Track alignment. Buildings. Signalling. Slips.
North from Upper Hutt North	1 day Up to 12 months	12 months	18 months	Depends on extent of slips at Paekakariki Hills.
Ports Airport	1–2 days 1–2 days if plant available, 4 days otherwise	6–8 weeks 6 weeks	12–24 months 6–2 months	Access. Power. Access and earthmoving plant. Asphalt plant. controls and navigation aids

by the old established commercial and industrial areas, and high-density residential areas.



Vulnerability The operation of port facilities relies on skilled labour, the maintenance of surface transport links and the communications network, and to a lesser extent on reliable electricity and water supplies. Ports are low lying and can be affected by several natural hazards. The interdependence of ports and other infrastructure is shown in Table 5.3

Importance to the city. A failure of port facilities can usually be absorbed within normal trading fluctuations for a few days, but longer disruptions can have a very serious effect on the national economy and food supplies. The direct cost of a disruption of trade for a short time is based on the loss of exports and loss of use of imports, and so is readily quantifiable. The cost of longer disruptions is more difficult to calculate; the consequences would include complex domino effects, counter-balanced by gradual adoption of alternative means of trading and partial adjustment of the market to local products. Loss of exports would significantly affect the economy and may result in lost market share.

In Metro Manila, it is normal procedure to close port operations during a tropical cyclone. Although this is inconvenient and costly, trade resumes when the cyclone has passed. Much of the city's import and export trade is off loaded from ships moored in the bay into barges; this reduces the vulnerability of the port to many of the effects listed in Table 5.5. Mitigation measures are listed in Table 5.6.

It may be that some facilities could quickly be restored on a temporary basis, enabling partial use of the port. However, the cost of repairs must also be considered. The cost of the assessed risk can be compared with the cost of mitigation measures, and decisions made accordingly.

Table 5.5 Potential effects of natural hazards on ports

Natural hazards	Components	Effect	Consequences
High winds	Cranes	Blown over	Access restricted
	Breakwaters	Breached, overtopped	Reduced use of port facility
	Cargo Sheds	Roofs torn off, flooding by wave action	Cargo damaged
	Overhead cables	Blown down	Power failure
Storm surge	Ships	Blown against structures	Ships sink
	Cargo sheds	Flooding, damage and goods and materials washed away	Loss of cargo
	Open storage areas	Washed away	Operations shut down
	Cranes and mobile equipment		
Heavy rain	Open storage areas	Flooded	Loss of cargo
Earthquake	Quays, crane and crane rails, rail track	Partial collapse due to strong motion or liquefaction	Operations shut down
	Embankments, buildings, breakwaters		
	Oil storage		Oil spillage

Table 5.6 Mitigation measures for ports

Spread the risk	Develop or maintain an alternative port or system for unloading ships
	Provide additional storage in off-port areas

Surface transport



City systems. Roads often provide the primary means of transport within the city, although traffic congestion is perceived as a major problem in most large cities and many authorities either operate or are planning to operate fixed track systems. The road network requires special attention in risk assessment and mitigation planning, in order to allow routine activities to continue and to guarantee passage for emergency services.

Paved roads are often not maintained adequately and may be restricted to the city centre, trunk routes and more prosperous areas; many roads are unsurfaced. In some informal communities, roads are merely an allocation of space between dwellings, sometimes only wide enough for pedestrians.

Large cities act as focal points for regional and national transport networks, and external highways and railways are essential to maintain these links.

In Metro Manila, there is one main road leading north and one leading south; the consequences of these external links being destroyed has been considered in relation to man-made disasters. However, lahar flows from Mount Pinatubo in the rainy season caused the collapse of bridges and damage to the main route north, increasing the price of vegetables in the city. Critical bridges have been identified, failure of which would cause economic chaos.

Vulnerability of the system. To be usable, roads and railways need functioning surface water drainage systems, communications and, in the case of railways, a power supply. They must be kept free of obstructions of all types, including encroachment by informal housing.

Damage to a small part of a road system, for example a collapsed bridge or culvert or a washed-out road, can effectively isolate large areas of a city or prevent movement between the city and its hinterland. Similarly, a localized failure in the railway network could cause enormous damage to the local and national economy (see Table 5.7).

In Metro Manila, a moderate earthquake disturbed the track alignment on one short section of an extensive light rail network: the railway was closed down for several days and services were limited for several months afterwards, forcing commuters to switch to road transport.

Vulnerability of the population. People will suffer from the direct effects of the disruption of transport, and from secondary effects such as lack of access for emergency services. Informal communities can be particularly vulnerable as access to these areas is often limited in normal circumstances; they may be isolated after a disaster. However, informal communities often develop independent coping mechanisms.

Importance to the city. Highways are crucial for supplying some types of fuel, food and possibly water for the operation of emergency services, and for transport of heavy equipment and materials for the building industry. The interdependence of highways, railways and other infrastructure is shown in Table 5.3. Light rail and underground systems depend on electricity supplies and communications networks; however, as they are used primarily for passenger transport, their disruption would not directly affect other physical infrastructure. The cost of highway and railway failures are quantifiable. In the 1994 Northridge, Los Angeles earthquake, minor damage to the highway network was estimated to have caused losses of many millions of dollars. The relatively small amount of serious damage must be viewed as a success for the state's programme of

Table 5.7 Potential effects of natural hazards on highways

Natural hazard	Highway component	Effects	Consequences
High winds	Overhead signs, electricity and telephone cables Suspension and cable stay bridges	Blown over	Highway restricted Electricity failure Restricted use
Storm surge	Underpasses Embankments and bridges Cuttings Roads at grade	Flooded Scoured or washed away Landslip Temporarily flooded	Closed to traffic Closed to traffic Closed to traffic Temporarily closed
Heavy rain	Underpass Bridges Roads at grade Embankments Cuttings Drainage systems	Flooded Scour at foundations Temporarily flooded, culverts washed Liquefaction, landslide, washout Liquefaction, landslide Scour damage, collapse	Closed to traffic Closed to traffic Temporarily closed, roads severed Road closed Road closed Road closed
Earthquake	Embankments Bridges and flyovers Tunnels Roads at grade	Settlement foundation failure and liquefaction Failure of abutment, failure of columns, displacement of deck Portal failure Lining failure Ground failure and liquefaction	Closed to traffic Closed to traffic Closed to traffic Partially or completely closed
Landslide	Embankment Roads at grade Tunnels	Ground failure Ground failure, burying Portal blocked	Closed to traffic Closed to traffic Closed to traffic
Volcano	At grade Operation	Dust and lahar cover Very low visibility	Traffic restricted Traffic restricted
<i>Additional vulnerability of railways (including light and underground)</i>			
Earthquake	Track Portals Stations and tunnels	Distortion Collapse Fire	Closed, no service Closed, no service Closed, no service
Floods	Tunnels and underground railways	Flooded	Closed, no service



retrofitting older bridges, but not all structures had been dealt with and this led to the failure of some bridges on critical routes. Such events can highlight the lack of redundancy in the highway system.



The cost of the assessed risk from specific hazards can be calculated for each part of the network. These costs of restoration can then be compared with the cost of mitigation measures and decisions made accordingly. Some elements of the network may have such a critical role that the introduction of redundancy by construction of an alternative route may be justified. However, as provision of additional road space in congested areas tends to generate extra traffic very few urban primary roads can be described as redundant under normal conditions. Areas which could be isolated by a specific failure also need careful attention.

It is likely that existing public investment in the highway network is relatively so great that mitigation of all potential risks would be financially prohibitive. Each element of the network needs to be assessed according to the effects that its failure would have, and according to an acceptable level of risk. Priorities could then be established for retrofitting of structures in the network.

Airports



Characteristics. The role of airports in facilitating international passenger and freight transport is particularly important to the national and local economy and because each city generally has access to only one airport, its role is particularly significant.

Some airports are low-lying and may be built on reclaimed land only a few metres above sea-level. Damaged runways are relatively easily and quickly repaired but the associated facilities, if severely damaged, will take some time to make operational. Airports are usually the primary means of international access, and are therefore essential in the provision of emergency aid after a natural disaster.

A modern international airport contains a wide range of facilities, including runways, taxiways and aprons, passenger terminals, carparks, offices, hotels, cargo sheds, aeroplane repair hangers, oil storage tanks, power station, water treatment plant, sewage treatment plant, garages for emergency vehicles, highways and rapid transit systems.

Vulnerability. If damage results in an airport becoming inoperational, some cities may be served by a smaller airport or military airfields which could be used. Aprons and taxiways of major airports can also be used by small aircraft in an emergency, should the main runway be unserviceable.

Airports may operate independently of the city's electricity and water supplies if city services are interrupted, although they must rely on surface transport and on the operation of specialized equipment and the telecommunications network. However, the infrastructure of the city does not depend on airport operations, except for delivery of some emergency supplies.

Table 5.8 lists some of the potential natural hazard effects on airports.

Importance to the city. Hazard events are unlikely to result in the closure of a major airport for more than a few days, with the exception of landslides and earthquakes which could cause substantial damage requiring closure for a long time.

The disruption of airport facilities can result in substantial economic loss, but this can usually be covered to some extent by appropriate insurance. An early return to operational use after a disaster can be helped by having specialist equipment held on standby. Mitigation methods are listed in Table 5.9.

Table 5.8 Potential effects of natural hazards on airports

Natural hazards	Component	Effect	Consequences
High winds	Operations	Dangerous flying conditions	Temporary shut down
	Cargo sheds	Roofs torn off	Loss of cargo
	Terminals and other buildings	Roofs torn off	Loss of business
	Planes	Damaged	Loss of service
	Masts and cables	Blown down	Electricity supply and communications failure
Storm surge	Operations	Flooded	Temporary shut down
	Runway, aprons and taxi ways	Debris	Restricted operation
	Cargo sheds and hangars	Flooded	Loss of cargo
	Terminals and other buildings	Flooded	Loss of business
	Unsurfaced areas	Washout	Restricted operation
Heavy rain	Operations	Temporarily flooded	Temporary shut down
	Runway, taxi way and aprons	Temporarily flooded	Restricted operation
	Drainage systems	Damage, blockage	Extended period of flooding
Earthquake	Runway, taxiway and aprons	Ground failure and cracking	Restricted or no operation
	Buildings	Partial collapse, fires	Restricted or no operation
	Building contents, equipment	Collapse and damage, fires	Loss of service
	Oil storage	Partial collapse, fires	Pollution
Landslide	Runway, taxiway and aprons	Partial collapse or covered with debris	Restricted operation
Volcano	Runway, taxiway and aprons	Covered in dust	Restricted operation
	Buildings	Partial collapse due to weight of dust	Reduced services
	Operations	Very low visibility, engine failure	Temporary shut down
	Sensitive equipment	Damaged by dust	Restricted operation
Snow	Operation	Poor visibility and obstruction	Temporary shut down
	Runway, taxiway and aprons	Covered in snow	Temporary shut down
	Buildings	Partial collapse from weight of snow	Restricted service

**Table 5.9** Mitigation measures for airports

Preventive measures	Provide bunds around all ancillary oil equipment where the change in rigidity could precipitate a fracture
Spread the risk	Develop or maintain the facilities of an alternative airport. Plan for the temporary use of an existing military airport

Water and public health

Water supply and distribution



City systems. An adequate supply of clean drinking water is vital for all communities. However, some cities have difficulty in providing adequate water supplies, and their rapid expansion often results in large areas being without piped water or with inadequate or interrupted supplies. Securing an adequate supply of potable water for all was the aim of the United Nations International Decade 1980–1990, but this has yet to be achieved in many urban areas.

Piped supplies are generally available in formal sectors, but often only for limited periods. Tanker deliveries are sometimes available in more prosperous areas. People in informal areas often connect illegally into the nearest main, carry water for long distances, draw from local wells or resort to buying from private vendors.

Water requirements for megacities are often in excess of local availability allowing for other demands. A small change in per capita demand or leakage represents a large change in volume. Water supply and sanitation should meet agreed local aspirations bearing in mind the severe consequences of a breakdown of their services in a huge population many of whom are living in congested conditions (ADB TA 5506, *Managing Water Resources to Meet Megacity Needs*).

The components of water supply and distribution systems may include dams and reservoirs, well fields, desalination plants, river off-take works, transmission mains, aqueducts, canals, treatment works, service reservoirs, pumping stations, distribution and supply mains.

Vulnerability of the system. The provision of water supplies depends on a reliable electricity supply for operation of controls and pumping. Although alternative arrangements for supply can be used in an emergency, they are of limited value unless they can continue to operate for several weeks.

Most hazard events are unlikely to result in serious damage to water supply systems (Table 5.10) and it should be possible to restore services within days. Significant loss of life is also unlikely, although repair costs could be high. In the past, landslides and lahar flows have caused disasters by precipitating dam failure or overtopping, but it is earthquakes which are most likely to cause the greatest damage to water supply systems. Possible effects of an earthquake include failure of dams, severe damage to treatment works and multiple fractures of pipelines. Secondary effects may include widespread flooding and a shortage of water for fire-fighting, resulting in further damage. Flooding is more likely to result from small appenditure failures preventing the closure of valves than from a dam failure.

Vulnerability of the population. Any hazard event can disrupt the water supply, and may create public health problems, particularly if the source of supply is remote from the city. The supply may become polluted with the consequent risk of widespread sickness. Public awareness of basic hygiene precautions and the need to purify water will help to reduce these risks.

Importance to the city. Interruption of water supplies can be tolerated for a short time, as many people have become accustomed to routine shortages and interruptions, but a lack of clean water for more than a few hours threatens public health and health risks are increased if sanitation systems break down. Protection of water supply systems is therefore of the highest priority; emergency supplies need to be made available within hours and the system returned to normal operation within days.

Water supplies are, of course, essential for hospitals and emergency facilities to function. After an earthquake, water for fire-fighting will be needed immediately.

Table 5.10 Potential effects of natural hazards on water supply systems

Natural hazards	Components	Effect	Consequences
High winds	Reservoirs	Wave surcharge, overtopping of dams	Scour downstream, endangered dams
	Overhead cables	Blown down	Power and telecoms failure
Storm surge	Treatment works	Flooded	Close down
	Pumping station	Flooded	Close down
Heavy rain	Reservoirs	Overtopping of dams	Possible dam failure
	Rivers	Riverine floods	Difficult treatment
	River offtake	Scour	Loss of source
	Treatment works	Flooding	Close down
	Pumping stations	Flooding	Close down
Earthquake	Reservoirs	Structural failure of dams	Loss of supply, flooding damage downstream
	Ground-water	Liquefaction of deposits	Fracture of wells, supply failure
	Transmission mains, aqueducts, canals	Line fracture	Supply cut
	Treatment works	Damaged	Loss of operation, reduced output, close down
	Service reservoirs	Damaged	Loss of storage
	Pumping stations below and above ground	Damaged	Lost or reduced capacity
	Distribution system	Pipe fracture	Burst, increased leakage through pipes, loss of storage
Landslide	Reservoirs	Overtopping or failure of dams	Loss of supply, flooding damage downstream
	River offtake	River diversion	Loss of source
	Rivers	High sediment	Turbidity
	Transmission mains, aqueducts, canals	Fracture by ground movement	Supply cut
	Service reservoirs	Damaged	Loss of storage
	Treatment works, pumping stations	Damaged by ground movement	Lost or reduced capacity
Volcano	Reservoirs	Pollution by dust	Difficult treatment
	Aqueducts, canals	Pollution and sediments from lahar	Blockage and supply failure



but this need not be of potable quality – any local source of fresh, salt or standing water can be used. Where no other suitable sources exist, storage within the distribution system can be used, even if means of replenishment are temporarily disrupted. Distribution systems with service reservoirs which have significant storage distributed by gravity will be more useful in fire-fighting than those systems in which water is pumped directly into the system.



Existing annual investment in the water supply system may be relatively small and expenditure specifically to mitigate low risks may be unjustified. This situation requires a strategy of reducing risks by dividing the city into relatively small isolation zones, together with a plan for swift repairs. New works should be designed according to principles of risk mitigation; for example, selecting the least vulnerable cost-effective solution. Some mitigation measures are listed in Table 5.11.

The shortage of drinking water in all areas of the city has made living miserable for lakhs [sic] of people, particularly those belonging to the lower tiers of society living in shanty towns and Kachchi [sic] abadis and others of the lower middle class who cannot afford to pay for the tanker supply. In fact, the entire population suffers water scarcity in varying degrees daily or periodically (*Dawn Newspaper*, Karachi, June 1993).

Informal communities. Informal communities often make their own arrangements to obtain water and, where funds for investment in water supply and public health facilities are limited, encouraging self-help may be the most practicable way of improving standards. With the provision of materials and technical support, communities could install their own reticulation system which could be supplied by bulk delivery to the perimeter of the settlement.

Although droughts are not considered in this document, their impact on public health in cities can be severe. Water supplies to many cities are inadequate even in normal climatic conditions, and severe shortage in drought conditions can seriously affect public health. It is suggested that some attention be given to this issue, and plans prepared for a response to conditions of severe water shortage.

Table 5.11 Mitigation measures for water supply systems

Preventive measures	Enforce adequate engineering design and construction codes Establish procedures to conserve existing water storage after a hazard event, such as manual or automatically controlled shut off valves If not already in place, provide district shut off valves, controlled by district operators, to limit leakage. (Also advisable for sound operation of the system, easier repairs and loss reduction.) Ensure valves are in place on mains either side of bridges and fault crossings. Where possible, locate installations in less vulnerable areas Use ductile materials such as steel or polyethylene to replace cast iron mains in soils which could be subject to liquefaction or strong movement.
Spread the risk	Develop alternative sources of supply.
Spread the responsibility	Encourage, licence and regulate the provision of tankered water supplies.
Cover or minimize the impact	Strengthen policies to conserve water, reduce demand and re-use treated waste water. Identify potential sources of water for fire fighting and provide dead storage tanks in areas with limited emergency supplies.

City systems The components of a city's waste-water collection and disposal systems which may be affected by natural hazards include the sewerage network and manholes, pumping stations, submarine outfalls and sewage treatment works and disposal facilities, together with their associated electrical and mechanical equipment (Tables 5.12 and 5.13). Some installations operate without mechanical plant and septic tanks and cesspools are in widespread use.

Waste-water collection and disposal



Vulnerability of the system After the installation of a waste-water collection and disposal system, the city becomes increasingly dependent on it, because the other means of disposal are abandoned and the system becomes increasingly vulnerable as more sophisticated equipment is installed. The operation of waste-water collection and disposal systems with mechanical plant depends on reliable electricity supplies and on telemetry systems and surface water drainage systems; failure of the latter and the resultant flooding will affect the sewerage system. Outfalls can be damaged by sea surge and river scour. The disposal of sludge from treatment works may depend on road access or marine loading facilities.

Earthquakes are likely to cause most damage to a system, seriously damaging or destroying treatment works and pumping stations and causing multiple pipe fractures.

Primary and secondary effects of damage to the system A sewage treatment system is essential to prevent the spread of disease by direct contact with untreated sewage or by pollution of drinking water. Failure of the system can defeat that objective by polluting the city, contaminating drinking water and perhaps causing long-term environmental and ecological damage.

Failure of a particular pumping station could create localized problems such as sewage flooding of streets and houses. A general electrical failure affecting all pumping stations could create extensive flooding of sewage. Failure of systems which accept untreated sewage from hospitals and industrial areas will create additional hazards from the spread of bacteria and toxins. A severe outbreak of disease after a hazard event would adversely affect the population and have subsequent social and economic effects which would delay recovery from the event.

Few large cities currently have comprehensive piped sewerage and waste-water treatment, as investment in this sector is often a low priority. But increasing prosperity will bring opportunities to design systems to withstand the effects of natural hazards.

Informal communities. Informal communities often make their own arrangements for waste-water drainage, sometimes to the detriment of the formal sector. Where funds for investment in public health facilities are limited, encouraging independent provision could be very beneficial. Waste-water collection facilities could be provided on the perimeter of the settlement, and with the provision of subsidized materials and technical support. Communities could then provide, maintain and operate their own waste-water collection systems.

For example, in Orangi, an unofficial settlement in the city of Karachi, a low-cost sanitation system has been installed by residents with the technical and organizational support of Orangi Pilot Project – Research and Training Institute. Training provided by the institute has increased skills within the community and enabled residents to successfully maintain the system.

**Table 5.12** Potential effects of natural hazards on waste-water facilities

Natural hazard	Component	Effect	Consequences
High winds	Reservoirs, lagoons	Overtopping of retaining structures	Progressive failure
	Overhead cables	Blown down	Loss of power
	Sludge disposal facilities	Shut down	Sludge disposal halted
	Treatment works	Damaged laboratories, stores	Operations inhibited
Storm surge	Reservoirs, lagoons	Retaining structures breached	System failure and pollution
	Treatment plant	Destroyed	System failure and pollution
	Road access	Damaged, out of use	Sludge disposal halted
	Sewerage system	Flooded	Sewage in streets
	Pumping station	Flooded	Surface ponding of sewage
	Sludge disposal facilities	Flooded	Sludge disposal halted
Heavy rains	Sea outfall	Fractured	Inshore pollution
	Road access	Damaged, destroyed	Sludge disposal halted
	Reservoirs, lagoons	Overtopping	Progressive failure
	Collection systems	Flooded	Escape of raw sewage
	River outfall	Failure by scour	Local flooding
Earthquake	Collection system	Multiple fractures: Manholes damaged change of gradients by liquefaction	Polluted groundwater, spillage of sewage
	Pumping stations	Damage from ground failure and tilting by ground motion and liquefaction.	Systems failure and pollution
	Treatment works	Damage, damage to road access	Systems failure and pollution, sludge disposal halted
	Reservoir, lagoons	Base, wall and embankment failure by liquefaction	Systems failure and pollution
Landslide	Collection system, rising mains and canals	Fracture by ground movement	Polluted ground-water, spillage of sewage
	Treatment works	Failure by ground movement	Systems failure and pollution
	pumping stations	Failure by ground movement	Systems failure and pollution
Reservoirs, lagoons	Reservoirs, lagoons	Failure by ground movement	Systems failure and pollution
	Collection system	Pollution by dust and ash	Reduced efficiency
	Treatment works	Process failure due to dust and ash	Local flooding and pollution
Volcano	Collection system	Pollution by dust and ash	Bacteriological pollution of receiving water
	Treatment works	Process failure due to dust and ash	

Table 5.13 Mitigation measures for waste-water facilities

Preventive measures	Where possible, locate installations in less vulnerable areas. Use ductile materials such as steel or polyethylene to replace cast-iron mains in soils which could be subject to liquefaction or strong movement. Implement adequate engineering design and construction codes. Minimize dependence on mechanical and electrical plant and equipment
Spread the responsibility	Encourage, licence and control the maintenance and operation of private sewage disposal systems.
Cover or minimize the impact	Adopt a proactive policy for on-site pre-treatment of industrial effluent (including re-use of treated waste-water) and hospital sewage. Where possible, provide standby plant and equipment. Monitor and control sewage collection with a telemetry system Establish procedures to minimize water pollution following system failure, such as flood routing of sewage when pumping stations fail. Plan and locate waste-water treatment plants to anticipate possible failure.



City systems A solid waste disposal system is necessary to maintain standards of hygiene, to minimize the spread of disease, and to discourage illegal disposal methods. Although a hazard event is unlikely to have a very serious effect on waste disposal, disruption of the system would compound social, economic, drainage and health problems (Tables 5.14 and 5.15).

Disposal of waste may involve landfill, incineration, composting or recycling reusable waste. Recent developments in solid waste management focus on reducing the volume of waste, or 'waste minimization'.

Vulnerability of the system. The solid waste disposal system depends on supplies of fuel for collection vehicles and for disposal sites, and on efficient

Solid waste collection and disposal

**Table 5.14** Potential effects of natural hazards on solid waste disposal

Natural hazard	Component	Effect	Consequences
High winds	Vehicles	Stop operation	Streets polluted by dumped refuse
	Disposal sites	Blown debris	Local contamination
Storm surge/ tsunami	Disposal sites	Flood	Ground and water pollution
Heavy rain	Highways	Restricted access	Ground and water pollution
	Landfill	Increased leachate	Possible ground and water pollution
Earthquake	Highways	Restricted access	Refuse pollution
	Landfill disposal sites	Fracture of membrane	Groundwater pollution
	Incinerator disposal sites	Damaged by ground movement	Systems failure
Landslide	Highways	Restricted access	Ground and water pollution
	Disposal sites	Disturbed by ground failure	Systems failure
Volcano	Highways	Access restricted by lahar flow	Ground and water pollution
Snow	Highways	Restricted access	Ground and water pollution

**Table 5.15** Mitigation measures for solid waste

Preventive measures	Locate facilities on less vulnerable sites Minimize dependence on mechanical and electrical equipment
Spread the risk	Plan collection and disposal routes, with alternative options for vulnerable sections. Store collection vehicles in several locations, rather than a central depot.
Spread the responsibility	Encourage informal communities to arrange collection and delivery to an agreed point on the border of the area for compaction and final disposal. Encourage manufacturers and suppliers to collect, re-use or dispose of their waste products.
Cover or minimize the impact	Adopt a proactive policy for re-use and recycling of waste materials. Adopt a long-term proactive policy to gradually reduce quantities of waste, for example, by reducing packaging.

transport networks. An efficient system reduces the risk of surface water drainage systems being blocked by waste and of potential health problems.

Informal communities. Squatter areas and congested central residential areas are unlikely to receive a regular waste collection service, but they could be encouraged to deliver solid waste to a transfer station, for conveyance to a disposal site.

Surface water drainage and flood defence



City systems. The provision of surface water drainage facilities is often neglected during rapid and unplanned development. Pressure for urban land often leaves little space for waterways, and buildings encroach into areas which should be kept clear for drainage purposes. When a city expands, more ground is covered by impermeable surfaces and rainfall run-off is increased. The risk of flooding is thereby increased if the additional run-off is not catered for in a properly designed drainage system (Tables 5.16 and 5.17). Systems need to be planned and designed as integral parts of the city's development and installed before the building development takes place. All components of the system retain sediment, which needs regular clearance if the structures are to be effective over the mid- to long-term.

The overflow of streams is the most common cause of inland flooding and the most vulnerable areas are the floodplains. In large cities, floodplains tend to be areas in which much of the development is concentrated and, therefore, large parts of the built areas can be affected.

Sea surges generated by extreme winds combined with low pressure and heavy rainfall or tsunami waves can cause flooding in coastal cities, especially those which have expanded onto coastal swamp areas. Land subsidence, caused by, for example, the abstraction of oil or water, drainage of wetlands, or mining, and rising sea-levels relative to the land may increase the frequency of risk of coastal flooding.

Vulnerability of the system. The efficient functioning of a surface water drainage system can be disrupted in a number of ways. For example, pipes, culverts and channels can be blocked by debris, including uncollected refuse; they can fail by bursting or scouring under excessive surcharge; watercourses can overflow or their training walls and embankments can fail; and a power failure will de-activate pumps.

Table 5.16 Potential effects of natural hazards on storm water drainage and flood defence

Natural hazard	Component	Effect	Consequences
High winds	Lakes, balancing ponds	Surge waves	Overtopping and flooding
Sea surges/ tsunami	Pumping stations	Flooded, damaged	Local flooding, water pollution
	River levees	Breached, overtopped	Flooding of city
	Sea walls	Breached, overtopped	Flooding of city
Heavy rain	Channels, pipes culverts	Blocked with debris, burst	Surcharged and flooding, water pollution
	River levees	Breached, overtopped	Flooding of city
	Rivers	High levels, banks overtopped	Flooding of city
Earthquake	Channels, pipes culverts	Fractured, scoured	Local flooding, water pollution
	Pumping stations below ground	Damage from ground failure	Local flooding, water pollution
	Pumping stations above ground	Damage from ground motion, and liquefaction	Local flooding, water pollution
	Embankments and levees	Damage from ground failure	Flooding of city, water pollution
Landslide	Pumping stations	Damaged	Local flooding
	Rivers	Blocked	Flooding of city, water pollution
	Channels, pipes culverts	Fractured by ground movement	Flooding of city, water pollution
Volcanoes	Rivers	Blocked with lahar	Flooding of city, water pollution
	Channels, pipes culverts	Blocked with ash and lahar	Local flooding, water pollution

Table 5.17 Mitigation measures for surface water drainage

Preventive measures	Maximize the extent of gravity drainage, minimize the extent of areas requiring pumping stations Ensure that drainage systems are designed as part of land use planning activities. Ensure that drainage systems are installed before development is occupied Ensure that development is controlled to conform with the land-use strategy Ensure regular cleaning and maintenance of the system, especially before rainy seasons.
Cover or minimize the impact	Identify the failure mode when the flood exceeds the capacity of the drainage system. Establish procedures to minimize the effect of surface flood waters – develop surface flood ways through city streets and open areas



Some powerful land-grabbers have encroached upon both banks of the Sungal storm water drains running between Scheme 33 and the Block 4-a of Gulshan-i-Iqbal, along Ispanhani Road off Super Highway. The land-grabbers erected high rise buildings reducing the 100 feet width of the Sungal to 30 feet. Last year the residents had to take refuge on the rooftops to avoid the flood water (*Dawn Newspaper*, Karachi, 29 June 1993).

The likely extent and depth of flooding, covered either by rainfall, storm surge or dam break, can be estimated. Meteorological records and water level and rainfall infiltration can be used for flood warning purposes and tide data for operational warning of sea flooding. However, models are available for predicting flooding by a dam break. The risks of overtopping, or failure of river levees, embankments and coastal defences designed to offer protection from floods require special design attention, because the consequences of failure could be more destructive than the effects of flooding without embankments. A warning system and evacuation plans are essential.

Informal communities Informal communities should be encouraged to provide some form of surface water drainage system, with an outfall provided to an agreed point or points on the border of the settlement. Support can be provided by technical guidance, subsidized materials and regulation of standards. The development of unplanned communities in areas at risk should be prevented, if at all possible, if flood prevention measures are unpracticable. Where communities develop in river flood plains, or along flood canals or other major water courses, very little can be done to protect dwellings from flooding, warnings and evacuation routes become important to the saving of life.

Utilities

Gas and oil



City systems Gas supplies within a city may be of natural gas, delivered through high-pressure transmission mains and low-pressure distribution mains, town gas derived from oil or coal or liquefied petroleum gas delivered in bottled form or by tanker to on-site storage. Other fuels, such as fuel oil and kerosene are also stored and distributed in urban areas.

Vulnerability of the system There are various components in a gas-supply system which are vulnerable to natural hazards, i.e. well fields, processing plant, pumping and booster stations, transmission mains, storage tanks and bottled-gas stores, regulator stations, distribution mains and house connections (Tables 5.18 and 5.19).

Distribution of gas and oil relies on the provision of a supply main from the supply fields or port, and on transport facilities for conveying fuel to energy transfer works. Electricity is needed to operate gas pumps and control valves, and a communications network is needed to operate monitoring and control systems. Oil supply lines to refineries and depots, from ports and between facilities, although not dispersed across the city, could also be vulnerable.

Gas and oil infrastructure must be designed with a built-in safety system, as secondary hazards such as fire could be catastrophic. Even under normal conditions, distribution networks can be regularly fractured in numerous locations due to subsidence or other interference (see Fig. 5.3).

Systems safety – design To ensure the safety of a gas system and reduce its vulnerability to hazard events requires high standards of design, installation and maintenance; systems which have developed over many years, with a mixture of old and new pipelines and equipment, require special attention. The recommendations of the Institution of Gas Engineers (U.K.) (IGE) on transmission

**Table 5.18** Potential effects of natural hazards on gas and oil infrastructure

Natural hazard	Component	Effect	Consequence
High winds	Offshore rigs	Damage to	Restricted supply superstructure
Sea surge	Offshore rigs	Damage to substructure	Loss of supply, pollution
	Coastal refineries, tank farm bunds and other facilities	Damage from flooding	Loss of supply
Heavy rain	Refineries and other facilities	Damage from flooding	Loss of supply
Earthquake	Transmission and distribution system	Fractures from ground motion and failure	Explosions, leakage, fire
	Refineries and other facilities	Damage from ground motion and failure	Explosions, leakage, fire
	Offshore rigs	Damage from ground motion and failure	Explosions, leakage, fire
	Tank farms	Damage from ground motion and failure	Loss of supply, pollution
Landslide	Transmission and distribution system	Fracture from ground movement	Loss of supply, pollution
	Refineries and other facilities	Damage from ground movement	Explosions, leakage, fire
Volcano	Transmission and distribution system	Damage from lahar flows	Loss of supply, pollution
	Refineries and other facilities	Damage from ash and fumes	Restricted operation

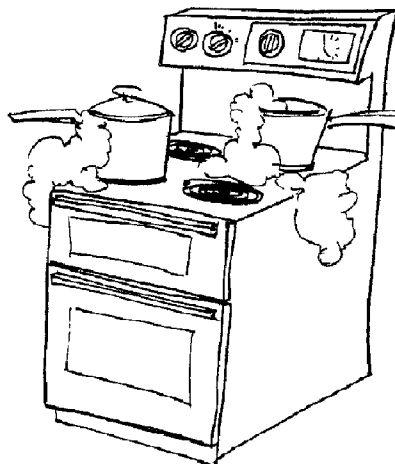
Table 5.19 Mitigation measures for gas and oil infrastructure

Preventive measures	Locate production and storage facilities, high-pressure mains and compression machinery in least-vulnerable areas. Provide local shut-off valves, controlled by local operators, to limit leakage (This is also recommended for sound operation of the system, easier repairs and loss reduction.) Provide valves on both sides of bridges and fault crossings. Use ductile materials such as steel or polyethylene to replace cast-iron mains in soils which could be subject to liquefaction or strong movement. Provide bunds around all ancillary oil equipment where the change in rigidity could precipitate a fracture
Spread the risk	Develop alternative sources of supply.
Spread the responsibility	Encourage, licence and control the provision of bottled and tanker supplies.



Figure 5.3

Automatic shut-off valves will reduce secondary effects



and distribution practice are acceptable standards worldwide, and include:

- IGE TD/1 Edition 3 1993 – Steel Pipelines for High Pressure Gas Transmission
- IGE TD/3 Edition 3 1993 – Distribution Mains
- IGE TD/4 Edition 3 1993 – Gas Services.

Equivalent national or international standards may be equally appropriate

Control of pressure and gas flow are key elements of the network and must include designed-in safety features. IGE/TD/9 and IGE/TD/10 recommend good practice for offtakes and pressure regulatory installations. There are many other aspects relating to gas network design and reference should be made to the appropriate technical data to ensure that the network is fit for the purpose.

The Natural Gas Corporation of NZ [New Zealand] Ltd uses various measures to mitigate the risk to gas mains which cross faults, according to the location. In rural areas, the main will be supported on trestles above ground, allowing relative movement between the pipe and the ground. However, where pipes are trenched across a fault the preferred solution is for the buried pipeline to cross at right angles, with the depth of burial minimized and the trench backfilled with light and preferably granulated material. In this situation, the main must be straight for a distance of at least 200 m on either side of the fault. The ground movement will then put the pipe in tension and not compression. An increase in wall thickness is also recommended for mains which cross fault lines (*Lifelines in Earthquakes*, The Centre for Advanced Engineering, University of Canterbury, New Zealand, 1991).

Systems safety – operations Safe operation of gas networks is the first priority of gas suppliers. If designed, installed and maintained in accordance with best practice, day-to-day control of the system is likely to be from a control centre facility, using communication equipment to monitor and control the system. Clear operating instructions to all personnel working on the system are essential. Guidelines are also important for non-specialist personnel working in the vicinity of gas installations.

Comprehensive safety recommendations are available from the IGE, including IGE/SR/20 – Recommendations for Dealing with Reported Gas Escapes. Gas suppliers should ensure that employees and contractors are trained to the level of competence necessary to safely complete routine tasks

Systems safety – emergency procedures. It is good practice to prepare for all anticipated incidents by the provision of written emergency procedures. These

must be produced by competent qualified people, suited to local circumstances, and tested regularly by practice drills with all people involved, both directly and indirectly. Regular in-depth training and briefing on emergency procedures should be given to all personnel.

Most modern industrial appliances are designed to shut off automatically in response to the drop in pressure which a major leakage would cause. Seismic shut off valves can provide additional protection in earthquake-prone areas. The restoration of services can take time because of the need for safety checks, but this delay allows leaks to be repaired, pipes to be purged of air, and gas pressure to build up. Numerous small leaks, which do not trigger automatic shut off, give more cause for concern and although identification and repair of fractures is still needed, safety depends much on the awareness of individual customers.

Actions in an emergency. Emergency procedures will define levels of emergencies and responses needed. For example, in a major emergency, initial action will probably require an assessment by a senior competent person, and the establishment of an emergency control centre is usually the first step in a major emergency affecting a large area. The location of control centres should be identified and specified in local and national emergency plans, and officers-in-charge nominated, who will ensure that emergency procedures are followed. Communication is vital, particularly with gas company personnel and emergency services.

In some emergencies, people will need to be evacuated before the integrity of the system can be secured. The make-safe and restoration phases of emergency procedures as recommended by IGE are comprehensive and detailed, and must be followed precisely. The person in charge will use emergency procedures and personal judgement to manage the emergency to a safe conclusion.

City systems. The components of a city's power supply system which may be affected by a natural hazard include power stations (thermal, geothermal, hydroelectric, nuclear), transmission lines, main and distribution substations, and distribution systems (overhead and underground) (Tables 5.20 and 5.21). Power stations may be within or near a city but are often remote.

Electricity generation and distribution



A prolonged breakdown in electricity supplies would disrupt economic, political and commercial activities, and would restrain long-term local and national economic development. However, many cities already experience acute shortages in supply because of insufficient capacity and the provision of electricity may be delayed for several years after the completion and occupation of buildings.

In Karachi, sudden temperature rises caused by heatwaves lead to increased use of air-conditioning and consequently to widespread overloading and shutdown of the electricity system. Planned power cuts are often used to restrain demand; standby arrangements are common, as are protests: 'Angry women attack Karachi Electricity Supply Centre complaints office in Nazimabad, partly damage two vehicles and furniture in protest against power breakdown in the area for the last three days' (*Dawn Newspaper*, Karachi, June 1993).

Vulnerability of the system. Power generation depends on supplies of primary fuels, and on the communications network, and electricity supplies are, therefore, at risk not only from direct effects of hazard events, but also from indirect effects. A reliable supply of electricity is in turn essential to the water supply, gas supply, telecommunications network, transport systems, and to hospitals, industry and commerce.

**Table 5.20** Potential effects of natural hazards on electricity generation and distribution

Natural hazard	Component	Effect	Consequence
High winds	Transmission towers and lines	Collapse	Loss of supply
	Generating stations, cooling towers, sub-stations	Damage and partial collapse	Loss of supply
	Distribution lines (overhead)	Collapse	Loss of supply
Sea surge	Generating stations, other facilities	Equipment flooded	Shut down
	Distribution cables (underground)	Flooded	Loss of supply
Heavy rain	Reservoirs	Overtopping of dams	Possible progressive failure
	Generating stations, other facilities	Flooded	Loss of supply
Earthquake	Dams	Damage from ground failure and motion	Loss of supply
	Generating stations, sub-stations, other facilities	Damage from ground failure and motion, e.g. isolators, equipment support frames	Loss of supply
	Distribution lines (overhead)	Collapse of lines and pole mounted transformers	Local loss of supply
Landslide	Dams	Failure from overtopping	Loss of supply
	Generating stations, other facilities	Failure by ground movement	Loss of supply
	Transmission lines	Failure by ground movement	Loss of supply
Volcanoes	Transmission lines	Swept away by lahar flows and short-circuited by ash deposits	Loss of supply

Transmission line towers designed to withstand extreme winds may resist the ground motion generated by some earthquakes, but liquefaction may cause foundation failure. The risk of failure at generating stations will depend on construction quality, design features and equipment types, such as use of rigid bases which are frequently shown to be susceptible to failure.

Vulnerability of the population. Where electricity supplies are routinely interrupted or inadequate, the population will have adjusted to this situation, and may therefore be less inconvenienced by possible disruptions caused by hazard events. However, increasing prosperity raises aspirations and increases demand for electricity, and disruptions to the supply may then appear more significant. Informal settlements rarely have access to mains power supplies, but some will make illegal and dangerous connections to the mains network, while others will install small generators.

Table 5.21 Mitigation measures for electricity generation and distribution

Preventive measures	Locate facilities in less vulnerable sites. Protect equipment where practicable (e.g. bunding substations against flood). Install more plant, hold spares, rehabilitate power generation installations, substations and electricity distribution, brace equipment.
Spread the risk	Develop alternative sources of main power supplies Avoid dependence on one main substation



The 1994 Northridge earthquake disrupted power supplies to a large number of customers; however, services were quickly restored:

Time	Number without power
Initially	2,000,000
By dusk	1,100,000
After 24 h	725,000
After 3 days	7,500
After 10 days	Virtually all power restored

Although power systems suffered significant damage, this event demonstrated the resilience of the Los Angeles electrical system, and the importance of redundancy.

Importance to the city. Electricity supplies are essential for many critical facilities in a post-disaster situation, including hospitals, water-pumping stations, media, and street lighting. Strategic facilities often possess alternative power supplies, but these are usually intended to cover brief interruptions in the main supply and therefore have limited fuel reserves. Prolonged disruption of the mains supply would stretch the capacity of alternative supplies, and may cause extensive health and economic damage.

City systems. The range of communications systems available has increased rapidly in recent years, and includes telephone systems, cellular radio telephone systems, private radio networks (both corporate and amateur), and radio repeater systems in the VHF/UHF bands (Tables 5.22–5.24).

Communications systems consist of a limited number of principal components including telephone exchanges (central offices), microwave radio equipment and communication towers, above ground and/or below ground distribution cables. The functions of principal components are discussed below.

- Remote line units (concentrators) – small units (capacity of 200–2000 lines) to which subscriber lines are connected, typically with limited stand-alone capacity, which are normally connected to a local exchange for wide-area connection, but can interconnect calls between its subscribers if connection to the local exchange is cut.
- Local exchanges (processors) – provide processing power and wide-area interconnection capability for concentrators. Each serves typically 10–20 concentrators.
- Tandem exchanges – used to switch telephone traffic between exchanges to reduce individual routes between local exchanges; not directly connected to customers' lines.
- Toll (trunk) exchanges – used to connect long-distance calls between exchanges; similar function to tandem exchanges.

Communications systems



**Table 5.22** Potential effects of natural hazards on communication systems

Natural hazard	Component	Effect	Consequence
High winds	Radio and TV towers	Disorientation of aerials Collapse	Disruption to or loss of transmission capability Complete loss of transmission
	Overhead cables	Collapse of poles Severing of cables	High fault rate Loss of service
Earthquake	Radio and TV towers	Damage/collapse	Complete loss of transmission
	Overhead cables	Collapse of poles, severing of cables	High fault rate, loss of service
	Underground cables	Minor quake: little damage Major quake: severed cables and broken ducts	High fault rate Complete loss of service
	Telephone exchanges	Minor quake: dislocation of printed circuit boards Major quake: collapse of building	Temporary loss of service Long-term loss of service
Heavy rain	Radio and TV towers	Interference with signal path	Temporary loss of service
	Underground cables	Flooded	High fault rate
	Telephone exchanges	Flooded Flooding and major damage	Complete loss of service Long-term complete loss of service
Storm surge	Radio and TV towers	Flood damage to radio equipment	Complete loss of transmission
	Overhead cables	Collapse of poles, severing of cables	Loss of service
	Underground cables	Flooding	High fault rate
	Telephone exchanges	Flooding and major damage	Complete loss of service
Volcanoes	Telephone exchanges	Failure of air conditioning due to dust	Temporary service disruption
		Lahar flow damage	Long-term complete loss of service

Table 5.23 Mitigation measures for communications systems

Preventive measures	Reduce the vulnerability of components as recommended in Table 5.24.
Spread the risk	Introduce network management Decentralize as far as possible. Build diversity into the system
Cover or minimize the impact	Install portable microwave radio antennae on roofs of all exchanges. Seek contracts with major international suppliers for support in disasters Provide as an emergency stock item, a standby portable (VSAT or Marine) satellite antenna

**Table 5.24** Reducing the vulnerability of communications components

Component	Vulnerability	Mitigation
Remote line units (concentrators)	Loss of power	Standby power
	Flooding	Careful site selection, provide splicing room above ground, dual cable vault pumps
	Isolation from processor	Separated links to processor
Local exchanges	Loss of power	Standby power
	Flooding	Careful site selection, provide splicing room above ground, dual cable vault pumps
	Earthquake	Anti-earthquake braces for equipment
Tandem exchanges	Loss of power	Standby power
	Flooding	Careful site selection, provide splicing room above ground, dual cable vault pumps
		Extensive interconnection with other Tandems
		Use of network management
	Earthquake	Anti-earthquake braces for equipment
Toll (trunk) exchanges	Loss of power	Standby power, dual power grid source
	Flooding	Careful site selection
		provide splicing room above ground, dual cable vault pumps
		Extensive interconnection with other Tandems
		Use of network management
	Earthquake	Anti-earthquake braces for equipment
Trunk routes	Cable routes affected by land dislocation	Diverse routing
	Collapse of poles	Deepen setting of cable poles
	Radio routes affected by strong winds	Diverse routing
Junction routes	As above	As above
Network management	Loss of power	Standby power, dual power grid source
	Loss of connection to exchanges	Alternative emergency routing
Cellular radio telephone	Loss of connection to fixed network	Alternative emergency routing

- Trunk routes – long-distance connections between trunk exchanges.
- Junction routes – shorter distance connections between local exchanges.
- Network diversity – ability of the network to route calls over physically different paths, separated by geography, by transmission media or a combination.
- Network management – ability to control flow of telephone traffic in a network by a combination of expansive and restrictive controls. Expansive controls allow more options for routing calls through a diverse network to enable traffic to bypass an area of damage. Restrictive controls reduce the



number of calls entering or leaving a point in the network to the level that the network can accommodate.

- VHF and UHF radio – systems operating over a short distance (line of sight) not usually capable of connection into public telephone systems
- Cellular radio telephone – connected via radio links to transmitters/ receivers with permanent connections to public telephone systems, offer full telephone access, including international calls. Instruments can be used from any cell (an area covered by a transmitter/receiver) operated by the company, and alter frequencies automatically if the instrument moves from one cell to another during a conversation

Vulnerability of the system. Telecommunications networks depend on a reliable supply of electricity. As Table 5.3 shows, every other component of the city depends on reliable communications and a hazard event will generate excessive demands on the system. This issue needs to be addressed.

The vulnerability of a network is concentrated within a few critical areas

- the supply of electricity to central offices for operation of exchanges
- potential damage to telephone exchanges due to their location
- local reticulation using copper conductors
- cabling between exchanges using fibre-optic cables
- ducts and cables entering buildings in areas subject to ground movement
- the misalignment of aerial systems for microwave radio
- unbraced equipment
- insufficient spare parts
- flooding of basement and ground floor equipment

The Philippines Long Distance Telephone Company is undertaking an extensive programme to reduce the vulnerability of its network, including, providing a figure-of-eight loop microwave system to enable alternative routing; providing standby generation and other emergency facilities in all telephone exchanges; and establishing special fire precautions.

Buildings and structures



General issues affecting construction

This section focuses primarily on buildings; however, its general principles can be applied, with a little variation, to other types of physical structures such as bridges, dams and tunnels. These other structures are not discussed in detail for three reasons: as bridges, dams and tunnels vary widely in physical form and function, it is difficult to make general statements concerning their vulnerability to hazards; and, as they generally form part of the physical infrastructure network, specific structures are discussed in more detail in preceding sections

Modern techniques of design and construction are increasingly complex and sophisticated, and incorporate extensive specialist techniques which reduce the impact of natural hazards upon physical structures. For new construction these techniques can be utilized to reduce the risk of building damage from hazard events. However, in practice these techniques are often not applied or are applied incorrectly.

The existing building stock of most cities will mostly predate such techniques and regulations. Lack of maintenance and alterations or additions will also affect the quality of many buildings. The 1995 earthquake in Kobe, Japan, tragically illustrated the vulnerability of an ageing building stock, even given the existence of building codes thought adequate at the time of construction.

Building regulations, standards and codes of practice exist to ensure new construction is appropriate to characteristics of the local area and is of an acceptable standard in terms of safety and quality. These regulations are based on existing documents used in other, more highly developed countries, and are then gradually revised to reflect local conditions. The location and nature of buildings are also influenced by planning regulations and local byelaws. However, in many countries, although regulations are generally satisfactory, their application is severely inadequate. Application is dependent upon the capacity of the building control department to monitor and control all stages of all design and construction work; is an enormous task for which resources are often completely inadequate.



Other factors which influence the construction process include the size of the local labour market and its level of experience and technical skill, type, quality and cost of materials available, predominant ownership patterns and methods of financing construction. In practice, technical skills are often concentrated on large projects, resulting in poor standards of construction on smaller projects.

Ownership patterns can give an indication of the degree of vulnerability of building types.

Ownership patterns

- Ownership by a government agency is most common for buildings which are designed for public use and for government offices. As government agencies generally have access to expert technical advice and can command the resources required, such buildings are now often designed and constructed to relatively high standards by qualified professionals. However, existing building stock is generally based upon standard designs which predate these technical developments.
- Ownership by the private sector is common for commercial and industrial premises. These companies also generally have access to the resources and expert advice required for a high standard of construction. However, as their objective is essentially to create profits, they may see little incentive to meet high standards unless the wisdom of so doing is explained to them.
- Ownership by the private sector is also common for residential buildings occupied by tenants. This category extends from established property development agencies owning a range of properties to individuals owning one or two properties. The profit objective is the common feature, and can often result in properties which are overcrowded and badly maintained.
- Many residents are also owners of their properties, and therefore have some incentive to ensure that the building has been properly constructed and is adequately maintained. However, this may not occur in many cases due to lack of awareness or lack of resources. Residents of informal communities generally construct their own dwellings using any materials that are available and without access to technical advice or professional assistance of any kind. Although these dwellings are generally of a low standard by conventional criteria, it is their vulnerability to natural hazards which is of immediate concern.

It is important to distinguish between the general standard of design and construction and the specific application of hazard-resistant principles; an expensive building of complex construction may be no more resistant to particular hazards than a simple dwelling in the informal sector. For each type of building, the priority should be to identify specific features which make the building more or less vulnerable to specific hazards.

Vulnerability to hazards



The principles of hazard-resistant construction are based upon an understanding of hazard processes. For example (see Fig. 5.4):

- Earthquakes produce horizontal ground movements which are amplified by the structure itself, affecting the stability of the structure and often cause partial or complete collapse. They may also result in liquefaction, which induces failure or collapse of the foundations. Heavy roofs may hasten the collapse of unstable structures.
- Extreme winds produce horizontal surface loading, mainly in one direction, which may lead to partial or complete collapse. They also produce uplift loading on roofs; light roofs, if not designed to resist these forces and fastened securely, can be torn off. This in turn will remove lateral restraint to the top of the walls and progressive collapse of the building as a whole.
- Volcanic eruptions and tsunamis have great force and will destroy or inundate buildings in their path.
- Floods can cause buildings to collapse through scour or unequal pressures, and can cause gradual deterioration of the building and its foundations.
- Landslides produce directed loads, the angle of which can vary widely; the degree of loading will depend on the speed and weight of material involved.

Considerable research has been undertaken in recent years into quantifying the vulnerability of buildings and structures; some examples are given in Chapter 4.

Mitigation measures

Although land-use planning and preparedness measures will often provide the most significant contribution in mitigating the impact of the other hazards mentioned, hazard-resistant construction principles can be extremely effective in mitigating the impact of earthquakes and extreme winds (Table 5.25). For example, these principles and potential weaknesses include an understanding of the characteristics of different building materials; recent earthquakes have illustrated the severe vulnerability of masonry structures, of poorly constructed reinforced concrete structures and, in isolated cases, of fabricated steel.

Improved application of building regulations, standards and codes of practice, are valuable long-term objectives (together with general improvements in design and construction standards). Designers, builders and occupiers could be encouraged to adopt improved standards through the provision of financial

Figure 5.4
Relationship between
earthquake intensity and
building damage.
Source: The Great Hanshin
Earthquake, Japan. Alexander
Howden Group Ltd, 1995.

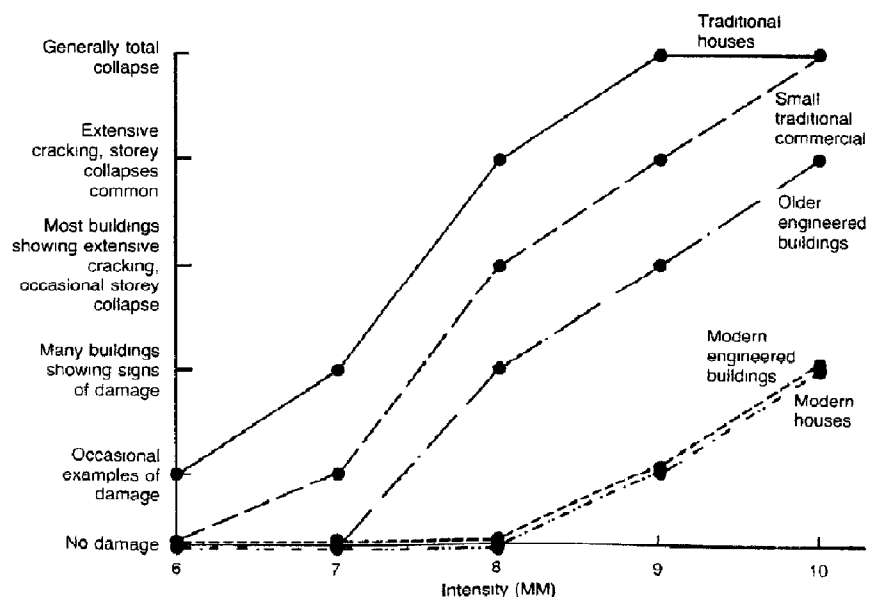


Table 5.25 Mitigation measures for buildings and structures

Preventive measures	Ensure good land-use planning to locate buildings in less vulnerable areas. Teach tradesmen and building officials the ABC (Anchorage, Bracing, Connections) of building construction. Develop model hazard-resistant dwelling types of various sizes and standards, and promote their widespread adoption Encourage the use and periodic updating of relevant codes of practice and building regulations. Encourage the proper construction of relevant designed buildings. Three basic principles can help guide development workers to understand the weaknesses, strengths and potential improvements which can be made to local construction to resist natural disasters of all types (Dr R. Spence, Cambridge University). The principles are (a) Provide sideways support – the building should be designed so that walls, roof and floors provide mutual support. Walls should buttress each other. The roof and floors should be used to provide additional horizontal stiffness. Windows and doors near corners should be avoided. (b) Provide strength in tension – timber- and concrete-frame buildings should have strong joints which will not pull apart. Earth, stone and brick buildings should be tied together with timber or steel. Roofs should be firmly attached to the walls. (c) Encourage local good practice – the observance of locally evolved good practice regarding such things as sound foundations, a sensible choice of location, good materials, and regular maintenance will usually go a long way towards achieving safer buildings
Spread the risk	Through land-use planning, develop provision of facilities in several centres throughout the city.
Spread the responsibility	Make owners responsible for ensuring that buildings and structures have been designed to withstand potential hazard events. Encourage buyers to insist on a hazard audit and make a hazard building audit report an essential part of any deed of sale. Make the construction industry legally responsible for setting and maintaining standards Promote awareness amongst designers and building officials of the increased vulnerability resulting from architectural features such as soft storeys, dramatic changes in shape, balconies, infill panels, cladding details, orientation, proximity and ?
Cover or minimize the impact	Provide designated buildings or parts of buildings as shelters



incentives (such as low interest loans and grants, subsidized materials, tax relief, and reduced insurance premium); many of these measures could be implemented or facilitated by the city government.

Providing training in the basic principles of safe construction should also be a high priority, and could initially focus on residents of the informal sector. Fundamental understanding of these principles is often restricted to a small circle of specialist professionals within the construction industry; the long-term objective



should be to disseminate understanding throughout the industry (and associated groups such as the insurance sector) as widely as possible.

A recent proposal to improve quality in the construction industry included the following recommendations.

1. Identify the builders and stakeholders in construction and survey the nature, size and culture of the construction industry.
2. Identify the points of leverage to improve construction quality.
3. Focus on the requirements for improved hazard resistance. (Paper by A. G. Davenport for the United Nations World Conference on Natural Disaster Reduction, 1994)

It is the third recommendation, to which this chapter aims to contribute, which is now of the highest priority.

Summary of main points

- The potential effects of hazard events on each element of the city's infrastructure should be studied in detail
- Hazard zonation maps should be used to identify areas suitable for development.
- Resources should be concentrated on reducing the vulnerability of key components of the infrastructure, particularly those of post-disaster significance.
- The planning, design and construction of new infrastructure should incorporate disaster mitigation principles;
- Infrastructure networks should, where feasible, incorporate duplication and redundancy to allow operations to continue if individual sections are damaged.
- Response plans should be designed to minimize the time required to restore each section of the infrastructure to normal operation.
- Where resources are limited, technical guidance and other forms of support should be provided to enable informal communities to install and maintain basic infrastructure and services within their area

Human dimensions in disasters

6

Survivors said that there were two particularly hot and sultry days, unrelieved by occasional showers, which developed into a thick fog. The water in the wells muddied and noises were heard, followed by climatic flashes and an ear-splitting bang before the earth began shaking violently, destroying or damaging most buildings in the city. 240,000 people perished because the people had not been prepared nor the buildings made strong enough. The social life and economy of the city was ruined (*The Great Tangshan Earthquake of 1976: An Anatomy of a Disaster*. Pergamon Press, 1988).

Social perspective



It is people who suffer as a result of disasters and of a lack of preparedness and disaster mitigation measures. It is also people who will prepare for and mitigate the impact of disasters. It is, therefore, vital to develop a social perspective on disaster mitigation and preparedness.

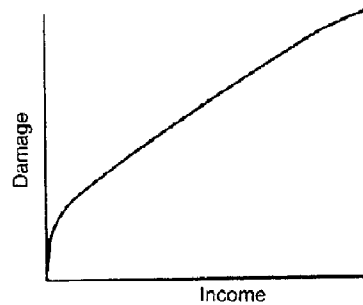
In most large cities there will be specialists in planning, architecture, engineering and science who are in contact with a world-wide network within their discipline. Knowledge of the effects of natural hazard events is extensive, and the planning and engineering solutions to mitigate the effect of these hazards are well established. So why does instituting mitigation measures remain a problem? To some extent this is because of the low priority accorded to mitigation compared to other needs of the city. It is also partly because mitigation plans often ignore the people and their needs when planning and setting priorities and when considering implementation, or assume that people form one homogeneous group with the same needs, abilities and aspirations.

For example, it is easy enough to see how people with different levels of income are likely to be affected differently by the same event. If it is assumed that the investment that households make in their housing and other property varies with their income level, then it is likely that the damage suffered will be similarly related. However, low-income households tend to invest a relatively high proportion of their capital income in housing; although in absolute terms their losses may be low, these losses will represent a comparatively high proportion of their income.

This is graphically illustrated by Fig. 6.1, where the damage line rises steeply and then flattens out to reflect the probable lack of mitigation by owners of the cheapest structures and a correspondingly greater investment made to safeguard more expensive structures. The generally rising line reflects the increase in material damage suffered as incomes rise.



Figure 6.1
Amount of damage to housing
and property in relation to
household income



However, the vulnerability to disaster of different income groups reduces with increasing income. This is partly because more expensive structures are more likely to have been engineered and therefore to incorporate mitigation measures in their design and construction, but also because more prosperous households are more likely to live in planned areas that should be less vulnerable to hazards such as flooding, landslides or mudslides. Poorer households (and certainly the poorest households) are likely to live in marginal locations, the low value of which often reflects their vulnerability. This is shown in Fig. 6.2

For the poorest households, the greater concern is not how to reduce the effect of the disastrous events that are the focus of mitigation planning, but how to cope with the more immediate need to survive, to ensure an adequate livelihood and to prevent being evicted. These are perceived as much more real and pressing than events that may happen at some distant point in the future. In many situations, even where a household knows that the land it is occupying is liable to be inundated every year, as happens for example in many parts of Bangladesh, it nevertheless affords a living, and there is always the hope that the next year's floods may not be as catastrophic as last year. If this relative concern for the hazards of everyday living is compared to that for isolated disasters, it is likely that this will vary with income, as shown in Fig. 6.3.

Cynics might claim that these households deliberately take such risks knowing that they will be bailed out by society in the event of a disaster. Even if it were true, surely it does not reflect well on society that some members have to resort to such desperate measures merely to obtain something so basic as housing.

Income has been used as one variable to suggest how different groups in the same city are likely to react differently to different hazards and to different types of mitigation measures. Analyses for different social, ethnic and cultural groups will show a similar variance. Gender, age and other such differences are likely to impact upon the perception of hazards and willingness to adopt mitigation measures.

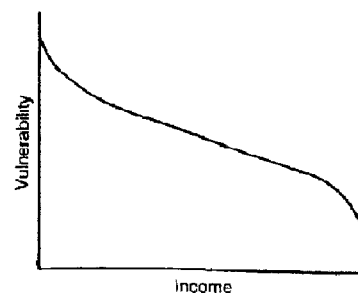


Figure 6.2
Vulnerability of households to
disaster in relation to household
income

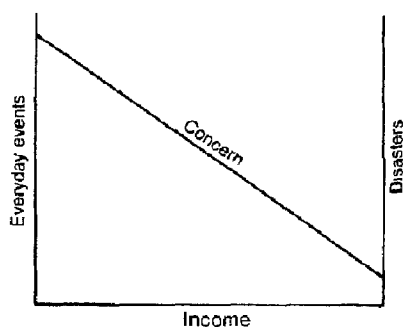


Figure 6.3
Income may influence the predominant concerns of households

Therefore, before any mitigation or preparedness plans can be developed the socio-economic environment of the city needs to be understood. This should incorporate a perception of

- the social structure of the city classified by social groups according to their socio-economic, cultural, ethnicity, age, gender, and religious conditions
- the vulnerability of the various social groups to disaster events
- the nature of all (not just disaster focused) existing strategies for coping classified according to social group
- the nature and roles of existing social support networks
- the city's institutional framework (community, private and public)
- the city's formal approach to disaster management and development including the division of existing responsibilities for disaster preparedness and mitigation

Understanding the social situation involves identifying and characterizing the range of coping strategies and reasons for any differences, such as the ethnic, religious, cultural, economic or political context. The extent to which people are integrated into coping strategies should be assessed. Are women and children, for example, more vulnerable to disasters than men because they are more likely to be trapped in the home? Are women's clothes more likely than men's to cause them to drown? Are the elderly or disabled more vulnerable? Poverty and gender are likely to be significant determinants of vulnerability to disaster in much the same way as they are of other aspects of development and access to opportunities and benefits. Consequently the most vulnerable groups should become a principal focus of mitigation and preparedness planning.

Analysis will depend on the availability of information. In most countries a great deal of data are available from many sources, such as national, regional, provincial and city institutions, research agencies and non-government organizations (NGOs).

Information is of two main types. Primary information is new information collected for a specific purpose. Secondary information is derived from existing material, and may include published and unpublished documentation of various kinds, including statistical data collated from regular surveys (such as national censuses and household surveys), 'one-off' surveys, official records and reports both within government institutions and in non-government agencies in the community or private sectors.

Good-quality information is essential if there is to be timely and realistic preparedness and mitigation, and appropriate decisions relating to change in policy or action are to be made. However, where information is collected primarily for other purposes, the approach may be inflexible, or may not relate to the precise area of interest, or may be costly to undertake and lack the speed of publication required for the results to be useful to policy makers and managers concerned.



with disaster preparedness and mitigation. The quality of information can be evaluated in terms of:

- its relevance and clarity – do the data available provide the information needed and relate to the precise area of interest?
- its timeliness – can data be obtained when needed?
- its cost – is it affordable in terms of the human effort or financial costs involved in its collection?
- the regularity and frequency of its collection, interpretation or publication
- its reliability and accuracy.

Disaster preparedness and mitigation should focus on the collection not only of quantitative information but also of qualitative information. Large collections of data, especially when they have extensive geographical coverage, take a long time to process. A small focused survey or study, designed to meet specific requirements and emphasizing the collection of qualitative data, should be more readily accessible. Specific problems highlighted by such a survey can be explored in more depth and detail at a later date if necessary.

Approaches to quantitative data collection such as random sample survey techniques are well known. Techniques for qualitative information, which are less well known, include 'rapid appraisal' techniques. Guidance on using these techniques is given in Chapter 9. During the past decade the phrase 'rapid appraisal' and its various synonyms (rural reconnaissance, rapid low-cost methods, intermediate methods) have entered the vocabulary of the development professions.

The rapid appraisal (RA) method has a number of strengths, three of which are pertinent to preparation for disasters and mitigation of their results. Firstly, they can be completed quickly. Secondly, it is possible to reach a large number of communities and individuals in a short period of time. In view of the limited resources available for all planning and management activities in large cities this advantage is invaluable. Thirdly, as explained by Kumar (K. Kumar, ed. *Rapid Appraisal Methods*, World Bank, 1993), they are particularly appropriate when (as is the case with understanding and evaluating the nature of existing coping strategies and the nature and roles of existing social support networks):

- there is a desire to hold extensive discussions with householders, in order to gain insight into their economic and social environment, the institutional constraints they face in adopting recommended innovations, and their views and perceptions about development intervention
- an understanding is required of the motivations and attitudes that may affect peoples' behaviour, in particular the behaviour of target populations
- the primary purpose of the study is to generate suggestions and recommendations
- available resources are limited.

Once a detailed picture of the social organization and structure has been established attention should focus on identifying the range of needs of those likely to be affected by the different hazards to which the city is susceptible. At this point it should be possible to begin strengthening the social institutions (family, religious, political) and to enhance the role of existing coping mechanisms in absorbing the shock of a disaster. This can be attempted as an integral part of the development process, through institution building, increasing the number of coping mechanisms and broadening the contacts of local groups.

Using the analytical approach suggested above, it should be possible to develop a matrix of the type shown in Table 6.1, in which various social groups in the city are mapped against each hazard. The level and type of risk is shown in the intersection, thus indicating who is at what risk from which hazard.



Table 6.2 shows the mitigation strategy that each social group currently deploys in order to cope with the particular hazard. These refer only to disaster events, and for many groups the coping strategy will be dictated more by everyday hazards. The investigation of coping strategies needs to be done with care, because they may not be apparent to the casual observer nor to one who uses a set of values at variance with those of the particular social group. Through informed discussion with the people themselves, both the objectives and the mechanisms of coping strategies can be ascertained.

In some cases the coping strategy adopted by a particular social group may be adequate to reduce or minimize the risk of that particular hazard to an acceptable level. In other cases, the coping strategy may be inadequate, reflecting perhaps the inability of the group to either perceive the need for, or to conceive of or perhaps to implement a more effective strategy. In each case, however, city planning and management actions may have an impact on the coping strategy. For example, a perfectly acceptable coping strategy may be rendered ineffective if the city authorities enforce rigorous planning or building regulations. In the case of an inadequate strategy, supporting intervention by the city authority is of course crucial. Such support may be legislative or advisory, or may be in the form of access to more appropriate construction materials, or even strengthening of the structure. Table 6.3 suggests types of support which city authorities could provide to enable different social groups to cope with disaster events.

Approaching the issue of mitigation and preparedness in this manner provides an opportunity for external mechanisms such as international agencies, governments and national bodies, which invariably are involved, to 'harness' and enhance rather than to inadvertently break up internal coping mechanisms.

The objective of this planning phase should be to increase the degree to which city residents and municipal authorities together have the capacity to take effective action in facing the threat of disaster. This may involve sharing successful experiences and strategies among identifiable groups and institutions within the city, developing and restructuring institutional networks from the local level up to provincial level. Emphasis needs to be placed on developing an integrated and participatory mitigation and preparedness process within the city context. This should be cooperative and collaborative, operating both horizontally and vertically.

Table 6.1 Who is at risk from which hazard?

Social groups	Hazard				
	Earthquake	Fire	Flooding	Landslide	Cyclone
Upper income suburban households	Limited	Limited	Restricted access	Limited	Not applicable
Fringe squatters	Structural damage	Whole settlement at risk	Whole settlement at risk	Not applicable	Extensive roof damage
Women-headed households in fringe squatter settlements	As above	Trapped inside	As above	Not applicable	As above
Children in inner city squatter settlements	High risk from surrounding structures	High risk	Low risk	Low risk	

**Table 6.2** What coping strategies are being deployed?

Social groups	Earthquake	Fire	Hazard		
			Flooding	Landslide	Cyclone
Upper income suburban households	Building codes	Limited	Landfill above flood level	Pile driving and slope stabilization	Building codes
Fringe squatters	Lightweight structures – cardboard	None	Some building on stilts	None	Weighted with stones
Women-headed households in fringe squatter settlements	As above	Outdoor kitchens	As above	None	
Children in inner city squatter settlements	Street sleeping				

By developing an effective institutional framework, major mitigation activities can be undertaken more effectively and efficiently. Activities include settlement planning to reduce settlement vulnerability, economic diversification, strategic placement of job and income generating activities, to include the siting of industry, services (e.g. hospitals) and communications (e.g. radio stations), public education and housing improvement plans. This overall process is part of a vulnerability reduction strategy.

The more thoroughly and seriously the above measures are implemented, the less will be the likelihood that the following common mistakes in mitigation will be made:

- placing responsibility for certain mitigation activities in the wrong type of organization
- insufficient direct contact with people and over-reliance on regulatory measures
- failure to identify all disaster threats
- failure to determine the complete range of options
- failure to incorporate vulnerability reduction in routine development planning and activities.

Table 6.3 What support should be provided?

Social groups	Earthquake	Fire	Hazard		
			Flooding	Landslide	Cyclone
Upper income suburban households	Inspections, advice	Inspections, advice	Warning signs	Inspections, advice, slope protection	Inspections, advice
Fringe squatters	Information, advice	Form fire-breaks	Diversion of stream, channelization	Inspections, advice	Building of shelters
Women-headed households in fringe squatter settlements	As above	Safer stoves		Inspections, advice	As above
Children in inner city squatter settlements	As above				

Effective and sustainable disaster mitigation requires the development of an institutional planning and management approach which is different from the 'emergency' response which dominates the current process.



Preparedness requires a similar integrated participatory approach and should be considered as an extension of the mitigation process. Using this perspective it is possible to see how such an approach can positively contribute to the pre-determination of effective warning and evacuation procedures, appropriate modes of involvement, the development of tools needed by emergency staff, the development of plans for the actual response to disasters, training for crisis operations, and strategic stockpiling. Areas at risk need to be determined and mapped, and vulnerable settlements identified. Possible responses need to be examined, available resources estimated and deficiencies listed. Then a preparedness plan can be developed.

An integrated and participatory approach should greatly enhance these related processes. It should bring together a wide range of experience and knowledge concerning all aspects of the city. Careful organization is an obvious prerequisite but should be simplified if mitigation and preparedness are part of the overall development planning process. By integrating as much experience as possible in a comprehensive and structured way, the level of understanding of the situation at hand (an important aid to the mitigation and preparedness process) should increase greatly.

The above discussion is general, and emphasizes a particular approach to, or perspective on, disaster mitigation and preparedness. There is, of course, a need to put this approach in context. Its advantage is that it does not distinguish between the identification of issues (which involves detailing the cultural situation and ascertaining expressed needs) and the development of a plan. Both are part of one process which incorporates the same participants at all times. This is a logical approach but one which has been missing in other domains of development until the recent past.

Some specific social issues which are likely to be relevant but will require added details and substantiation in context are as follows:

- decentralization rather than centralization of activities should be achieved where possible
- intermediary bodies, NGOs and religious organizations should be incorporated into predisaster planning
- community groups should be established, each with assigned tasks
- training should be accorded adequate (high) priority
- the local informal powerbase should be understood and utilized where possible
- coordination of disaster activities should be planned between industrial, commercial and residential areas. Mitigation and preparedness plans for both need to exist at all times of the day and night. Workers will want to either get home or feel assured that their family stands a good chance of surviving when a disaster strikes
- the leadership, governance, decision-making and organizational skills of ordinary people should be developed and utilized. Such attributes exist however poor people may be
- outside aid must be provided in ways that recognize and support the capacities and resources of the people
- early warning systems need to be simple and intelligible to all persons
- for every sector of the city there should be clear understanding of what to do when a warning is given or a hazard event occurs



- the implications of false alarms should be understood
- any indigenous warning, mitigation and preparedness measures should be utilized
- public awareness should be developed and sustained through schools, adult classes, radio and television programmes, community and theatre groups, leaflets and drills
- in all social situations alternative access must be available to facilitate 'means of escape'
- buildings which can act as refuges during and after a hazard event must be clearly identified, and their toilet and water facilities upgraded if necessary
- the siting of disaster shelters and stockpiled resources should be carefully appraised to conform to inhabitants' needs where possible.

Human reactions to natural disasters are listed in Table 6.4.

Social and health needs after disaster

Relocation of displaced persons



In the event of an earthquake or windstorm, buildings are damaged and destroyed. Survivors are displaced to the extent that their homes may be uninhabitable but, in general, they are not necessarily displaced away from their community. This presents an opportunity for the relief and rehabilitation phases following disaster as many social structures can be retained. Maintaining the social *status quo* avoids the problems of losing skills, morale and social support and coherence, characteristic of many other situations in which people are displaced over considerable distances away from their home communities.

If a flood or mudslide causes a disaster, survivors often have to be moved considerable distances away, to camps where social cohesion is difficult to maintain, and a culture of dependency can rapidly grow. As a result, recovery time until resettlement in their home community can be greatly extended.

Whatever the nature of the disaster, several features are common. Natural disasters typically strike suddenly and often without warning. People lose their homes and possessions, many lose relatives and friends and are thus faced with disaster at a time of bereavement. Many will be in shock. Needs in the immediate aftermath are great and resources are almost invariably unavailable. Following a natural event such as an earthquake or flood, inept management of the response can compound the initial effects.

The immediate human need is for shelter (especially in cold weather), first aid and clean water. Low temperatures and rain or snow can cause death from exposure within a few days. People need water every day and if clean water is not available, thirst will drive people, within hours, to drink water they know to be dangerous. Following the provision of safe water, there is a need for food and epidemic control measures. Thereafter comfort can be provided with the provision of blankets, clothing, medical attention and more comfortable accommodation.

Despite this well-recognized hierarchy of need, responses often focus on the rescue of individuals and provision of doctors and food, rather than measures such as vaccination and provision of water supply which will eventually prevent the loss of life in huge numbers in the days and weeks after the event. When developing preparedness plans it is vital that the broader picture is understood by all so that the organization and management of key elements receives wide acceptance.

Table 6.4 Human reactions to natural hazards (adapted from a table by Key, 1988)

Stage	Time relative to event	Reaction	
		Positive	Negative
1	Before event	Understand warnings, preparedness	Panic, fear
2	During event	'What should I do?'	Fatalism: 'Act of God'
3	1 min to 1 day after event	Response by survivors, initial search and rescue	Looting; sight-seeing adding to traffic chaos
4	1 day to 1 week week after event	Community effort, search and rescue by emergency services	Increase in price of basic food and commodities
5	1 week to 1 month after event	Provision of temporary camps, burial of dead, analysis of problems	Provision of wrong food and medicine, disposal of dead
6	1 month to 1 year year after event	Clear up debris, commitment for major rehabilitation projects international funds	Provision of unsuitable and unacceptable temporary accommodation, allocation of blame, corruption and misuse of emergency funds
7	1–5 years	Some mitigation work, some progress on rehabilitation	No visible evidence of damage, bureaucracy and aid-fund accountability delays rehabilitation and reconstruction
8	5–30 years after event	Increased mitigation works, review preparedness and response programmes	Conflicting objectives lead to relaxation of building regulations to reduce cost of social housing, smaller event produces same effect on larger city
9	Until next major event in 100 200 or 500 years	Steady programme of mitigation works	'Not happened in my lifetime', no votes for mitigation, funding reallocated
10	Next major event	See stages 1–9 above	Urban area much larger, effect much worse.



The timing, management and usefulness of assistance provided by outside agencies must be considered very carefully. Many NGOs and government agencies wish to respond to the rescue phase as well as to the recovery period following a disaster. However, rescue of victims is most effectively done by local people and organizations because they are able to do so much more quickly than outside agencies. International groups can sometimes impose a further burden on local resources by arriving in an unplanned way. Greater benefits would accrue from the provision of water supply kits and engineers, or of telecommunications support and repair teams.

Relief supplies often include large quantities of unwanted medicines which are inappropriate for the local situation and labelled with foreign brand-names which local relief workers cannot identify. Typically less than 30% of donated drugs are suitable for emergency use. The World Health Organization has developed



*Recovery, identification
and burial of the dead,
and care of the
bereaved*

emergency health kits, the contents of which vary according to the needs of specific situations.

Preparedness plans should address each stage of the post disaster period, tackling needs in order of priority, and allocating resources accordingly. The most effective response is likely to be one which establishes planning, response, facilities and resources on a local level. This minimizes complications arising from chains of command which work well under normal circumstances but may be unsuited to a disaster situation and even exacerbate the difficulties faced.

Hodgkinson and Stewart (*Coping with Catastrophe*, 1991) identified four main factors which contribute to the recovery of the bereaved:

- the type of death, and the extent to which the survivor feels responsible
- their relationship with the bereaved
- psychological characteristics of the bereaved, such as their ability to express emotion
- social circumstances such as the absence of family, isolation from cultural or religious support systems, employment situation, degree of social and economic stability, and the effects of other losses.

It has been estimated that one-third of bereaved people may need counselling to help them to accept their loss. Appropriate burial or cremation of the dead is a major priority in most countries. Respect for the dead can sometimes outweigh the needs of the living; for example, blankets given to refugees for warmth have been used as shawls for the dead. The psychological impact of fatalities on relatives, friends, communities and the emergency services is often disregarded or underestimated. However, an understanding of this impact must form part of any disaster preparedness plan.

Several common responses to the health problems posed by disaster are inappropriate. For example, as corpses tend not to pose a health hazard, hasty liming, communal internment or mass cremation do no good medically and tend to demoralise the bereaved relatives. Moreover, contrary to popular belief, spraying people with disinfectant and bulldozing rubble will not have any effect on disease rates (*Natural Disasters*, David Alexander).

*Search, rescue and
medical care of the
injured*

Much information is available on this topic, including statistics on injuries caused by natural hazards. For example, studies of one earthquake showed that out-patient treatment was sufficient for 90% of injuries, with only 10% requiring hospitalization. Less than 50% of people trapped inside collapsed buildings can be expected to survive for more than 2–6 hours, and 85–95% of rescues are made within a day after the event. There are also studies of the types of injuries most common at different stages after the event, for example, psychological trauma is usually manifested after about three days.

Factors influencing the number of fatalities and the type and extent of injuries caused by an event include the time of day, social strata, topography, strengths and weaknesses of the communities, religious customs and dwelling types.

The initial response to an event will be by surviving members of the local community, who will need to undertake search and rescue work and to provide initial first aid. The significance of their contribution cannot be emphasized too strongly, and enhancing their capacity to respond effectively should be given high priority.

Disasters do not generate 'new' diseases but, by altering the environment, they may increase transmission of diseases that already exist in a region (PAHO, 1982).

Veterinary surgeons have an important role in the control of disease and in protecting people from the effects of natural disaster. In most cases their work will need to be coordinated with that of human response services such as health, fire and police services. Cross-disciplinary action and mutual collaboration are therefore of primary importance in launching operational programmes which cover preparedness, mitigation, response and rehabilitation (Table 6.5).

Control of disease vectors, animals and food supply



Disease vectors. A secondary effect of natural disasters is the breakdown of the public health equilibrium and the development of animal-related emergencies caused by epizootic (rapid disease or pathogen among many animals) and zoonoses (disease transmitted from lower animals to human beings). Particularly within informal communities, natural disasters weaken those who are already weak and encourage diseases which have been controlled, as disturbed pathogens may proliferate. In general, populations of mosquitoes and other potential disease vectors increase after cyclones and tropical storms, as water which has collected in roof gutters and various types of litter provides new breeding habitats.

After such an event action must be taken to reduce the potential of disease transmission, for example, street-cleaning programmes and health education campaigns on issues such as the safe storage of water. During and after a disaster, regular water supplies may be interrupted and people may store water in inadequately covered containers. In such habitats, mosquito vectors of dengue, yellow fever, malaria, lymphatic filariasis and other diseases can multiply rapidly, causing nuisance through biting and the potential transmission of disease if the agent is endemic or introduced.

Blame for the plague outbreak can be laid at the insanitary door of *rattus rattus*, the black or ship rat. The species is susceptible to bubonic plague, which is passed onto humans by fleas looking for a new host when the rats die. Human bubonic plague victims swiftly develop lung infections. Their coughing spreads the disease in a new form, pneumonic plague (Maharashtra earthquake secondary effects, *Daily Telegraph*, 30 September 1994).

Public health officials, including the veterinary surgeon, need to plan for intervention in response to these potential emergencies, by utilising local knowledge and through anticipation and prevention of possible emergencies based on the means and resources available. Effective preparedness measures will ensure that adequate resources are available, and effective mitigation measures will ensure that the emergency is contained. Planning intervention measures enables rapid and efficient operation in the event of an emergency. Preliminary activities are a basic prerequisite for effective intervention in any emergency, and include surveying the area concerned, identifying the competent authority, establishing priorities, acquiring the necessary judicial tools, preparing an action plan and providing accurate news bulletins for the media.

Food supply. Protection of safe food supplies is likely to require the cooperation of veterinary surgeons from different regions, to ensure that the region affected by a natural hazard receives an adequate supply of wholesome food. Veterinary surgeons and public works officials would need to ensure that transport systems were operating and that cold stores were maintained at the correct temperature, that food supplies affected by chemical or radioactive substances were condemned and destroyed, and that diseased animals were also destroyed. If people or animals are



Table 6.5 Immediate and delayed effects of disease vectors (from *Emergency Vector Control After Natural Disaster*, PAHO, 1982)

Vector	Immediate: 1–7 days	Delayed: + 30 days
Filth flies	Annoyance	Diarrhoea, dysentery, conjunctivitis, typhoid, cholera, fly larvae infestation, annoyance
Mosquitoes	Bites and annoyance	Encephalitis, malaria, yellow fever (urban), dengue, filariasis, annoyance and bites
Rodents	Rat bites	Rat bite fever, leptospirosis, salmonellosis, rat bites
Lice	Bites and annoyance	Epidemic typhus, louse-borne relapsing fever, trench fever, bites and annoyance
Fleas	Bites and annoyance	Plague, endemic typhus, bites and annoyance
Mites	Bites and annoyance	Scabies, rickettsial pox, scrub typhus, bites and annoyance
Ticks	Bites and annoyance	Tick paralysis, tick-borne relapsing fever, Rocky Mountain Spotted Fever, tularaemia, bites and annoyance
Bed bugs, kissing bugs	Bites and annoyance	Bites and annoyance, Chagas' disease
Ants, spiders, scorpions, snakes	Envenomization, bites and annoyance	Envenomization, snake bites, bites and annoyance

compelled to eat unusual foods, or if food is restricted or severely limited, illness may develop due to natural food toxicants. Protecting the food supply requires a plan which includes both preparedness and mitigation measures.

Animals. The welfare and disposal of livestock and poultry, companion and wild animals also needs consideration. As a general rule all animals suspected of contamination should be slaughtered. Disposal can be by incineration, burial or by the use of chemicals; however these methods can all create environmental pollution problems and must be planned in accord with predeclared best practice.

It will also be necessary to capture stray animals, to identify their owners and, if they have had to leave the area, to care for the animals. The spread of venomous disease carriers must also be monitored and controlled.

The role of veterinary surgeons The role of veterinary surgeons can be summarized as follows.

- understand the various aspects of human/animal/environment relationships, so as to differentiate the 'normal' from the abnormal
- foresee the problems which may occur in case of natural disaster
- decide on the measures which should be taken into consideration
- pre-determine 'evacuation centres' for animals
- assist others involved in disaster management
- Monitor the situation.

Table 6.6 Mitigation measures for health services

Preventive measures	Locate facilities in less vulnerable areas. Measures to reduce the structural vulnerability of buildings, as discussed in Chapter 5.
Spread the risk	Ensure that hospitals and clinics are distributed throughout the city.
Spread the responsibility facilities.	Encourage private sector provision of additional health care facilities.
Minimize the impact	Provide extensive first aid education for the community
Plan disaster management	Health services must have an adequate plan for emergency response, incorporating both mitigation and preparedness measures and addressing.



Hospitals are a focal point for any community and, after a disaster, have a vital role in attending to the injured. However, hospital buildings and facilities can also be susceptible to the effects of natural hazards. Many occupants of a hospital building will be particularly vulnerable, due to their reduced mobility and their high dependence upon technical equipment.

Hospitals and health clinics

There is a widely held expectation that hospitals are prepared to deal with any crisis. In general this perception may be accurate; however past events, such as the January 1994 Northridge earthquake, have demonstrated that hospital buildings may be particularly vulnerable to earthquakes and therefore rendered unable to respond.

Health-care facilities are also vulnerable to the effects of hazards on other lifelines. The efficient operation of health-care facilities requires a transport system to provide access for staff and patients, a reliable supply of electricity to regulate temperatures and operate equipment and lifts, an adequate supply of potable water, and effective systems for waste water collection, solid waste disposal and surface water drainage. For efficient operation during and after a major disaster an effective emergency plan is essential.

Hospitals in Umargao and the neighbouring towns of Latur and Sholapur were overwhelmed with survivors, many grievously wounded. Doctors were hampered by the lack of electricity and medicines (*The Guardian*, 1 October 1993).

The potential effects of natural hazards on health care facilities are similar to the effects on other types of buildings described in Chapter 5, but also include flooding of basements and service ducts, and damage to specialized equipment by volcanic dust or earthquake movement (Table 6.6).

Provision of services.

- Define overall responsibility for health care, e.g. Ministry of Health.
- Identify organizations providing health-care services (e.g. Ministry of Health, city authorities, military, industrial and commercial agencies, private agencies including NGOs and private practitioners).
- Coordinate and define lines of responsibility.
- Assess the geographical coverage of the emergency services.
- Plan routes of access for emergency vehicles
- Formulate detailed plans and triage procedures for each health care unit.



Resources capacity.

- Audit the range of services available throughout the city and assess their capacity to respond to emergencies in terms of skilled trained personnel and the availability of necessary equipment.
- Provide training for medical treatment in emergencies and accidents, within hospitals and local communities, including use of locally available materials for bandages, splints and stretchers

Prevention Identify potential secondary health problems, by preparing maps showing the location of potential sources of risk (such as industrial complexes which could release toxic substances if damaged), potential medical effects and vulnerable communities.

The main priority for the administrator is to ensure that the appropriate agency is given responsibility and resources to coordinate emergency response, and that the agency has a legal authority to act which overrides that of others during a declared disaster emergency.

Summary of main points

- The socio-economic environment of the city – including factors such as: income, culture, ethnicity, age, gender, and religious beliefs should be assessed when formulating a mitigation strategy.
- The nature of existing coping strategies and of existing social support networks should be assessed as an essential part of the framework of an effective mitigation strategies.
- Activities should be decentralized, rather than centralized, wherever possible. local intermediary bodies, community organizations and religious organizations should be involved in the formulation of the disaster mitigation strategy.
- The leadership, decision making and organizational skills of ordinary people should be developed and utilized.
- Outside aid must be provided in ways that recognize and enhance the capacities and resources of local people
- Response plans should focus on immediate human needs for water and shelter, and take into consideration the psychological needs of the bereaved.
- Veterinarians play an important role in the aftermath of a disaster, protecting food supplies, looking after the welfare of animals, disposing of carcasses, and controlling disease vectors such as vermin and insects.
- Response plans should draw upon the knowledge of the types of injury that can result from hazard events
- Plans should identify health care capacity and training requirements, and prepare plans and procedures for post-disaster medical assistance.
- The risk of damage to health care facilities should be reduced by the dispersal of facilities throughout the city and by strengthening buildings

Part 3

Reducing the risk

City management

Institutions consist of informal constraints and formal rules, and of their enforcement characteristics. Together they provide the rules of the game of human interaction. As I have defined institutions they could include organizations, since organizations also provide a structure to human interaction. Indeed, when we are examining the costs that arise as a consequence of the institutional frameworks, they are the result of both the basic institutional framework and the organization that arises from it (*Rationality, Institutions and Economic Methodology*, Uskali Maki, Bo Gustafsson and Christian Knudsen, eds, Routledge, London, 1993)

This chapter examines the role that city governments may play in the face of the risk of natural hazards. City governments can seek to reduce the risks of natural hazards by taking action in any of their five main areas of activity:

- Offering general protection from the risks of disaster, in addition to the standard activity of protecting the public (i.e. maintenance of public order, supporting the rule of law and property rights, and collection of local taxes).
- Providing – or urging other government departments to provide – infrastructure, utilities and land for housing, and to ensure the provision of public transport, waste removal, sanitation and public health services to standards that ensure the mitigation of disaster risk.
- Guiding the public sector into lines of action that protect the public interest through offering incentives and disincentives, planning advisory manuals, and supporting laws and regulations that will help to reduce risks. The revision of building codes and strict implementation of land use planning and zoning regulations are particularly important areas
- Regulating developmental activity in the city or undertaking development projects directly (and/or in partnership with private bodies) to improve the urban environment, its safety and general viability.
- Developing special programmes for the urban poor by devising, with their participation, low-cost solutions to water supply, solid waste removal, sanitation and house construction, offering subsidies and cross-subsidies for particularly deprived neighbourhoods at vulnerable locations.

A comprehensive approach to urban disaster mitigation will combine actions in all of the above. An implementing agency within city government, with supporting

City government





Mitigation strategies and institutions

Forms of government administration

task force, will need to act as 'focal points' for planning, for monitoring of implementation, and for evaluation.

The form of the administration of risk-reduction measures in a metropolitan government will reflect the national system of government. Examples are given below

Centralized at the national level

- Planning at the national level for pre-disaster risk reduction is through an office in the department of the chief minister or president, or delegated to a ministry or department for relief and mitigation planning.
- In both cases there is generally an advisory council of professionals (government and private), and a cabinet or governing council subcommittee on risk reduction, relief and rehabilitation. If there is a state planning committee then this sometimes provides the executive arm to the governing council subcommittee.
- In this model a city corporation is, in many activities, directed from the national level.

Dispersed.

- Mitigation action under a national policy committee is delegated to provinces and sometimes to administrative districts and to city corporations. This dispersal can be accompanied by dispersal in another form in which each ministry (national or provincial) contains an administrative unit responsible for disaster mitigation and preparedness in its professional area of operation, for example, in water resource planning, irrigation, highways and bridges.
- In this model city governments have more responsibility for ensuring preparedness and mitigation. They coordinate the contributory efforts of implementing agencies working in their geographical area

Polycentric.

- The polycentric form of governmental organization is particularly associated with large cities. They may have no overall city government but are governed by a loose grouping of geographically determined urban district councils. If they form part of a national or provincial governmental structure there may be implementing agencies for utilities, services and land development operating in the city's geographical area. The relative status of each department is often difficult to determine, so making collaboration between their officers difficult.
- The pattern of a metropolitan institution's form of organization reflects its place in a particular national array of institutions and the allocations of duties and functions within that array. One-function agencies such as gas and electricity suppliers tend to have 'clearer' forms of organization than do the administrative and multifunctional bodies responsible for public health, community care or development.

Overcoming institutional constraints

All institutional structures have advantages and disadvantages. An administration designed to control financial allocations, cash flow and the implementation of legal instruments may not be the most effective to design, manage and implement strategies and development projects. An institution with abilities in infrastructure project implementation may be inexperienced in maintenance management and operational supervision. Such strengths and weaknesses need recognition and adjustment if mitigation policies and strategies are to be put in place and sustained

Coordinated planning of infrastructure provision is a necessary part of mitigation planning, which has been covered in detail in Chapter 5. Supply agencies are accustomed to set their own priorities and to establish their own emergency repair and rehabilitation plans, in isolation from one another and according to their own criteria. It is a considerable task to achieve a cross-referencing of agency priorities, and to enforce design standards that will ensure mitigation. However, failure to effect this will have major consequences. The following are two typical examples. In flood-prone areas which are compartmentalized by dykes, rail and road embankments, natural drainage is impeded, so the flood waters are held in compartments, or tanks, unintentionally devised. The insertion of bridges, conduits, canal drains and local urban drains, together with pumping stations for those areas otherwise impossible to drain can be a costly and time-consuming way of correcting such accidental planning.

Coordination in project design and maintenance



Designers of major buildings in flood-prone areas should consider a design brief in which either the ground or first storey is assured as being above the level of potential flooding. Supply and service lines should ideally enter and leave above this level. All mechanical equipment and electrical equipment (such as lift engines, telephone switchboards and emergency power plant) should then be placed above the critical level. Water storage should, at least in part, be provided on the roof rather than in a basement tank. One external stair should protrude beyond the building in a straight flight so that boats on flood water can effect a landing point at whatever height the water level may be.

In any particular country or city, such modifications or enhancements of infrastructure and buildings will be undertaken by a number of agencies, the benefits would be greatly increased by better coordination. A liaison system, linking agencies at a number of administrative levels, would enable cooperation in the planning of new work and maintenance. For example, liaison could be required twice a year at director-general level, quarterly at the level of planning and works and maintenance deputy directors, and monthly between operations officers within specific neighbourhoods at a time when any construction works of any kind are in progress.

In addition to national institutions, representative offices of international agencies such as UNDP and other United Nations agencies, the World Bank and regional banks such as the Asian Development Bank are found in all but the smallest countries. These agencies can act as catalysts. Most have become increasingly sensitive to the need for disaster mitigation over the last decade. Regional seminars have been organized to demonstrate how mitigation measures can and should be included in the design of investment projects.

Representation of international agencies

International 'donors' can formulate assistance programmes with city governments, with the approval of the authorising arm of the national government. Donors seldom have the autonomy to be the nominated signing authority on an arranged loan, unless the loan is part of a previously agreed programme with the national government. A city government may be appointed the executive agency for a nationally conceived programme or project. If funds are granted, central government may disperse them to the city. This grant is conditional upon the formulation of a detailed programme that includes 'milestone' achievements and precise auditing of expenditure and quality.

Mitigation organization in Metro Manila. In the Philippines, a presidential decree has strengthened the natural disaster control capability and established a national programme of community disaster preparedness. In addition, a National



Disaster Coordinating Council (NDCC) has been created, chaired by the secretary of the department of national defence.

The NDCC, which is duplicated at the regional, provincial, city/municipal and barangay levels, utilizes the Office of Civil Defence (OCD) in discharging its functions.

(i) Office of Civil Defence

The OCD is the national agency mandated to coordinate the activities and functions of the various agencies and instrumentalities of the national government and private institutions and civic organizations devoted to public welfare. The intention is that the facilities and resources of the entire nation may be utilized to the maximum extent for the protection and preservation of the civilian populace and property during time of war and other national emergencies of equally grave character. It is also the operating arm and the secretariat of the National Disaster Coordinating Council (NDCC), the highest policy-making body of the country for disasters.

(ii) Department of Public Works and Highways (DPWH)

The government has placed substantial emphasis on flood control and drainage works in metropolitan Manila, as frequent flooding has become a major constraint on economic activities and the provisional social services. Flood control and drainage works are exclusively handled by the DPWH. Metropolitan Manila Infrastructure, Utilities and Engineering (MMINUTE), takes responsibility for urban sanitation, and carries out minor infrastructure improvement works.

(iii) Metropolitan Waterworks and Sewage System (MWSS)

The MWSS is a government corporation attached to the DPWH. Its principal work is the construction and maintenance of water supply and sewage systems in metropolitan Manila. MWSS collaborates with MMINUTE in undertaking a drainage scheme called the programme to reduce and eliminate sewage from streets.

(iv) Metropolitan Manila Authority (MMA)

The MMA, created in 1975 as a commission, does not have the power to implement projects. Its major practical activities are garbage collection, sanitation improvement and minor cleaning work inside water-courses.

(v) Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA)

This organization, which functions as a meteorological office attached to the Department of Science and Technology, has been carrying out flood forecasting and warning systems in the major river basins, except for metropolitan Manila, and for dam operations

(vi) Philippine Institute of Volcanology and Seismology (PHIVOLCS)

The institute is a research and service agency under the umbrella of the Department of Science and Technology. It is tasked to avert disasters that may arise from volcanic eruptions, earthquakes, tsunamis, landslides and other geotectonic phenomena through monitoring and forecasting and issuance of timely warnings, hazard assessment and zonation, disaster reduction planning and promotion of geologic disaster awareness and preparedness. PHIVOLCS operates a network of volcanological and seismological monitoring stations throughout the archipelago.

(vi) Laguna Lake Development Authority (LLDA)

The authority was created in 1966 to lead, promote and accelerate the development and balanced growth of the Laguna Lake area, a local source of many flood problems in Manila. The lake's watershed has largely been stripped of its

forest cover and sediment flow into the lake has been high. Pollution from excreta has been high: water quality for use in Manila is low.



Finding a place in the metropolitan agenda

Those responsible for the government of a city have crowded agendas. Issues include the internal problem of the administration of their own staff and agencies, raising of revenues, provision and supervision of services, responding to new policy pressures (from various sources) and management of emergencies such as those of public health or storm-water flooding.

Although the adoption of risk-reduction policies may be seen as an unaffordable addition to an already full agenda, the introduction of such policies does not generally entail exceptional items of new direct expenditure. The costs of supporting a small technical staff group to advise and coordinate mitigation measures, of implementing a public awareness programme and of undertaking hazard mapping are small in return for protecting human life and the physical and economic assets that underpin the metropolitan economy and provide its investment and developmental base. The two main components of a risk reduction policy are

- redirecting the on-going tasks of administration and maintenance to ensure that exposure to identified risks from natural hazards is lessened
- defining terms of reference for all new development programming and project briefs so that reducing exposure to natural hazard risks forms part of the programming and project specification.

In addition, environmental impact assessments of project proposals should include an estimate of how the proposed development will reduce the risk from natural hazards both within and around the development project area.

In this way, mitigation action can be seen as a component of maintenance work that is already obligated, of environmental protection and biological conservation policies already under consideration or being implemented, and of urban land-use planning. Adopting a mitigation policy ensures the protection and sustainability of all these other constructive policies in the face of natural hazards

Project finance can be assembled in such a way that its format helps to sustain the mitigation procedures and works. Major projects are now often financed from a number of sources and levels, both externally (beyond the national boundary) and internally. This can be seen as an asset of the project which supports sustainability. National funds are often supported by international agencies. Some funds could be raised through city sales taxes. In flood-prone regions, management and supply charges raised by local water boards could be directed towards the project finance panel to provide funds for capital works. Some dyke construction and maintenance work, channel clearance and foundation digging can be undertaken by local communities, who thus contribute towards mitigation measures of local concern (as is done in Vietnam). 'Food for work' agencies could offer support and community parties could be held at construction sites to celebrate completion of sections. These and other unconventional solutions will need to be considered if mitigation strategy is to be sustained.

Project finance

Policy makers and prospective implementers of disaster management strategies have a major communication task

- to gain the attention of busy people

The development of risk-reduction strategies



- to link the abstractions of policy objectives with a definite plan of execution
- to shape and use a policy document that presents an agreed strategy shared by all agencies active in the city.

The first step in gaining this attention is the implementation of a workshop or conference for key government and professional people in the city, to which regional, international and national representatives are invited. Such an event spreads the realization that many elements in society will be involved in shaping and implementing a risk-reduction policy.

Open discussion in conference clarifies the need for an integrated strategy that brings together development, project design and programming with disaster reduction measures. (these concepts have been discussed in Chapter 3). Recommendations for a mitigation strategy should then emerge, leading to the establishment of a representative task force charged with preparing a draft strategy for comment and for formal metropolitan and government approval. The composition and terms of reference of such a task force are considered in Chapter 9.

Incentives and town planning law

Land-use planning is one method of reducing the risk of disaster. Within cities this planning is generally practised at the level of the metropolitan government, either by a department of that government or by an authority separately established to execute delegated powers.

... the regulation of the urban development process is going to reflect and support a government's wider economic and social policies and strategies, and any legal input into that regulation and development process will likewise be designed to advance or at least not impede, those wider policies. An awareness of this basic and inescapable fact of politics should assist any discussion of or proposal for any legal input; it will prevent too great a reliance being placed on law alone as a mechanism to bring about fundamental change in the urban development process. It will direct attention to the need to take full account of the political and societal context of that process and any possible changes to it, and of the fact that law is only one of the mechanisms which are available for use in the management and regulation of the process of urban development (Patrick McAuslan in *Managing Fast Growing Cities*, Nick Devas and Carole Rakodi eds. Longmans, London with John Wiley, New York, 1993).

When it is supported by existing planning law, and by experienced professional administration of development control, physical planning is credible and likely to be implemented. The planning process will then have the status to lead and guide development in particular locations within the zone of concern. In practice this presents a challenge to developing countries. In central urban areas that are declared to be 'development areas' laws and development regulations are accepted as a part of the project package and are generally recognized as being helpful. However, outside the declared development control areas, planning law proves difficult to enforce. If it does exist it is likely to be in the form of positive direction, rather than precise law, setting out 'what ought to be'. In this context, it serves as an awareness-raising, standard-setting backdrop to advocacy planning.

Advocacy planning and incentives

In advocacy planning, the planning team act as catalytic agents, presenting choices to various publics (government departments, professional groups, urban neighbourhoods) while seeking support for that approach which seems to bring the most benefits to a wide range of beneficiaries, at a cost that is affordable (see Fig 7 1).

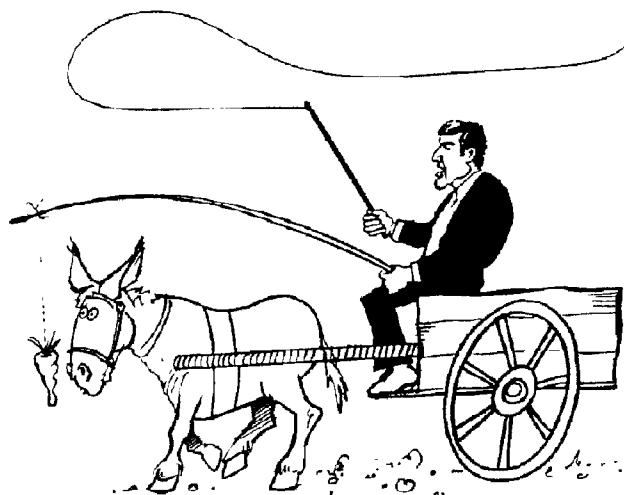


Figure 7.1
A combination of positive and negative incentives should be considered

In a government administration framework, a physical planning department is seldom a 'spending department'. It can propose but not dispose. Outside of the 'declared plan areas' it can only propose action by another agency or receive a proposal from an overall plan. It can seek to persuade, using whatever formal powers it has under the law or by political announcement. This coupled with advocacy needs to be supported by incentives. Governments' implementation of a particular mitigation plan may provide one form of incentive.

Advocacy planning is often advanced by presenting a well-publicized plan, but not one that necessarily has been formally approved. By stages it becomes accepted as the appropriate way ahead, but it is a poor substitute for comprehensive planning legislation, the importance of which must be recognized.

Private enterprises can be encouraged to comply with a plan through incentives. For example:

- land development subsidy can be offered in some areas, and development overhead charges levied in others
- industrial and residential location can be encouraged to safe areas by giving these areas priority in urban servicing and utilities installation
- the public can be encouraged towards certain areas by differential land pricing (in the sale of raw or slightly developed land) or by subsidizing transport to employment or shopping sites
- the provision of information to the public becomes a tool of advocacy planning, as it enables households to consider flood and earthquake risks they may face if they move to particular locations.

The project formats of international financing banks often provide support for the integration of disaster mitigation in urban development project design, and may stipulate the need to ensure that particular elements of mitigation strategy are carried out.

The planner using an advocacy approach is all too aware that households have other considerations as well as disaster mitigation. Being near to their place of employment, school or market place is of considerably greater interest to the average householder.

Organizations reflect national institutions. They vary in type and method, but can usefully be grouped under two main classifications

**Organizational
strengthening**



- organizations that promote and value a 'work to rule' administration
- organizations that promote the solution of problems encountered in the operational area of their concern.

The change from the first to the second type is necessary in the face of the challenges in major cities as they evolve. A shift of culture may be needed and could be cultivated by stating performance output targets against declared deadlines. Incentives and motivation can be introduced by forms of performance related pay and job tenure. These changes characterize the transformation of three types of metropolitan agencies:

- city urban planning and development control departments
- urban development authorities
- special project implementation boards of management and evaluation.

The first two must work closely together, and the third would work in combination with either or both.

City urban planning control

Planning guidance and development control are activities that cut across the projects of private developers and the functions of governmental agencies. Planning regulation commands popular support when it is seen, through a good public information policy, to be directed towards achieving public good and access to urban amenity and services. A high level of public consultation will ensure support and projects that reduce vulnerability to natural disaster are likely to command respect.

In practice many difficulties have been experienced in distributing responsibilities effectively within national governments and cities: the balance of powers is complex, involving national, provincial and metropolitan agencies and semi-autonomous utility boards and suppliers. The office of urban planning is expected by professionals and by the public to offer a sieve for ideas and proposals for city development and to give these direction. It is also expected to be pro-active and lead the development process, taking account of and encouraging private sector initiatives.

Planning which is tied in closely with the city's operational, developmental and maintenance budgets, perceived as one budget exercise to be managed as whole, has the potential to serve all, including minority interests. Within a uniting framework of grants-in-aid, taxation and expenditure programming, urban planning is an essential, rather than optional, activity, in which budgeting results in physical works and in the provision of services. Policies that seek risk reduction in the face of hazards can be integrated into this administrative framework with relative ease.

Through effective delegation to its office of urban management and planning, and to its other departments and agencies, a metropolitan government has instrumental powers to promote desired outcomes in risk reduction through ensuring that:

- new settlement areas avoid vulnerable locations (as indicated by hazard analysis and mapping)
- buildings and structures of post-disaster significance are located in the safer accessible areas
- risk reduction measures are promoted with the cooperation of professional institutes of environmental control, architecture, planning and engineering
- risk reduction is a criterion of appraisal in assessing development and building proposals

- building regulations are amended in accordance with new perceptions of hazard risk, and are appropriate to the wide range of building practices found in the city of their application
- grants and subsidies encourage mitigation work
- development areas and non-development areas are declared
- risk reduction is a priority in budget programming and item assembly
- risk-reduction seminars and urban property insurance seminars are promoted.



Urban development authorities are very much shaped by their origins. Some evolved out of implementing housing agencies whose experience demonstrated that housing could not be separated from work, shopping and education. Such agencies developed into urban settlement and development agencies, either with elected persons and local government officials on the board, or as semi-autonomous units providing a separate 'city government' in their areas of operation (such as the Kuala Lumpur metropolitan region of Malaysia).

Urban development authorities

In other cases urban development authorities have been established because the metropolitan government had been considered unduly committed to short-term difficulties and unable to manage the medium- to long-term issues of urban development planning. Authorities with this background may merge into matured metropolitan government. In other cases they remain detached and autonomous. The differing time scales adopted in urban decision making remain a barrier to unification of such agencies. The polycentric type of metropolitan government is particularly prone to differences of viewpoint, a situation experienced in Karachi.

A semi-autonomous authority can bring mitigation practices into its location choices, design and construction work ahead of any decision by higher authority. It can cooperate with community groups, non-governmental organizations and transport authorities on a one-to-one basis. At the same time it can promote a shared concern for risk reduction through city-wide discussion groups and committees. It can offer a service to others in the fields of:

- infrastructure data management
- mapping: geological, surface and settlement
- geographical information systems
- preparation of risk maps showing areas liable to flood, earthquake fault or landslide.

Special implementation boards emerge where the various agencies concerned with the urban environment, water supply, sewerage and drainage have been unable to find an administrative framework in which to work together. Despite general agreement that major infrastructure works are required to upgrade present systems, Karachi again offers an example. Under the influence of international lenders and donors, a special urban development board or unit is established to oversee, manage and evaluate progress. Under such a board, or within a government department but working on a smaller scale, project implementation units may be set up. While these units work in association with government departments, they are able to operate with fewer constraints than the agencies whose programmes they implement.

Special implementation boards of urban management and evaluation

The requirement for such boards and units highlights the fact that some local administrations are still captured in a rule-and-rote culture, and have yet to move to the problem-solving, implementation culture required for development work. Boards and implementation action units have considerable powers within their



Programming, projects and the public

area of operation and may be receptive to incorporating mitigation measures in their project designs.

In some circumstances it may be useful if the task force responsible for devising a mitigation strategy continues as a programming and review agency for urban maintenance and development projects. A number of projects may be initiated by the agency itself, although most will originate from other parts of government. Projects that do not have mitigation as a prime purpose could serve mitigation purposes, and the review body would ensure that this was done.

In other circumstances a new group may be established to follow through the work of the task force. This may be based in the office of the appointed lead department for disaster mitigation. In some countries (e.g. Indonesia, Bangladesh, Vietnam) this group has been called the disaster management unit, and also operates as an information centre and as a professional advice centre on mitigation techniques for designers of metropolitan projects.

Where a project review board is already in existence, a representative of the disaster management unit could join that board, acting along the lines of the mitigation agenda set out in Chapter 9.

Where a development project is centred on flood control or cyclone protection the designers will be seeking a high standard of protection. Where a project is multipurpose, such as a water resources project, the project designers and the review body will be seeking the best possible mitigation of flood and cyclone risks given the wider purposes of the project. Conflicts may arise, for example in the case of lakes or reservoirs, where levels are best kept low in order to reduce the risk of flooding, but high levels are required to provide adequate storage during seasonal drought.

Almost every project proposed, whether highway maintenance, river embankment and bridge building, new drainage or neighbourhood extension schemes, will effect a change in overall disaster risk for good or ill. To ensure that every project is reviewed in the context of risk reduction, disaster risk assessment could form part of an environmental assessment where this is conducted for project submission.

Almost every city project will have an impact on the urban community or communities. Meetings should be held with communities when the project is in the initial feasibility study stage. The success of a project and its continued operation will partly depend on local understanding, goodwill, support and participation. For example, drainage channels which are not kept clear of solid waste materials by local householders will soon cease to meet surface water drainage needs in a time of flooding.

Sustaining policy initiatives

During its initial decade of implementation, a mitigation strategy needs recognition and leadership from a high governmental and city management level, if it is to be sustained through a network of implementing agencies and metropolitan neighbourhood councils. Periodic renewals of policy statements, instructive seminars for professionals engaged in mitigation work and public education programmes will be needed. Agencies such as infrastructure and utility providers should be required to publish statements, in their annual or biannual reports, of the environmental impact of work undertaken, the impact on disaster preparedness strategies and upon mitigation against flood, earthquake, high winds and landslide (see Fig. 7.2).



Figure 7.2
Sustaining policy initiatives
depends upon effective
communication

A major objective of the first decade of implementing a mitigation strategy is to involve all sectors of society to some degree, in contributing to the formulation of appropriate mitigation measures, and in the execution of work where possible. Some sectors will be involved in policy formulation at the national level, others in policy elaboration at the provincial and city government level, and others at the level of urban neighbourhoods and local communities known to be at high risk. Good communication within the network of programmes, projects and actions is needed to sustain understanding and appropriate actions. Opening ceremonies offer an opportunity to note the contribution of many people, groups and agencies and perhaps make awards to community groups who have assisted physically in implementation of a drain or a dyke.

In the flood-prone Netherlands, a complex web of institutions and works has been developed to manage sea and river flood risks. Policies stemming from the national level are developed at provincial and city level and in many aspects are implemented by local water boards. The tasks at each level and of each agency are set out by law. Sharing of agendas and priorities is practised and a constant review of the results of actions is made so that policies and works are sustained over time.

- City government should add the protection of the public from the risk of natural hazards to the administration of law and order and property rights, as an integrated civic task.
- To implement a mitigation strategy, city governments should pursue two types of activities: redirecting routine tasks of administration and maintenance to mitigate exposure to identified risks, and creating new programmes and projects that incorporate features which will mitigate damage.
- Provide or require other agencies to provide infrastructure and utilities, buildings and installations of hazard-resistant standards.
- Encourage the private sector to implement mitigation strategies by offering development incentives and disincentives for particular forms of land use in accordance with approved urban development plans.
- Initiate mitigation work in the city by undertaking selected key projects directly or in collaboration with the private sector.
- Develop a special programme to mitigate the vulnerability of the urban poor.
- Identify an implementing agency headed by a key person, such as the director of urban disaster mitigation and preparedness unit, as a focus of the mitigation planning and guidance programme. Provide access to an information desk.
- Consider the establishment of a mitigation task force.
- Ensure that institutions and organizations are sufficiently staffed to be able to attend to mitigation work and that the staff are given a career path, adequate training and administrative and policy support.

Summary of main
points

Public awareness

Disaster mitigation is currently not well integrated within donor aid programmes. Why this should be the case is not entirely clear, but a key factor is likely to be the view, which was widely shared among developing country governments and donor officials for much of the last three decades, that disasters represent a temporary distraction from efforts directed towards the overall goal of raising living standards (*Guidelines for Aid Agencies on Disaster Mitigation*, OECD, 1994).

The actions of government and of other public bodies will be central in alleviating vulnerability to natural hazards, but the need to increase public awareness of the risks posed and of the strategies by which such risks can be reduced, is equally important.

Increased awareness amongst communities at risk, the general public and specific groups of people will enable each to contribute most effectively to the task of alleviating vulnerability and reducing risk. In the long term, increased awareness will also help to create a climate of informed public opinion which can influence political priorities both directly and indirectly.

In general, any activity which brings together large groups of people with a shared interest can provide an opportunity to promote disaster mitigation but, to be successful, this process must focus on the issues, risks and mitigation strategies which are relevant to that particular group of people in that area. It must also concentrate on developing understanding rather than simply disseminating information, and should therefore be viewed as an educational process involving practical activities and group discussion. For example, local residents' organizations could be helped to develop 'risk maps' which identify the specific areas of hazard and vulnerability within their community.

This educational process should be supported by distributing information as widely as possible: the role of government authorities should be to coordinate the collation and distribution of information. The type of information and its presentation will depend on the needs of those to whom it is distributed. Detailed technical knowledge will be appropriate for the professional specialist implementing disaster mitigation strategies, while posters and leaflets with simple messages and clear diagrams will be more suitable for residents of hazard-prone areas or the semi-literate.

Mitigation Introduction





This chapter discusses the role which the following agencies could undertake in promoting a greater awareness of risks and of mitigation and preparedness strategies:

- schools and other educational establishments
- local community organizations and residents' groups
- local health clinics
- private sector companies and public sector bodies
- professional and trade associations
- higher education establishments
- the communications media
- monitoring and warning agencies
- the insurance industry.

The role of schools and other educational establishments



Lessons in disaster mitigation can be provided as part of the normal school curriculum. Long-term objectives of the city or national government might be to establish such lessons as a requirement in all schools, and to provide teaching material and training courses for teachers. For example, the government of the Philippines is considering the inclusion of 5 h tuition per year on natural hazards and mitigation, as a standard requirement for all schoolchildren and students. Learning basic principles of disaster mitigation at an early age will enable children to benefit from this understanding throughout their life, and therefore to contribute positively to the formulation of mitigation strategies in the future. Children can also share these basic principles with their parents and other adults in their households (see Fig. 8.1).

Many schools also act as focal points for the adult population, providing space for adult education and other community activities. They could therefore be used to provide education in disaster mitigation for the community as a whole.

Local community and voluntary organizations, and residents' groups



These organizations can also act as a forum for raising awareness of natural hazards and mitigation strategies amongst residential communities. This process could be integrated into existing activities, such as infrastructure improvement schemes, which involve the community as a whole.

Marginalized communities are often the most at risk from natural hazards, and particular emphasis should be given to raising awareness amongst them. Most communities will have focal points around which people gather; these may be local religious centres or traditional leaders, established organizations which represent residents or which work with them on social issues. To ensure that the needs of the community are properly addressed and that their own experience and skills are exercised, educational programmes should be provided by, or with the close cooperation of these focal points.

Local health clinics



These organizations are also essential in providing education for groups of people who would not otherwise have access to it, including children who are not at school, the illiterate and the unemployed.

Local health clinics can promote health education campaigns which address the potential medical effects of natural disasters, which give advice on survival, preventing disease, and recovery, and which provide training in basic first aid. They often serve as a focal point for the community, particularly for women with children.



Figure 8.1

Schools can play an important role in raising awareness of the benefits of mitigation.

Companies and organizations should be responsible for providing education in disaster mitigation to their members of staff. This should emphasize the risks which staff may face at work, actions which they should take to minimize these risks and emergency procedures. The process should be integrated into training on general safety procedures to avoid accidents and to minimize risks from technological hazards.

Private sector companies and public sector bodies



Public authorities also have an important role to play in raising the profile of disaster mitigation, both within the city and in wider spheres. They should aim to train their staff and to promote and encourage good practice in disaster mitigation education, for example by presenting awards in recognition of effective schemes.

These organizations can provide more extensive training in specialized areas, for their members and other relevant groups. For example, organizations representing civil and structural engineers have a significant role in encouraging their members to learn about hazard-resistant design and construction techniques.

Professional and trade associations



The role of these establishments is similar to that of professional and trade associations: ensuring that professionals and other specialists have a basic understanding of the disaster mitigation issues affecting their work and an opportunity to develop that understanding further. This role also encompasses research – furthering knowledge of natural hazard processes and developing more effective mitigation techniques. With the benefit of advanced training and research, these professionals can then help to increase knowledge and awareness amongst their colleagues (particularly those without specialist education or training).

Higher education establishments and other agencies involved in research



This role can be adopted by all academic disciplines, although the topics involved will differ. The contributions which various disciplines could make to disaster mitigation are suggested below:

- scientific disciplines (e.g. geology and hydrology): understanding natural hazard processes, forecasting their occurrence and predicting their intensity, identifying hazard-prone areas
- construction disciplines (civil and structural engineering, architecture): understanding the effects of natural hazards upon structures, and hazard-resistant design and construction principles
- development and planning disciplines (e.g. geography, urban planning, economics): understanding the processes involved in directing development away from hazard-prone areas and in controlling potentially vulnerable development
- medical disciplines: understanding the medical effects of hazard events, their prevention and treatment

- social disciplines (e.g. sociology, psychology): understanding the effects of natural hazards on different groups of people, and the ways in which communities can be mobilized to take protective action
- legal and political disciplines: understanding the constitutional framework within which regulations are implemented and the processes by which institutional change can be effected.

Large cities are generally focal points for higher education, and should therefore be a natural focus for developing expertise within the country in each of these disciplines. Incentives may help to encourage promising students to specialize in these fields; for example, many aid agencies provide funding for post-graduate students to undertake education and training in other countries.

One way of promoting study in disaster mitigation would be to establish a separate research and training centre within an existing establishment. This centre could draw staff from each of the relevant disciplines, who could then specialize in disaster mitigation, working together to develop coordinated interdisciplinary programmes of study. These staff movements would need to be carefully planned to ensure maintenance of career structures.

A centre of this type could also:

- develop teaching materials for use in schools and other organizations
- undertake risk and vulnerability assessments and develop mitigation programmes on behalf of public authorities
- organize workshops and short training courses to meet the specific needs of different employers.

The communications media



The communications media (newspapers, radio and television) can be very influential and effective in disseminating information and raising awareness, but their effect will depend on the number of people who have access to them, and on how those people use them (for example, many people watch television purely for entertainment and may choose not to watch 'educational' programmes).

The use of these media in the process of public education requires some form of public control or influence over their output. Such influence is often not available, the media of many countries being in private ownership often controlled by transnational interests. The growing availability of videocassettes and of transnational satellite services also reduces the potential for public influence over the content and consumption of the media. Where such influence exists, it is generally exerted at a national, rather than a local level and in these circumstances, there is some potential for the media to contribute to public education programmes at a national level. For example, Radio Tanzania played a major role in a series of mass education campaigns held between 1969 and 1975. These focused on issues such as preventive health measures and emphasized the importance of group discussions among listeners.

Public education is unlikely to be a priority for media services in private ownership, but it may be an important element in local and community media, where these are owned and operated by non-profit-making organizations. For example, Radio Sutatenza in Colombia is one of a number of 'radio schools' in Latin America which offer informal educational programmes to local peasants, supported by other teaching materials.

Increased public awareness will enable the community as a whole to contribute more effectively during the stages of preparedness, response and recovery. This section considers the dissemination of information during each of these stages (see Fig. 8.2).

With the development of international information gathering systems and improved forecasting and monitoring techniques, the provision of forecasts and warnings to the public could improve considerably. However, clear procedures for issuing information have to be agreed between the scientific agencies and public authorities responsible because without such procedures, there is a danger of inaccurate and misleading reports creating unnecessary panic and confusion. In 1990, for example, a business consultant in the United States incorrectly predicted an earthquake; the media did not question the accuracy of the prediction, but exploited its inherent news value, re-screening a network television special on a fictitious earthquake disaster. The consequences included time wasted in preparedness measures and anxiety for millions of people, with the direct and indirect costs being estimated at millions of dollars:

In issuing forecasts and warnings of hazard events, the main requirements are:

- speed: the warnings must be given as quickly as possible
- clarity: the situation must be explained as clearly and accurately as possible, and recipients should be given clear advice on appropriate preparedness and response measures
- comprehensiveness: the warning must reach as many of the affected people as possible
- credibility: the warning system as a whole must be perceived as accurate and reliable, with false alarms minimized.

Radio and television services can offer both speed and clarity, although they cannot guarantee to reach the entire population. For hazards of relatively slow onset, newspapers can also be useful in presenting more detailed, complex information. For all media, some form of regulation is required to ensure that information is conveyed accurately and without sensationalism; this is a practical requirement and should not be confused with control of the media for political purposes

Preparedness, response and recovery

*Forecasts and warnings.
the role of the media*

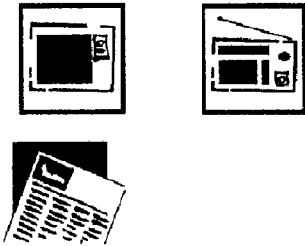


Figure 8.2

Preparedness measures should include advising the community on how to respond to warnings and hazard events.



The following examples illustrate the dangers of irresponsible and inaccurate reporting:

- During 10–14 November 1993, international television news services warned that a cyclone developing in the Indian Ocean was likely to strike the city of Karachi. This caused panic amongst residents, many of whom evacuated the city. However, the local meteorological station, which had been monitoring the situation with radar equipment, correctly advised the city government that the cyclone would change course and would not strike the city. By that time, the international media were no longer covering the story, which had lost its potentially sensational value
- In February 1994, scientists monitoring volcanic activity around Mount Pinatubo in the Philippines detected underground vibrations. Reports of the detection of an increasing number of tremors featured prominently in a leading newspaper, raising fears of a repeat of the devastating eruption of 1991. Scientific opinion that, despite an increase in the number of tremors, any explosion would be small and insignificant, was not reported. The story was discarded when the number of tremors per day started to fall.

Public authorities within the city could contribute to improving standards of reportage, for example by encouraging the training of local media personnel in this area. For the reasons discussed above, such improved standards will ultimately be ensured only through the development of protocols and codes of practice for media reporting at international level. Activities in this area are being progressed through UNESCO.

Forecasts and warnings: the role of other agencies



It is most important that public agencies and the local community supplement the role of the media in issuing warnings of imminent hazard events, their role being to ensure that accurate warnings are transmitted to every person in the affected area. Detailed planning is needed to ensure that this takes place, with the methods used depending on the local situation and resources available. Simple equipment such as public address systems are extremely useful in transmitting warnings comprehensively and the responsibility for ensuring that this is done could be devolved to community leaders at the local neighbourhood level. Similarly, public buildings such as schools and commercial premises could assign the responsibility for transmitting warnings to selected members of staff.

Communication during an emergency situation



During and immediately after an event, the most important communication is that between relief agencies and those affected. Media reporting can sometimes serve three useful functions:

- publicizing relief and rehabilitation efforts and the resources available to those in need
- providing information to friends and relatives of those affected
- alerting the international community to the need for assistance.

Although newspaper publishers and radio and television stations are completely dependent on electricity supplies, they will often have standby generators which can be used if the mains supply is interrupted. While transmission to affected areas may also be interrupted, information can usefully be conveyed to other areas. Disaster preparedness plans should therefore address the role of the media, to ensure that reporters are well briefed and are given access to affected areas providing they do not hinder the efforts of relief workers.

The role of insurance

Insurance cover can reduce the economic impact of disaster by providing recompense for losses caused. Increased awareness of risks can encourage business and

property owners to insure against the effects of hazards. Conditions can be imposed by lending agencies to make insurance a requirement of business and other property loans. Insurance could also be made mandatory by statute. Building regulations, codes of practice and site supervision quality can also influence insurance rates.

Adoption of hazard insurance



Insurance against indirect economic effects is a more complex issue. Individuals can take out personal insurance policies (although the majority of residents in developing countries will be too poor to afford insurance), and industries can take out consequential loss policies. Although this form of insurance can help companies to stay in business after the secondary effects of the hazard have subsided, it does not contribute to recovery unless employers are required by law to pay workers compensation for loss of earnings.

Insurance transfers part or all of the risk of loss from the individual business or company to the insurer. The adoption of insurance and other protective actions depends largely upon the individual's perception of potential hazards. It has been shown (Arnell, 1983) that individuals do not think purely in economic terms, they are likely to take action to reduce their vulnerability regardless of whether they are insured.

Incentives for mitigation measures

It is apparent, therefore, that the insurance industry can encourage the adoption of damage mitigation measures. Deductible premiums can be imposed, sharing the risk of loss between the individual and the insurance company. Such risk-sharing may encourage the property owner to seek protection against small losses and may also save the insurance company the expense of dealing with small claims. However, the benefits must be attractive to both parties. Insurance companies need to make profits and therefore prefer to trade in areas where the possibility of damage is slight and the perception of risk is relatively high, rather than where the possibility of damage is greater and there is a low perception of risk. In the latter case, the insurance industry has decided not to trade in some areas (see Fig. 8.3).

The insurance industry, therefore, has an incentive to encourage the adoption of mitigation measures in return for reduced premiums, while ensuring that the measures taken will reduce the level of claims more rapidly than the premium income. The success of this strategy depends on the population having a high perception of risk.

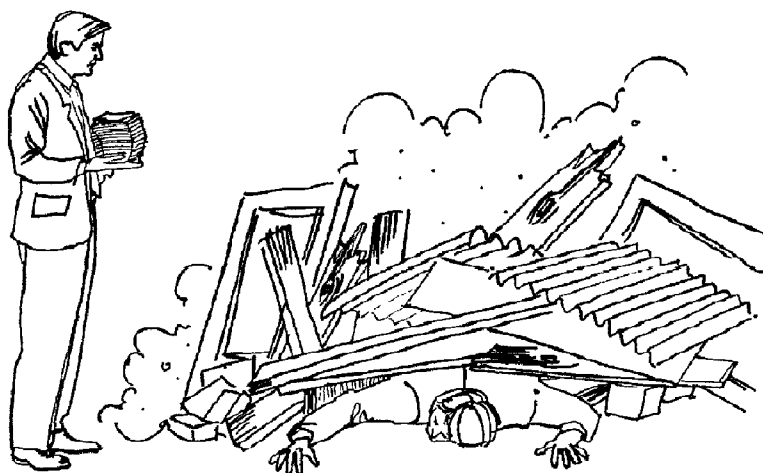


Figure 8.3

Prompt payment by insurance companies can reduce the impact of natural hazards, but is not a substitute for mitigation.



Coping with catastrophes

Higher premiums could be charged for dwellings which do not incorporate hazard resistant features, and for commercial and industrial buildings which have not been designed or audited by qualified engineers. Insurance can also be used to influence the local administration's planning process, encouraging appropriate land use which takes account of the principles of hazard mitigation. These conditions could be established by the insurance industry, by national government legislation or by local regulations.

The losses caused by hazard events pose special problems for the insurance industry, as they tend to be very high and irregular. Losses in the Northridge, Los Angeles earthquake of 1994 were estimated at U.S.\$30,000 million, although not all would have been covered by insurance. The 1990 earthquake in Luzon, the Philippines caused damage estimated at about £100 million, although only £2 million was covered by the private insurance market.

The particular problems associated with hazard insurance can be overcome by:

- limiting the amount paid on claims – by limiting the maximum payment and by applying deductibles or franchises
- controlling the number of policies sold in a particular area, by limiting the exposure of an insurer
- managing large losses by using reserves or by establishing a pool of insurers to cover for catastrophic losses
- managing large losses by the insurance company reinsuring against its own losses
- establishing government assistance or national insurance schemes.

However, if insurers limit payments on claims and/or limit the number of policies within an area, the public may not receive the service it requires. Nor will they if insurers cease trading. Government assistance may be limited where the national economy is weak. However, national catastrophe funds have been established in some countries, such as Iceland and New Zealand, to cover direct losses caused by natural hazards; similar schemes could be considered elsewhere. The use of reserves could be impractical due to the size of the potential loss, and could be difficult to manage. Re-insurance, with or without company reserves and government assistance, can facilitate private insurance companies discharging their contractual liability for any size of loss. Although re-insurance spreads the risk across a wider base and reduces the need for private insurance companies to have large reserves, regulations are necessary to ensure that it is not restricted within a local market of companies which may already be highly exposed. To be financially sound, re-insurance may have to be placed in other countries. Re-insurance brokers are currently both raising their conditions and insisting on mitigation surveys and correction work prior to their participation.

When providing insurance cover for catastrophic losses, insurers examine details of the probable maximum loss (PML) for specific natural hazards with specific annual probabilities (Fig. 8.4). (A methodology for calculating the PML is illustrated in Fig. 9.2.) Many factors will influence the calculation of the PML; while different urban developments may illustrate similar patterns, values will vary considerably from city to city, depending on their levels of vulnerability.

In the context of this project, it is possible to consider a world pool of insurance where member nations self-insure critical elements of infrastructure such as water distribution, electricity and transportation. While it would be essential that this cover was limited to single points of failure of the infrastructure, participants could readily both pay and receive premiums. This mechanism could be instrumental

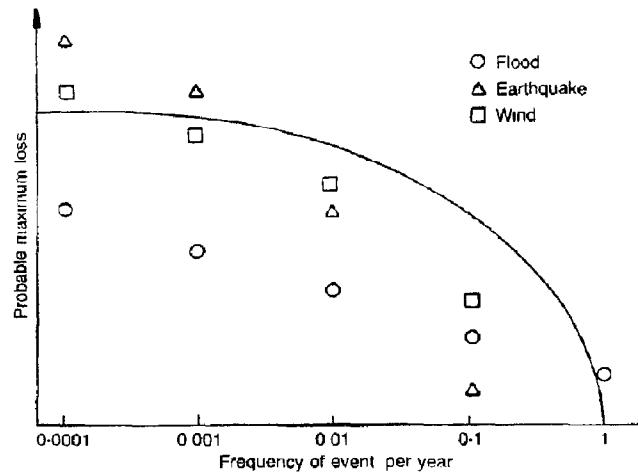


Figure 8.4
Theoretical relationship between probable maximum loss and frequency of event.

in combating the spread of disease and limiting the economic impact of a catastrophe to ensure self-sufficiency once again for the impaired economy. The United Nations may very well perceive that 'seed' money covering the costs of risk evaluation and administration of the pool would be a more effective way of providing assistance than reaction to events. This would ensure the 'building' of a world-wide fund and limit the extreme calls on disaster funding currently requested.

After a natural hazard event has occurred, the media are often instrumental in initiating widespread public debate, which can be developed through the other agencies involved in public awareness. Such debate provides an opportunity for all involved to evaluate the strengths and weaknesses of mitigation and prevention strategies, of preparedness and response measures, and of the rehabilitation process. Valuable lessons can be learned from this debate; the strength of public, professional and political opinion at such a time provides an opportunity to effect fundamental positive change.

The role of public awareness in long-term reconstruction

- Raise awareness – coordinate a range of public education programmes, devolving implementation to specific agencies and local community groups.
- Provide information and teaching materials to support public education programmes.
- Encourage professional training and post-graduate research in disaster mitigation.
- Promote improved standards in media reporting – support local community media and encourage training of media personnel
- Agree on procedures for issuing warnings with warning agencies and the media.
- Plan procedures for transmitting warnings, using the resources of public administration and the social structures of local communities.
- Plan the role of the media in reporting events, using press briefings and regulating access to affected areas.
- The insurance industry should be given incentives to encourage the adoption of mitigation measures, in return for reduced premiums. Reinsurance schemes should be considered.
- High premiums should be charged for buildings which do not incorporate hazard-resistant features, or have not been designed by qualified engineers

Summary of main points

9

Strategy for mitigation

Earlier chapters have described the extent of natural hazards and their increasing impact upon cities; the need for long-term disaster mitigation strategies as a fundamental aspect of urban development has been emphasized. The process of mitigation has been described, with particular reference to physical infrastructure.

Many countries have established disaster management committees, which generally operate at national level and are mainly concerned with response and preparedness. Although there are examples of committees which aim to deal with disaster *mitigation*, few have resources to implement the requirements of even a basic mitigation strategy. Current solutions to natural hazards can be described as responsive, though they may contain an element of preparedness for disaster events in the future.

Although the level of relevant professional expertise and experience in most cities is very high, an explicit and continuous commitment to mitigation is not a common feature. The establishment of a mitigation committee or task force, responsible for disaster mitigation within a large city, would enable individual specialists to combine their expertise in formulating a coordinated strategy.

This chapter gives general guidance on the formulation and implementation of a comprehensive mitigation strategy at municipal level, with reference to previous chapters for more detailed discussion of each stage. Typical decisions and actions aimed at achieving this objective are considered, and potential problems and solutions identified. The chapter contains proposals for similar actions at international, national and local community level, and by private sector organizations. It concludes with a summary of proposals relating to specific mitigation measures recommended in the relevant chapters and gives models for action, for reference and use by city administrators.

Different sequences of actions and different strategies could be equally effective, provided that they address the following questions:

- What are the potential natural hazards facing the city?
- What is the vulnerability of the infrastructure?
- What are the risks facing the city?
- What level of risk is acceptable?
- Which areas of risk reduction should be given highest priority?
- What are the most cost-effective ways of reducing these risks?

Background



Introductory principles

- Is this strategy compatible with other policy objectives?
- Can measures to reduce risk be incorporated into existing programmes?

The role of the administrator

Develop a wider base of commitment



A wider base of commitment could be developed through a workshop or conference (Fig. 9.1), as suggested in Chapter 7.

The reader may comprehend the benefits of mitigation but be constrained in terms of political influence and command of resources. It is crucial to address these constraints which inhibit progress. Influential individuals within the city and its government need to be convinced that natural hazards present unacceptable risks and that mitigation of these risks is necessary and feasible. A similar commitment at national level will be of critical significance, but the lack of such commitment should not deter progress at city level.

It is also important to develop commitment at city district level, within the smaller political and administrative units to which many aspects of city management are devolved. It is often at this level that actual progress can be most readily achieved. Developing and maintaining commitment within the city is a continual process, which is necessary to establish a momentum for implementation.

Awareness of the risks presented by natural hazards and of the potential benefits of mitigation is low amongst the authorities and populations of some large cities. Financial pressures and the realisation of other political objectives may seem much more compelling than the need for disaster mitigation. To change such attitudes, continued emphasis needs to be given to the wider societal and economic benefits of mitigation. Financial provision is only one of the criteria for successful implementation of a mitigation strategy; information, education, communication and the creation of incentives will be equally important. In the long term, stable economic development will be the decisive factor.

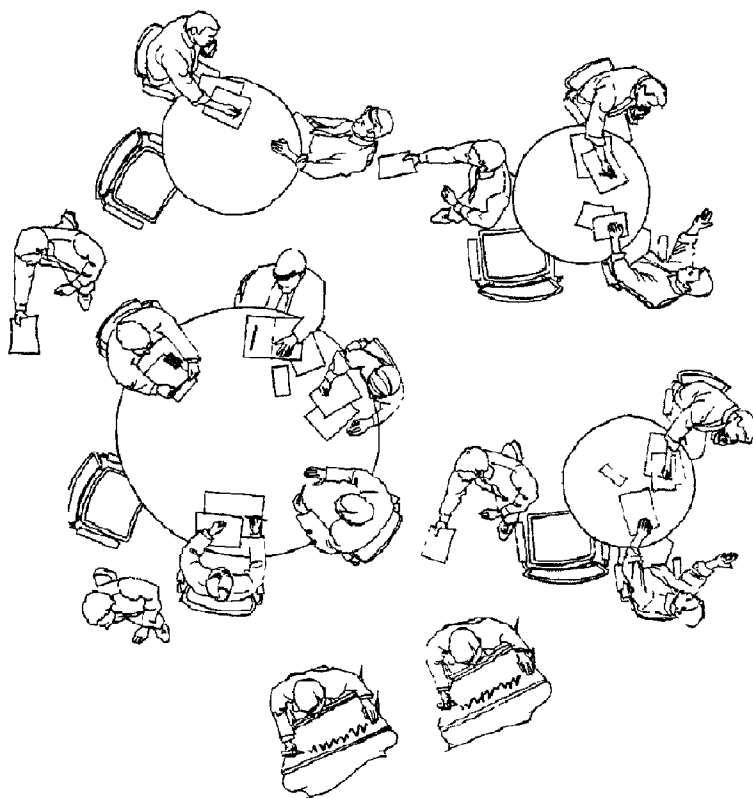


Figure 9.1

Workshops are an effective way of encouraging involvement and sharing experience

This aim might be expressed in general terms as 'to reduce the risks posed by natural hazards to an acceptable level, while contributing to other economic and social policy objectives'. It should be supported by all those who have an interest in mitigating risks within the city. To ensure this support is a continual process requiring both development of commitment and identification of 'stakeholders'. Defining an acceptable level of risk in the short term will no doubt depend on economic factors, and in the longer term, on education and public awareness.

Agree on the ultimate aim of a mitigation strategy



Successful implementation of a finite programme of actions is considerably more productive than developing an ambitious programme which is never put into effect. The former course of action will develop the skills, experience and institutional strength required for long-term mitigation. It is necessary to identify a series of clearly focused medium-term targets, such as undertaking a preliminary risk assessment, passing legislative measures and identifying high-priority actions.

Many groups of people both within the city and nationally have a potential interest in reducing the risks which the city faces; the commitment and contributions of these groups to the mitigation strategy will be a key to its success. These groups are included within the intended readership of this book, and are referred to collectively as 'stakeholders'. They might include:

Identify 'stakeholders'

- the existing emergency planning and response agency or committee
- ministries of the national government and city government
- urban district governments
- representatives of service and utility providers, such as power, water, sewerage, highways, transport, public works, energy and telecommunications
- representatives of the building sector, including construction, education, health, sport and agriculture
- representatives of local urban communities and informal settlements
- university research groups and other technical, scientific and professional organizations with expertise in relevant disciplines
- local voluntary and community organizations
- flood, storm and earthquake control commissions
- appropriate training organizations
- private sector industries and employers
- the insurance sector
- international agencies working in the region.

Many stakeholders will be progressing existing programmes of activities, into which mitigation actions may be incorporated at little or no extra cost. Stakeholders may also have the resources to initiate new activities.

Such a wide range of stakeholders will inevitably include groups with diverging objectives and priorities; an essential element of the mitigation strategy is to develop consensus. The establishment of a representative task force should ensure that all views are represented and a level of consensus is achieved.

Existing resources which could contribute to the implementation of a mitigation strategy include organizational structures, professional expertise and technical skills, sources of funding, sources of information and technical data, and available labour

Identify resources available

A preliminary review of the organizational structure of the city and national government will help to identify the most suitable agency through which the mitigation strategy can be implemented. This implementing agency should be

clearly identified, must have the resources and capacity to coordinate further action and should be linked to a key city agency such as the office of the chief executive, mayor or commissioner.

Other resources will be available both within and external to the city government structure. Full account should be taken of centres of excellence, such as specialist research departments of universities, which can provide both professional expertise and data. National government and international agencies are sources of potential funding. In all cases, the powers of the implementing agency to call upon these resources should be reviewed and, where feasible, realized

Strategic requirements

Establishment of a mitigation task force



The task force should comprise representatives of appropriate government agencies and other major stakeholders such as scientific organizations, the private sector and of local communities. Its task should be to prepare a detailed mitigation strategy for consideration and approval by metropolitan representatives, which translates broad policy objectives into specific actions. Its terms of reference should require the task force to:

- review existing data relating to natural hazards and previous disasters
- recommend an organizational framework that can ensure effective use of existing and supplementary resources in responding to the risk; building where possible on existing organizational strengths
- recognize the current responsibilities of government departments, so as to assess the need for additional resources to review how reduction of risks might be approached strategically
- assess the role and functions of any separate government organization set up to carry through elements of risk reduction, and to guide the preparedness measures and plans of other organizations
- establish the role and duties of individuals and organizations in a counter-disaster framework by administrative level and by geographical location
- define the role of working groups established to progress specific actions within the overall strategy
- devise a time schedule, in draft, of the implementation periods for acting on the recommendations made; the action plan'
- advise on the role for non-governmental organizations (NGOs)
- advise on private sector assistance that may be required to act on the recommendations
- draft the content of a law or ordinance for disaster mitigation and preparedness (should one not exist)
- recommend incentive programmes to encourage development which supports the mitigation strategy
- identify professional development needs in disaster management and staff training programmes required.

Those developing a strategy must seek to balance the powers and interests of the national, provincial and metropolitan governments active in the city, which will entail a 'parallel action' approach to devising the timing and coordination of specific mitigation policies. This approach could be organized around an implementation framework setting out:

- Core activities under the leadership of specific government departments. These might report to a joint executive committee of, for example, the IDNDR or a Flood Control Commission (at the highest level of government) or the metropolitan government. Core activities would include international water resource planning, river basin planning, flood plain zoning, urban development control, micro-zoning of risk and development areas.

- Adjunct activities of the development departments of government (as embodied in the national budget and in a rolling plan), which are undertaken primarily to meet other policy objectives. These could include development programming and projects, proposed water management and irrigation schemes, the siting of major installations of ports, industry and agricultural processing (as these will accelerate urban growth in particular directions).
- Associate activities undertaken by private organizations and NGOs, including public education and organization staff training (see also Chapter 8)



Core, adjunct and associate activities are implemented within the on-going maintenance and developmental activities of agencies and private bodies. The mitigation strategies should be embodied in programmes that may already be in existence, and will entail adding new objectives to those programmes. For example, a water supply network will be designed for resilience in the face of earthquake and flood, rather than just to a standard 'best practice' specification.

The implementing agency should coordinate and host meetings of the committee, and could also provide an information sharing office to encourage liaison between the agencies involved in implementing the strategy.

The first core activity which should be undertaken is a preliminary assessment of hazard, vulnerability and risk, utilizing the research and data resources that have been identified. This should be completed fairly rapidly (within three to four months) in order to identify priorities for further action. Results should be taken as indicative only, as they may be modified by further, more detailed studies. It should identify, using existing sources of information wherever possible:

City hazard vulnerability and risk assessment (city audit)

- the nature of potential hazards: their predicted frequency, intensity and duration
- the geographical areas of the city which are most vulnerable
- the communities, business sectors and infrastructure components which are most vulnerable
- the estimated losses which would result from hazard events of different magnitudes

Methods of assessing hazards and vulnerability are discussed in Chapter 4. The combination of these assessments enables risk to be quantified, as a measure of estimated losses. The process of risk assessment is similar to that of estimating probable maximum loss (PML). Data on the PML for specific hazard events is examined by the insurance sector in setting premiums and accepting re-insurance. There may, therefore, be some scope for cooperation between public authorities and the insurance sector in collecting data and assessing risk. An illustration of this process is given in Fig. 9.2.

A possible organizational structure for the assessment is given in Fig. 9.3. Within this structure, the assessment would be undertaken by a working group, consisting of members of the task force with appropriate expertise and other specialists coopted as necessary. Its programme and results would be regularly reviewed by the task force, to ensure that they meet the needs of the overall strategy.

The implementing agency would provide financial resources, logistic services, office accommodation and technical staff resources in support of the work. The working group would seek advice and information from specialists in all relevant disciplines. Specific sections of the assessment could be delegated to existing agencies where appropriate. For example, utilities and other service infrastructure could be appraised by the service providers, and structures by local authority

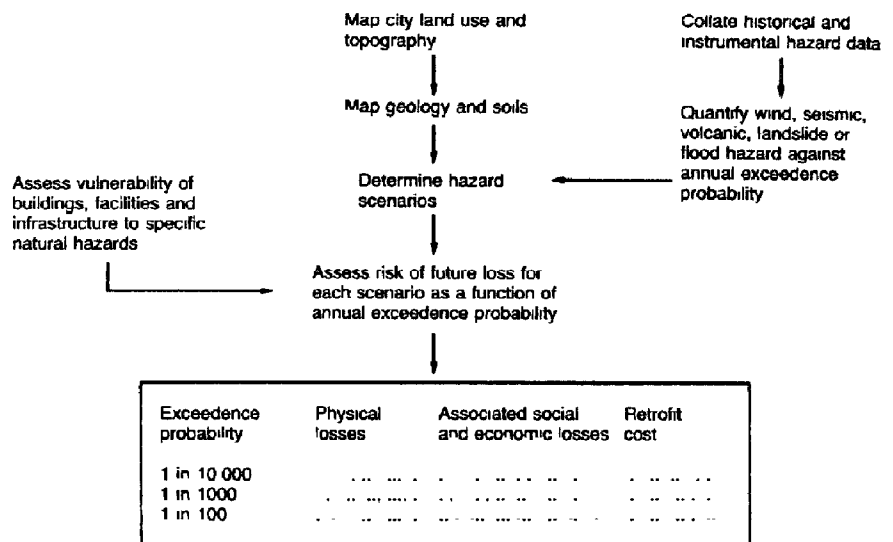


Figure 9.2
Methodology for calculating probable maximum loss.

engineering departments. Similarly, estimates of economic losses should be made in consultation with the city's commercial and professional associations, and with government ministries for trade, industry, finance and economics.

Detailed strategy and plan

The next priority is to link the abstractions of policy objectives with a concrete plan of execution, by identifying the following:

- the range of possible actions to mitigate these risks; and
- the estimated costs and benefits of these actions.

The initial appraisal will identify areas of greatest risk, to which priority should be given. Scope for further action will depend largely upon the type and extent of resources available; for example, funding may be available for some types of action but not for others, or may be subject to various conditions.

It may seem that the extent of action required is far in excess of the funding available. However, finance is only one of several resources that should be utilized; labour, political mechanisms, specialist skills, and sources of information can be equally important to progress. For example, labour-intensive projects can be particularly appropriate for low-income communities; the financial cost of such projects could be relatively low, the degree of community involvement and support correspondingly high.

The principle of cost-benefit analysis should be applied at this point. Cost-benefit analysis is a process of assessing all of the costs of a particular action or project, and all of the benefits which it will bring when completed. Actions or projects for which the benefits will be greater than the costs are described as 'cost-

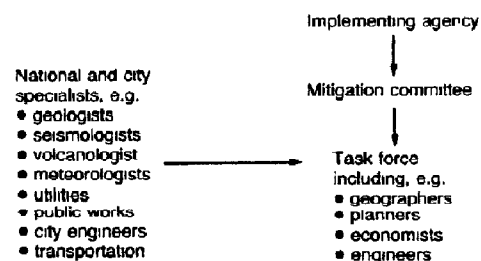


Figure 9.3
Project organizational structure.

effective', and should be given higher priority than those for which the costs are greater than the benefits (see Fig. 9.4).



Costs and benefits include social, political and environmental factors, as well as financial factors. These factors need to be given values, to enable the total costs and benefits to be assessed. A difficulty with cost-benefit analysis is that different groups of people disagree about the value of various factors; for example, the construction of a new road may be supported by those who place more importance on economic factors but opposed by others on environmental grounds. The benefits of disaster mitigation actions also include reduced risk; the value of these benefits will be based upon the estimated social, physical and economic costs of the risk.

A major difference in carrying out a cost-benefit analysis for a disaster mitigation programme, compared with a single major development, is that the programme will consist of a large number of separate and interrelated mitigation activities. Some activities will give a better cost-benefit ratio than others; judgement needs to be applied.

Having considered these points, the stakeholder committee should agree upon a set of actions which address high-priority concerns and can be achieved within the prevailing constraints. The relative costs of alternative measures should be estimated to allow decision makers to select the more appropriate strategy. To facilitate this, the proposed measures can be evaluated for their likely impact. Thus the costs can be compared to the value of the assets protected.

In Fig. 9.5(a), two hypothetical alternatives are evaluated. Option A is a high-cost measure which offers a low value of protection, while option B is a low-cost measure which results in a high value of protection. Clearly, option B would be preferred. In fact, any measure which falls in the top triangle would be preferred over any measure that falls in the bottom triangle. Indeed, options that fall in the bottom triangle should not be implemented since the value of the assets they protect is less than the cost of implementing the measure.

Similarly, different options can be evaluated in terms of the number of people, or percentage of the population (of the city or area being protected) that they would protect (Fig. 9.5(b)). Here, the options in the upper rectangle (those that reach more than half the population) should always have priority over those in the lower rectangle (which reach a minority of the population). Ordinarily, public monies should not be spent on measures that fall in the lower rectangle.

Finally, the options can also be evaluated against their relative risk-reduction implications (Fig. 9.5(c)). Options under curve B would involve a higher cost for

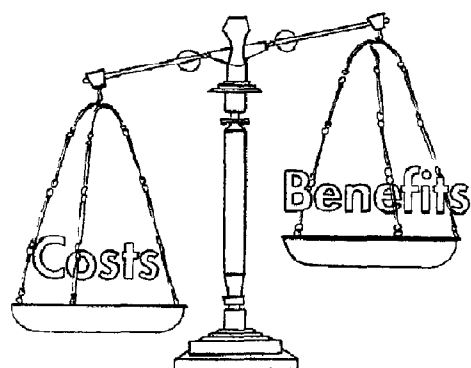


Figure 9.4

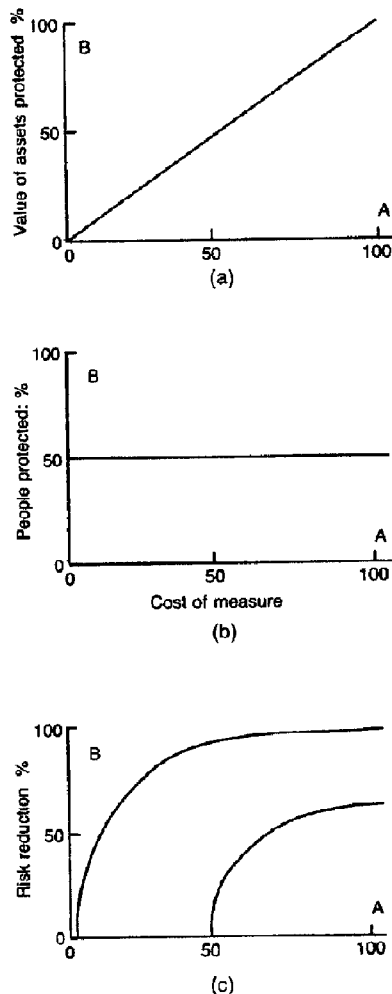


Figure 9.5
Alternative measures for disaster mitigation should be evaluated according to several criteria



a lower reduction of risks than those under curve A. Obviously, the options that fall under curve B should be selected in preference to those under curve A

In practice, it is suggested that all of these evaluation matrices should be used simultaneously, so that decisions regarding risk-reduction strategies are taken in the light of their relative costs and benefits. It will also mean that for a given level of funds, those risk-reduction measures will be implemented that will produce the greatest benefits for the largest number of people.

Coordination

A mitigation strategy should encompass both actions which are initiated or controlled by the implementing agency and also actions undertaken independently by other stakeholders.

While it is advisable to encourage different stakeholders, such as utility providers and local communities, to initiate action in their own spheres of activity, it is essential to ensure that these are complementary and that they contribute to the overall aim of the strategy. This coordinating role should be the responsibility of the implementing agency, and should be undertaken by a full-time 'project manager' under the guidance of the task force, who should be appointed prior to the preparation of the detailed strategy and plan.

The project manager should have professional experience in a relevant discipline, such as geography, urban planning, engineering or public administration, and should be responsible for:

- maintaining commitment and consensus through continual liaison with stakeholders
- identifying and resolving potential problems
- facilitating action by stakeholders, through identifying and securing additional resources
- working with stakeholders to identify ways in which existing programmes can be revised or extended to incorporate the objectives of disaster mitigation.



The work of the project manager should be reviewed and monitored regularly by the implementing agency to ensure that the strategy is being implemented effectively.

While implementation of medium-term targets should be devolved to the implementing agency, project manager and stakeholders, the initiator of the programme should focus upon achieving long-term fundamental objectives. These objectives could include:

- to reform planning processes and development mechanisms
- to review and improve standards for building regulations, codes of practice and specifications, and their implementation
- to improve professional standards, standards of construction and of construction supervision.

This section proposes key objectives for the international community, national governments and regions. It is of particular relevance to those who are able to exert influence at international or national level. The support of other readers will further contribute to the realization of these objectives.

Sources of international direction and information, and sources of international funding, are specified in Appendices 3 and 4.

Direction and information. The United Nations (UN) should give specific consideration to the concept of:

- establishing on a permanent basis a non-executive central agency to coordinate research and implementation of disaster mitigation activities world-wide, including the activities of other UN agencies
- maintaining a database of relevant information, including sources of expert advice, which is 'user-friendly' and directly and easily accessible to all countries, perhaps based upon the DHA (Department of Humanitarian Affairs) database or the UNIENET electronic bridge
- generating resources for the progress of work in developing countries
- facilitating the establishment of regional forums to exchange ideas and information
- monitoring and encourage advances in technology with regard to hazard prediction and environmental change (including climatology)
- ensuring that technological and scientific advances are incorporated into mitigation and response strategies world-wide
- promoting the review and reform of warning and reporting standards among the media
- promoting exchange visits between key officials and experts from large cities, to enable them to learn from major disasters affecting urban areas.

Funding. Major international funding agencies (e.g. UNDP, World Bank, and the regional banks such as the Asian Development Bank) are represented in most

Long-term targets

International,
national and
regional
objectives

At international level

countries. They have become increasingly aware of the need for disaster mitigation, and have organized regional seminars to demonstrate how mitigation measures can be included in design and standards.

International funding agencies should seek to amplify policies that promote the significance of investment to ensure mitigation. Grants should be conditional upon specific conditions of quality of planning and enforcement of standards. These conditions should be clearly specified. Such linkage will have a considerable effect in ensuring the advancement of mitigation plans.

At national level

Governments should be urged to:

- adopt a disaster management strategy covering mitigation, preparedness, prevention, response, recovery, reconstruction and development
- ensure that the existing disaster management structure augments or amends its system and constitution to ensure a sufficient emphasis on mitigation and preparedness
- allocate an adequate proportion of the national budget towards disaster mitigation
- define an appropriate role of the military sector in planning mitigation strategies for physical infrastructure
- consider the establishment of volunteer organizations to provide civil aid in emergency
- develop existing centres of expertise and the scope of technical data available
- enhance public awareness

At regional level

District authorities and community organizations should be encouraged to:

- identify vulnerable components within the district
- ensure that all members of the community are aware of the potential effects of natural disasters
- disseminate advice notes and good practice guides for disaster mitigation by the community
- maintain contact with officials responsible for planning, construction, health and welfare, issuing warnings, fire and crowd control
- ensure that members of the community receive suitable first aid training
- implement community education and awareness programmes by working with local schools
- identify escape routes and the location of 'safe sites' and refuges.

Within the private sector

Commercial and industrial employers should be encouraged to

- nominate a senior executive to be responsible for disaster mitigation
- ensure that staff are aware of the potential effects of natural disasters and of regional safety procedures in force
- audit buildings and infrastructure lifelines and assess the vulnerability of facilities
- adopt a policy of planned disaster mitigation
- avoid dependence on one supplier
- work with other firms to introduce lower insurance premiums, to accord with a policy of risk reduction
- retain duplicate records in an alternative location
- adopt recycling policies to minimize dependence on water supply and new materials
- provide standby generators and fuel for strategic operation
- disperse production and storage facilities over several industrial areas

Specific mitigation measures are recommended in the relevant chapters elsewhere in this book; this section summarizes those recommendations.

Chapter 5 identifies the components of a city's physical infrastructure and their potential vulnerability; the effects of the primary natural hazards on these components are stated and mitigation measures are recommended under the following headings

- preventive measures
- spreading the risk
- spreading the responsibility
- covering or minimizing the impact
- planning disaster management.

Mitigation of risks within informal communities can be difficult due to the lack of an adequate tax base to raise revenue. The most realistic solution will often be to enable communities to install, operate and maintain infrastructure and services within their area. This solution will require the provision of technical support and guidance, and of other assistance such as subsidized materials, by the city government. Provision of secure tenure, land rights and incentives to residents to improve their environment will often be the only effective way of ensuring fundamental lasting improvements in these areas.

Chapter 7 discusses the social perspective of disaster mitigation and preparedness, and recommends the rapid appraisal method for assessing vulnerability. Brief discussions of post-disaster social and health needs are included, and recommendations are made on the management of these needs, on the need to control disease vectors, animals and food supply, and on the requirements for burial of the dead and care of the bereaved

The chapter also highlights the need for background information on health, and recommends the formulation of natural hazard casualty models in order to predict the number and type of casualties for a range of disaster scenarios. Recommendations for reducing the physical vulnerability of hospital buildings are given, due to their crucial post-disaster role.

Chapter 8 discusses the role of the following agencies in increasing public awareness and specialist knowledge of natural hazards and disaster mitigation:

- schools and other educational establishments
- local community organizations and resident groups
- local health clinics
- private sector campaigns and public sector bodies
- professional and trade associations
- higher education establishments
- the communications media
- monitoring and warning agencies.

Schools also have a particularly valuable post-disaster role, in providing a focal point for social cohesion, space for emergency shelter, and a central point for distribution of emergency aid. An emphasis on higher education raises the profile of disaster mitigation by increasing the level of professional expertise and training. The media can and often does make a positive contribution to public awareness, for example by showing reports from events in other countries

Specific mitigation measures

Physical infrastructure



Social and health measures



Public awareness and education



The role of the media in disseminating forecasts and warnings of events is very important. Close cooperation and regular briefings between the administration, warning agencies and the media is required. Forecasts and warnings must be given as quickly as possible, must explain the situation and advise on precautions as clearly as possible, must reach as many of the affected people as possible, and must be perceived as generally reliable and accurate.

Recommendations for government actions to raise awareness are summarized in Chapter 8.

Models for action

This section provides guidance on implementing mitigation strategies. Contact details are provided for international agencies and specialist centres with relevant expertise. Examples of typical documentation are included for use as models.

Action plan

The following logic has been proposed for action at municipal level:

- agree on the ultimate aim of a mitigation strategy
- identify stakeholders, and establish a formal mitigation committee
- identify resources available
- identify and task an implementing agency
- establish a mitigation task force, under the aegis of the implementing agency
- carry out an initial appraisal of the city (within one to two months)
- appoint a full-time project manager
- carry out a detailed city hazard vulnerability and risk assessment (city audit)
- establish a detailed strategy and city action plan, on the basis of cost-benefit analysis (see Table 9.2)
- ensure support of the detailed city action plan within nation government
- where appropriate, apply to national budget and international funding agencies for support in implementation of city action plan
- implement city action plan, which is to be reviewed at regular intervals.

Table 9.1 Example of estimated costs (at 1995 levels)

1. Initial appraisal of city (duration 4 weeks)			
		Person weeks	Typical cost
Project manager		4	£4,000
Support staff (engineers, scientists, planners, economists)		12	£6,000
Expert consultants		4	£8,000
Expenses (travel costs, information, report production)			£6,000
Total cost			£24,000

2 City Hazard vulnerability and risk assessment (city audit)				
Stage 2.1 – Project set up				
Stage 2.2 – Data collection and analysis				
Stage 2.3 – Reporting				
		Person months		Typical cost
	2.1	2.2	2.3	
Project manager	1	2	2	£20,000
Support staff	2	8	4	£28,000
Expert consulting	1	4	2	£56,000
			Cost	£104,000
Expenses				£24,000
			Total cost	£128,000

Estimates of costs will depend on local rates and on the availability and extent of data for the city. Costs given here are indicative only, based on 1995 levels.

Table 9.2 Draft outline for city action plan

-
- Invite all stakeholders to a workshop or seminar, to discuss their contributions to and roles in the mitigation programme, with the active involvement of the mitigation committee, project manager and task force
 - Invite stakeholders to contribute to a preliminary assessment of hazard, based on surveys of the natural environment, historical research, classification of physical infrastructure, economic surveys, social surveys, medical research and veterinary public health, against a standard framework of criteria.
 - Invite scientific organizations to assess the probability of hazard events of different magnitudes occurring in the city, and to present this information in the form of hazard zonation maps.
 - Invite those stakeholders who are responsible for provision of public services and infrastructure to identify the vulnerability of critical sections of lifelines and buildings of post-disaster significance and to prepare schedules of elements at risk, against a standard framework of criteria.
 - Require the engineering profession to review existing codes of practice.
 - Publish regular reports on progress within different sectors to promote awareness.
 - Prepare a prioritized programme based on economic and social criteria for mitigation actions including retrofitting or replacement for each major section of the infrastructure.
 - Undertake feasibility studies for specific projects, and apply for funding.
 - Establish education and training requirements based on assessment studies, and initiate programmes
 - Prepare good practice guides for the building trades and self builders, including model units.
 - Initiate low-cost community participation programmes.
 - Raise the profile of disaster management, in particular mitigation. Increase numbers of national professional experts and encourage contact with international sources of expertise
 - Invite stakeholders to report annually on their progress in implementing agreed actions.
-

A suggested budget for an initial assessment of the city and for a more detailed city audit are given in Table 9.1. Table 9.2 shows an outline of a draft city action plan. Table 9.3 outlines a draft mitigation project review form and Table 9.4 gives some rapid appraisal techniques.

Notes on workshop. Nominated 'champions' of organizations are invited to the workshop, at which they would be asked to assess the potential effects of a natural hazard, or of the failure of a lifeline on which their service depends, upon their organization's primary network. Results would help to identify critical nodes and areas of weakness and provide the basis for an analysis of the cost of a failure and its consequences, and the cost of strengthening.

The workshop would provide a forum for organizations which have already made progress with mitigation to pass on experience, and an opportunity to establish what additional information and assistance organizations require. Copies of briefing documents could be distributed. Champions would be made aware that a review of their organization's vulnerability would highlight the importance of the service and provide a basis to support applications for funding of mitigation projects.

Notes on feasibility studies. Before agreeing to provide funding for a project, an agency will require a feasibility study. This should be submitted with the project review form, and should include

- details of implementing agency and project team
- description of scheme
- cost-benefit analysis of scheme, including arrangements for servicing of loan

Table 9.3 Disaster mitigation project review form. A generic draft to be amended for use in each city

Until disaster mitigation is fully embodied in the project design process, this review form may be attached to the formal project document, annual programme review or project evaluation document.

- 1 Project/programme title and reference number
- 2 Budget line and period of implementation
- 3 Mode of finance: contributions from
 - local community
 - urban administrative unit
 - provincial government
 - central government
 - international grants and loans
 - other
- 4 Repayment assumptions and programming
- 5 Location of project in city
 - gas distribution system
 - water distribution main
 - waste-water system
 - electricity supply
 - flood protection works
 - mass transit system
 - area development for mixed uses
 - low-income housing area upgrading
 - buildings of post-disaster significance
 - other
- 6 Use made of mitigation decision aids in project design:
 - surveys and hazard mapping
 - character and locations of past incidents
- 7 Method of establishing the safety and security standards adopted, for example 'the design flood', 'the cyclone wind', the earthquake force and anticipated effect on local ground conditions
- 8 Nature and assessment made of the underlying and direct causes of settlement vulnerability at identified locations
- 9 Define structural and non-structural steps taken in project design to reduce vulnerability
- 10 Describe how project design meets the requirements of associated policies
 - development of societal facilities
 - development of economic and industrial facilities
 - reduction of environmental pollution
 - conservation of heritage sites and buildings
 - conservation of nature
- 11 Assess and give reasons for the impact that the project will make on local disaster risk:
 - lower risk
 - no change
 - increased risk (unless other steps are taken)
- 12 Define other measures external to the project framework that should be undertaken to ensure the risks are lowered as the project design proposes
- 13 Define project implementation risks that need to be managed

- environmental impact assessment of scheme
- details of how the scheme will be implemented and managed
- proposals for operation and maintenance of the scheme once it is completed
- implementation programme or schedule.

Guidelines for city sectors

One way of encouraging widespread involvement is to develop guidelines for each sector, model guidelines have been prepared for the following seven sectors:

Table 9.4 Rapid appraisal techniques

Rapid appraisal techniques involve various permutations of the following:

- key informant interview
- interviewing a select group of individuals who are in a position to provide the needed information, ideas and insights; for example teachers or other representatives of the community. Thus, for example, 'mothers' are in a good position to talk about the impact of disasters on the well-being of the family

Key informant interviews

- are essentially qualitative interviews
- are carried out with interview guides listing topics and issues to be covered in the session
- involve a small number of interviewees selected on the basis of their specialised knowledge and experience of the subject under investigation.

The accuracy and depth of information obtained depends primarily on:

- selecting suitable informants
- developing suitable interview guides
- training interviewers
- the care taken in conducting interviews, probing informants, and recording responses.

Focus group interviews

Interviews conducted to discuss a specific topic in group sessions. Participants discuss ideas, issues, insights, and experiences among themselves, and each member is free to comment, criticize, or elaborate on the views expressed by others. The premise underlying the focus group method is that free discussions generate fresh ideas and insights because the participants stimulate each other

Community interviews

The interviewer asks questions, raises issues, and seeks responses from the participants. The primary interactions are between the interviewers and the participants rather than among the participants. Although community interviews can be conducted by one interviewer, a team of two or more is preferable, because it is difficult for a single individual to preside over the meeting, ask relevant questions, and record the answers.

Structured direct observation

Involves careful gathering of data based on observation forms, which are designed to take into consideration the nature of the object to be observed (for example, house construction). In most instances, direct observation also involves individual or group interviews, or both. Direct observation can deal with physical objects but not directly with activities and institutions.

Direct observation is better conducted by a team of experts than by a single individual. A team approach contributes to more comprehensive data collection and helps to prevent individual biases.

Informal surveys

Such surveys are usually conducted on the basis of an open-ended questionnaire that permits respondents to answer questions in their own words. The sample size usually ranges from 25 to 50 people.

MG1 – Schools

MG2 – Hospitals

MG3 – Industries

MG4 – Emergency services

MG5 – Utilities

MG6 – Media

MG7 – Building owners

These model guidelines are considered adequate to form the basis for the preparation of detailed guidelines, which will differ significantly in different cities. Other guidelines which could make a useful contribution to awareness and mitigation in the city should be prepared for several other sectors including: transport, food and catering, NGOs; and commerce.

Sector : Transport
Division : Highways (bridges)
District : Central

All structures have
been strengthened

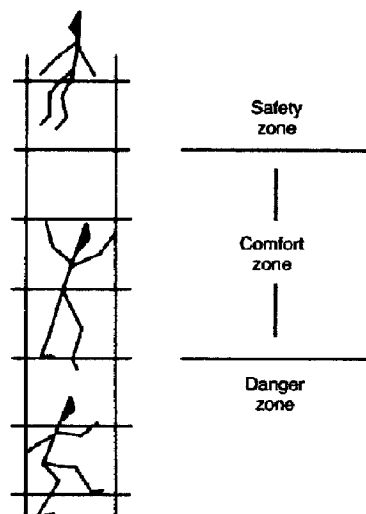
We have received the
funds and started work

We have an action plan
and applied for funds

We know what the
problems are

We are carrying out
an audit

We are considering
the situation



Note: Similar ladders to be prepared for all
divisions of the infrastructure

Figure 9.6

*Assessment ladder to show
progress with mitigation of
vulnerability.*

Model guideline 1

Guidelines for schools (to be edited for each interest group; interest groups: governors and owners, staff, children, parents, community leaders)

Understanding the requirements



Those involved in education should be aware of the requirements of disaster management (see Chapter 3) and of the activities appropriate to each stage. For example:

- Preparedness – formulate an emergency plan, with staff responsibilities defined as for fire drills, prepare for all contingencies (such as absence of the headteacher), provide training for staff in first aid, store emergency supplies of food and medicines.
- Mitigation – locate schools in buildings which can resist extreme hazard events, or which have specially designed ‘safe’ areas, and which have detailing and strategic equipment that will remain stable during a hazard event.
- Warning – disseminate official warnings and take appropriate action, as detailed in the emergency plan.
- Impact – practise safety drills, for example climbing under tables when an earthquake occurs.
- Response – search and rescue, apply first aid and assess the stability of school buildings.

Individual responsibilities

Owners and governors

- What does the national and municipal law require?
- Has an audit been carried out to identify safe areas within school buildings and grounds?
- What are the consequences of failure of the water supply, drainage, gas and electricity supply, telecommunications and transport links?
- Ensure that the school has a short-term preparedness plan and long-term mitigation plans, including clear procedures for action before, during and after an event
- Ensure that staff understand their roles in the event of a disaster, and carry out periodic drills.
- Ensure the fire safety team, first aiders and evacuation team receive specialized training.

- Include hazard awareness and disaster management principles within the school curriculum.



Headteachers, deputies and staff.

- Ensure that procedures are in place and advise the owners or governors of the school if any are not
- As part of the emergency plan, define the role of each member of staff in disaster response (for example, fire safety, first aid, search and rescue, site security, food supply, communications and media, coordination of volunteers).
- In secondary schools and colleges, help students to create 'risk maps' of their classroom, school and neighbourhood, identifying hazards, counter-measures and resources.
- As part of the emergency plan, distribute a map showing the location and telephone numbers of the nearest hospitals, clinics, fire station, police station and public works department

Parents.

- Is your children's school safe from natural hazards? You should be entitled to receive reassurance from the owners and governors.
- Do you understand the potential effects of natural hazards and their mitigation? If not are you interested in attending adult classes to learn more?

The school and community.

- Is the school located in a disaster-prone area? Should the building be strengthened? What facilities does the school have which would make it a useful community resource?
- Have education programmes been arranged for children, staff and parents?

A strategy and action plan for the school should consider.

- what are the risks of different hazard events?
- plans for response
- day or night
- plans for preparedness
- long-term plan for mitigation.

Guidelines for health care to be edited for each interest group; interest groups: governors, owners, health centre staff, community leaders.

Model guideline 2

Health-care organizations should be aware of the requirements of disaster management (see Chapter 3) and of the activities appropriate to each stage. For example:

- Preparedness – formulate an emergency plan, including triage procedures, stores of medicines and dressings, training of health-care personnel in emergency first aid and disaster-related injuries such as crushing and burns, food supplies to sustain the staff and patients and emergency water and electricity supplies. The plan must be tested.
- Mitigation – ensure that hospitals and clinics are distributed around the city, established in buildings which can resist extreme natural hazard events and have detailing and strategic equipment which will remain stable during and after an event, have guaranteed alternative sources of water and electricity and are readily accessible from alternative transport routes

Understanding the requirements





Individual responsibilities

- **Warning** – disseminate official warnings and take appropriate action, as detailed in the emergency plan. This could include discharging some patients or relocating them to other health-care centres.
- **Impact** – take cover
- **Response** – search and rescue, ensure that the building is safe, liaise and coordinate with emergency services and city authorities.

Owners and governors:

- what does the national and municipal law require?
- Has an audit has been carried out to identify any weaknesses in the location and structure of the buildings and finishes?
- Ensure that the consequences of failure of the water supply, drainage, power supplies, telecommunications or transport have been assessed, and where necessary make arrangements for alternative facilities.
- Ensure that the health-care facility has a short-term emergency plan and long-term mitigation plans, including procedures for response to an event.
- Ensure that key members of staff understand their roles in disaster response, and that they carry out regular drills.
- Ensure that key members of staff receive specialist training.

Chief executives, administrative managers and health-care staff:

- Because many health-care facilities are occupied continuously, it is particularly important to ensure that all necessary procedures are in place. If this is not the case, the owners or governors must be advised immediately.
- As part of the emergency plan, define the roles of each member of staff in the event of disaster (for example fire safety, first aid, search and rescue, site security, logistics, communications, media liaison, volunteer coordinator).
- Dedicate a small medical unit to observe and record.

The health-care facility and the community – what role can the centre undertake after a hazard event?

Training and education for each health centre – what programmes have been arranged for staff?

- seminars
- workshops
- specialist.

Strategy and action plan for each health centre – do you have the information and have you prepared a plan?

- what natural disasters
- plans for response
- day or night
- plans for preparedness
- long-term plan for mitigation.

Model guideline 3



Guidelines for industries to be edited for each interest group; interest groups: owners, shareholders, directors, managers and staff.

These guidelines are particularly suitable for those working in the chemical industry who wish to develop a suitable risk control and safety strategy

Where there are no definitive and mandatory rules on the level of protection to be provided against the risk of industrial hazards, minimum legal requirements

for basic health and safety are unlikely to provide for adequate protection of property and persons in the event of a major hazard event.



The dynamic processes that take place during a natural hazard event can trigger industrial hazards. Chemical processing plants may present significantly higher risks than other industrial facilities. Safe design, adequate loss control and safety systems, and risk-control management are therefore required to minimize the risk and consequences of losses. The level of safety in design and loss control provision should consider a number of factors, including risk management philosophy, cost-benefit analysis, insurance considerations, and business interruption factors relating to long-term risk.

Industrial enterprises should be aware of the activities involved in each stage of disaster management (see Chapter 3).

Understanding the requirements

Preparedness. Formulate an emergency plan, briefing staff on their roles during a disaster, holding regular fire and emergency drills, training some members of staff in first aid and storing emergency medical supplies relevant to the industry. An emergency plan must also cover:

- risk – an understanding of the potential effects of a hazard event on industrial facilities
- fire protection – water and foam systems and, for large sites, fire trucks
- emergency response – team organization, training and procedures, communication with relevant city services
- supplies – adequate provision of critical spare parts
- training and awareness – continual training of public and private sectors, knowledge of response required by the local population (such as evacuation and response of fire services)
- response measures – strategic placing of appropriate resources such as containment and handling equipment
- communications – alternative means of communication to receive warnings and to communicate with emergency management agencies.

Mitigation. Long-term planning to develop an industry which is not seriously affected by hazard events. Mitigation should include consideration of the following.

- site location – soil conditions, emergency access and proximity to emergency services, exposure of the site to natural hazards and risk to the site during hazard events
- site layout – separation and segregation between process units, control buildings, offices and hazardous storage facilities
- construction – protection of critical control systems
- spillage control and drainage – containment of the maximum expected process spill
- utilities – backup and redundancy to provide safe plant shut-down
- insurance – property and production underwriting and standards for compensation

In addition, a number of pre-event measures should be considered:

- regulatory measures – development of regulations and rigorous guidelines on natural disaster risks and empowerment of agencies to monitor compliance with regulations and guidelines
- mitigation programmes – analysis, development and implementation of programmes, projects and plans
- vulnerability analysis – research into the interaction between natural hazards and industrial emergencies
- risk reduction – dispersal of industrial facilities.



Warning. Disseminate official warnings and take appropriate action, as detailed in the emergency plan. Where necessary, establish a communication specific warning system and evacuation plans for high-risk disasters and potential secondary industrial emergencies.

Impact. The emergency plan should establish procedures, such as safe areas of the industrial complex where staff can assemble. Separate areas might be located within each building.

Response. Search and rescue, apply first aid, ensure that the plant and buildings are safe.

Training and education. What programmes have been arranged for staff?

- seminars
- workshops
- specialist.

Strategy and action plan. Do you have the information and have you prepared a plan?

- what natural disasters
- plans for response
- day or night
- plans for preparedness
- long-term plan for mitigation

Model guideline 4

Understanding the requirements



Guidelines for emergency services to be edited for each interest group; interest groups: city councillors, managers, staff and the public.

Those involved in providing emergency services [police, fire brigade, ambulance and street clearance (PWD)] should make themselves aware of the requirements of disaster management and understand the roles necessary for each stage. For example.

- Preparedness – have a disaster plan with staff job functions defined so that each individual knows his role without waiting for instructions. Ensure that if the piped water supply fails, all potential sources of water are accessible for fire fighting – lakes, sea water, swimming pools, streams, fire tanks. Ensure that all health facilities that can treat accidents – burns, crush, shock – are known and alternative access routes identified. Make plans for dealing with 1000, 10,000, 100,000 or 1,000,000 fatalities, e.g. temporary mortuaries, procedures for identification of the dead, mass burial grounds. Ensure that there is a plan to control traffic to facilitate free movement of emergency vehicles
- Mitigation – have police, fire and ambulance stations in every district of the city, each with independent communication systems and supplies of water available if the piped system fails.
- Warning – stop all leave and motivate staff. If necessary, recruiting auxiliary staff. Help to make space in hospitals to receive casualties.
- Impact – search and rescue.
- Response – search and rescue, clearing streets of debris, extinguishing fires, controlling crowds, maintaining lifelines (food and water tankers)

Individual responsibilities

City councillors.

- Insist on the preparation of a city audit which will show how and where the city could suffer damage from a major natural hazard.
- Ensure that the services are adequately funded so that equipment and staff can be located in every district of the city and kept in good order.



- Ensure that there are clear lines of responsibility for all city organizations for disaster response. Ensure that there is no doubt which is the lead organization for each stage of a natural hazard event
- Ensure that the emergency services are site and community driven and are not subject to a theoretical central bureaucracy
- Ensure that you appreciate the scale of a potential natural hazard disaster (e.g. could be 1000 times normal daily problems) and all city services have a plan to cope with the scale of the problems.
- Encourage all communities, commercial and industrial organizations to nominate their own 'first aiders' and fire guards.

Emergency services chief executives and managers.

- Ensure that equipment and staffing levels are sufficient to meet requirements and that equipment is regularly serviced and tested.
- Establish secondment arrangements for augmenting equipment and staff to be available to deal with the problems of very large natural hazard events.
- Ensure that regular specialist training is given to all emergency services staff.
- Implement extensive public training programmes in first aid and fire prevention, such as weekend or evening courses.
- Ensure that all staff know their responsibilities in the event of a major natural hazard.
- Ensure that all fire teams know where to obtain water if the piped water supply fails. Ensure that all ambulance crews know to which health centre to take casualties, taking into account blocked roads and damaged hospitals.
- Are you aware of how other large cities in hazard-prone areas organize their emergency services?
- Have you developed scenarios for a range of potential events: e.g. a gas explosion, a plane crash, a flood?

Public

- Do you know the location of your nearest fire station, health care unit, ambulance station, police station?
- Do you know what to do in the event of a fire, injury to a member of your family or a neighbour, particularly if no assistance is immediately available?
- Are there people in your community who have been trained in first aid or fire prevention?
- Do you or members of your community know where fire prevention or first aid training can be obtained?
- Does your office, industrial complex or centre carry out fire drills?

Training and education What programmes have been arranged for directors, managers and staff?

- seminars
- workshops
- specialist presentations
- exchange visits
- joint exercises.

Strategy and action plan. Do you have the information and have you prepared the plans?

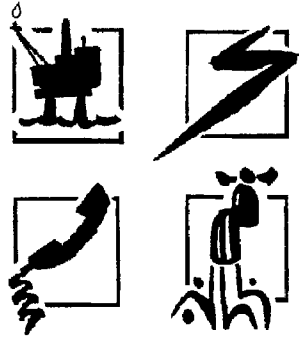
- what natural disasters: earthquakes, cyclone, flood, tsunami, landslide, volcano?
- the coincidence of two or more natural hazard events
- time of event: working day, non-working day, night

- plan for preparedness
- long-term plan for mitigation.

Model guideline 5

Guidelines for utilities to be edited for each interest group; interest groups: directors, chief executives, managers, head office staff, field staff and users

Understanding the requirements



Those involved in providing utility services (gas, electricity, water, drainage) to residential, commercial and industrial consumers should make themselves aware of the requirements of disaster management and understand the roles necessary for each stage. For example:

- Preparedness – have a disaster plan with staff job functions defined primarily to bring the service back into operation as quickly as possible. Hold spares, test stand-by equipment, keep fuel tanks full, test shut-off valves, keep fire reservoirs full, retain a fleet of water tankers.
- Mitigation – strengthen systems so that natural hazards have minimum effect or the design the system so that, after failure, it can be brought back into full operation within hours or days. Provision of redundancy and alternative routing, provision of isolation valves and automatic shut-off valves. Dedicate supplies for emergency services and strategic buildings.
- Warning – cancel leave. Put repair teams on stand-by.
- Impact – shut off services which could be damaged.
- Response – shut off services which have been damaged, carrying out emergency repair work, starting with mains, then industrial supplies and, finally, all domestic supplies. Ensure that if piped domestic supplies are not available, then regular tanker supplies are provided.

Individual responsibilities

Directors.

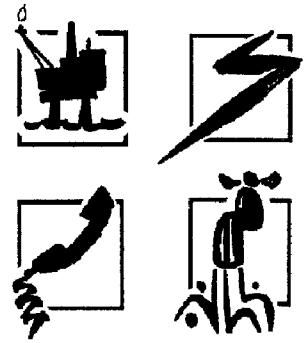
- What is your utility's responsibility for maintaining a continuous supply to hospitals, pumping stations, the media, etc?
- Ensure that an audit is carried out on the likely effect of natural hazard event on your utility
- Ensure that an assessment is made on the likely time necessary to return to normal operations after different magnitude natural hazard events.
- Ensure that your company has got a strategy for reducing the impact of natural hazard events.
- Ensure that your company has a department which manages your mitigation programme.
- Ensure that staff understand their roles in the event of a disaster and encourage them to participate in training programmes for disaster management

Field staff.

- Learn requirements of disaster management.
- Ensure that you have a plan which is kept up-to-date of the service in your district and details of how and where it connects to the main system.
- Ensure that you are familiar with the service in your district, its strengths and weaknesses, and have an idea where a failure might occur.
- Ensure that you have access to and regularly test all shut-off valves which may need to be operated before, during and after a hazard event.
- Ensure that you have an up-to-date programme of the services that must have priority for operation after a hazard event.

Users.

- How long can your community manage without water or electricity supplies? Can water supplies be obtained within a reasonable walking distance? Is the alternative supply of drinking water standard?
- What community action can be undertaken before or after a hazard event, e.g. clearing drains?
- How long can your industry manage before the lack of water/electricity/ gas effects production or damages the plant? What arrangements have you made to mitigate or reduce the impact of natural hazards?
- Have you got access to a mobile telephone?
- Do you know where to switch off gas supplies until the service has been checked for leaks?



Training and education. What programmes have been arranged for directors, managers and staff?

- seminars
- workshops
- specialist presentations
- exchange visits.

Strategy and action plan Do you have the information and have you prepared plans?

- what natural disasters cause what damage
- recovery of service – preliminary assessment of the time to recover following a major event
- time of event: day or night
- plan for response
- plan for preparedness
- long-term plan for mitigation.

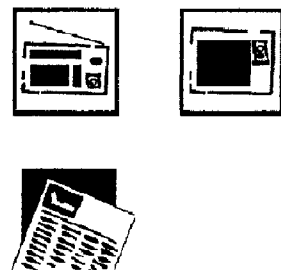
Guidelines for the media to be edited for each interest group; interest groups: proprietors/directors, office manager, journalists and the public.

Those involved in the media (radio, television, newspapers) should make themselves aware of the requirements of disaster management and understand the roles necessary for each stage. The media has a special responsibility to assist the city and report matters dispassionately without their usual role of looking for stories. For example:

- Preparedness – have a disaster plan with staff job functions defined primarily to maintain the media in operation before, during and after a hazard event, so that the city residents and the international community can be warned and kept informed. Media preparedness also means testing their stand-by generators and ensuring that adequate fuel supplies are held. Agree with city officials the access needed to the media by them, to provide official announcements.
- Mitigation – have facilities in more than one location. Strengthen buildings to minimize the impact of a natural hazard. Provide an independent communications system.
- Warning – attend briefing meetings with scientific centres and report to the public in an informative way.
- Impact – quickly fly over damaged area to provide assessment of the extent of the damage.
- Response – fly over damaged area to provide re-assessments of the extent of the damage. Assisting the emergency services by reporting which roads

Model guideline 6

Understanding the requirements



are blocked, which hospitals are damaged, which areas are flooded. Assist the public by passing on information and advice.

Individual responsibilities



Proprietors/directors.

- Agree with the city authorities how the media can best serve the public interest in reporting warnings and natural hazard events.
- Ensure that an audit is carried out on the likely effect of natural hazard event on your station, mast, printing facilities, offices, electricity supply.
- Ensure that your company has a strategy for reducing the impact of natural hazards.
- Agree with the educational and city authorities how the media can assist with public awareness and education campaigns for many areas of disaster mitigation.
- Consider running prize competitions for communities progress and ideas for mitigation, and also for other city sectors such as schools and industry.

Journalists

- Arrange meetings with scientific and technical groups and reach an outline agreement on how technical information should be supplied to the media and how the media should present it to the public.
- Establish a liaison committee with all relevant city groups to review media activities, with meetings to be held on a regular (e.g. twice yearly) basis.
- Find out what assistance the city and emergency services require and publicize these requirements, e.g. blankets, tents, money, specific medicines. Do not encourage international rescue teams to offer their services
- Have you got access to independent communications?

The public.

- Do you understand how natural hazard warnings are given? Do you understand what they mean?
- Do you know what to do when natural hazard warnings are given?
- Do you know how to contact the media to report local events?

Training and education.

What programmes have been arranged for directors, managers and journalists?

- seminars
- workshops
- specialist presentations
- exchange visits.

Strategy and action plan Do you have the information and have you prepared plans?

- what information do you have about the city and the damage that can be cause by different natural hazards
- the effect of the time of event: day or night
- plan for response
- plan for preparedness
- long-term plan for mitigation.

Model guideline 7

Guidelines for the building industry to be edited for each interest group; interest groups owners/directors, managers, owner occupiers, designers, contractors, tenants and the public

Those involved with buildings (housing, flats, offices, public halls, factories, warehouses, shopping complexes, hotels) should make themselves aware of the requirements of disaster management and understand the roles necessary for each stage. For example.

- Preparedness – have a disaster plan with staff job functions defined for public buildings, including fire officers and first aiders. Consider keeping some emergency supplies of water, medicine and food. For residential buildings, issues guidance notes to all tenants on what to do before, during and after a hazard event.
- Mitigation – design new buildings, particularly public and residential buildings, to resist hazard events. Design ‘safe’ areas which have non-structural finishes and strategic equipment that will remain stable during a natural hazard event. Up-grade all strategic buildings by retrofitting.
- Warning – cancel leave of strategic personnel. Take appropriate action to protect the building.
- Impact – search and rescue. Shut off services (gas, water, electricity).
- Response – search and rescue, applying first aid. Make building safe. Find or provide temporary accommodation.

Understanding the requirements



Owners/directors.

- Know what the national and municipal law requires and what your responsibilities are for people's safety.
- Know the strength of your building to withstand natural hazards.
- Arrange for safe areas in the building if moderate damage is possible from a natural hazard.
- Arrange for emergency plans to be developed to deal with damage from natural hazards.
- Ensure that people using the building have a procedure to follow in the event of a natural hazard event.
- Provide information for emergency services at the entrance – floor plans, structural plans, services and the location of shut-off valves.
- Before buying a building, insist on full information – an ‘audit’ – of the building, covering the foundation, structure, cladding and other finishes.
- Before commissioning a new building, ensure your design team is expert in the design of buildings to minimize the impact of the relevant natural hazards.

Individual responsibilities

Designers (architects/engineers).

- Become familiar with the natural hazard events that could occur in the city and the likelihood of different magnitudes.
- Understand that natural hazards can severely damage *all* buildings and structures if they are not designed correctly. Make yourself familiar with the likely effects of natural hazards on buildings including the cladding and finishes and research the best designs to resist the natural hazard forces.
- Be familiar with the city zonation plans; including the areas that require special foundations and those areas which have a high exposure to natural hazards.
- Use relevant specifications and codes. Adopt an international code if the local one is out-of-date or not comprehensive.
- Ensure that detailing of steelwork, ties, bracing, anchors are in accordance with good practice.
- Ensure that the client is aware of the need for detail supervision of the construction.



Tenants

- Do you understand the natural hazard events that can occur in your city?
- Is your house, office or factory vulnerable? Do you know the strength of the building to withstand natural hazards. Is it located in an area which could be susceptible to landslides or floods?
- Do you know what to do when a natural hazard warning is given?
- Do you know who in the building has had first aid training?

Training and education.

What programmes have been arranged for owners, designers and contractors?

- seminars
- workshops
- specialist presentations
- study teams.

Strategy and action plan.

Do you have the information and have you prepared plans?

- what information do you have about the city and the damage that can be cause by different natural hazards
- the effect of the time of event: day or night
- plan for response
- plan for preparedness
- long-term plan for mitigation, including retrofitting.

IDNDR world conference objectives: outcome of the conference, including a plan of action for natural disaster reduction

Appendix

1

Draft Yokohama message submitted by the Chairman of the Open-ended Drafting Group of the Main Committee, Mr Daniel D. C. Don Nanjira (Kenya), at the World Conference on Natural Disaster Reduction, 23–27 May 1994.

We, the State Members of the United Nations and other States, having met at the World Conference on Natural Disaster Reduction, in the city of Yokohama, Japan, from 23 May to 27 May 1994, in partnership with non-governmental organizations, and with the participation of international organizations, the scientific community, business, industry and the media, deliberating within the framework of the International Decade for Natural Disaster Reduction, expressing our deep concern for the continuing human suffering and disruption of development caused by natural disaster, and inspired by the Yokohama Strategy and Plan of Action for a Safer World,

Affirm that:

The impact of natural disaster in terms of human and economic losses has risen in recent years and society in general has become more vulnerable to natural disasters. Those usually most affected by natural and other disasters are the poor and socially disadvantaged groups in developing countries as they are least equipped to cope with them.

Disaster prevention, mitigation, preparedness and relief are four elements which contribute to, and gain from, the implementation of sustainable development policies. These elements, along with environmental protection and sustainable development, are closely interrelated. Therefore, nations should incorporate them in their development plans and ensure efficient follow-up measures at community, national, sub-regional, regional and international level.

Disaster prevention, mitigation and preparedness are better than disaster response in achieving the goals and objectives of the Decade. Disaster response alone is not sufficient, as it yields only temporary results at a very high cost. We have followed this limited approach for too long. This has been further demonstrated by the recent focus on response to complex emergencies which, although compelling, should not divert from pursuing a comprehensive approach. Prevention contributes to lasting improvement in safety and is essential to integrated disaster management.

The world is increasingly interdependent. All countries shall act in a new spirit of partnership to build a safer world based on common interests and shared responsibility to save human lives, since natural disasters do not respect borders. Regional and international cooperation will significantly enhance our ability to

achieve real progress in mitigation of disasters through the transfer of technology and the sharing of information and joint disaster prevention and mitigation activities. Bilateral and multilateral assistance and financial resources should be mobilized to support these efforts.

The information, knowledge and some of the technology necessary to reduce the effects of natural disasters can be available in many cases at low cost and should be applied. Appropriate technology and data, with the corresponding training, should be made available to all freely and in a timely manner, particularly to developing countries.

Community involvement and their active participation should be encouraged in order to gain greater insight in to the individual and collective perception of development and risk, and to have a clear understanding of the cultural and organizational characteristics of each society as well as of its behaviour and interactions with the physical and natural environment. This knowledge is of the utmost importance to determine those things which favour and hinder prevention and mitigation or encourage or limit the preservation of the environment for the development of future generations, and in order to find effective and efficient means to reduce the impact of disasters.

The adopted Yokohama Strategy and related Plan of Action for the rest of the Decade and beyond:

- (a) Will note that each country has the sovereign responsibility to protect its citizens from natural disasters;*
- (b) Will give priority attention to the developing countries, in particular the least developed, land locked countries and small island developing states;*
- (c) Will develop and strengthen national capacities and capabilities and, where appropriate, national legislation for natural and other disaster prevention, mitigation and preparedness, including the mobilization of non-governmental organizations and participation of local communities;*
- (d) Will promote and strengthen sub-regional, regional and international cooperation in activities to prevent, reduce and mitigate natural and other disasters, with particular emphasis on;*
 - (i) Human and institutional capacity-building and strengthening;*
 - (ii) Technology sharing, the collection, the dissemination and the utilization of information;*
 - (iii) Mobilization of resources.*

The framework of action of the International Decade for Natural Disaster Reduction provides all vulnerable countries, in particular the developing countries, with the opportunity to achieve a safer world by the end of this century and beyond. In this regard, the international community, and the United Nations System in particular, must provide adequate support to the International Decade for Natural Disaster Reduction, and its mechanisms, especially the Secretariat of the Decade to enable them to carry out their mandate.

The Yokohama Conference is at a crossroad in human progress. In one direction, lie the meagre results of an extraordinary opportunity given to the United Nations and its Member States. In the other direction, the United Nations and the world community can change the course of events by reducing the suffering from natural disasters. Action is urgently needed.

Nations should view the Yokohama Strategy for a Safer World as a call to action, individually and in concert with other nations, to implement policies and goals reaffirmed in Yokohama, and to use the International Decade for Natural Disaster Reduction as a catalyst for change.

Glossary

This glossary is based upon definitions given by the United Nations Department of Humanitarian Affairs (DHA) in its publication, *Glossary: Internationally Agreed Glossary of Basic Terms Related to Disaster Management*.

Acceptable risk Degree of human and material loss that is perceived by the community or relevant authorities as tolerable in actions to minimize disaster risk.

Assessment Survey of a real or potential disaster, to estimate actual or expected damages, and to recommend prevention, preparedness and response measures.

Civil defence Systems of measures, usually run by a governmental agency, to protect the civilian population in wartime, respond to disasters, and prevent and mitigate consequences of major emergencies in peacetime.

Damage classification Evaluation and recording of damage to structures, facilities, or objects according to three (or more) categories: (a) 'severe damage' precludes further use of the structure, facility, or object for its intended purpose. (b) 'Moderate damage' to principal members which precludes effective use of the structure, facility, or object for its intended purpose, unless major repairs are made, short of complete reconstruction. (c) 'Light damage' such as broken windows, slight damage to roofing and siding, interior partitions blown down, and cracked walls. the damage is not severe enough to preclude use of the installation for the purpose for which it was intended.

Design earthquake Earthquake parameters selected for designing an earthquake-resistant structure according to code requirements.

Design flood Flood hydrograph or peak discharge adopted for the design of a hydraulic structure according to code requirements

Design storm Rainfall amount and time distribution adopted over a given drainage area, used in determining the design flood.

Disaster A serious disruption of the functioning of society, causing widespread human, material, or environmental losses which exceed the ability of the affected society to cope using only its own resources. Often classified according to its cause (natural or manmade).

Disaster epidemiology Medical discipline studying the influence of such factors as lifestyle, biological constitution and other personal or social determinants on the incidence and distribution of disease as it concerns disasters.

Displaced persons Persons who, for different reasons or circumstances, have been compelled to leave their homes. They may or may not reside in their country of origin, but are not legally regarded as refugees

- Elements at risk** The population, buildings and civil engineering works, economic activities, public services and infrastructure, etc. exposed to hazards.
- Environmental degradation** Unfavourable modification of the ecological state and environment through natural processes and/or human activities.
- Evaluation** Post-disaster appraisal of all aspects of the disaster and its effects.
- Exceedance probability** Probability that a given magnitude of an event will be equalled or exceeded.
- Forecast** Statement or statistical estimate of the occurrence of a future event. Used with different meanings in different disciplines, as is 'prediction'.
- Hazard** A threatening event, or the probability of occurrence of a potentially damaging phenomenon within a given time period and area.
- Lifelines** Public facilities and systems that provide basic life support services such as water, energy, sanitation, communications and transportation
- Mean return period** The average time between occurrences of a particular hazardous event.
- Microzonation (microzoning)** Subdivision of a region into areas where similar hazard-related effects can be expected. Seismic microzonation is the mapping of a local seismic hazard using a large scale (order of magnitude from 1/5000 to 1/10,000)
- Mitigation** Measures taken in advance of an event aimed at decreasing or eliminating its impact on society and environment.
- Non-governmental organization (NGO)** Non-profit making organization operating at local, national and international levels, with no statutory ties to a national government.
- Non-structural elements** Parts of a building (e.g. partitions, ceilings, etc.) which do not belong to the load-bearing system.
- Population at risk** A well-defined population whose lives, property, and livelihoods are threatened by given hazards. Used as a denominator
- Prediction** Statement of the expected time, place and magnitude of a future event (for earthquakes and volcanic eruptions).
- Preparedness** Activities designed to minimize loss of life and damage, to organize the temporary removal of people and property from a threatened location, to facilitate timely and effective rescue, relief and rehabilitation.
- Prevention** Activities designed to provide permanent protection from disasters, including engineering and other physical protective measures, and legislative measures controlling land use and urban planning.
- Public awareness** The process of informing the community of the nature of the hazard and actions needed to save lives and property prior to and in the event of disaster
- Reconstruction** Actions taken to re-establish a community after a period of rehabilitation following a disaster, including construction of permanent housing, full restoration of all services, and complete resumption of the pre-disaster state.
- Rehabilitation** Operations and decisions taken after a disaster which aim to restore a stricken community to its former living conditions, and to encourage and facilitate the required adjustments to the changes caused by the disaster.
- Relief** Assistance and/or intervention during or after disaster to meet life preservation and basic subsistence needs. It can be of emergency or protracted duration.
- Resettlement** Actions needed for permanent settlement of persons dislocated or otherwise affected by a disaster to an area different from their last place of habitation.
- Response** Decisions and actions taken during and after disaster, including immediate relief, rehabilitation, and reconstruction.
- Risk** Expected losses (of lives, persons injured, property damaged, and economic activity disrupted) due to a particular hazard for a given area and reference period. Based on mathematical calculations, risk is the product of hazard and vulnerability.

Search and rescue Process of locating and recovering disaster victims and application of first aid and basic medical assistance as required.

Secondary hazards Hazards occurring as a result of another hazard or disaster, i.e. fires or landslides following earthquakes, food shortages following floods.

Voluntary agencies Non-governmental organizations or agencies. Some possess personnel trained to assist when disaster strikes. Some have capabilities extending from local to national and international levels

Vulnerability Degree of loss (0–100%) resulting from a potentially damaging phenomenon.

Warning Dissemination of message signalling imminent hazard, which may include advice on protective measures.

Zonation Subdivision of a geographical entity (country, region, etc.) into homogeneous sectors with respect to certain criteria (e.g. intensity of the hazard, degree of risk, same overall protection against a given hazard, etc.).

Appendix

3

International agencies active in disaster mitigation

DHA-UNDRO – Department of Humanitarian Affairs/Office of UN Disaster Relief
Coordinator
Palais des Nations
CH-1211 Genève 10
Switzerland

Tel: (41 22) 734 60 11

[disaster emergencies: (41 22) 733 20 10]

Fax: (41 22) 733 56 23

- assists in disaster assessments and relief management
- advises on hazard risk assessments
- gives advice on mitigation planning and implementation.

FAO – Food and Agriculture Organization
Viale delle Terme di Caracalla
I-00100 Roma
Italy

Tel: (39 6) 52251

Fax: (39 6) 5225 3152

- offers technical advice on the reduction of vulnerability
- monitors and advises in food production, including urban market gardening.

UNCHS (Habitat) – United Nations Centre for Human Settlements
2 UN Plaza
Room DC-2-0946
New York, NY 10017
U.S.A.

Tel: (1 212) 963 4200

Fax: (1 212) 963 8721

- advises on settlement planning that will reduce risks
- advises on post-disaster reconstruction.

UNDP – United Nations Development Programme
One United Nations Plaza
New York, NY 10017
U.S.A.

Tel: (1 212) 906 5788

Fax: (1 212) 906 5365

- incorporates disaster mitigation in development planning
- funds technical assistance for disaster management

Core agencies of
the United
Nations

United Nations agencies with support roles in mitigation

- offers administrative support to resident coordinator
- advises on flood loss prevention, mitigation and management, through agencies such as Economic and Social Commission for Asia and the Pacific.

UNESCO – United Nations Educational, Scientific and Cultural Organization
7 place de Fontenoy
F-75700 Paris
France

Tel: (33 1) 45 68 10 00

Fax: (33 1) 45 67 16 90

- research in mitigation
- strengthening of heritage structures against flood and earthquake damage
- supportive of flood management programmes
- publications programme.

UNCRD – United Nations Centre for Regional Development
Nagano 1-47-1
Nakamura-ku, Nagoya 450
Japan

Tel: (81 52) 561 9377

Fax: (81 52) 561 9375

- provides training and research in regional development and planning, and related fields, for developing countries
- projects focus primarily on research and training, but include advisory services and information dissemination components
- operational units include Regional Disaster Prevention Unit (RDPU).

UNEP – United Nations Environment Programme
P.O. Box 30552
Nairobi
Kenya

Tel: (254 2) 230 800, (254 2) 520 600

Fax: (254 2) 226 890

- perceives and includes disaster mitigation in its environmental programming
- working relationship with UNCHS (Habitat)
- publications programme.

UNICEF – United Nations Children's Fund
UNICEF House
Three United Nations Plaza
New York, NY 10017
U.S.A.

Tel: (1 212) 326 7000

- attends to well-being of women and children including at time of disaster
- collaborates with WHO and WFP in social programmes, including improvement of water supply, sanitation and health
- publications programme
- now entering into disaster preparedness, planning and mitigation work in alliance with other agencies.

UNIENET – United Nations International Emergency Network
c/o United Nations
Department of Humanitarian Affairs
New York, NY 10017
U.S.A.

Tel: (1 212) 734 6011

Fax: (1 212) 733 5623

- through a network of computer, places members of the worldwide disaster management community in direct communication with each other, and provides them instantaneously with both background and operational disaster related information.

WFP – World Food Programme

Via Cristoforo Colombo 426

I-00145 Roma

Italy

Tel: (39 6) 522 821

Fax (39 6) 512 3700

- provides targeted food aid, sometimes linked to 'food for work' programmes for construction of flood protection structures
- coordinates emergency food aid pre- and post-disaster
- publications programme.

WHO – World Health Organization

CH-1211 Genève 27

Switzerland

Tel. (41 22) 791 21 11

Fax: (41 22) 791 07 46

- assistant in post-disaster rapid response
- promotes 'healthy cities' programme
- supportive of disaster mitigation measures
- the South American Regional Office (Pan American Health Organization) is active in disaster preparedness and mitigation planning, studies and advice
- publications programme

ADB – Asian Development Bank

P.O. Box 789

1099 Manila

Philippines

Tel: (632) 711 3851

Fax: (632) 741 7961

- finances projects in Asia and the Pacific
- committed to ensuring disaster mitigation is included in programming of its projects
- publishes mitigation handbooks
- publishing programme and advisory work under technical assistance.

ADPC – Asian Disaster Preparedness Centre

G.P.O. Box 2754

Bangkok 10501

Thailand

Tel: (66 2) 524 5353

Fax: (66 2) 524 5360

- provides an advice, training and information service for countries in the Asia and Pacific regions, to formulate policies and develop capabilities in all areas of disaster management.

Major
international
agencies

ECHO – European Community Humanitarian Office
 c/o European Commission
 DG VIII – Emergency Aid Unit
 Rue de la Loi 200
 B-1049 Bruxelles
 Belgium
 Tel. (32 2) 299 32 45
 Fax: (32 2) 299 28 76

- newly founded, but active in the development of disaster-mitigation strategies
- the parent body (Commission of European Communities) organizes funding of mitigation structures such as cyclone shelters in Bangladesh
- forums and publication programme.

IIED America-Latina – International Institute for Environment and Development
 Avida Corrientes 2835
 Cuerpo A – 6 piso B
 1193 Buenos Aires
 Argentina
 Tel: (54 1) 961 3050
 Fax: (54 1) 961 1854

- promotes and disseminates research on:
 - the development of tenements and squatter settlements in urban areas
 - social factors which cause or contribute to natural disasters; and
 - interventions that can limit their impact on the poorest sectors of society
- provides technical assistance to national and international agencies.

OECD – Organization for Economic Cooperation and Development
 2 rue André Pascal
 F-75775 Paris Cedex 16
 France
 Tel: (33 1) 45 24 82 00
 Fax: (33 1) 45 24 85 00

- has issued guidelines, through its Development Assistance Committee, to aid agencies on disaster mitigation
- publications programme.

World Bank (IBRD – International Bank for Reconstruction and Development)
 1818 H Street NW
 Washington, DC 20433
 U.S.A.
 Tel: (1 202) 477 1234
 Fax: (1 202) 477 6391

- offers structural adjustment and project loans
- plays catalytic (sometimes controversial) role in the development of mitigation strategies
- funds large-scale flood control and water management projects
- publications programme.

National bodies assisting overseas

ODA – Overseas Development Administration (U.K.)
(Foreign and Commonwealth Office)
94 Victoria Street
London SW1E 5JL
U.K.

Tel: (44 171) 917 7000

Fax: (44 171) 917 0072

- operates disaster response unit
- undertakes advice and studies in disaster mitigation
- finances consultancy and construction work post-disaster and for disaster preparedness
- publications programme.

OFDA – Office of Foreign Disaster Assistance (U.S.A.)
Room 1262/A NS
Agency for International Development
Washington, DC 20523
U.S.A.

- holds regional seminars on mitigation strategies
- supplies advisors and publications
- publications programme.

Specialist centres

This appendix lists sources of specialist information and expertise in various disciplines related to disaster mitigation. These sources include international associations, and government and independent research agencies. The latter are based primarily in the U.K., although comparable agencies exist in other countries.

IAEE – International Association for Earthquake Engineering
Kenchiku Kaikan 3rd Floor
5-26-20 Shiba
Minato-ku
Tokyo 108
Japan
Tel: (81 3) 453 1281
Fax: (81 3) 453 0428

- promotes international cooperation among scientists and engineers in the field of earthquake engineering, through exchange of knowledge, ideas and results of research and practical experience.

IAVCEI – International Association of Volcanology and Chemistry of the Earth's Interior
Australian Geological Survey Organisation
G.P.O. Box 378
Canberra ACT 2601
Australia
Tel: (61 6) 249 9377
Fax: (61 6) 249 9746

- studies scientific problems related to volcanic processes
- encourages volcanologists to alert authorities to the importance of adequate surveillance of volcanic activity and of volcanic risk assessment.

ISC – International Seismological Centre
15 Windmill Lane
Epsom
Surrey KT17 1HY
U.K.
Tel: (44 1635) 861022
Fax: (44 1635) 872351

- collects, analyses and publishes data on terrestrial seismic events, to advance scientific knowledge of the Earth's structure and prediction of earthquakes

International
scientific and
technical
associations

- publishes and keeps seismogram readings from world stations for analysis in computer-readable form
- computes and publishes focal coordinates and magnitudes for events for which adequate data are available.

Research and training agencies

Asian Disaster Preparedness Centre
Asian Institute of Technology
G.P.O. Box 2754
Bangkok 10501
Thailand
Tel: (66 2) 524 5354
Fax: (66 2) 524 5360

- provides training programmes, technical advice and information on disaster management in Asia and the Pacific
- works in collaboration with the United Nations, governmental and non-governmental agencies
- conducts research into hazard-resistant construction, vulnerability and risk analysis.

British Geological Survey
Murchison House
West Mains Road
Edinburgh EH9 3LA
U.K.

Tel: (44 131) 667 1000
Fax: (44 131) 667 1877

- consultancy and research in earthquake and tsunami
- geologic information prepared for planning use
- publications programme.

Building Research Establishment
Garston
Watford WD2 7JR
U.K.

Tel: (44 1923) 894040
Fax: (44 1923) 664010

- risk reduction studies for large dams and major structures
- detailed design in the face of specific hazards
- advisory work
- publications programme.

Cranfield Disaster Preparedness Centre
Cranfield University
RMCS
Shrivenham
Swindon SN6 8LA
U.K.

Tel: (44 1793) 785287
Tel: (44 1793) 782179

- provides research, training and consultancy services in disaster management
- special interests include institution building, community preparedness and emergency management.

Development Planning Unit
University College London
9 Endsleigh Gardens
London WC1H 0ED
U.K

Tel: (44 171) 388 7581

Fax: (44 171) 387 4541

- research and education in development planning, with expertise in the informal and non-engineered sectors.

Geohazards International
123 Townsend Street #655
San Francisco, CA 94107
U.S.A.

Tel: (1 415) 543 9030

Fax: (1 415) 543 9032

- charitable consultancy dedicated to reducing the social and economic consequences of earthquakes
- through the Seismicity Program, focuses international technical and policy expertise on specific cities at risk.

Intermediate Technology Development Group (U.K.)
Myson House
Railway Terrace
Rugby CV21 3HT
U.K

Tel: (44 11788) 560631

Fax: (44 11788) 540270

- promotes disaster mitigation at the community level
- special focus on mitigation in South America.

Ministrie van Verkeer en Waterstaat
Strategische Beleidsgroep
Plesmanweg 1-6
2597 JG Den Haag
The Netherlands

Tel: (31 70) 351 6761

Fax: (31 70) 351 6988

- water resources management and flood control
- publications programme.

Overseas Development Institute
Regent's College
Inner Circle
Regent's Park
London NW1 4NS
U.K.

Tel: (44 171) 487 7413

Fax: (44 171) 487 7590

- independent non-governmental centre for research into institutional and economic development issues.

Oxford Centre for Disaster Studies (U.K.)
Oxford Brookes University
Gipsy Lane
Headington
Oxford OX3 0BP
U.K.

Tel: (44 1865) 819230

Fax: (44 1865) 819455

- provides training, consultancy and research on post-disaster response and sustainable rehabilitation

University of Delaware
Disaster Research Center
University of Delaware
Newark
Delaware, NJ 19716
U.S.A.

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- undertakes research on sociological and social research aspects of disaster.

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- disseminates information and training materials, such as self-study courses and UNDP/UNDHA Disaster Management Training Programme
- provides professional training, including Disaster Management Diploma Programme.

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