CONFRONTING CATASTROPHE

New perspectives on natural disasters

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Preface

Despite 75 years of constantly accelerating progress in the field, there is something profoundly unsatisfying about modern studies of natural disaster. Theories, and the practice that has generated them, have not fully explained why the toll of deaths and losses is rising as steeply as it is (Alexander 1993: 2). I believe this is because disaster has not been considered sufficiently in light of present-day worldwide trends and tendencies. In the way that it illuminates a subtle interplay of progress and setback, catastrophe opens a window upon the inner workings of society. To make full use of this insight we must broaden the context of our studies and view disasters in terms of how the world is changing. This requires some analysis of history and some of human cultures. Although "culture" is an elusive concept, and one that is open to myriad different definitions, it is nevertheless fundamental to any understanding of the impact of disasters, for it embodies the historical imprint of events, as these are carried forward into the future through the mediation of experience and knowledge.

Disasters are holistic phenomena. I believe that they should not be studied in an *interdisciplinary* way, which implies obstacles to be surmounted, but through a *non-disciplinary* approach, which suggests a lack of boundaries. The nature of the problem to be solved should determine the methods applied to it, and the key to success is to discover and bring to light the links between disparate phenomena and events. Put more simply, we need to achieve a better marriage between the physical and social sides of disaster studies. So far, there has been a remarkable failure of nerve in this respect. Academics have spent too much time defending their own territories and propounding incomplete theories. At times one wonders whether we really seek to relieve human suffering by virtue of our erudition or merely attempt to make intellectual capital out of the sum of human misery. Nevertheless, during the 1990s, the International Decade for Natural Disaster Reduction, studies of calamity have achieved increasing respectability and have now accumulated a substantial body of knowledge and theories. But they have not produced an adequate unified theory to explain the phenomena under study according to simple universal principles. Perhaps this is an impossible goal, although it remains an alluring one: the "philosopher's stone" of the nascent discipline of "disasterology".

One reason for the failure to unify is the increasing divergence between the developed and developing worlds, and obviously not merely in terms of the strongly differential impact of disasters. The industrialized countries are rich in technological capital, whereas the developing nations abound in human resources. There is an increasing sense of distance between the two. As a result, the few cultural bridges that might facilitate the transfer of technology for mitigation are being gradually destroyed by exploitation, forced militarization, economic manipulation and widening income gaps. Except where there is a strong sense of kinship, there tends to be an unwillingness to learn from other societies. Yet many fundamental principles are universal: for example, disaster mitigation must go hand in hand with socio-economic development in any society, rich or poor. Equity concerns are ubiquitous, even though the proposed solutions tend not to be.

My intention in this book is not to produce a systematic account of disasters, or another distillation of the current literature, but to give the reader a personal view. It is all too easily forgotten that disaster studies should be a marriage of learning and experience, the latter as practical as possible. Too much abstraction is dangerous – it obfuscates rather than illuminates the situation. My aim here is to confront some of the awkward realities of disaster as directly as possible without resorting to the dry, abstract debate that characterizes so many learned discourses on the subject of catastrophe, or to the miserable trail of unconnected anecdotes that constitutes the main alternative approach. My solution is to use an alternation of principles and examples, using the latter as occasion to comment on what general factors they illuminate. If this bares some prejudices and predilections, then so be it: *dulce est desipere in loco.*[1]

I would like to thank Lorna Stinchfield, Carol Vogel and Annabelle Lucas for typing the first draft of this book from my notes, and Roland Sarti for reviewing part of the text.

I dedicate this book to Joyce M. Alexander and Eric E. Alexander on the occasion of their fiftieth wedding anniversary.

David Alexander
San Casciano in Val di Pesa, Italy
June 2000

1. "It is fun to mess around a bit, when there is enough time to do so" (Horace, *Odes*).

CHAPTER 1

Introduction

You must learn that the disasters
govern the man, not man the disasters

A few days before I sat down to write this book and a few tens of kilometres from my desk, it began to rain heavily in the Versilian Mountains of northwest Italy. Some 415 mm of precipitation fell on the steep wooded slopes in only 24 hours; half a year's rainfall in two days. Suddenly, the mountain streams rose and transformed themselves into heaving torrents of mud and rock. They roared through the ancient stone villages that nestle in the narrow wooded valleys: Stazzema, Cardoso, Fornovalasco. The mud and water rose nimbly out of the beds of the torrents and flooded into the streets, the squares and the huddled groups of stone houses. Torn from its moorings, a propane tank danced in the current, spurting twin jets of gas into the rain-soaked air. Cars parked in a piazza rose in the flow, bobbed around for a while and one by one set off sedately down the valley to be smashed to pieces on the rocks below. An ancient stone bridge collapsed with a crash, and the rubble streamed away piece by piece in the midst of the hungry black water. Spates of mud and boulders rolled turbulently through the narrow streets, smashing vehicles and fixtures and demolishing the walls of houses. Thirteen people died in the floods. The boiling water took a four-year-old girl from her collapsing house, transported her body 20 km down stream and laid it to rest on the shore of the Tyrrhenian Sea, hideously disfigured. The narrow, winding roads through the valleys disappeared in a welter of landslides and meander scars. A kilometre of the main Tyrrhenian coast railway was buried under tonnes of mud, rocks and uprooted tree trunks; its bridges were washed away, leaving the track suspended over the cavernous holes left by the streams.

In short, a flash flood occurred with a recurrence interval of somewhere between 100 and 700 years, which was, for the area, a truly exceptional event.

The full apparatus of civil protection rose to the occasion. Within hours the sky was thick with helicopters and the access roads were thronging with trucks and ambulances. Soldiers, volunteers, firemen, policemen, cabinet ministers, regional politicians, camera crews, even coach parties of tourists, converged on the stricken villages.[1] The people who live in the mountains are taciturn and accustomed to hardship, but many appeared dazed and incredulous as the men in orange jackets led them to safety.[2] Several hundred of them had lost their homes, and US$30 million of damage had been done by the floods.

In a world context the Versilian floods were a truly unexceptional event. They coincided with disastrous wildfires in Mongolia, catastrophic inundations in Yemen, Hurricane Arthur in Mexico, and several other extreme events. But in the minds and lives of everyone who experienced and survived them, the Italian floods will form a permanent marker, a point of reference with which to position other events in time and with which to measure their significance.[3] They were, after all, the worst floods in Tuscany since 3 November 1966, when the River Arno burst its banks in Florence and killed 31 of that city's inhabitants (Di Leva 1996).

Thus, in terms of the perception of those who participate in it, a disaster is a unique event. If time is linear, as the mediaeval mind would have it, and not cyclical, as Plato and Aristotle supposed it was, then disasters cannot repeat themselves (Gould 1987). Each time one occurs, the ingredients, the controlling parameters and the outcome variables are present in unique mixtures. But disasters are also subject to generalization. The common elements are nearly always present in terms of a well mapped spatial and temporal unfolding of more or less consecutive phases (see Figs 1.1, 1.2).[4] Thus, the survivors of the Versilian floods formed part of a much larger and more widespread group: according to Red Cross data, each year 130 000 people are killed, 90 000 are injured and 140 million are affected by an average total of more than 200 natural disasters (IFRCRCS 1998).[5]

Much attention has been given to the question of what a disaster actually represents.[6] Given that there are at least six schools of thought on the subject, collectively representing more than 30 different disciplines (Alexander 1991a;

1. The classic work on convergence behaviour is by Fritz (1957). Scanlon (1992) reconsidered the subject in the light of more recent findings.
2. See Wallace (1956) for an early investigation of the psychological "disaster syndrome". See also Horowitz (1986).
3. See Erikson (1976) for a classic study of disaster as a permanent marker in the lives of individuals and communities.
4. But see the critique of these phases given by Neal (1997).
5. One reason why deaths outnumber injuries is the high mortality in droughts, which is not accompanied by a toll of injuries.
6. See, for example, Quarantelli (1995).

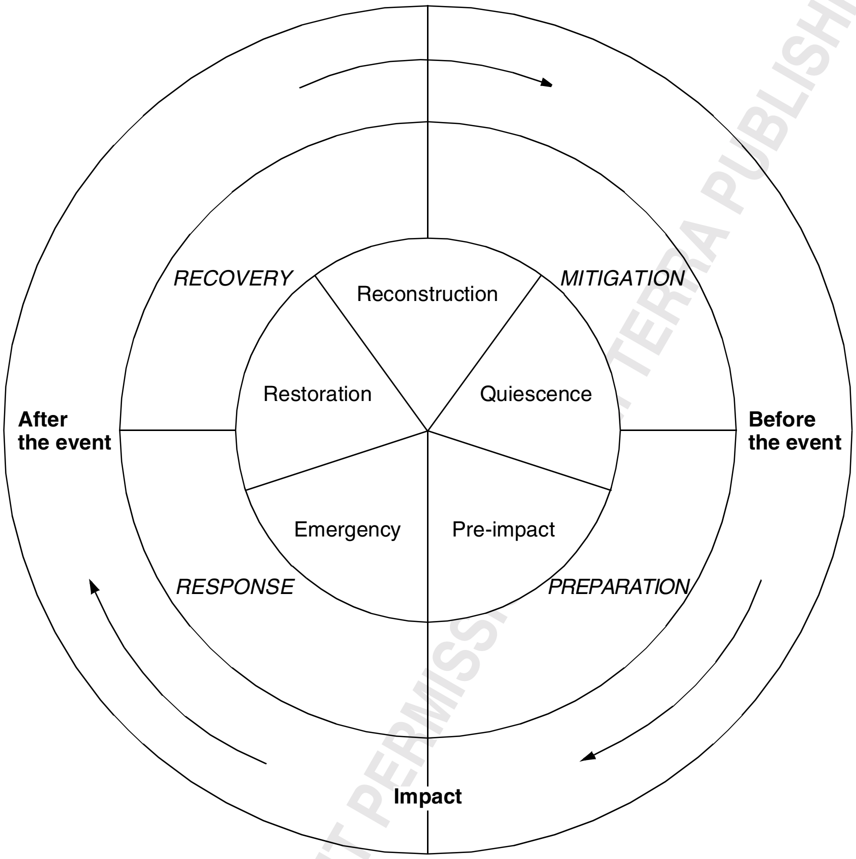

Figure 1.1 The disaster cycle.

1993: 12–14), the answer is bound to be complex and multifarious. In one sense, disaster is a window on society, a chance to observe the workings of social and cultural processes under an extreme duress that exposes their inner essence. Physically, one is dealing with destructive extreme events, socially with a phenomenon that puts human organization under stress or in crisis (Barton 1970, Gillespie 1988) and which puts human adaptability to the test. In economic terms, disasters result in the accelerated consumption of goods and services (Jones 1987); logistically they provide an opportunity to improve mitigation measures. Mitigation measures can be viewed as a "window of opportunity", in which a recent disaster sensitizes public and political opinion, and brings forth demands for improved safety in the future.[7]

7. See Solecki & Michaels (1994) for a practical study of this aspect of disasters.

CHAPTER 2

Definitions

This chapter will examine some contemporary interpretations of hazard and disaster and a few of the developing trends in analytical methods used by students of this field. This is intended to provide a basis for understanding the social, technological, moral and practical issues that combine to shape natural disasters as phenomena of the modern world.

The problem of how to define disaster[1] and its many components is far from solved and has been the subject of considerable debate in various disciplines.[2] Let us begin by examining the question of how to define four key terms: hazard, risk, vulnerability and disaster.

A **hazard** is an extreme geophysical event that is capable of causing a disaster. "Extreme" in this case signifies a substantial departure in either the positive or the negative direction from a mean or a trend: hence, flood disasters result from unusually high precipitation and river discharge, whereas drought disasters stem from unusually low values. The fundamental determinants of hazards are location, timing, magnitude and frequency. Many hazardous phenomena are recurrent in time and predictable in terms of location. For example, hurricanes (typhoons or intense tropical cyclones) occur between 5° and 25° north and south of the Equator and tend to be seasonal phenomena. In the North Atlantic Ocean they develop in late summer and autumn in response to the meteorological perturbations known as easterly waves (Hess & Elsner 1994, Diaz & Pulwarty 1997). For floods and earthquakes, magnitude of event corresponds to a given average recurrence interval. In fact, the **magnitude-frequency rule** states that

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1. In this book, "disaster", "calamity" and "catastrophe" will be treated as synonyms. I do not believe there are any adequate grounds for defining these terms differently from one another.
2. See, for example, Bailey (1989), Kreps (1989), Kroll-Smith & Couch (1991) and Quarantelli (1998) among the sociologists, and Ball (1979), Frerks et al. (1995) and Kelly (1996) among the relief and development specialists. Further definitions are given in Alexander (1991a; 1993: ch. 1).

over a sufficient interval of time there will be many small events and few large ones (Wolman & Miller 1960). Hence, the average return period of small events is short and that of large events is long. In terms of the environmental changes wrought by geophysical events, one expects there to be a rough sort of equilibrium between the cumulative effects of small events and the occasional solitary impact of large events (Hewitt 1970; Smith 1996: 10–11).

It is perhaps unwise to be too glib about the magnitude–frequency rule. In the first place, detailed data are seldom available for long enough periods of time to allow magnitude–frequency graphs to be constructed with any degree of statistical certainty. To combat this problem, much statistical artifice is employed, but predictions tend to be unreliable when events of large magnitude and long return period are involved (this is especially true of volcanic eruptions, in which there may be no measurable periodicity at all). Environmental reconstruction and absolute dating have done much to fill in the gaps and reconstitute the time series of extreme events, but it is not uncommon to find that datable evidence is only partial: perhaps ancient flood deposits have been eroded away, or earthquakes have occurred without producing datable surface ruptures.[3] Secondly, in the timespan of human lives, average recurrence intervals can be highly irregular and hence difficult to predict. For hazards that have a meteorological origin, such as floods and droughts, actual recurrence intervals can be highly irregular and hence difficult to predict.[4] Thirdly, to some extent the size of disaster may be independent of the magnitude of the geophysical event. Thus, the mudflow that killed 144 people at Aberfan, South Wales, in 1966 involved only 75 000 m^3 of debris, which moved at walking pace through the schools and houses of the town. In contrast, no disaster was caused by the Sherman landslide of 1964, which sent 30 million m^3 of rock crashing down at more than 100 km / hr into an uninhabited valley of central Alaska (Alexander 1993: 9–10).

Lastly, in the Earth sciences there is an unresolved, and possibly unresolvable, debate about the significance of large infrequent events. In the physical landscape, does the cumulative effect of many small events outweigh the impact of the occasional cataclysm, or vice-versa (see Brunsden & Thornes 1979)? We may look upon the dilemma as a duel between uniformitarianism and catastrophism, a debate that has lasted for most of recorded history.[5] Among

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3. Note that for the most part, regardless of whether geochronological methods are relative or absolute techniques, they can date only what is there, not what is missing because erosion has stripped it away, which must be inferred (Mahaney 1984).
4. Glantz (1982) and Mayer & Nash (1987) tackled some of the consequences associated with difficulties of prediction.
5. A classic reference here is the Frank Dawson Adams scholarly account of the history of the Earth sciences (Adams 1938). After 60 years it is still in print.

the Ancients, Aristotle, Plato, Strabo and Herodotus were uniformitarianists. Centuries later, Athanasius Kircher, John Ray, Nikolaus Steno and Abram Gottlob Werner were catastrophists. At the global scales, uniformitarianism underlay Wegener's theory of continental drift and much of the early formulation of plate tectonics. At the local scale, the uniformitarian approach was best exemplified by a paper in which M. Gordon Wolman and John P. Miller argued that the morphology of mid-latitude streams in humid temperate climates results from precipitation events and flood flows of modest dimensions and almost biennial occurrence (Wolman & Miller 1960). Lately, however, neo-catastrophism has come back into fashion. Intense interest in mass extinctions has been coupled with the realization that global change can occur quite abruptly when certain turning points are reached. With the aid of a dose of millennialism (a form of prophecy to which scientists are by no means immune), the research community has been stimulated to look again at many phenomena in a neocatastrophist light (Dury 1980, Baker 1988). Even the uniformitarian view of small mid-latitude stream channels has been tempered by a re-evaluation of the significance of large flood deposits and deep erosional scars (Baker et al. 1988).

However, it is all too easy to oversimplify the uniformitarianism / catastrophism debate. In reality the two points of view need not – perhaps *should* not – be mutually exclusive. Leonardo da Vinci offered a good example of this: his studies of water flow revealed a considerable predilection for catastrophism, but his interpretations of sedimentation and stratification were firmly rooted in uniformitarianism (Alexander 1982a).

Whether it is the summation of relatively small events or the occasional occurrence of large cataclysms that causes disaster, it seems reasonable to suppose that there is a threshold value of the physical forces unleashed that defines the lower limit at which extreme geophysical phenomena are capable of causing disaster.[6] However, it is abundantly clear that such a value depends critically on the human impact of such forces: the vulnerability of people, society and the built environment may alone determine the magnitude at which an event becomes a disaster.[7] In this respect we define **natural hazards** as extreme events that originate in the biosphere, lithosphere, hydrosphere or atmosphere. The term is useful because it distinguishes such phenomena from **technological hazards** – including explosions, releases of toxic materials, episodes of severe contamination, structural collapses, and transportation, construction and manufacturing accidents – and from **social hazards**, such as crowd crushes,

6. See Figures 9.4 and 9.5 (pp. 232–233).
7. Hewitt (1983) went some way towards sustaining this view in his "radical critique" of causality in disaster. It seems to be gathering ground: according to Cannon (1994), the emphasis on the economic and political causes of disasters seems to have reached some sections of the public, and some politicians and aid workers (see also Hendrickson 1998).

CHAPTER 3

The study of disaster

This chapter begins with a critique of alternative models of hazard management. Given the role of academic research in stimulating societal adjustment to hazards, and other forms of adaptation to risk, it will then be appropriate to take a critical look at how researchers have set about studying extreme natural phenomena and their consequences. As some of the shortcomings of academic study have resulted from the difficulty of obtaining data of adequate quality, this problem is considered in some detail. One consequence of the unreliability of data is a lack of studies and models that express the geographical pattern of disasters. We examine why this is so, because it is an important shortcoming of academic work in the field in question. The present chapter closes on a more optimistic note with a re-evaluation of the human ecological approach to catastrophe, after more than three quarters of a century in which it has been employed to reveal how people are affected by environmental extremes.

The evolution of approaches to natural disaster

A classic model of the evolution of human adjustments to natural disaster has emerged (Kates 1971, White 1973, 1974, Burton et al. 1978, 1993). It can briefly be described as follows. Initial settlement of the hazardous area has low density and slow rates of urban growth. Protection against natural hazards is generally lacking or minimal, and disasters cause damage that is gradually repaired or substituted by rebuilding. Neither the cultural nor the technological underpinnings of society favour energetic mitigation, although a form of hazard aversion often emerges in the selection of sites for buildings and towns. As agriculture requires both an intimate knowledge of land capability and slow painstaking development, it is often the only field in which mitigation is practised, through, for example, modest efforts at flood or erosion control. With the passage of time, industrialization or increasing urban-economic growth occur. Untrammelled expansion of human activities increases the exposure to risk of both people and fixed capital. Hence, the toll of disaster impacts rises. Initially, the response to disasters is simply to refinance development by giving unconditional grants and loans, a practice that has been termed "forgiveness money", because it does nothing to curb imprudence (Kunreuther 1974, Sorkin 1983, Burby et al. 1991). Reconstruction therefore takes place with a fair degree of geographical inertia – the failure of disasters to dislodge human settlements from vulnerable sites – which may prolong or even extend vulnerability to natural hazards.[1] But at a certain point a threshold of intolerance is crossed and structural protection is instigated in a major way. Its extent and level of sophistication correspond to needs identified by losses incurred in past disasters. At the same time, further urban and economic growth occurs, and more expensive and extensive structural protection is required. Growth and hazard mitigation thus exist in an uneasy state of mutual sustenance; the former stimulates the latter in an intermittent sort of way, but erroneous assumptions about the efficacy of structural protection are often used as an excuse to permit further growth. Thus, for example, the building of levees on the Mississippi River led to increased urbanization of their floodplains under the assumption that the protection was sufficient (Belt 1975, Myers & White 1993, Changnon 1996). In this and other cases, rarer higher-magnitude impacts lead to greater disasters (as the levees are overtopped by flood levels that are not foreseen).

The first response to the failure of structural protection is usually one of renewed investment in it: higher levees, more dams, deeper relief channels, and so on. But structural protection inevitably has its limitations, the results of which are manifest in higher disaster losses, and so the next recourse is to non-structural protection. This can encompass a mixture of approaches, including warning and monitoring, evacuation procedures, civil protection and disaster management, norms and codes, land-use control through planning instruments, and insurance and financial incentives to encourage hazard mitigation. Broadly speaking, the measures can be classified variously as incentives, restrictions and first-aid procedures (White 1973, Godschalk 1991). Four types of problems tend to be encountered with such approaches: opposition on the part of libertarians and opportunists who would resist government interference in their activities, failure to observe enacted norms and laws, inability to finance agreed measures, and failure to organize an effective response to the hazards. We might add that there are also risks of encouraging a population to depend on measures that have been determined outside the community, and often to rely on unstable sources of funding, which can lead to aid-dependence or "assistentialism", as

1. For a description of geographical inertia, see Alexander (1993: 5).

it is sometimes ironically known.[2] Moreover, it is surprising how rarely cost–benefit approaches are used to define mitigation strategies, even though common sense rules that scarce resources must be invested wisely in order to obtain the maximum mitigation benefit (Ouellette et al. 1988, Britton & Oliver 1997).

The end product is a package of mixed structural and non-structural mitigation measures, in which damage is reduced and lives are saved by a pluralistic approach to coping with the hazard.[3] Currently, there is also a trend towards an "all-hazards" approach, in which protection is extended to counter a range of risks that might significantly affect each site (Perry 1985, Rosenthal & Kouzmin 1997).

In the twentieth century, progress has generally been equated with economic and technological growth. Industrial research and development have fuelled rises in gross national product and gross domestic product, and these have been widely regarded as indicative of human wealth and wellbeing. Although natural hazards can act as a significant brake upon wealth-generating processes – especially in small, poor countries with low and precarious growth rates – in no case have natural disasters put a stop to economic growth. In economic terms, they are mere irritants, perturbations in the flow of capital.[4]

The primacy of the economic growth model in the affairs of nations has in large measure conditioned the approach to hazards. Structural mitigation is preferred for obvious reasons by the construction and economic growth lobbies. Technological hardware production, fruit of the "military–industrial complex", as that agglomeration of industries and politics has come to be known, has offered ever more complex, expensive and sophisticated solutions to the problem of hazards.[5] Yet growth at any price represents a potential source of vulnerability.

Consider, by way of example, the central Italian city of Perugia. This regional capital, and commercial and industrial centre, spreads its 145 000 inhabitants across a series of hills and valleys, some of which have unstable slopes. In the 1950s, residential development spread up slope from the main railway station,

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2. However, Bradbury (1998: 332–3) questioned the existence of this phenomenon.
3. In an earlier work (Alexander 1995b), I suggested that the usual progression from structural to mixed structural and non-structural approaches to disaster may be inappropriate for some developing countries, which could more efficiently limit their dependence on expensive engineering measures and pass directly to an increased reliance on non-structural approaches.
4. This view is both confirmed and contested by the excellent historical review of the economic impacts of disasters in Europe and Asia given by Jones (1987). A contrary view was expressed by Shah (1995), who suggested that a repeat of the 1923 Tokyo earthquake could jeopardize the world's financial stability.
5. For an analysis of the consequences of this in developing countries, see COPAT (1981). See also Albala-Bertrand (1993) and Pugh (1998).

CHAPTER 4

Society and culture

In this chapter we will consider how extreme natural phenomena interact with human cultures and societies. The previous chapter examined some contemporary interpretations of hazard and disaster and a few of the developing trends in analytical methods used by students of this field. This was intended to provide a basis for understanding the social, technological, moral and practical issues that combine to shape natural disasters as phenomena of the modern world. We now move on to consider how extreme natural phenomena interact with human cultures and societies. This will require a blending of themes that are historical, contemporary and predictive; in other words, how we arrived at the current situation, where we are now, and where we are going. To begin with, it is useful to define some parameters for further analysis. One of the most important – and often underrated – of these is the concept of **culture**, which, as will be shown in the next section, has a distinct bearing on how disasters are interpreted and faced up to.

Fuzzy boundaries: disasters and human cultures

In social anthropology, human ecology is more properly known as *cultural* ecology (Butzer 1989). The difference is not a question of transforming the concept but instead indicates that culture is a fundamental variable in the way that people interact with, and react to, their environments. The word "culture" is so all-embracing that it is very hard to define. In essence it consists of the summation of beliefs and behavioural patterns, the imprint of history and the force of achievements of a particular people. It is made explicit in artefacts and symbols, ideas and systems of values. The resulting cultural systems are both the fruit of past actions and a strong conditioner of future ones (Alexander 1991b: 60–61).

This is all very well, but it has to be borne in mind, first, that the individual is usually conditioned by many more influences than merely his or her culture of origin. Secondly, individuals can migrate between and absorb cultures, thus becoming more cosmopolitan with experience and perhaps diluting the cultures they pass through. Thirdly, cultures are dynamic phenomena that can mutate, sometimes rapidly and, finally, the term is not necessarily all embracing. Thus, hazards researchers write of "disaster cultures" or "disaster subcultures",[1] in which the repeated threat or impact of catastrophe engenders a particular reaction among groups that may or may not be culturally defined in other respects; in other words, disaster creates a culture of its own that cuts across pre-existing cultural boundaries. Very positive forms of disaster culture may hold civil protection and hazard mitigation in high regard. Negative ones may perpetuate myths and erroneous assumptions about disaster. Most forms combine both traits. Norms, values, beliefs, knowledge and technology all take on specific subcultural forms (Hannigan & Kueneman 1978, Granot 1996). For instance, in Western societies, which tend to be overconditioned by the electronic media, disasters may be transformed by television news services into a form of voyeuristic entertainment, especially where there is little sense that the viewers are in some way personally involved in the tragedy. It has also been argued (Drabek 1986: 340) that disaster subcultures abate the sense of threat in hazards and can even lead to complacency when coupled with mitigation measures such as warning systems.

Let us return to the question of culture as a universal guiding force. If there are enough elements in the organization and self-expression of a large group of people to permit the definition of a culture, this will contain elements that are both unique to that culture and others that are common between cultures. Researchers have analyzed these in terms of **emics**, the search for the unique or specific, and **etics**, the study of general and universal characteristics (Berry 1969, Brislin 1980, Gherardi 1998).[2] At the risk of oversimplifying, one can hypothesize that cultural survival is a form of **emic value** and cultural dynamism is a form of **etic value**; the former includes inherited attitudes and traditions, the latter enables new ones to be grafted on and the resultant cultural matrix to adapt to change.

But the cultural matrix must again be subdivided. The unique and general characteristics, the ancient and modern, the emics and etics of culture, generate responses in terms of both *perception* and *action* (see Fig. 3.7). The former involves cognizance by the general public, the mass media and officialdom. Together with the latter it enables the signal given by the threat or impact of disaster to be translated into adjustment, mitigation and loss-absorbing actions (Parker & Harding 1979, Whittow 1987).

1. Dynes (1970: 79) defined *disaster culture* as "the blueprint for individual behaviour before, during and after disaster". Disaster subcultures, instead, are seen as "group-level coping mechanisms" (Hannigan & Kueneman 1978: 130). See also Granot (1996).
2. A hazards perspective has been provided by Sorensen & White (1980).

The importance of perception to action cannot be overestimated, and the connections made between them are usually based on the idea that people respond to stress in two stages. First, they seek to establish equilibrium by using resources to cope with dangerous hazards. If this fails, they attempt to safeguard vital operations that are needed for survival (Mitchell 1984: 46). Several other dualities are encountered when hazard perception is related to actions taken by the perceivers. First, perception can be divided into that pertaining to the likelihood of damage and that relating to the role of mitigation (Mileti 1980). Furthermore, accuracy of hazard perception is tempered by both the extent to which the resources of the threatened place are needed and the social problems of the population at risk (Burton et al. 1978: 102). In this respect there is considerable variability in the extent to which natural hazard risks are perceived. Some resource users will carry out what seems to be the most appropriate strategy while examining a wider range of alternatives (Haque 1988: 434), but information itself is not necessarily the key to mitigation, even though much hazard abatement is practised in the aftermath of major impacts when information flows are at their most vigorous (Saarinen 1982, Cate 1995). Mitigation action is stimulated more by experience than by anticipation of risk and, on the whole, experience *does* tend to lead to better preparedness (Bollens et al. 1988: 313).

On this basis it is now possible to relate the concept of culture to a fundamental dialectic in human experience, and to consider the result in terms of how we react to disasters in human ecological terms.

Since time immemorial, but especially since the start of the Industrial Revolution, humanity has been faced with a choice of whether to live by exploiting or sustaining the natural environment. The former suggests *parasitism* and the latter *symbiosis*, but in reality there is no such clear-cut distinction. Some degree of artificial manipulation of environmental forces and commodities has always been practised and is a necessary safeguard against many risks to our wellbeing. Moreover, symbiosis is not always either possible or desirable, if it cannot be achieved without major sacrifice. In fact, the consumption of non-renewable resources is not necessarily a "sin" in its own right, and obviously not all pollution is catastrophic or irreparable. There are dangers in associating hazard mitigation exclusively with "green" environmental philosophies, and therefore laissez-faire attitudes to disaster with exploitation of the environment. This is often the case, but it is simply wrong to be categorically opposed to technology when one of its uses is to make our world safer (Pepper 1996).

Nevertheless, technology is a double-edged sword: it can be a source of either mitigation or vulnerability, depending on how it passes through the cultural filter that we use to perceive and interpret it (see Fig. 3.1). A strongly mechanistic attitude to technology can be labelled **technocentrism**, whereas one that emphasizes the role of culture in interpreting and guiding it may be regarded as

CHAPTER 5

Past, present and future

An historical approach to modern disasters

The aphorism "those who ignore history are condemned to repeat it" contains enough of a grain of truth to be repeated often. Yet it still smacks of cliché, for, strictly speaking, history does not repeat itself, although failure to heed its lessons can mean that the same mistakes are made repeatedly. One of the great weaknesses of disaster studies has been their lack of a historical perspective. Where history has been tackled, the tendency has been to describe events rather than historical processes. Thus, there is ample scope to investigate the relationship between natural disaster – with its many connotations of risk, hazard, and vulnerability – and the currents of human history. The task is too vast to attempt in a work such as this, although some effort can be made to point the way. But the eventual reward will be a deeper understanding of present and future disasters, and a wider perspective on the evolution of human attitudes to natural catastrophe (Barkun 1977).[1]

No doubt every historian recognizes the fundamental dangers of an historiographical approach to events. To begin with, history is neither a linear nor a cyclical process, although both models have been used to render it more intelligible. Secondly, whether the fundamental forces that drive events are the product of conspiracy or coincidence is a matter of the deepest conjecture; probably there are elements of both. Thirdly, when interpreting history, one risks what Gordon Herries Davies has termed "historical whigishness": the tendency to view past processes with hindsight as a stumbling progress towards the current state of truth and light (Davies 1989). In reality, even the present state of advanced knowledge is a mere marker on an uncertain path that stretches far into the future. Finally, the study of history is replete with predilections: cultural and ethnic biases, the preoccupations of the moment, and the unwitting expression of ingrained prejudices. To some extent it is unavoidable that we view the

1. See Short & Rosa (1998) for a different perspective.

past in terms of what concerns us about the present. It is even a legitimate approach if the aim is to cast light on the origins of present-day situations. But it has profound implications for objectivity: the nature of what is considered an orthodox or legitimate interpretation of the past is continually changing in subtle ways. Even history can be obsolescent in this shifting world.

The first task of the historically minded "disasterologist" should be to ask some fundamental questions that will help define the relevance of history to current processes and begin to reveal its lessons (Alexander 1993: 593–602). Here are few of them:

- What impact has natural disaster had upon the course of civilization?
- What is the relationship of natural disaster to the formative processes of society in the socio-economic, political and military spheres?
- To what extent have past disasters acted as vehicles of change?
- How was disaster interpreted in the past and what does that tell us about society's relationship to extreme geophysical events?
- What is the message of past disasters for future trends and future efforts to tackle the problem of natural catastrophe?

As space is limited in the present work, I will discuss only a few general reflections and a couple of examples.

To begin with, the fact that both the Colosseum in Rome and University of California stadium at Berkeley are built on seismically active faults suggests that the historical process is not one of lessons learned. Broadly speaking, history has bequeathed the following to the student of disasters: a long legacy of periodic loss and reconstruction, punctuated by relatively few good examples of innovative mitigation; a scientific understanding of geophysical phenomena that is extremely recent; a much longer intuitive understanding, although one clouded by frequent misconceptions; and a very patchy record of adaptation to natural hazards – a process held in check by lack of population, resources and technology. We will now address in turn the physical and the human aspects of natural catastrophe.

Knowledge of physical hazards in history

The history of the physical side of disaster illustrates the difficulty of gaining any true understanding of extreme natural phenomena without a basis of observational science and its theoretical underpinning, Newtonian mechanics. The operation of gravity, so fundamental to so many processes, cannot be understood intuitively, for it must be known experimentally and by deduction based upon observation. Hence, in 1691 Giovanni Domenico Guglielmini

(1669–1710), who was Professor of Medicine and Natural Philosophy at the University of Bologna, could not adequately explain why rivers meander; although he had many quantitative observations on their flow processes, his understanding of gravity was incomplete (Chorley et al. 1964). Many geophysical processes could not be understood without adequate knowledge of the rock cycle, which depends critically on the role of volcanism. Although volcanic processes and landscapes have long fascinated observers of the natural world – Dante, for example (Alexander 1986c) – since time immemorial, the true role of volcanism in contributing material to the Earth's crust was not appreciated until the advent of romantic and scientific journeying, the age of the Grand Tour (Tinkler 1985).

Thus, in 1751 Jean-Etienne Guettard (d. 1785) climbed the 1465 m peak of Puy de Dôme and saw – for the first time since the Romans – 50 extinct volcanoes (Guettard 1752). Through dogged fieldwork, his successor, Nicholas Desmarest, demonstrated that the columnar basalts of the Auvergne had been intruded into the surrounding granites (Desmarest 1771), and in 1763 Rudolph Raspe discovered that the central European basalts were also volcanic in origin. These observations gave birth to the school of the Vulcanists, who were fewer and intellectually less powerful than their great rivals, the Neptunists, whose view of the origin of rocks was diluvial. But even among the latter there were rumblings about the power of volcanoes. Leopold von Buch (1774–1853) was one German Neptunist who provided a link with the Plutonists, who were next to rise to prominence and who recognized the role of intrusive igneous activity in creating the Earth's crust (Von Buch 1824). Upon visiting the volcanic fields of Naples in 1798 and 1805–6, he was profoundly impressed by the ability of volcanism to create landforms, and he began to search for similar phenomena elsewhere. This led him to the Auvergne and in 1815 to the volcanic island of Tenerife. Thus, he helped show that volcanic rocks were much more widespread than Neptunism allowed. He ended by proposing that orogeny (mountain building) was the result of the intrusion of igneous rocks and their accompanying steam and vapours: basalt jacked up volcanoes, whereas augite porphyry heaved up, contorted and split open mountain ranges by being intruded into the crust, causing the transformation of limestone to dolomite. It was a full chemico-physical theory of the creation of physiographic relief.

It was left to Sir William Hamilton, an enthusiastic amateur volcanologist, to fill in the details as he observed the spectacles provided by the frequent eruptions of Vesuvius in the late 1700s and early 1800s (Hamilton 1772, Knight 1990). The discovery of the geological significance of volcanism was a true revelation: after centuries of conjecture about the Earth's interior, a basis of fact could be built from which to launch more sustainable theories. The process continues vigorously to this day.

The notches on the Nilometer[2] recorded flood levels for nearly 2000 years

CHAPTER 6

Technology, economics and logistics

The world's affluent societies, and even to some extent the poorer ones, have entered a technological age. A quiet but fundamental revolution has occurred on the basis of the electric motor, the internal combustion engine, the cathode ray tube, the transistor, the computer microchip and the satellite. Technology has become progressively cheaper, more widely available and more sophisticated. The price of this revolution is undoubtedly very high but presently incalculable, for the consequences have yet to be assessed fully. For the time being, human society has learned to embrace technology but not fully to assimilate it. The cultural shock has been followed by cultural disorientation, for life's points of reference are being changed profoundly by technological development. In this chapter we will examine the technological changes that have occurred and assess their impact on perception of and attitudes to disasters.

The power of the mass media

Nothing illustrates the perils and challenges of the technological revolution better than television. It has assumed not merely the position of the principal medium of electronic communication but also the status of an authority that is difficult to challenge. My own experience of appearing in and making television programs, limited though it is, suggests that the process of orchestrating facts and opinions into a form acceptable to television leads them to undergo subtle and often profound changes. In short, television distorts reality by abstracting it: at best this renders things more comprehensible, at worst it can turn truth into lies.[1] Yet as a medium it is inescapable: not only has it reached practically all homes in the affluent West but it has also invaded public space – shops, airport

1. See Anderson (1997) for a close analysis of how it does this with respect to environmental extremes.

lounges, aircraft, buses and many other places. Power is the control of what appears on television – on the popular channels, at least – and even those people who would despise it have little option but to treat the medium with respect. Television thus has the ability to inform people about hazards or keep them in the dark, to tell great truths about natural catastrophes or to perpetuate myths, and to motivate public solidarity in the face of the suffering that disasters cause, or to not stimulate it. No matter how civil protection is organized, television is a part of it.

At the end of the twentieth century, mass media of all kinds are susceptible to three distinct problems. First, the filtration of news, which is widely practised in order to make it palatable, involves an excessive degree of selectivity. In order to avoid too heavy a demand on the viewer's concentration, news is reduced to "bite-size chunks". That which lacks immediacy and instant relevance is discarded. The result often bears little relationship to the distribution of important events around the world. Secondly, the process of imparting an angle, or slant, to news is a dangerous one, which easily leads into the trap of confusing fact with fiction (Goltz 1984, Singer & Endreny 1993). This is especially the case when news merges into entertainment. Indeed, the latter has begun to assume an authority that amounts to the status of an icon and it reflects very uneasily on popular priorities. A complete outsider subjected to a prolonged dose of popular media would probably assume that entertainment is far more important in our lives than news, current affairs or education, and that it is the principal source of our values. The task of piecing together some form of objective reality from the modern media is laborious (Anderson 1997). Given the plethora of sources, it is not impossible, but it involves a great deal of reading between the lines, interpreting the media's way of presenting things and searching for information in obscure places. Few training opportunities exist for this difficult enterprise, and most people seem to prefer to have their news digested for them. Making sense of disaster via television images is therefore not the simple exercise that it purports to be, but a difficult and highly specialized enterprise.

The role of the mass media has been studied in a wide variety of situations, including mass emergencies and disasters, although largely with respect to newspapers (which are easier to monitor than television or radio) and almost exclusively with respect to Western media sources (Alexander 1980, 1997, McKay 1983). Many of the findings cast considerable doubt on the ability of news personnel to report on disasters in a rational and objective manner (Seydlitz et al. 1994, Ploughman 1997). Although it is still too early to make a very comprehensive and systematic analysis of the discrepancies between fact and reporting, some consistent regularities have emerged. For instance, there is often a wide difference between reporting of domestic and foreign disasters, in terms of extent of coverage, aspects emphasized and reporters' attitudes to the events and people they are describing (Alexander 1980, Needham 1986). However, a more positive school of thought also exists in which it is held that careful briefing and management of the news media can enhance their role in providing useful information to the public in emergencies (Scanlon et al. 1985).

Television and relief appeals

Television is well adapted to bring home the immediacy of disaster. Graphic images of casualties, destruction and the violence of nature lend a strong sense of reality to events that otherwise would usually be remote in the minds of the public. But the camera work is not objective. To begin with, there is an understandable tendency to concentrate on the worst, most cataclysmic scenes. It is easy for the viewer to believe that the whole disaster area is in such a state. For example, moderate earthquakes that affect cities often cause spectacular but highly localized structural collapse, perhaps involving only a handful of buildings. Given the tendency of commentators to use superlatives (if that is not too positive a word) when describing damage, the viewer who sees images of a large building that has collapsed, perhaps with victims trapped inside, is easily convinced that the whole city has been shaken to the ground. Sober reality is very much less exciting than what can be made of an eye-catching image.

Nevertheless, nothing can motivate a public response to disaster quite as effectively as television coverage. For example, there was a telling image from the 23 November 1980 earthquake in southern Italy, one in which damage was indeed widespread in at least 36 urban areas. In a devastated town centre only one building remained functional amid the rubble. It was a bar and it had a television set on the wall and still had electricity. A group of local men sat huddled around the flickering screen. They were watching live coverage of a devastated town centre strewn with rubble.[2]

When heart-rending and catastrophic scenes appear on television, there is often a substantial public response in terms of solidarity, donations, and perhaps volunteerism (Moran et al. 1992). Were such a thing possible, it would be very interesting to attempt to measure the degree of correlation between the duration and magnitude of television coverage and the longevity and strength of public response to a disaster. The fundamental hypotheses would be first that, by covering or not covering the event, television is virtually capable of turning public response on or off like a tap, and, secondly, that the nature of television coverage bears a positive relationship to the strength of public involvement or donation.[3]

2. I am indebted to Dr Robin Stephenson for this example.

CHAPTER 7

Moral and philosophical issues

This chapter shifts the balance of argument from technology to moral, philosophical and social issues. In the modern world, technology is, of course, a major influence on these. Hence, what we often encounter is a subtle, inadvertent mutation of the time-honoured existential questions, as the methods and mechanics of technological change impinge insidiously upon the relationship between people, their perceptions, and environment in disaster. We begin with warfare, a corollary of natural disaster and at least as pervasive a problem in the modern world.

Natural disasters and armed conflict

Pliny the Elder recorded that a large earthquake occurred during the second Punic War in 264 BC, at the height of the Battle of Trasimeno. The ground shook vigorously, towns were ruined, landslides cascaded down hillsides, and rivers were impounded or rerouted. But the fighting did not stop. Hence, the carnage and destruction caused by nature were added to those produced by mankind's bellicosity (Alexander 1984). Yet, although this one example describes a mere coincidence, it highlights the need to view the two faces of the Janus of destruction – wanton and inadvertent – in the context of each other. In the modern world, armed conflict has become such a pervasive influence on life that, in many of the countries most afflicted by natural disasters, it provides a constant setting; warfare is disaster carried on by other means.[1]

To begin with, there are obviously many forms of warfare. Conflicts may be formally declared, informally prosecuted, or carried on by clandestine means. International wars, involving invasion and cross-border bombardment, are complemented by civil conflicts, but given the frequent propensity of the latter

1. See Macrae & Zwi (1992) for details.

to stimulate outside intervention – the two are not mutually exclusive. These are usually forms of intensive conflict, but there is also a tendency for low-intensity conflict to proliferate in the form of guerrilla activity, insurgency, terrorism and torture. Thus, the spectrum of conflict ranges from mere armed tension and sporadic incidents to all-out warfare. Yet, such is the destructive power of modern weaponry, and its copiousness in the field, that the two ends of the spectrum have begun to approach each other, for destruction can be achieved on a large scale with greater efficiency and less exertion than ever before.

Two great conflicts marred the twentieth century, but since the second of these more than 150 local and regional wars have broken out. The early part of the century saw warfare globalized and the latter part has seen that tendency continued by superpower polarization and the widespread revivals of nationalism, separatism and fundamentalism, not to mention the persistence of the age-old desire to dominate and subjugate. Immense investments in technology and strenuous efforts to market it have made warfare a vastly more efficient destructive process than ever before. This leads to some oddly ironic contrasts. A glance through the international catalogue of armaments, *Jane's weapons systems*, reveals that it is full of advertisements for cannonry that will pierce the best available defences and armour that will resist the most powerful cannons. One cannot have it both ways. The sheer intensity of technological, economic, social and political investment in warfare means not only that wars often persist for decades without conclusion but that *total warfare* is a much more common phenomenon than ever before. Some 90 per cent of the victims of war in these past 50 years have been civilians, not soldiers, and a majority have been women and children. At the same time, the global threat of nuclear war has extended the potential front line of conflict to every citizen of our planet (Bunge 1966: 277; Sagan & Turco 1991), and has induced both brinkmanship in international relations and precisely the apprehension that this would be expected to produce.

In peace or in conflict, warfare is less remote than we may think, for, even in countries at peace, the global economy is strongly based on the so-called military–industrial complexes that design and produce armaments. Defence, as it is euphemistically known (its borderline with aggression is diffuse and permeable) is a major expenditure. Moreover, conflict has resulted in over 50 million refugees, and only the displacees have been counted, not the ones whose lives have been ruined or disrupted but who have no status under the Geneva Convention of 1951 (Loescher & Monahan 1990, Toole & Waldman 1991).

Although rape and pillage are doubtless as old as armed conflict itself, the traditional view of military action is still one of clearly defined enemies who attack each other in well planned battles. But modern wars have begun to assume the guise of an all-out assault on the civilian population and its environment.[2] From the napalming of Vietnamese tropical forests to the "ethnic cleansing" (an obscene euphemism) of Yugoslav peoples, the strategic objective has shifted subtly from denying the enemy cover to total eradication of the opposition. The new weapons not only include mortars, grenades and tanks, they scorch the very ground of the theatre of conflict. Millions of landmines have been sown, and most often where they will do maximum damage to civilian women, children and livestock. Rural people are terrorized and tortured, women are raped, and children drugged and conscripted (they tend to make compliant, obedient soldiers). Property is expropriated and wantonly destroyed, vegetation is defoliated or burnt down, resources are hoarded or impounded. Aid is denied to civilian populations in order to make them compliant, food is rationed in order to weaken them, and if they do not bend to the will of the military, slavery and conscription may await them (Macrae & Zwi 1992).

Let us now compare some of the negative characteristics of natural disaster with those of warfare. When drought, flood or wildfire occur against a background of military conflict, the repeated impact of extreme geophysical events may lead to progressive environmental degradation (Varley 1993, Black 1994). Weakened by the dual attack of man and nature, social systems may fail to recover adequately between one disaster and the next and may fail to develop sustainable coping mechanisms. Thus, lack of protection of civilian populations leads to social and personal insecurity.[3] The territoriality of war makes access to land difficult and tends to reduce people's means of coping. Strongly deteriorating conditions may be accompanied by atrocities. The logical conclusion is that, where they occur together, natural disasters and armed conflict are weakening influences on populations.

Warfare is often a cause of weakened environmental resistance to disaster. To begin with, defoliation by bombing or napalming slopes in humid tropical areas can make them especially unstable in times of seasonal rain and can vastly increase landsliding, water yield and the sediment load of streams. Conversely, fire has for centuries been a chosen weapon or inadvertent consequence of fighting and it can of course be immensely destructive to ecosystems when used more intensively or more often than nature would do, especially if it becomes more frequent or more intense than to permit recovery of the vegetation and soil. In this context, warfare has traditionally included an element of environmental vandalism, for example by breaching sea defences of irrigation canals, destroying dams, or by diverting streams. It now includes sinking oil tankers,

2. See El-Baz (1999) for a comprehensive historical and modern assessment of the environmental impact of warfare, and Kibreab (1997) for an assessment of environmental deterioration in relation to the refugee problem.
3. In 1988 a conflict and poor harvests caused famine in southern Sudan. Aid was denied to tens of thousands of people, and the death rate exceeded 7 per cent per week (Duffield 1990).

CHAPTER 8

Worlds apart

One of the most striking aspects of the modern world is the persistent gulf between the rich and poor nations. It is a deeply rooted phenomenon that has more or less prohibited any convergence between attitudes and expectations. Old-fashioned colonialism may have ended, but that has not allowed the world's poorer countries to grow more like the richer ones. Other forms of exploitation, often cruder and even more destructive, have taken the place of colonial overlordship, and neocolonialism has come to the fore in the depredations of capital and commodities markets. Most depressingly, warfare has continued unabated in countries that desperately need stability in order to create economic growth and wellbeing. Often it has been conducted as a proxy for confrontation between global or regional powers; at other times it has resulted from more direct exploitation and repression. Thus, it is hardly surprising that attitudes to hazards, impacts of disasters and strategies to mitigate risk all differ substantially between the rich and poor countries. However, this is not to imply that all Third World countries are alike in their response to natural catastrophe (Wijkman & Timberlake 1984). Especially in this case, "Third World" is a rather misleading term, as it masks a wide variety of problems and solutions. This chapter will delve into these in order to investigate what disasters really mean to the developing world and what light they throw on the tortuous relationship between the rich and poor countries.

The first few sections of this chapter will offer a survey of the current situation regarding disasters in selected parts of Asia, the Middle East and Africa. Following on from observations about disaster relief made in these sections, a brief study of World Food Programme (WFP) operations will be presented in order to illustrate some of the dilemmas of international aid in the modern world, when military action commonly affects disaster aid and the relief agencies find themselves at a moral and operational crossroads (Hendrickson 1998). In the interests of holism, the two sections that follow this will change the focus from the international to the local level, in order to assess how disasters appear to the people who matter most: the potential and actual victims. Finally, the conclusion of this chapter will briefly assess the prospects for disaster relief in developing countries. It will also tackle the vexed question of whether interest in the poorer countries' disaster problems on the part of the richer nations can be sustained, given the occurrence of "donor fatigue" (Macrae 1998).

Natural disaster in Asia

In a world context, Asia stands out in terms of the impact of natural disasters, in both historical and contemporary contexts (Freeberne 1962, Uitto 1998). Poverty, high population densities, and the distribution and variety of natural hazards combine to produce situations of persistent and recurrent tragedy. To understand this situation better it is worth examining the particular vulnerability and recent record of catastrophe in several Asian countries. The choice is an open one, as many criteria justify the selection of different nations, but let us focus on China, the Philippines and Bangladesh as examples of Asian vulnerability. In an account such as this, it is impossible to survey the situation in each country thoroughly, but it is possible to examine why vulnerability should be so high there and to develop a comparative perspective on each case.

China

In many respects, China is the country that is most affected by natural disaster. Some 1156 million people live in its 9536500 km^2 and have a mean per capita GNP of US$370. The vast land of China is climatically and geologically of extreme diversity and it varies from uninhabited desert to some of the world's largest and most densely settled conurbations. Every kind of natural hazard is present, and records indicate that serious natural disasters have occurred in at least one province, and sometimes as many as a dozen, virtually every year for the past two millennia (Wang & Zhao 1981, Jones 1987).

One of the most widespread and serious problems that China faces is land erosion and degradation, which has a strong impact on the nature and incidence of floods, landslides, subsidence and desertification. Some 150 million ha, or 15.6 per cent of national territory, are eroded, which represents an increase of 30 per cent on 1979 values (Han Chunru 1989, Wen Dazhong 1993). Soil erosion is estimated to have increased by 100 per cent in the past three millennia and 50 per cent in the twentieth century alone. Two thirds of the 720000 km^2 Yangtse River basin is suffering from erosion. It is particularly serious in the Loess Plateau, an area of 530000 km^2, which is covered by deposits of aeolian silt

30–200 m thick. Sixty million people live in this area and one third of soil loss comes from the land that they cultivate. Three quarters of the plateau shows significant signs of erosion, which yields between 20 and 200 tonnes / ha / yr of sediment, a total of 2.4–2.5 billion tonnes per year. Much of the solid load goes into the Yellow (Huanghe) River, as the Loess Plateau falls within its 680 000 km^2 watershed. The sediment load at the mouth of this 5464 km-long river, which flows for 400 km across the loess deposits, is estimated to be 1.2–1.6 billion tonnes / yr (equivalent to 1 cm per year of soil loss across the eroded area of the plateau) and deposition along the lower reaches has raised river-bed levels by up to 12 m above the surrounding land. When floods occur, they tend to inundate such vast tracts of land that tens of millions of people are affected, and damage, especially to crops and villages, amounts to billions of dollars (Robinson 1981, Jing Ke 1988).

Seismically active fault complexes and neoseismic orogens abound in China, which has some spectacular tectonically dominated landscapes (Doornkamp & Han 1985, Petrov et al. 1994). Records indicate that the largest-known earthquake death toll (830 000) occurred in 1556 at Shensi. Indeed, China accounts for about half of known earthquake deaths, owing to the combination of high recurrent seismicity, high population densities and weak building stocks (Coburn & Spence 1992). In the 1976 Tangshan earthquake, in which 240 000 people died, only four multistorey buildings survived relatively intact out of 352, and a city of 1 million inhabitants was reduced to rubble (Cheng Yong et al. 1988). Earth tremors are, moreover, frequently linked to mass movement; for instance, the 1920 Gansu earthquake caused flow failures 1.5 km long that killed 100 000 people (Song et al. 1989). In all, at least 156 lethal earthquakes have killed 610 000 people in China in the twentieth century (Chen Zhiming 1996).

Many other hazards afflict China. Like floods, drought is an annual occurrence and in historical times it has resulted in about 5 per cent of the population dying of starvation. Desertification is also serious: of the 11 per cent of the country that is under crop land, one fifth suffers from salinization, and in the north and west of the country migrating sand dunes are a problem over vast tracts of land. In the Chengdu area of Sichuan Province massive rock avalanches and debris flows are a persistent problem, because of unstable mountainous terrain and a wet climate (Bruhn & Li 1989). In the South China Sea, typhoon tracks frequently bring major tropical storms to landfall along the populous coast, with inevitably high numbers of casualties and high losses (Beijing Normal University 1992).

The vicissitudes of the Chinese people have been numerous during the Revolution, Cultural Revolution and subsequent economic liberalization. China has remained throughout this time a country of tensions between provincialism and bureaucratic centralism, a polarization that has characterized it throughout

CHAPTER 9

Finem respice

Previous chapters have considered the theoretical, social, technological, moral and development issues involved in natural catastrophe. It is now time to draw some conclusions from this survey of change and trends in a world afflicted by recurrent natural disasters. Given the accelerating pace of the transformations discussed in this book, the conclusions are destined to be both provisional and incomplete: they, too, must adapt to circumstances.

This final chapter will not attempt to review or even synthesize the diverse subjects covered in the previous chapters, but will underpin them with a comprehensive theoretical model, which, it is hoped, will help to enlighten them.

The DNA of disaster

The most widely accepted view of cause and effect in disaster can be conceptualized as follows:

Extreme geophysical events
act upon
human vulnerability and risk taking
to produce
casualties and damage

Deliberate risk taking is dominant in affluent societies where there is ample opportunity for choice, and it produces foreseeable or avoidable vulnerability. On the other hand, the risk taking associated with poverty and marginalization results in inadvertent or unavoidable vulnerability and the range of practicable choices is severely restricted. However, the view is gaining ground that the physical agents of catastrophe are not the starting point in the chain of cause and effect: rather, human vulnerability and risk taking are held to be (Quarantelli et al. 1995). One way of conceptualizing this is:

Society's risk taking and vulnerability
interact with
extreme geophysical events
to produce
casualties and damage

A more extreme reorganization of the fundamental variables gives the following chain of causality:

Human risk taking and vulnerability
produce
casualties and damage
when there are
extreme geophysical events

However, the consensus is still in favour of integrating the physical and socio-economic aspects of disaster *in that order*, and hence this is the line that this section will follow, although it will make allowance for feedback mechanisms.

One justification for this approach is that physical impact is followed consecutively by human response. Although it is not a process in its own right, time is the linear backbone of disaster, whose medium of expression is geographical space. The other principal dimensions are magnitude, a measure of the size of the physical event, and intensity, a measure of the size and extent of its effects (Alexander 1991a, 1994a, 1995a).

The temporal pattern of hazards varies considerably with the type of event, but essentially there are ten different forms in which they occur, which will now be listed with examples:

- *Non-repetitive hazards* Some hazards occur only once. This is commonly the case for the large debris avalanche–slide–flow phenomena that occur in Alpine and other mountain areas and are known as *sturzströme* (Hsü 1975).[1] Non-repetitive events are also characteristic of the interaction of natural and anthropogenic hazards, as in the case of a dam burst (Ellingwood et al. 1993).
- *Remobilized or reactivated hazards* Continuous erosion (by a basal stream or by the sea at the base of a cliff), can cause a complex of multiple-regressive landslide blocks repeatedly to pass the threshold to instability (Seed & Wilson 1967).
- *Continuous hazards* Subsidence of the ground often falls into this category, especially if compaction–consolidation of saturated granular sediments occurs constantly (Chilingarian et al. 1995).

1. However, there are some good examples of repetition even here: for example, the disasters of 1962 and 1970 at Mount Huascarán, Peru (Plafker et al. 1971, Browning 1973).

- *Episodic hazards*. Coastal erosion is often an episodic phenomenon (Kaufman & Pilkey 1984, US National Research Council 1990).
- *Seasonal*. Drought and floods are usually conditioned by seasonal variations in weather patterns; so are hurricanes and other cyclonic storms (Kundzewicz et al. 1993). When viewed on an annual basis, coastal erosion tends to be highly seasonal, although varied geomorphic settings lend resistance to erosion an episodic character (Herbich & Haney 1982, Dolan et al. 1987).
- *Other regular spacing*. Endogenous forces within the Earth can sometimes impart regularity or pseudo-regularity to the pattern of earthquakes or volcanic eruptions. In the former case, strain builds up gradually between fault blocks until it is abruptly released in the form of seismic energy (Thatcher 1976, Chen et al. 1998), whereas in the latter case magmatic pressure accumulates underground until it is sufficient to force its way to the surface and start an eruption (Ryan 1990). Regular volcanicity is a characteristic of so-called closed-system volcanoes, which are fed by a relatively isolated magmatic convection system (Lirer et al. 1987).
- *Irregular*. Although there is a standard frequency distribution for tsunami occurrence in the Pacific basin, the actual pattern shows a fair degree of irregularity, as not all large offshore or littoral earthquakes are tsunamigenic (Lockridge 1988).
- *Progressive with thresholds*. Accelerated erosion is often identifiable by the creation of dense systems of rills and gullies, or deep flat-floor canyons. In such cases, the erosional system has crossed a threshold from superficial slope wash with low sediment load, to the wholesale export of sediment by a process of vigorous downcutting (Cooke & Reeves 1975). Likewise, desertification involves thresholds in biophysical productivity and land capability (Phillips 1993).
- *Progressive without thresholds*. When drought extends across several seasons, its effects on biological productivity tend to deepen in a smoothly progressive manner (Kassas et al. 1990).
- *Compound or complex*. Any combination of hazards – seismic landsliding, for instance – can give rise to complex sequences. Large and prolonged volcanic eruptions are also temporarily complex. For example, as described in previous sections, Mount Vesuvius was active in several hundred eruptive phases between 1631 and 1904.

The repetitiveness of hazards can also be considered in terms of frequency distributions. At the most basic level, the magnitude–frequency principle leads us to expect many small insignificant events and, in the long term, increasingly fewer events as magnitude rises: thus, there is a negative linear-logarithmic relationship between magnitude and return period or recurrence interval (Fig. 9.1a;

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