1 Natural and Anthropogenic Disasters: An Overview

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1. INTRODUCTION

Disasters are undesirable and often sudden events causing human, material, economic and/or environmental losses, which exceed the coping capability of the affected community or society. They are caused either by natural forces/processes (known as '*natural disasters*') or by human actions, negligence, or errors (known as '*anthropogenic disasters*'). Natural disasters are generally classified into three major groups (CRED, 2009): (i) 'geophysical disasters' (e.g., earthquake, volcanic eruption, rockfall, landslide, avalanche, and subsidence); (ii) 'hydro-meteorological disasters' (e.g., flood, drought, storm, extreme temperature, wildfire, and wet mass movement); and (iii) 'biological disasters' (e.g., epidemic, insect infestation, and animal stampede). Similarly, anthropogenic disasters are broadly classified into two major groups (http://en.wikipedia.org/wiki/Disaster): (i) 'technological disasters' (e.g., disasters due to engineering failures, transport disasters, and environmental disasters); and (ii) 'sociological disasters' (e.g., criminal acts, riots, war, stampedes, etc.).

In the *anthropocene* (most recent period in the earth's history when human activities have a significant global impact on the earth's climate and ecosystems), most natural disasters are aggravated by anthropogenic activities. Thus, hazards, which are part of nature, often turn into disasters due to human actions or inactions (UNESCO, 2007). For example, severe flooding is often aggravated by deforestation, urbanization, silting, and buildings in floodplains. Destruction of nature's natural defenses such as wetlands and coastal swamps is responsible for the severe damage by tropical cyclones, apart from ecological damage and loss of biodiversity. Failure to impose building codes and implement earthquake-resistant techniques is mainly responsible for the collapse of buildings and human fatalities even by relatively low intensity earthquakes. Human activities are also responsible for the threat of global climate change and rising sea levels as a result of global warming caused by increased greenhouse gases (GHGs) concentrations in the atmosphere (IPCC, 2007). Today, the world is experiencing a dramatic increase of suffering from the effects of various disasters, ranging from extreme droughts to severe floods caused by the poor land and water management and probably by climate change. More than 2,200 major and minor water-related disasters occurred in the world during 1990-2001 period, of which floods accounted for 50%, water-borne and vector diseases accounted for 28%, and droughts accounted for 11% of the total disasters (UNESCO Water Portal, 2008).

Disasters result in a serious disruption in the functioning of a society and widespread damages to life, property, infrastructure, and environment. They have adversely affected mankind since the beginning of our existence. About 94% of natural disasters occur due to four major causes — earthquakes, tropical cyclones (also known as typhoon, hurricane, cyclone, tropical storm, and tropical depression depending on their location and strength), floods and droughts (UNDP, 2004; UNESCO, 2007). About 75% of the global population reside in the areas which were affected by one or more of these catastrophic phenomena at least once between 1980 and 2000. More than 184 deaths per day are recorded in different parts of the world due to disasters triggered by earthquake, tropical cyclone, flood or drought (UNESCO Water

Portal, 2008). It has been found that the earthquakes and volcanic eruptions cause almost half of all natural disaster casualties, whereas the storms and other hydro-meteorological disasters cause the most economic damage (UNESCO, 2007). Disasters not only trigger direct losses, but also aggravate other stresses and distress such as a financial crisis, social/political conflict, disease, and environmental degradation.

The United Nations had declared the 1990s as the "International Decade for Natural Disaster Reduction". However, it should be aptly called the 'decade of natural disasters' with a record of flooding, earthquakes, landslides and droughts rarely seen in such profusion (UNESCO, 2007). The loss from natural disasters in the 1990s exceeded the combined losses of the four previous decades. This pattern has continued into the 21st century with spectacular catastrophes. Ever-increasing population (world's population doubled in the past 40 years), rapid urbanization (urban population quintupled in the past 40 years), and growing techno-economic development have resulted in widespread unsustainable development which is responsible for an increasing burden of risk at the dawn of the 21st century. On the top of it, global climate change and extremes of weather increase the domain and cost of disasters. They are responsible for increasing calamities in terms of frequency, scale, severity (social, economic and environmental losses), and complexity (Coppola, 2007; UNESCO, 2007). For example, during a recent two-year period (December 2004 to November 2006), the world community faced an extremely severe wave of disasters. The August 2006 report of the UN Secretary-General revealed that in the period from June 2005 to May 2006, there were 404 disasters with nationwide consequences in 115 countries, including the death of 93,000 people and economic losses totaling 173 billion US dollars. Another UN report issued in November 2006 estimated that 91 million people had their lives devastated by natural disasters in the first eight months of 2006 (UNESCO, 2007). Table 1 summarizes major disasters experienced in different parts of the world between December 2004 and June 2009. Thus, the spectacular catastrophes of the 21st century such as the Indian Ocean tsunami (December 2004), powerful earthquakes in northern Pakistan and India (October 2005) as well as in China (May 2008), devastating Hurricanes Katrina and Rita in the U.S.A. (August-September 2005), Cyclone Nargis in Myanmar (May 2008), flooding of New Orleans in Louisiana, U.S.A. (August 2005), and recurrent floods of increasing magnitude in India and Bangladesh, just to name a few, already shattered any assumptions that some nations have solved the disaster risk problem. Through their overwhelming and destructive fury, they have proved that all the nations, whether rich or poor, have much to learn about preparation and mitigation for, response to, and recovery from various types of disasters that continue to afflict us (UNESCO, 2007; CRED, 2009). Indeed, despite even the best efforts taken by the governments and non-governmental organizations involved in disaster management, the fury of nature and/or the folly of human beings frequently result in catastrophic incidents in several parts of the world (Coppola, 2007). These catastrophes overwhelm not only the local response capacity but also the response capacity of entire region or nation.

In spite of the ample availability of scientific knowledge and expertise about natural/anthropogenic hazards and their mitigation, the global vulnerability is growing because of unsustainable development; increasingly large populations are at risk mostly in developing and low-income countries (O'Brien et al., 2006; MunichRe, 2007; UNESCO, 2007; CRED, 2009). There are obvious trends in disaster occurrence on the earth (Coppola, 2007; CRED, 2009): (i) there is an upward global trend in natural disaster occurrence observed over the last decade, (ii) almost all the countries face increased risk from known or unknown disasters, and (iii) the disasters have larger adverse impacts on humanity and environment. According to the World Bank as cited in UNESCO (2007), "Accelerated changes in demographic and economic trends have disturbed the balance between ecosystems, increasing the risk of human suffering and losses. Today's populated areas – cities and agricultural zones – constitute an increasingly valuable asset base. Potential human, social and economic losses from natural disasters grow year by year, independently of nature's

Table 1. Major natural and anthropogenic disasters experienced in different parts of the world between December 2004 and June 2009 (modified after Coppola, 2007)

Sl. No.	*Type of disaster*	*Affected countries*
1	Strong Earthquake	Peru, Pakistan, Japan, Chile, South Africa, China.
2	Tsunami	Thailand, Indonesia, Sri Lanka, India, Somalia, Maldives, Myanmar, Malaysia, Kenya, Tanzania, South Africa, Madagascar.
3	Volcanic eruption	El Salvador, Ecuador.
4	Landslide	United States, El Salvador, Nicaragua, India, Honduras, Indonesia, Guatemala, China.
5	Avalanche	India, Pakistan, Nepal, Greece, United States, Austria.
6	Severe flood	Vietnam, India, Bangladesh, China, Canada, Austria, Bulgaria, Germany, Romania, Switzerland, United States.
7	Famine	Malawi, Niger, North Korea, West Africa, Lesotho.
8	Severe drought	Paraguay, United States, Australia, Botswana, Bolivia, Cambodia, Djibouti, Somalia, Ethiopia, Eritrea, Tajikistan, Thailand.
9	Extreme heat	United States, Bangladesh, Nepal, Pakistan, India.
10	Hurricane	United States, Guatemala, Mexico, Iran, El Salvador, Indonesia, Haiti, Cuba, Jamaica, Nicaragua.
11	Tornado	United States, Bangladesh.
12	Typhoon/Cyclone	Japan, Myanmar, China, Philippines, Thailand, India, Nepal, Germany, Austria, Poland, Czech Republic.
13	Windstorm	Pakistan, United States, South Africa.
14	Wildfire	Spain, Portugal, United States, India, Russian Federation, Brazil, South Africa, Peru, Ukraine, Madagascar, Argentina.
15	Structural fire	France, Egypt, Argentina.
16	Marine disaster	Ecuador, United States, Bangladesh, India, Nepal, Pakistan.
17	Mine accident	China, United States.
18	Structural Failure	Bangladesh, India, Russian Federation, Australia, China, Spain, France.

forces. Increased vulnerability requires that natural disaster management be at the heart of economic and social development policy of disaster-prone countries". Therefore, disaster reduction has been on the top of global and national policy agenda in recent years. For instance, it is an important part of United Nations' Millennium Development Goals (MDGs) for poverty reduction. The United Nations Decade of Education for Sustainable Development (2005-2014) is a second strategic instrument for mitigating natural and anthropogenic disasters. UNESCO is closely involved in creating **public awareness** and **improving education** about disasters, which are two effective coping strategies to reduce the vulnerability of a disaster-prone area, region, or nation.

This chapter focuses on the fundamentals of natural and anthropogenic disasters and their trend, definition/description of salient disaster-related terms, differential impact of disasters on communities across the world, a succinct history of disaster management, global recognition of disaster management, and modern approaches for disaster management.

2. DEFINING DISASTER-RELATED TERMS

In this section, the definition/description of salient terms related to disaster management is presented.

2.1 Disaster and Its Characteristics

The term '*disaster*' is derived from the Greek pejorative prefix *dus*- plus *aster*, which mean "bad star". Thus, the root of the word 'disaster' comes from an astrological theme in which the ancients used to refer to the destruction or deconstruction of a star as a disaster (http://en.wikipedia.org/wiki/Disaster). In simple words, 'disaster' is the tragedy of a natural or anthropogenic hazard which negatively affects society and/or environment. Not all the adverse events (i.e., hazards) are disasters, rather only those adverse events which overpower the response capacity of a society, community, or nation are called disasters. According to UN (1992), 'disaster' is defined as "a serious disruption of the functioning of society, causing widespread human, material, or environmental losses which exceed the ability of the affected society to cope using only its own resources". CRED (2009) defines 'disaster' as "a situation or event which overwhelms local capacity, necessitating a request to a national or international level for external assistance; an unforeseen and often sudden event that causes great damage, destruction and human suffering". Disasters are measured in terms of losses of lives, losses or damage of property, infrastructure and national assets, and environmental degradation. The impacts of disasters could be direct or indirect as well as can be tangible or intangible.

Based on the nature of disaster occurrence, disasters can be characterized as *rapid-onset disasters* and *slow-onset* (or *creeping*) *disasters* (UNDP, 2004; Coppola, 2007). Rapid-onset disasters are triggered by an instantaneous shock and often occur with no or little warning. The impact of such disasters may unfold over the medium- or long-term (UNDP, 2004), though most of their damaging effects prolong within hours or days. The examples of rapid-onset disasters are earthquakes, tsunamis, volcanic eruptions, landslides, tornadoes, tropical cyclones, and floods. Slow-onset disasters, on the other hand, occur when the ability of concerned agencies to support people's needs degrades over weeks or months. They emerge along with and within development processes. The hazard can be felt as an ongoing stress for many days, months or even years (UNDP, 2004; Coppola, 2007). The examples of slow-onset disasters are drought, famine, soil salinisation, soil erosion, and AIDS epidemic. Furthermore, based on the intensity and extent of disasters, they can be characterized as *local*, *national* and *international* (Coppola, 2007). If a local/state government can manage the consequences of a disaster, it is known as a *local disaster*. If the intervention of a national government is required to manage the consequences of a disaster, it is known as a *national disaster*. If one or more national governments are unable to manage the consequences of disaster, it is known as an *international disaster*. International disasters necessitate intervention by a variety of international response and relief agencies/organizations.

2.2 Hazard

Although there is a dispute about the origin of the term '*hazard*', it likely came from either the Old French word *hasard*, a game of dice predating craps, or from the Arabic word *al-zahr*, which means "the dice" (Coppola, 2007). Clearly, the term 'hazard' is rooted in the concept of chance. In practice, the term 'hazard' is used to denote a danger or potentially harmful situation. Thus, 'hazard' is a situation which poses a level of risk to life, health, property, or environment (http://en.wikipedia.org/wiki/Hazard). Hazards are defined as "events or physical conditions that have potential to fatalities, injuries, property damage, infrastructure damage, agricultural loss, damage to the environment, interruption of business, or other types of harm or loss" (FEMA, 1997). According to UNISDR (2004), 'hazard' is defined as: "A potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation".

Hazards can include latent conditions that may represent future threats. Most hazards are dormant or potential, with only a theoretical risk of harm. However, once a hazard becomes active (i.e., the hazard is

certain to cause harm because no intervention is possible before the incident occurs), it can create an emergency situation (http://en.wikipedia.org/wiki/Hazard). There are many causes of hazards which can be classified into two major categories: (a) natural (geophysical, hydro-meteorological, and biological hazards), and (b) man-made or anthropogenic (environmental degradation, global warming, and technological hazards) (UNISDR, 2004). The level of risk/threat and vulnerability associated with a hazard determines whether the hazard will be called a disaster. Generally, severe and large-scale hazards are known as disasters.

2.3 Risk

The term '*risk*' is a concept which denotes the precise probability of specific eventualities. Technically, the notion of risk is independent from the notion of value and, as such, eventualities may have both positive (favorable) and negative (undesirable) consequences (http://en.wikipedia.org/wiki/Risk). Thus, the concept of '*risk*' can have varying meanings depending on the context. It is sometimes used in a positive manner to denote "venture" or "opportunity" (Jardine and Hrudley, 1997). Such variance in use comes from the Arabic word *risq* meaning "anything that has been given to you by God and from which you draw profit" (Kedar, 1970). In contrast, the Latin word *risicum* describes 'a specific scenario faced by sailors attempting to circumvent the danger posed by a barrier reef', which seems to be more appropriate for use in disaster management where the term 'risk' is always used in negative sense. Unfortunately, even among the risk managers, there is no single accepted definition for this term (Coppola, 2007). However, in general usage, the term 'risk' is used to focus only on potential negative impact to some characteristic of value which may arise from a future event (http://en.wikipedia.org/wiki/Risk). One of the simplest and most common definitions of risk used by many disaster managers is as follows: "Risk is the likelihood of an event's occurrence multiplied by the consequence of that event, if it occurs" (Ansell and Wharton, 1992; UNDP, 2004). That is,

$$\text{Risk} = \text{Likelihood } (L) \times \text{Consequence } (C) \tag{1}$$

Likelihood is expressed in terms of probability (e.g., 0.15 or 15%) or frequency (e.g., 1 in 1000 or five times per year) of an event whichever is appropriate for the analysis. Consequence is a measure of the effect of hazard on human, property, and/or environment (i.e., impact of the event). It is clear from Eqn. (1) that by reducing either the likelihood of a hazard (L) or the potential consequences which might result (C), risk can be effectively reduced. Similarly, any action which increases the likelihood or consequences of a hazard increases risk.

2.4 Vulnerability

The term '*vulnerability*' has been derived from the Latin word *vulnerabilis,* which means "to wound" (Coppola, 2007). It denotes the susceptibility of a person or community to physical or emotional injury, or attack (http://en.wikipedia.org/wiki/Vulnerability). Vulnerability is also the extent to which a community or system can be affected by the impact of a hazard. It is defined as: "The conditions determined by physical, social, economic, and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards" (UNISDR, 2004). In the global warming context, 'vulnerability' is defined as "the degree to which a system is susceptible to or unable to cope with adverse effects of climate change, including climate variability and extremes" (http://en.wikipedia.org/wiki/Vulnerability). Thus, vulnerability is a complex and multifaceted concept which has physical, social, economic, and environmental dimensions. Vulnerability can be decreased through the actions which lower the

susceptibility to changes that can harm a system, or it can be increased through the actions which enhance that susceptibility. For example, constructing resilient buildings to withstand an earthquake in earthquake-prone areas will decrease the buildings' vulnerability to this natural hazard, thereby lowering earthquake risk. People's vulnerabilities can be increased or decreased according to their practices, beliefs, and economic status (Coppola, 2007).

Moreover, from the hazards and disasters point of view, 'vulnerability' is a concept which links the people's relationship with their environment to social forces and institutions and the cultural values that sustain and contest them (http://en.wikipedia.org/wiki/Vulnerability). Thus, "the concept of vulnerability expresses the multidimensionality of disasters by focusing attention on the totality of relationships in a given social situation which constitute a condition that, in combination with environmental forces, produces a disaster" (Bankoff et al., 2004). Further, an emerging paradigm called '*comprehensive vulnerability management*' is defined as "holistic and integrated activities directed to the reduction of potential disasters by diminishing risk and susceptibility, and building resistance and resilience" (Simonovic, 2009).

2.5 Resilience

In relation to hazards and disasters, the term '*resilience*' is opposite of vulnerability and is a measure of susceptibility to avoid losses. It is defined as (UNISDR, 2004): "The capacity of a system, community or society potentially exposed to hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure". Resilience is determined by the degree to which a social system is capable of organizing itself to increase this capacity by learning from past catastrophic events for better future protection and to improve risk reduction measures (UNISDR, 2004).

2.6 Safe

Many people think that the word "*safe*" indicates complete elimination of all risks. However, such an absolute level of safety is virtually unattainable in the real world (Coppola, 2007). In fact, all the aspects of life involve a certain degree of risk. Disaster managers may determine the threshold of risk that defines a frequency of hazard occurrence below which the societies should not worry about a hazard. According to Derby and Keeney (1981), "a risk becomes safe or acceptable, if it is associated with the best of the available alternatives, not with the best of the alternatives which we would hope to have available".

2.7 Composite Disaster

Sometimes two or more completely independent disasters occur at the same time, which are termed '*composite disasters*' or '*compound disasters*' (Coppola, 2007). For examples, an earthquake strikes during flood event, cyclone and associated flooding, flood occurs in one part of a country and drought in another part, and epidemic outbreaks after a severe earthquake or flooding. Thus, composite disasters can occur either sequentially or simultaneously with one or more disasters. However, more commonly, one disaster triggers secondary hazards. Some secondary hazards only occur as a result of a primary hazard such as tsunami from earthquakes, volcanoes or landslides, whereas others can occur either due to or independent of other disasters such as landslides which can be triggered by heavy rains, earthquakes, volcanic eruptions, or other reasons, or can occur purely on their own (Coppola, 2007). Composite disasters usually worsen consequences and increase victims' stress and isolation. They can make search and rescue, and other response and recovery operations more difficult, and can significantly increase the risk of harm to victims and responders equally (Coppola, 2007).

2.8 Humanitarian Crisis

"A '*humanitarian crisis*' is an event or series of events which represents a critical threat to the health, safety, security or wellbeing of a community or other large group of people, usually over a wide area" (http://en.wikipedia.org/wiki/Humanitarian_crisis). According to Coppola (2007), humanitarian crisis is "a special situation that results from a combination of the realized consequences of a hazard and the severely diminished coping mechanisms of an affected population". In such situations, the health and life of a vast number of people are seriously threatened, and hence it is sometimes also known as a '*humanitarian disaster*'. The characteristics of a humanitarian crisis usually include mass occurrence of (Coppola, 2007): (i) starvation/malnutrition, (ii) disease, (iii) insecurity, (iv) lack of shelter, and (v) a gradually increasing number of victims. Armed conflicts, wars, epidemics, famine, natural disasters, and other major emergencies may all involve or lead to a humanitarian crisis. Humanitarian crises are likely to worsen without outside intervention. The examples of recent humanitarian crises are (http://en.wikipedia.org/wiki/Humanitarian_crisis): Cyclone Nargis in May 2008, Hurricane Katrina in August 2005, the 2005 Kashmir earthquake, the 2004 Indian Ocean tsunami, the 1994 Rwanda genocide, the Sri Lankan civil war, the Israeli-Palestinian conflict, the Afghan civil war, the Darfur conflict, and the Iraq war.

2.9 Disaster Risk Management and Coping Capacity

'*Disaster risk management*' is defined as: "The systematic management of administrative decisions, organization, operational skills and abilities to implement policies, strategies and coping capacities of the society or individuals to lessen the impacts of natural and related environmental and technological hazards" (UNDP, 2004).

'*Coping capacity*' is defined as: "The manner in which people and organizations use existing resources to achieve various beneficial ends during unusual, abnormal and adverse conditions of a disaster phenomenon or process" (UNDP, 2004).

2.10 Disaster Risk Reduction and Sustainable Resilient Community

The term '*disaster risk reduction*' is defined as "conceptual framework of elements considered with the possibilities to minimize vulnerabilities and disaster risks throughout a society, to avoid (prevention) or to limit (mitigation and preparedness) the adverse impacts of hazards, within the broad context of sustainable development" (UNISDR, 2004).

The goal of building resilient communities shares much with the principle of intergenerational equity inherent in the principle of 'sustainable development'. '*Sustainable resilient communities*' can be defined as "societies which are structurally organized to minimize the effects of abrupt change and at the same time, have the ability to recover quickly by restoring the socio-economic vitality of the community" (Simonovic, 2009).

2.11 Structural and Non-Structural Measures

The term '*structural measures*' means hardware measures, which are based on technological solutions. They denote "any physical construction to reduce or avoid possible impacts of hazards, which include engineering measures and construction of hazard-resistant and protective structures and infrastructure" (UNISDR, 2004). On the other hand, the term "*non-structural measures*" means software measures which include "legislation, policies, insurance, awareness, knowledge development, public commitment,

and methods and operating practices, including participatory mechanisms and the provision of information, which can reduce risk and related impacts" (UNISDR, 2004).

3. IMPACT OF DISASTERS: RICH VERSUS POOR NATIONS

Every country has its own hazard profile, vulnerability level, and rise or fall of disaster management systems as well as has unique socio-economic, cultural, and political characteristics (Coppola, 2007). As a result, the disaster impact and management scenario vary appreciably from one country to another. The disparity is clearly visible between rich and poor countries of the world. Disasters strike hardest at the world's poorest nations, which have limited capacity to respond to and recover from disasters (UNESCO, 2007; CRED, 2009). In general, developing and low-income nations are more vulnerable to disasters; for instance, of the more than 2,200 disasters occurred in the world during 1990-2001, 35% occurred in Asia, 29% in Africa, 20% in the Americas, 13% in Europe, and 3% in Oceania (UNESCO Water Portal, 2008). The burden of losses due to various disasters is also greatest in poor countries, where 13 times more people die in disasters than in rich countries (UNESCO Water Portal, 2008). The basic disparities in disaster impact between rich and poor countries are summarized in Table 2. The ways in which disasters harm poor nations beyond the initial human fatalities, injury and devastation are briefly described below (modified after Coppola, 2007):

Table 2. Disparities in disaster impact between rich and poor countries (modified after UNDP, 2004; Coppola, 2007)

Rich countries	*Poor countries*
• They tend to suffer higher economic losses, but have adequate resources and effective plans to tackle these financial impacts.	• They have relatively less at risk in terms of financial value, but they maintain little or no buffer to absorb even low financial impacts. Economic impact can be considerable which in turn severely affects the socio-economic development of communities or nation.
• They have adequate resources, skill, and committed plans to take advantage of advanced and modern technologies to reduce loss of life and property such as efficient early warning and communication systems, enforced building codes and zoning, etc.	• They usually lack the resources and skill necessary to take advantage of advanced and modern technologies. They have little ability to enforce building codes and zoning even if these mechanisms do exist.
• Generally, they have immediate emergency and medical care that increase survivability and contain the spread of disease. Human fatalities and property losses are relatively less.	• They sustain massive primary and secondary casualties, and enormous loss of assets, infrastructure, agriculture, and ecosystems. They usually don't have immediate and efficient emergency services, which results in greater human suffering and chaotic situation.
• They transfer much of personal, private and public risk to insurance and reinsurance providers.	• They usually do not participate in insurance mechanisms. They divert funds from development programs to emergency relief and recovery.
• Recovery from disaster impact is much faster, and complete recovery is generally achieved.	• Recovery from disaster impact is very slow and often prolongs much longer, even years or decades. Complete recovery is often not achieved.

- Vital infrastructure is badly damaged or destroyed such as roads, railways, bridges, airports, ports, communication systems, power generation and distribution facilities, water supply and sewerage plants, which require years to rebuild. These damages not only create hindrance to relief and rescue operations but also significantly retard the recovery process.
- Dwelling houses are devastated or badly damaged, leaving disaster victims homeless for several months and thereby increasing their vulnerability and agony.
- Schools and colleges are destroyed or damaged, leaving students without an adequate source of education for months or even years.
- Hospitals and health centers as well as water supply systems are destroyed or damaged, which result in an increase in the vulnerability of disaster-affected people to disease; sometimes even the outbreak of epidemics. Also, water supply problem becomes grim.
- Formal and informal businesses are destroyed, resulting in surges in unemployment and decreased economic stability and strength. In addition, the destruction of agriculture severely affects the livelihoods of rural people.
- Disaster victims are forced to leave the affected area, often they never return, and thereby extract institutional knowledge, cultural and social identity, and economic viability from the areas which cannot afford to spare such resources. This situation badly disrupts the socio-economic condition of such areas.
- Poverty, almost a chronic evil in developing nations, leads to a rapid rise in crime and insecurity in the disaster-affected areas, which create added nuisance and unrest in the community.
- Sizeable portions of GDP are often diverted from development projects, social programs, or debt repayment to manage disaster consequences and start recovery efforts.
- National and/or international development efforts are inhibited, erased, or even reversed due to enormous financial stress caused by heavy disaster losses.
- A general feeling of despair and insecurity afflicts the disaster victims, which leads to increased rates of depression and a lack of motivation to regain independence from external assistance.

Moreover, it is well documented that the poor countries of the world often experience either stagnant or negative rates of development due to disaster impacts. For examples, countries like Honduras, Guatemala and Nicaragua which lost more than their entire gross domestic product (GDP) in hurricane Mitch in 1998 are still struggling to recover. This single storm reversed the rate of development in these and other Central American countries by at least a decade (as much as 20 and 30 years in some areas) (Coppola, 2007). Similarly, the Zimbabwe drought of the early 1990s was associated with an 11% decline in its GDP and a 60% decline in the stock market, whereas the 2000 drought in Brazil led to a 50% decrease in the projected economic growth (UNESCO Water Portal, 2008). The same effect can also be seen in many of the areas affected by the 2004 tsunami and earthquake events in Southeast Asia. For instance, the December 2004 tsunami caused a 20-year setback in the economic development of the Republic of Maldives, and it may take many years before the Maldivians can regain the level of prosperity they enjoyed prior to the tsunami disaster (Coppola, 2007; UNESCO, 2007). Such disasters are among the biggest obstacles to achieving the UN's Millennium Development Goals for poverty reduction. Further, it has been estimated that half of the population of the developing world is exposed to polluted sources of water which enhance disease incidence. Also, between 1991 and 2000, over 665,000 people died in 2,557 natural disasters, of which 90% were water-related disasters and a vast majority of victims (97%) were from developing nations (IFRC, 2001). Thus, disasters exacerbate the causes of poverty in developing nations and, therefore, minimizing the risk of natural hazards has become an important development issue in the 21st century (UNDP, 2004; UNESCO, 2007).

4. DISASTER MANAGEMENT

After the end of the Cold War in the early 1990s, the widely used term '*civil defense*' has been replaced with the term '*emergency management*' or '*disaster management*' which denotes a broader and modern thinking of protecting the civilian population. However, the terms '*civil protection*' and '*crisis management*' are widely used within the European Union (http://en.wikipedia.org/wiki/Disaster). An academic trend is to use the term '*disaster risk reduction*' which focuses on the mitigation and preparedness aspects of the disaster/emergency management cycle described in Section 4.3; the definition of the term is given in Section 2.10. This term has been adopted by the United Nations, which has developed an international strategy on promoting disaster risk reduction (called 'United Nations International Strategy for Disaster Reduction') because it has been proved to be very effective and less expensive. According to Haddow and Bullock (2004), *disaster management* or *emergency management* is a discipline which deals with and avoids risks. It involves preparation for a disaster (natural or anthropogenic) prior to its incidence, disaster response (e.g., emergency evacuation, quarantine, mass decontamination, etc.) as well as supporting and rebuilding society after the disaster. In general, any disaster management is a continuous process by which all the individuals, groups, and communities manage hazards in an attempt to avoid or ameliorate the impact of disasters. Actions taken depend in part on the perceptions of risk of exposed people (Wisner et al., 2004).

Of all the global environment issues, natural hazards are in some ways the most manageable (UNESCO, 2007). In spite of increasing frequency and severity of the catastrophes, it is becoming increasingly possible to prevent and mitigate the effects of a disaster because of gradually improved understanding about disasters and technological advancement (modern tools and techniques). Now, disaster risks can easily be identified and effective mitigation measures could be formulated (UNESCO, 2007; http://en.wikipedia.org/wiki/Disaster). The nature of disaster management in practice, however, largely depends on local socio-economic and political conditions.

4.1 Historical Perspective

Prior to the existence of humans on the earth, the presence of hazards or disasters is negated because the tragic events are not hazards or disasters without human involvement. With the appearance of humans on the earth, the incidence of hazards and disasters followed. The archeological discovery has revealed that our prehistoric ancestors faced many of the same hazards that exist today such as starvation, hostile elements, dangerous wildlife, violence by humans, diseases, accidental injuries, and so on (Coppola, 2007). Evidence indicates that they took measures to minimize the impact of hazards/disasters. The mere fact that they opted to live in caves is a testimony to this. Furthermore, the histological records including religious epics suggest that natural disasters occurred throughout the history and many of history's great civilizations were destroyed by floods, famines, earthquakes, tsunamis, El Nino events, and other widespread natural disasters (e.g., Fagan, 1999). Selected prominent disasters which occurred throughout the human history are summarized in Table 3. It should be noted that many of the historical disasters are record-breaking and unique even compared to the recent major disasters such as December 2004 tsunami which killed more than 300,000 people in an instant besides the loss of property, infrastructure and national assets in the affected countries.

Various applications of disaster management appear throughout the historical record. The story of Noah's Ark from the Old Testament, for example, provides the importance of early warning, preparedness, and mitigation in disaster management (Coppola, 2007). The evidence of risk management practices can be found as early as 3200 BC. In what is now modern-day Iraq lived a social group known as the 'Asipu'

Table 3. Selected notable disasters in the history (modified after Coppola, 2007)

Disaster	*Country*	*Year*	*Number of persons killed*
1. Mediterranean Earthquake	Egypt and Syria	1201	1,100,000
2. Shaanzi Earthquake	China	1556	830,000
3. Calcutta Typhoon	India	1737	300,000
4. Bengal Famine	India	1770	15,000,000
5. Caribbean Hurricane	Martinique, St. Eustatius and Barbados	1780	22,000
6. Tamboro Volcano	Indonesia	1815	80,000
7. Kangra Earthquake	India	1905	19,000
8. Influenza Epidemic	World	1917	20,000,000
9. Yangtze River Flood	China	1931	3,000,000
10. Famine	Russia	1932	5,000,000
11. Bihar-Nepal Earthquake	India and Nepal	1934	50,000
12. Bengal Famine	India	1943	3,000,000
13. Bangladesh Cyclone	Bangladesh	1970	300,000
14. Tangshan Earthquake	China	1976	655,000

(Coppola, 2007). When the community members faced a difficult decision, especially one involving risk or danger, they could appeal to the 'Asipu' for advice. The 'Asipu', using a process similar to modern-day hazard risk management, would first analyze the problem at hand, then propose several alternatives, and finally give possible outcomes for each alternative (Covello and Mumpower, 1985). Today, this methodology is known as *decision analysis*, which is the key to any comprehensive risk management endeavor. Early history is also marked by the incidents of organized emergency response (Coppola, 2007).

The birth of modern disaster management lies in the Civil Defense era (a particular period in the recent history) which witnessed the greatest overall move toward a centralized safeguarding of civilians. However, modern disaster management, in terms of the emergence of global standards and organized efforts to address preparedness, mitigation, and response activities for a wide range of disasters, did not begin to emerge until the mid-20th century. In most countries, this change materialized as a response to specific disaster events. At the same time, it was further stimulated by a shift in social philosophy because of advances in warfare technology, wherein the government played an increasing role in the management of disasters (Coppola, 2007).

In response to the threat posed by air raids and the ever-present and dreadful prospect of nuclear attacks, many developed nations started to form elaborate systems of civil defense. These systems included detection systems, early warning systems, hardened shelters, search and rescue teams, and local and regional coordinators. Most nations' legislatures also developed a legal framework to guide both the creation and maintenance of these systems through the enforcement of laws, the creation of national-level civil defense organizations, and the allocation of funding and personnel. Despite these encouraging efforts, surprisingly few civil defense units evolved over time into more comprehensive disaster management organizations (Quarantelli, 1995). However, the legal framework developed to support them remained in place, which provided a basis for modern disaster management.

Today, disaster management structures vary considerably from one country to another. Many countries developed their disaster management capabilities out of necessity, while other countries formed their disaster management structures not for the civil defense, but after the criticism for poor management of natural disasters; for examples, Peru in 1970, Nicaragua in 1972, and Guatemala in 1976, following

destructive earthquakes in each country (Coppola, 2007). On the other hand, some countries still have no real disaster management structures regardless of their disaster history (Coppola, 2007).

4.2 Global Recognition

At an international level, the recognition of disaster management can be traced back to 11 December 1987 when the United Nations General Assembly declared the 1990s as the "International Decade for Natural Disaster Reduction" (IDNDR). This action was taken to promote internationally coordinated efforts to reduce material losses, and social and economic disruption caused by natural disasters, especially in developing countries. The stated mission of IDNDR was to improve each United Nations member country's capacity to avoid or minimize adverse effects from natural disasters and to develop guidelines for applying existing tools and techniques to reduce the impact of natural disasters. Thereafter, in May 1994, the United Nations member states met at the first World Conference on Natural Disaster Reduction in Yokohama, Japan to assess the progress achieved by the IDNDR. At this meeting they developed the "Yokohama Strategy and Plan of Action for a Safer World" (ISDR, 1994), which provided landmark guidance on reducing disaster risk and impacts. The participating member states accepted the ten principles to be applied to disaster management within their own countries. The tenth principle formalized the requirement that each nation's government should accept the responsibility for protecting its people, infrastructure, and other national assets from the impact of various disasters (ISDR, 1994).

Moreover, immediately following the Indian Ocean Tsunami in December 2004, the United Nations General Assembly convened the second World Conference on Disaster Reduction from 18 to 22 January 2005 in Kobe, Hyogo, Japan. The goal of this conference was to review the progress in disaster risk reduction since the 1994 Yokohama Conference and to make plans for next ten years (UNISDR, 2005). It provided a unique opportunity to promote a strategic and systematic approach to reducing vulnerabilities and risks to hazards. The participating member states adopted what is known as the "Hyogo Declaration" and agreed upon a 'Framework for Action' for the decade 2005-2015 which aims at building the resilience of nations and communities to disasters (UNISDR, 2005). The Hyogo Framework for Action includes the following five commitments or priorities for the decade 2005-2015 (UNISDR, 2005):

(1) *Make disaster reduction a priority:* Governments should integrate disaster risk reduction into their laws, programs and plans, and ensure the participation of local communities in planning.

(2) *Know the risks and take action:* Countries should define and understand potential risks so that they can develop early warning systems adapted to the needs of each community.

(3) *Build understanding and awareness:* Governments should provide information, include disaster reduction in formal and informal education, and ensure that invaluable local knowledge about disaster risks is preserved and transmitted.

(4) *Reduce risk:* Countries should apply safety codes to ensure that schools, hospitals, homes and other buildings do not collapse in earthquakes; avoid allowing communities to settle in hazard-prone areas such as floodplains; and protect forests, wetlands, and coral reefs that act as natural barriers to storms and flooding.

(5) *Be prepared and ready to act:* Governments and regional or local authorities should conduct risk assessments; adopt contingency plans; test preparedness by such measures as evacuation drills; and ensure emergency services, response agencies, policy makers and development organizations are coordinated.

The above-mentioned five Hyogo commitments or priorities are the foundation of disaster

management practice. Unfortunately, this foundation is still lacking in many countries of the world (Coppola, 2007). Therefore, it has been recommended that in their approach to disaster risk reduction, national, regional and international organizations and other concerned actors must take into consideration the key activities listed under each of the five commitments/priorities and should implement them, as appropriate, to their own circumstances and capacities. For the details about the key activities under each Hyogo commitment, the interested readers are referred to the 'Report of the World Conference on Disaster Reduction' (UNISDR, 2005). An integrated, multi-hazard, comprehensive approach to address vulnerability, risk, assessment and disaster management, including prevention, mitigation, preparedness, response and recovery, is an essential element of a safer world in the 21st century (UNISDR, 2005). The Hyogo Framework for Action 2005-2015 is linked both to the Millennium Development Goals (MDG) and to the UN Decade of Education for Sustainable Development (2005-2014), which is led by UNESCO. Thus, there is a global recognition that the efficient management of natural and anthropogenic disasters is indispensable in order to make world safer and ensure sustainable development on the earth.

4.3 Modern Approaches

Modern approach to ensure comprehensive disaster management is based on a management cycle comprising four major components or phases (Alexander, 2002; Haddow and Bullock, 2004; Coppola, 2007): *mitigation* and *preparedness* (*preparation*) before the occurrence of disasters**,** and *response* and *recovery* after the occurrence of disasters (Fig. 1). Various diagrams illustrate the cyclic nature of disaster management by which these and other related activities are performed over time, though disagreement exists concerning how a "disaster management cycle" is visualized (Coppola, 2007). In practice, all of these activities are intermixed and are performed to some degree before, during, and after the disaster. Response is often visualized as beginning immediately after the disaster impact, though it is not uncommon for the actual response to begin well before the disaster actually occurs (Coppola, 2007). The four phases of disaster management cycle are described in the subsequent sections.

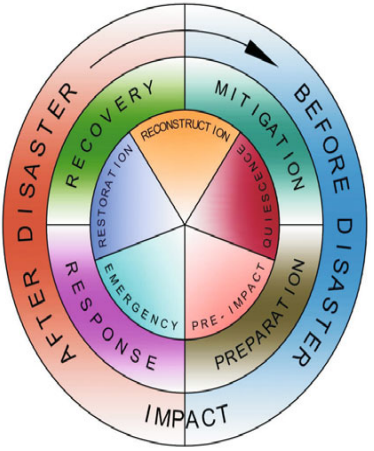

Fig. 1 Schematic of the comprehensive disaster management cycle (redrawn from Alexander, 2002).

4.3.1 Mitigation Phase

The goal of mitigation efforts is to prevent hazards from developing into disasters altogether, or to reduce the impact of disasters when they occur. The mitigation phase differs from the other phases because it focuses on the long-term measures for reducing or eliminating disaster risk (Haddow and Bullock, 2004). Thus, the identification of risks is a prerequisite to the mitigation process. Mitigation measures could be structural or non-structural. The implementation of mitigation measures/strategies can be considered as part of the recovery process if they are applied after the occurrence of a disaster (Haddow and Bullock, 2004).

4.3.2 Preparedness Phase

In the preparedness phase, disaster managers develop plans of action for the disasters which may occur in the future. It involves equipping people who may be impacted by a disaster or who may be able to help those impacted with the tools to increase their chance of survival and to minimize their economic and other losses. Another aspect of preparedness is 'casualty prediction', which is the study of number of deaths or injuries that may result from a disaster (http://en.wikipedia.org/wiki/Disaster). It gives planners an idea about the types of resources required to be ready in order to respond to a particular kind of disaster. Common preparedness measures include (http://en.wikipedia.org/wiki/Disaster): (i) communication plans with easily understandable terminology and methods; (ii) proper maintenance and training of emergency services, including mass human resources such as 'community emergency response teams'; (iii) development and exercise of emergency population warning methods along with emergency shelters and evacuation plans; (iv) stockpiling, inventory, and maintenance of disaster supplies and equipment; and (v) development of organizations of trained volunteers among civilian populations.

It is worth mentioning that preparedness and mitigation are the most cost-effective approach for reducing the impact of hazards/disasters. Therefore, it is said that a dollar invested in disaster preparedness and mitigation will prevent four to eight dollars in disaster losses (UNESCO, 2007).

4.3.3 Response Phase

The response phase involves taking action to reduce or eliminate the impact of disasters which have occurred or are currently occurring in order to prevent further suffering, financial loss, or a combination of both (Coppola, 2007). It includes the mobilization of necessary emergency services and first responders in the disaster-affected area. This is likely to include a first wave of core emergency services (e.g., firefighters, police, and ambulance crews), which may be supported by a number of secondary emergency services such as specialist rescue teams (http://en.wikipedia.org/wiki/Disaster). When the response process is conducted as a military operation, it is termed 'Disaster Relief Operation', but the commonly used term 'relief' is usually considered as one component of the response process. It should be noted that a well rehearsed emergency plan developed as part of the preparedness phase enables efficient coordination of rescue teams as well as emergency service providers, and that search and rescue efforts should commence at an early stage where needed.

4.3.4 Recovery Phase

The aim of the recovery phase is to restore the victims' lives to the normal/previous condition following the impact of a disaster (Haddow and Bullock, 2004; Coppola, 2007). It differs from the response phase in its focus; the recovery efforts are concerned with the issues and decisions that must be made after immediate needs are addressed (Haddow and Bullock, 2004). The recovery process primarily involves the actions such as rebuilding destroyed property and service systems, re-employment, and the repair of other essential infrastructure. This phase generally starts after the urgent response has ended, and may continue for months or years thereafter.

The above-mentioned modern approach of disaster/emergency management (i.e., '*comprehensive disaster management*') should be followed in practice by implementing another modern concept of management known as '*adaptive management*'. The concept of 'adaptive management' is based on the insight that our knowledge about natural systems is presently limited, and hence our ability to predict future key factors influencing an ecosystem as well as system's behavior and responses is inherently limited (Loucks and van Beek, 2005; Pahl-Wostl, 2007). Consequently, 'adaptive management' treats management strategies and actions as experiments, not as fixed policies (Ludwig et al., 1993). That is, management decisions

(e.g., designs and operating policies) should be flexible and adaptable; they should be continually improved as experience expands, new information emerges, and priorities change over time. The improved knowledge or new understanding arises from the facts that (Loucks and van Beek, 2005; van der Keur et al., 2008): (i) uncertainty exists in defining operational targets for different management goals, (ii) conflicting interests among stakeholders require participatory goal setting and a clear recognition of uncertainties involved, and (iii) the system to be managed is subject to change due to environmental and socio-economic changes. Adaptive management can be defined as "a systematic process for continually improving management policies and practices, as appropriate, by learning from the outcomes of implemented management strategies and the improved knowledge" (Loucks and van Beek, 2005; van der Keur et al., 2008).

Furthermore, 'adaptive management' takes into account the limitations of our current knowledge and experience as well as those learned by experiments. It helps us move toward meeting our changing goals over time in the face of this incomplete knowledge and uncertainty. Thus, adaptive management and decision-making is a challenging blend of scientific research, monitoring, and practical management which provides opportunities to *act*, *observe* and *learn*, and then *react* (Loucks and van Beek, 2005). Both monitoring and management actions need to be adaptive, continually responding to an improved understanding that comes from the analysis of monitored data in comparison to model predictions and scientific research (Loucks and van Beek, 2005). Loucks and van Beek (2005) emphasize that when predictions are highly unreliable, responsible managers should favor robust (i.e., good under a wide range of situations) actions, gain knowledge through research and experimentation, monitor results to provide feedback for the next decision, update assessments and modify operating policies in the light of new information, and avoid irreversible actions and commitments. Adaptive management in essence links science, values, and the experience of stakeholders and managers to the art of making management decisions (Maimone, 2004). For the details about 'adaptive management', the interested readers are referred to Holling (1978) and Walters (1986).

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