Tobin & Montz "NATURAL DISASTERS"

1 Natural Hazards and Disasters

When Potential Becomes Reality

NATURAL DISASTERS: A NORMAL STATE OF AFFAIRS

In 1985, an earthquake in Mexico killed 20,000 people; a tropical cyclone killed 11,000 in Bangladesh, and one in Vietnam killed 670; 300 died from landslides in the Philippines; a volcano erupted in Colombia killing 25,000; a flood in China added 500 to the death toll; a storm in Algeria killed 26; cold waves were responsible for 290 deaths in India and 145 in the United States; a heat wave killed 103 in the United States; and 52 died in Egypt from a fire (Glickman, Golding, & Silverman, 1992). It was not an exceptional year. In 1995, over 700 people in Chicago died from heat stress during a period of abnormally high temperatures, and Hurricanes Luis and Marilyn both devastated the Caribbean; on the island of St. Thomas alone, Hurricane Marilyn damaged more than 70% of the approximately 18,000 homes. Thus, although disasters and deaths were slightly above average in 1985, comparison with selected events from 1995 suggests that in many ways, 1985 was a "normal" year.

The litany of disasters goes on with deaths and damages mounting almost daily. In just 1985, globally there were 47 disasters that killed 62,500 people, averaging 1,330 deaths per disaster (Glickman et al., 1992). In 1945 through 1986, the 42-year period studied by Glickman, Golding, and Silverman (1992), there were on average 30 disasters and 56,000 deaths per year; this means that 2.34 million people lost their lives to extreme natural events during this period. The cost to the global economy is in excess of $50 billion every year, two-thirds of which is direct loss and one-third of which is the cost of prevention and mitigation (Alexander, 1993).

Describing such deaths and losses as normal seems callous, but represents reality for many people around the world. People do live in high-risk areas, and many communities are particularly vulnerable to the vicissitudes of natural events. The situation is complicated further when the data are examined more closely. Glickman et al. (1992) showed that the number of disasters and the number of deaths had increased during the 42-year study period; however, some disasters, such as droughts, were not even included in their data set because of difficulties in accounting for losses from such events. This means that their statistics probably underestimate significantly the total impact of extreme natural events.

The available data raise many questions. One, at least for many Westerners, concerns the total number of disasters and deaths (Tables 1.1 and 1.2). How could it be that so many disasters have occurred and so many people around the world have died, but for the most part, we remain totally unaware of the tremendous dimensions of such problems? This lack of awareness involves issues of place and significance as well as concerns about media coverage of such events. Other questions arise as to why such disasters occur and whether anything can be done to mitigate them. Since we know a great deal scientifically about their physical properties, why do natural disasters continue to cause such losses? Who is at fault: is it the government or the victims themselves or is it more complicated than that? In addition, there are questions about the nature of disasters. Given that the incidence of events appears to be increasing and the number of deaths rising, is the environment becoming more hazardous or are there other explanations for this disturbing increase? What can we learn from the spatial patterns of disasters? Do some regions experience more events, do they have more hazardous conditions than others, and if so, why? Can spatial and temporal trends be explained by differences in the incidence of extreme geophysical events or are there human/structural factors that need to be addressed to explain hazard vulnerability? Finally, will answers to the above questions provide sufficient information to develop an explanatory model of disasters and disaster impact? In order to resolve these questions, we must be clear about terminology so that we understand the components that combine to create disasters in some places, but not others.

In this chapter, we begin by distinguishing natural "hazards" from "disasters." While one represents a potential or threat, the other presents a very real set of problems and losses. We then turn our attention to the natural versus human debate that has concerned so much of hazards research. Because it does not suffice to look at disasters per se, we also devote attention to understanding risk and vulnerability, assessing the potential for catastrophe, and identifying and defining the victims of disasters. This discussion is followed by detailed examination of the spatial

TABLE 1.1. Deaths from Natural Disasters, a Selection of Events Worldwide

Year	Event	Location	Approximate death toll
1900	Hurricane	United States	6,000
1902	Volcanic eruption	Martinique	29,000
1902	Volcanic eruption	Guatemala	6,000
1906	Typhoon	Hong Kong	10,000
1906	Earthquake	Taiwan	6,000
1906	Earthquake/fire	United States	2,500
1908	Earthquake	Italy	75,000
1911	Volcanic eruption	Philippines	1,300
1915	Earthquake	Italy	30,000
1916	Landslide	Italy, Austria	10,000
1919	Volcanic eruption	Indonesia	5,200
1920	Earthquake/landslide	China	200,000
1923	Earthquake/fire	Japan	143,000
1928	Hurricane/flood	United States	2,000
1930	Volcanic eruption	Indonesia	1,400
1932	Earthquake	China	70,000
1933	Tsunami	Japan	3,000
1935	Earthquake	India	60,000
1938	Hurricane	United States	600
1939	Hurricane/tsunami	Chile	30,000
1945	Floods/landslides	Japan	1,200
1946	Tsunami	Japan	1,400
1948	Earthquake	USSR	100,000
1949	Floods	China	57,000
1949	Earthquake/landslide	USSR	20,000
1951	Volcanic eruption	Papua New Guinea	2,900
1953	Floods	North Sea coast	1,800
1954	Floods	China	40,000
1954	Landslide	Austria	200
1959	Typhoon	Japan	4,600
1960	Earthquake	Morocco	12,000
1961	Typhoon	Hong Kong	400
1962	Landslide	Peru	5,000
1962	Earthquake	Iran	12,000
1963	Tropical cyclone	Bangladesh	22,000
1963	Volcanic eruption	Indonesia	1,200
1963	Landslide	Italy	2,000
1965	Tropical cyclone	Bangladesh	17,000
1965	Tropical cyclone	Bangladesh	30,000
1965	Tropical cyclone	Bangladesh	10,000
1968	Earthquake	Iran	12,000
1970	Earthquake/landslide	Peru	70,000
1970	Tropical cyclone	Bangladesh	300,000
1971	Tropical cyclone	India	25,000
1972	Earthquake	Nicaragua	6,000

continued

TABLE 1.1. ***(cont.)***

Year	Event	Location	Approximate death toll
1976	Earthquake	China	300,000–700,000
1976	Earthquake	Guatemala	24,000
1976	Earthquake	Italy	900
1977	Tropical cyclone	India	20,000
1978	Earthquake	Iran	25,000
1980	Earthquake	Italy	1,300
1982	Volcanic eruption	Mexico	1,700
1985	Tropical cyclone	Bangladesh	10,000
1985	Earthquake	Mexico	10,000
1986	Volcanic eruption	Colombia	23,000
1988	Hurricane	Caribbean Islands	343
1988	Earthquake	USSR	25,000
1989	Hurricane	Caribbean Islands	56
1990	Earthquake	Iran	40,000
1991	Tropical cyclone	Bangladesh	138,000
1992	Earthquake	Turkey	547
1993	Floods	United States	50
1994	Earthquake	United States	57
1995	Earthquake	Japan	6,300

Note: Drought, famine, and certain meteorological events such as heat waves are excluded from this table. *Data sources:* Glickman, Golding, and Silverman (1992), International Federation of Red Cross and Red Crescent Societies (1993), Noji (1991), Office of U.S. Foreign Disaster Assistance (1990).

and temporal patterns of death and damage associated with disasters at the global scale. The significance of disasters to society and the individual also is addressed. Finally, we look to the future and discuss how a theoretical framework to model the hazardousness of a place (see, e.g., Hewitt & Burton, 1971) might improve our knowledge of natural hazards. Throughout this chapter, one basic theme prevails: natural hazards are normal events with which societies must deal. In some locations, they are frequent or perhaps even commonplace; in others they represent a relatively rare, once-in-a-lifetime event. To all societies, however, they present a challenge.

TABLE 1.2. Disaster Mortality by Type, 1960–1989

	Deaths		
Disaster type	1960–1969	1970–1979	1980–1989
Floods	28,700	46,800	38,598
Cyclones	107,500	343,600	14,482
Earthquakes	52,500	389,700	53,740
Hurricanes			1,263
Other disasters			1,011,777
Total			1,119,860

Data sources Glickman, Golding, and Silverman (1992), International Federation of Red Cross and Red Crescent Societies (1993), Noji (1991), Office of U.S. Foreign Disaster Assistance (1990).

DEFINITIONS: NATURAL HAZARDS AND DISASTERS

The term "natural hazard" sometimes creates confusion. It has been used imprecisely and with different implicit meanings, but in addition, the term has evolved with understanding of the components that interact to comprise hazardousness.

A *natural hazard* represents the potential interaction between humans and extreme natural events (Figure 1.1). It represents the potential or likelihood of an event (it is not the event itself). By definition, then, natural haz-

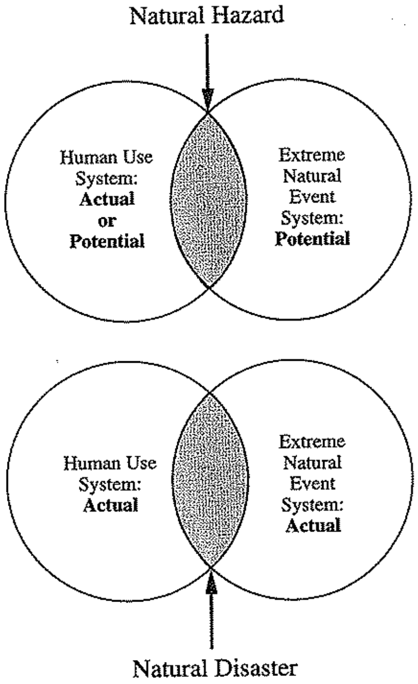

FIGURE 1.1. Natural hazards and natural disasters. In both cases, the overlap between human and physical systems is of concern; their difference relates to potential versus actual occurrences. Hazards represent potential events while disasters result from actual events. *Source:* Ericksen (n.d.). Reprinted by permission.

ards constitute a threat to society. Such a threat is ever-present, representing an intrinsic force with which all societies must cope in one way or another. The hazard exists because humans or their activities are constantly exposed to natural forces. For example, by locating property on flood plains, undertaking viticulture on the slopes of active volcanoes, or developing homes and resorts in hurricane-prone coastal zones, humans are exposed to natural hazards. It is possible, therefore, to identify some hazard-prone areas from a geographical perspective: for example, the Ring of Fire (along the margins of the Pacific Ocean) delimits an active zone of earthquakes, tsunami, and volcanoes. While not all hazards can be defined so accurately in space, it is possible to calculate levels of risk and the probability of dying from various events (Table 1.3). For instance, one's chance of being hit by a meteorite is 1 in 100 billion, a threat that is not high; however, if the earth were to find itself in the path of a succession of meteorites (such as those that crashed into Jupiter in 1994), clearly the risk would increase and the threat would be imminent. The same can be said of other hazards. The risk and ultimately the threat (often defined as *hazardousness*) change over time as human use and environmental processes change.

Only after an event occurs do we term it a "natural disaster." A *disaster* is usually defined as an event that has a large impact on society. Because our subject matter is limited to natural hazards, it is geophysical events that create disasters. Unfortunately, there are no definitive boundaries to determine exactly when a threshold has been reached such that we can categorically say, "*this* constitutes a disaster." A disaster might be defined qualitatively as a hazardous event that significantly disrupts the workings of society. It may or may not lead to deaths, but it usually has severe economic impacts. We might also search for quantitative measures and, by default, several researchers have categorized disasters by numbers of deaths or extent of damage. For instance, Sheehan and Hewitt (1969) defined disasters as those events leading to 100 deaths, 100 injuries, or $1 million in damages. Glickman et al. (1992) used 25 deaths as their threshold, a figure we shall use in this book.

TABLE 1.3. Risk of Death from Involuntary Hazards

Risk	Risk of death/person/year
Struck by automobile in the United States	1 in 20,000
Struck by automobile in the United Kingdom	1 in 16,600
Floods in the United States	1 in 455,000
Earthquake in California	1 in 588,000
Tornadoes in midwestern United States	1 in 455,000
Lightning in the United Kingdom	1 in 10,000,000
Falling aircraft in the United States	1 in 10,000,000
Falling aircraft in the United Kingdom	1 in 50,000,000
Release from atomic power station	
At site boundary in the United States	1 in 10,000,000
At 1 km in the United Kingdom	1 in 10,000,000
Flooding of dike in the Netherlands	1 in 10,000,000
Bites of venomous creatures in the United Kingdom	1 in 5,000,000
Leukemia	1 in 12,500
Influenza	1 in 5,000
Meteorite	1 in 100,000,000,000

Source: Dinman (1980). Copyright 1980 by American Medical Association. Reprinted by permission.

In addition, there are *catastrophes,* which for a given society might be defined as an event leading to 500 deaths or $10 million in damages. These figures, however, are arbitrary since levels of impact mean different things to different people in different situations. Furthermore, we cannot ignore the element of scale. It would be a catastrophe for a small community if every building were totally destroyed by flooding (as occurred in 1993 in Valmeyer, Illinois), but at the global scale, it would be an insignificant event if only 350 houses were involved (Horton, 1994). Similarly, $10 million in damage to some communities, would be devastating to some communities, especially in less wealthy societies, but others would be able to cope relatively easily.

The preceding discussion has introduced several concepts relevant to hazards, including risk, threat, vulnerability, impact, disaster, and catastrophe, each of which means something slightly different. In this text, these concepts delineate different elements of natural hazards.

This chapter focuses on losses from disastrous events. These indicate not only the enormity of the problems, but also help in understanding why the components of natural hazards are so important. Because of the probabilistic nature of hazards, they tend to be ignored or considered low priorities. However, it is too late to protect against loss once the event has occurred; instead, we must take action prior to the event (or before the next one). Understanding natural hazards provides opportunities, too often missed or ignored, to alter hazardousness of an area so as to reduce loss. The figures, concepts, and themes presented in this chapter illustrate the magnitude and range of the problems as well as how our evolving knowledge of interacting variables has altered approaches to mitigation. In particular, hazards research has undergone an evolutionary process, best exemplified by changing perspectives on just what constitutes a natural hazard as well as which factors need to be addressed in order to avoid disasters.

THE COMPONENTS OF NATURAL HAZARD: AN EVOLUTION

The earth is indeed hazardous to your health. According to Atkisson, Petak, and Alesch (1984), there are 516 active volcanoes with an eruption every 15 days (on average) somewhere in the world; global monitors record approximately 2,000 earth tremors every day, and there are approximately 2 earthquakes per day of sufficient strength to cause damage to homes and buildings, with severe damage occurring 15 to 20 times per year; there are 1,800 thunderstorms at any given time across the earth's surface; lightning strikes 100 times every second; during the late summer there are something like 5 hurricanes developing at any one time; and tornadoes average 4 per day or 600 to 1,000 per year. As a physical environment, the earth is a risky place to live.

Physical Perspectives

The traditional view of natural hazards has ascribed all or almost all responsibility for them to the processes of the geophysical world. This approach has meant that the root cause of large-scale death and destruction has been attributed to the extremes of nature rather than encompassing the human world. Frequently, disaster victims have been viewed as unfortunates who could do little but react to physical processes. The physical world, then, has been seen as an external force, separate from human forces. For example, Burton and Kates (1964), defined natural hazards as those elements of the physical environment harmful to man and caused by forces extraneous to him.

This is not to say that early researchers did not concern themselves with the human dimension. Indeed, building on the work of White (1945, 1961, 1964), scholars such as Burton (1962), Kates (1962), Dynes, Haas, and Quarantelli (1964), Hewitt and Burton (1971), and many others established hazards research as a human-based discipline. Although their definitions and classifications were oriented toward physical extremes, through their contributions it was soon recognized that the human-use system could not be ignored and, in fact, probably played a profound role in determining hazardousness and eventually the extent and degree of death and destruction from natural disasters. Thus, by the midseventies, natural hazards were defined somewhat more liberally: "The concept of natural hazards is somewhat paradoxical; the elements of a natural geophysical event (e.g., wind and storm surge of a hurricane) are hazardous only when they prove detrimental to human activity systems" Baker (1976, p. 1).

Although still based on the physical perspective, this refinement places greater emphasis on the human use system. In essence, extreme geophysical events that do not affect human activities do not constitute a hazard. (The threats posed by an earthquake in a remote part of Alaska, a mud slide on an uninhabited slope in South America, or a tornado in the desert region of New Mexico are not natural hazards under this definition.) Although the actual events may be of great interest to the geologist, geomorphologist, and meteorologist and may substantially enhance our knowledge of physical processes, they are not hazards.

Human Dimensions

By the end of the 1970s, steps toward a more human explanation of natural hazards were being taken by many others. For instance, the American Geological Institute (1984) defined as a natural hazard "a naturally occurring or man-made geologic condition or phenomenon that presents a risk or is a potential danger to life or property." Since the 1980s and early 1990s, natural hazards have been seen as the product of an interaction of physical and human forces that, in combination, determine the significance and impact of disasters. Thus, Smith (1992) suggests that natural hazards result from a conflict between geophysical processes and people; that is, hazards lie at the interface between the natural-event and the human-use systems (as shown in Figure 1.1).

In some instances, physical processes are almost eliminated. In defining disasters, Taylor (1989, p. 10) focuses entirely on disruption to society rather than any underlying physical process, emphasizing "catastrophic events that (a) interfere severely with everyday life, disrupt communities, and often cause extensive loss of life and property, (b) overtax local resources, and (c) create problems that continue far longer than those that arise from the normal vicissitudes of life." However, in classifying disasters, he utilizes physical processes as one criterion by which to distinguish hazard type (Table 1.4). His classification of disasters is quite wide-ranging, encompassing natural, industrial, and human-induced events.

In any classification system, of course, some events do not fit easily into categories. In particular, the primary event may be compounded by secondary impacts that may actually trigger greater losses than the original event. How should such events be classified? A classic example is the San Francisco earthquake of 1906. The shaking lasted for only about 40 seconds whereas the fires, sparked by broken pipelines, raged for three days before being brought under control; an estimated 2,500 people died (Palm, 1995), of whom ten times more died from the fire than from the earthquake (Bolt, 1978; Thomas and Witts, 1971). Nor are the secondary impacts of earthquakes confined to fire hazards; they can trigger landslides on unstable slopes, snow and ice avalanches in mountainous terrain, soil liquefaction, land subsidence, dam failures and, when they occur underwater, tsunami. For example, the Alaskan earthquake of April 1964 caused $235 million in damage to public property, $77 million to real estate, and 131 deaths; these losses resulted from not only ground shaking but landslides and slumping that damaged many buildings, submarine slides and tsunami that

TABLE 1.4. A Disaster Classification

	Natural	Industrial	Human
Earth	Avalanches Earthquakes Erosion Eruptions Toxic mineral deposits	Dam failures Ecological neglect Landslides Radioactive pollution Subsidence Toxic waste disposal Outer-space debris fallout	Road and train accidents Ecological irresponsibility
Air	Blizzards Cyclones Meteorite and planetary activity Ice storms Tornadoes Thermal shifts Dust storms	Acid rain Chemical pollution Underground explosions Radioactive cloud and soot Urban smog	Aircraft accidents Hijackings Spacecraft accidents
Fire	Lightning	Boiling liquid/expanding vapor accidents Electrical fires Hazardous chemicals Spontaneous combustion	Fire setting
Water	Drought Floods Storms Tsunami	Effluent contamination Oil spills Waste disposal	Maritime accidents
People	Endemic disease Epidemics Famine Overpopulation Plague	Construction accidents Design flaws Equipment problems Illicit drugmaking and taking Plant accidents	Civil strife Criminal extortion by viruses and poisons Guerrilla warfare Hostage taking Sports crowd violence Terrorism Warfare

Source: Taylor (1989). Copyright 1989 by AMS Press, Inc. Reprinted by permission.

destroyed docks and ports, and liquefaction that undermined a residential neighborhood (Bolt, 1978).

There are numerous examples of secondary impacts. Paradoxically, floods can produce fire dangers. In the Texas floods of October 1994, a gas pipeline burst, spreading flames and burning buildings along the San Jacinto River; similarly, in Egypt in November 1994, flooding led to 250 deaths when a train of flammable liquids was overturned and burst into flames. During hurricanes, a host of secondary processes can spawn tornadoes, sea surges, heavy rain, flooding, and wind damage; combined with human-induced threats, these culminate in widespread destruction. The devastating surge of seawater often causes more damage and death than other aspects of hurricanes. Certainly, many of the 300,000 to 500,000 who died in Bangladesh in 1970 were victims of rising seawater rather than the tropical cyclone itself (Murty, 1988). (Note that different sources have different estimates of the number of deaths, illustrating the difficulties of using numbers alone to register the impacts of disasters.)

Many disasters in Taylor's classification can be triggered by human activities. To a degree, this is closely tied to human use of resources. On the one hand, floods are useful in that they deposit fertile sediment in agricultural areas; on the other, they represent destructive agents bringing hardship and death. A holistic view that includes the careful management of resources would seem pertinent. In Nepal, for example, the gathering of wood for fuel has resulted in deforestation of steep hillsides, altering the hydrological regimes of local streams and aggravating flooding and sedimentation downstream. In the United States, urbanization and the drainage of wetlands for agricultural purposes have greatly exacerbated the flood hazard in some areas; it has been suggested that some of the flooding in the Midwest in 1993 resulted from these human actions.

Another set of hazards includes those related to technological and industrial activities. Industrial accidents, chemical spills, radioactive fallout and the like can be triggered by geophysical processes, adding to the hazardousness of a place. For the most part, however, large-scale industrial accidents do not occur as frequently as natural events and they usually involve fewer deaths (Glickman et al., 1992). While this book does not deal directly with such events, any consideration of total risk at a place should not overlook these concerns, for they do create catastrophic losses.

Thus, focus on the physical world and geophysical processes yields an incomplete understanding of natural hazards. The human element is important not only because people are the victims when events occur, but also because humans define the very essence of a natural hazard. Natural hazards constitute a complex web of physical and environmental factors interacting with the social, economic, and political realities of society. In this sense, the risk from natural hazards is heightened by human use of resources.

Structural Constraints and Societal Controls

Hewitt (1983) castigated hazards researchers for the overwhelming attention devoted to geophysical processes and neglect of societal forces. He stressed three points. First, natural hazards are neither explained by nor uniquely dependent upon the geophysical processes that may initiate damage; this is not to say that geophysical processes do not play a role, but that too much causality has been attributed to them. Second, human awareness of and response to natural hazards are not dependent solely on geophysical conditions. Hewitt saw hazards as more dependent on the concerns, pressures, goals, and risks of society, not least the effectiveness of measures to reduce calamity; these factors, he said, reflect the values and institutions of the society. Third, the causes, features, and consequences of natural disasters are not explained by conditions or behavior peculiar to calamitous events; these can be explained by everyday forces. The important parameters are social order, its everyday relations to the habitat, and larger historical circumstances that help shape society. Thus, disasters result more from social than geophysical processes, and hazardousness varies as much (or more) as a result of social as of geophysical processes.

While not completely rejecting the role of the physical world, Blaikie, Cannon, Davis, and Wisner (1994) also place more responsibility on the structure of society. Natural hazards and hazard vulnerability can best be determined by understanding social processes that affect the choices of a society's members. Their description of natural hazards takes us even further along the physical-human continuum, placing much of the cause, blame, and responsibility squarely on the human-use system.

> . . . The relative contributions of geophysical and biological processes, on the one hand, and social, economic, and political processes on the other, vary from disaster to disaster. Furthermore, human activities can modify physical and biological events, sometimes at many kilometers' distance (e.g. deforestation contributing to flooding downstream) or many years later (the introduction by people of a new seed or animal, or the substitution of one form of architecture with other less safe ones). The time dimension is extremely important in another way. Social, economic, and political processes are themselves often modified by a disaster in ways that make some people more vulnerable to an extreme event in the future. The "natural" and the "human" are so inextricably bound together in almost all disaster situations, especially when viewed in an enlarged time and space framework, that disasters cannot be understood to be "natural" in any straightforward way. (Blaikie et al., 1994, pp. 5–6)

It is their focus on constraints and ties of the human-use system that makes Hewitt's (1983) and Blaikie et al.'s (1994) contributions to hazards research so valuable. Their work posits that natural hazards cannot be understood without close attention to the political, economic, and social structures that constitute a given society. Further, the relationships of that society to other societies also may affect hazard impact. Loss is not caused solely by the geophysical event (although it is certainly the agent of destruction and can affect the degree of loss), but also by the makeup of society and how it responds to physical processes.

To take one example, marginalized groups invariably suffer more than nonmarginalized groups during hazardous events. Kreimer (1980) pointed out that squatters and slumdwellers (who number 1.72 million in Calcutta, 1.13 million in Jakarta, and 0.81 million in Karachi) have little or no choice of location and few options in responding to floods, tropical cyclones, or earthquakes. In fact, such marginalized groups are excluded from many of the basic elements of life and are too poor to move elsewhere. Disasters compound their difficulties, exacerbating the poverty trap in which they exist. The inequities of shared resources are "normal" conditions for them (Anderson, 1991). Even strategies for recovery can aggravate their vulnerability. Crisis management, emergency relief, restoration policies, and reconstruction attempt to recreate "normal" conditions (Hewitt, 1983), but restoration of the status quo perpetuates the difficulties of marginalized groups and does nothing to change risk. Thus, social constraints can determine how a society responds not only to hazardous events, but to their long-term impacts.

A Time–Space Framework for Hazard Classification

In defining natural hazards, it is clear that both physical processes and the human-use system are important. In addition, we should incorporate spatial and temporal components of the hazard. The timing of events can affect the outcome of hazards. In 1994, an earthquake in Northridge, California occurred at 4:31 A.M. before roads were crowded with commuters; the death toll of 57 was probably much lower than it would have been hours later. Similarly, in the Loma Prieta earthquake of 1989, many deaths resulted from collapsed interstate highways and the crushing of cars on multilevel roadways; however, because a World Series game was due to start, many fewer people were commuting than would have been usual at that time of day. The importance of timing can be seen with other hazards; for example, flooding may benefit farmers by providing soil moisture and sediment at certain times of the year, but destruction may be high if crops are already growing or cannot be replanted.

In some hazard classifications, events are categorized in terms of a time scale. Natural hazards often are described in relation to the rate of onset of the geophysical process, distinguishing between rapid events and those of a more pervasive nature. Rapid onset events include those hazards that usually provide little time for warning or preparatory action such as tornadoes, flash floods, earthquakes, and windstorms. More creeping or pervasive hazards (such as droughts, heat waves, and cold waves) have no definite beginning or end, hence complicate how society might respond. In-between are those geophysical processes (such as floods, tropical cyclones, and tsunami) that can be more accurately delineated in time to permit some form of response. Other physical and temporal traits also can delimit natural hazards, including measures of intensity, duration, and frequency of occurrence. These characteristics are considered in detail in Chapter 2; it is sufficient here to note that the physical dimensions of hazards can help shape coping strategies. However, hazard response definitely is not based solely on reaction to physical processes.

A second criterion of classification is spatial location. Not all hazards occur in every part of the world. It is too cold for hurricanes in Arctic regions, blizzards do not occur in tropical areas (at least not at sea level), and tornadoes are relatively rare outside the United States and Australia. Again, physical parameters can help to define risk. It is very unlikely, for instance, that a volcano will erupt in Duluth, Minnesota, but a blizzard or ice storm is a distinct possibility most years. The distribution of natural hazards around the world should not be overlooked when considering their significance. In addition, geographic location helps to determine whether a particular event constitutes a hazard. A 15 cm snowstorm in Duluth would not be considered a particular problem, but in Atlanta, Georgia, such an event could effectively stop activities within the city; similarly, freezing is not a problem in temperate climates, but it can lead to considerable difficulties in subtropical areas, especially for citrus farmers.

Finally, some argue that the areal or spatial extent of a hazard should be considered. Some hazards are diffuse, extending over thousands of square miles but impacting relatively few people. For example, the Australian drought of 1994 created serious problems for farmers throughout many agricultural areas, but did not seriously affect the general population; if it had continued, however, more people would have been affected because food supplies would have been compromised. Similarly, heat and cold waves might be classified as diffuse hazards. At the other extreme, some hazards are highly concentrated in place and impact large numbers of people. Earthquakes and flash floods typically fit this category since even low-intensity events can cause major losses.

Nevertheless, it is not possible to classify hazards by a purely physical determination of spatial extent, since levels of concentration-diffuseness depend on land use and population density. It could be argued that any hazard occurring in Hong Kong or Singapore will be highly concentrated whereas hazards in the Sahara will be diffuse. Thus, classifying hazards by spatial extent poses its own problems. Over what area must an event extend in order to be considered a natural disaster? Is the destruction of a small hamlet by an avalanche in the Alps or Andes the same as an earthquake in San Francisco or Tokyo? Do distinctions based on spatial extent provide better insight into natural disasters? These questions are not easily answered. Clearly, an individual who loses his or her house has suffered some form of personal disaster, though in the global picture it may be insignificant; to a community destroyed by a tornado, the event is a catastrophe, but to the country at large it may go virtually unnoticed.

Thus, the question remains how many individuals must be affected before an event can be described as a disaster. As discussed above, a hazard can exist anywhere, but a disaster occurs only when a significant component of society is impacted. Where we set our limits and definitions can significantly alter our view of hazards.

THE SIGNIFICANCE OF LOSSES

As must be evident by now, natural hazards exact a heavy toll from society, killing large numbers of people, destroying homes, and damaging property throughout the world every year. The data presented at the beginning of this chapter for 1985 are merely a sample of the yearly devastation that occurs in one form or another in virtually all nation-states. However, in our attempts to evaluate the significance of natural hazards we are confronted with serious data limitations that prevent us from obtaining an accurate picture of the global costs of natural hazards. In many cases, data on death and damage are unavailable or have been poorly collected. In others, "closed" governments have not released details of disaster impacts for fear of losing control within their countries. This occurred in the Sahel in the 1970s when several African nations initially refused to acknowledge the famine resulting from severe drought in the area; national pride effectively blocked efforts to alleviate the problem.

Immediately after an event, when emergency relief and rehabilitation have priority, it is difficult to assess the number of deaths and total property loss and other damages. Data on impacts can be sketchy and often are exaggerated, especially during the early hours of the event. It is not unusual to find initial, unofficial estimates of deaths and damages to be considerably higher than final figures (Alexander, 1993), and, on many occasions, the media accept and repeat these wild estimates. The opposite scenario also can occur, further confounding hazards researchers. In some events, particularly earthquakes, the death toll gradually rises as bodies are discovered under the ruins of buildings, roads, and bridges. In Guatemala after the earthquake in 1976, the estimated death toll rose from 1,000 to over 20,000 during the first seven days as officials became aware of the size