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An overview on disasters

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Abstract

Purpose – This paper seeks to provide graduate students, researchers, and government and independent agencies with an overview of disasters.

Design/methodology/approach – Disasters have been the subject of research and a source of concern to academicians and government and independent agencies. In this paper disaster types are collected from several sources such as technical, general articles, internet web sites, and internal reports. Disaster types, definitions, hazards and mitigations are reviewed. Disasters are classified into natural disasters, man-made disasters, and hybrid disasters. Man-made disasters are classified into technological disasters, transportation accidents, public places failure, and production failure. Natural and/or man-made disasters sometimes lead to subsequent disasters.

Findings – Disasters are classified into three types: natural, man-made, and hybrid disasters. It is believed that the three disaster types cover all disastrous events. Disasters have different characteristics and impacts; however, disasters have a common element, which is their severity. Natural disasters are those disasters that result from natural forces. Man-made disasters are those disasters that result from human decisions. Hybrid disasters are those disasters that result from both natural and man-made causes. Subsequent disasters are those disasters that result from natural and/or man-made disasters. Epidemics could be a disaster or a subsequent disaster.

Originality/value – This paper presents the types, definition, hazards, and mitigation of disasters. Disasters are arranged into disaster types, sub-disasters, and disastrous events in the form of a disaster tree. An algorithm can be written utilizing this disaster tree. The algorithm can be used for training purposes to prevent or reduce disasters.

Keywords Disasters, Natural disasters, Man-made disasters

Paper type General review

Introduction

A disaster is defined by the Asian Disaster Reduction Center (2003) as:

A serious disruption of the functioning of society, causing widespread human, material or environmental losses which exceed the ability of affected society to cope using only its own resources.

Disaster types and definitions have been discussed by Turner and Pedgeon (1997), Richardson (1994), the World Health Organization (2003), the Federal Emergency Management Agency (2003a, b) and the Mid-Florida Area Agency on Aging (2003). Disaster types have been reviewed, and it was found that natural, man-made and hybrid disasters cover all types of disastrous events.

Natural disasters are catastrophic events resulting from natural hazards. Natural hazards result from internal (beneath the Earth's surface), external (topographical), weather-related (meteorological/hydrological) and biological phenomena. Natural disasters are beyond human control. Natural disasters are often termed an "Act of God".

Man-made disasters, on the other hand, are those catastrophic events that result from human decisions. Man-made disasters can be sudden or long-term disasters. Sudden man-made disasters are known as socio-technical disasters. Richardson (1994)



highlighted that socio-technical disasters occur in at least four types of organizational situations. These are:

- (1) plant and factory failures (major accidents);
- (2) transport failures;
- (3) stadia or other “public place” failures; and
- (4) production failures.

Long-term disasters tend to refer to national and international conflicts.

Hybrid disasters are a compound of human decisions and natural forces. Disasters have a common denominator, which is the severity of their impact on people, property, and the environment.

Natural and/or man-made disasters sometimes trigger subsequent disasters, such as displaced people or haze. Subsequent disasters have social and economic impacts.

This paper presents an overview of natural, man-made and hybrid disasters in addition to subsequent disasters. The overview covers disaster types, definitions, hazards and mitigations. The paper also proposes a disaster tree depicting the various disaster types.

Natural disasters

Natural disasters are catastrophic events resulting from natural causes, such as volcanic eruptions, tornados, earthquakes, etc., over which man has no control. Natural disasters are often termed an “Act of God”. Natural disasters can result from the following.

Natural phenomena beneath the Earth's surface

Natural disasters that result from phenomena beneath the Earth's surface can be summarized as follows.

Earthquakes.

- **Definition.** An earthquake is a sudden break within the upper layers of the earth, sometimes breaking the surface, resulting in the vibration of the ground, which where strong enough will cause the collapse of buildings and destruction of life and property (Centre for Research on the Epidemiology of Disasters, 2003). Earthquakes sometimes trigger landslides, avalanches, flash floods, fires, and huge, destructive ocean waves (tsunamis) (Federal Emergency Management Agency, 2003a, b). Powerful aftershocks frequently occur, causing further damage and increasing psychological stress (International Federation of Red Cross and Red Crescent Societies, 2003).
- **Hazards.** Earthquakes strike with no early warning and can be devastating. Quakes are measured according to the Richter Scale – the most devastating effects are seen at Level 6 and above and if the epicenter of the earthquake is located in highly populated areas. Earthquakes can cause high mortality from trauma, asphyxiation, dust inhalation (acute respiratory distress), or exposure to the environment (i.e. hypothermia) as well as serious destruction of buildings and infrastructure (International Federation of Red Cross and Red Crescent Societies, 2003; Songer, 2003). The origin and distribution of most earthquakes were discussed by Schneid and Collins (2001).

- Mitigation. The most well known prevention strategy regarding earthquakes is the prevention of a building from collapsing. Several jurisdictions in earthquake-prone areas require that all new buildings follow certain construction codes. These codes ensure that the building is structurally sound in the event of a significant tremor (Songer, 2003).

Tsunamis. Tsunamis are a series of large waves generated by sudden displacement of seawater by earthquakes or volcanic eruption, capable of propagation over large distances and causing a destructive surge on reaching land (Centre for Research on the Epidemiology of Disasters, 2003).

Tsunamis can originate hundreds or even thousands of miles away from coastal areas. Local geography may intensify the effect of a tsunami. The areas at greatest risk are less than 50 feet above sea level and within one mile of the shoreline.

Tsunamis reaching heights of more than 100 feet have been recorded. As the waves approach the shallow coastal waters, they appear normal and their speed decreases. Then as the tsunami coastlines, it may grow to a great height and smash into the shore, causing much destruction.

- Mitigation. People who are near the seashore during a strong earthquake should listen to the radio for a tsunami warning and be ready to evacuate at once to higher ground. Rapid changes in the water level are an indication of an approaching tsunami. Tsunamis arrive as a series of successive “crests” (high water level) and “troughs” (low water levels). These successive crests and troughs can occur anywhere from five to 90 minutes apart. They usually occur ten to 45 minutes apart (Federal Emergency Management Agency, 2003a, b).

On 26 December 2004, an earthquake measuring 9.0 on the Richter scale struck the area off the Western coast of Northern Sumatra, triggering massive tidal waves, or tsunamis, that inundated coastal areas in countries all around the Indian Ocean rim, from Indonesia to Somalia. At least 150,000 people died in the disaster, with over 525,000 injured, 1,600,000 displaced and over 1,000,000 homeless (International Federation of Red Cross and Red Crescent Societies, 2005).

Volcanic eruptions.

- Definition. A volcano is a mountain that opens downward to a reservoir of molten rock below the surface of the earth. Unlike most mountains, which are pushed up from below, volcanoes are built up by an accumulation of their own eruptive products, i.e. lava, ash flows, and airborne ash and dust. When pressure from gases and the molten rock becomes strong enough to cause an explosion, an eruption occurs. Gases and rock shoot up through the opening and spill over, or fill the air with lava fragments. Volcanic products are used as building or road-building materials, as abrasive and cleaning agents and as raw materials in many chemical and industrial processes. Lava ash makes soil rich in nutrients (Federal Emergency Management Agency, 2003a, b).
- *Hazards.* The most dangerous type of volcanic eruption is referred to as a “glowing avalanche”. This is when freshly erupted magma forms a hot pyroclastic flow, which has temperatures of up to 1,200 degrees. The pyroclastic flow is formed from rock fragments following a volcanic explosion; the flow surges down the flanks of the volcano at speeds of up to several hundred

kilometers per hour, to distances often up to 10 km and occasionally as far as 40 km from the original disaster site (International Federation of Red Cross and Red Crescent Societies, 2003).

Several health outcomes are associated with volcanic eruptions. Most notably, respiratory illnesses are of particular concern following an eruption. These may arise from the inhalation of toxic gases by persons close to the volcano at the time of the eruption, or from the inhalation of ash from the volcano. For individuals in close proximity to the volcano, some danger exists from lava flows, or more likely mud flows (Songer, 2003).

- **Consequences.** The most common consequence of volcanic eruption is population movement, as large numbers of people are often forced to flee the moving lava flow. Volcanic eruptions often cause temporary food shortages and volcanic ash landslides called lahars (International Federation of Red Cross and Red Crescent Societies, 2003). The volcanic eruptions to have occurred worldwide from 1933 to 1999, and their consequences, have been summarized by Schneid and Collins (2001).
- **Mitigation.** Oslen (2003) summarized the methods of mitigation of volcanic hazards. Oslen (2003) highlighted that volcanic eruptions are one of the most difficult natural hazards to mitigate. Most are low frequency, high magnitude events.

Distant locations that have a high probability of damage resulting from an eruption can be better mitigated. In these areas, proper planning through the use of hazard mapping can avoid damage to property and loss of life. Land-use planning can encourage the location of structures outside potential lahar zones. Reservoirs can be used as catchment basins for lahars and other flooding events associated with eruptions. Building codes can require steep-pitched roofs where tephra falls are likely. Evacuation plans can be designed prior to an eruption to increase efficiency. Arrangements for immediate accommodation for evacuees can be made in advance.

Songer (2003) pointed out that mitigation strategies for volcanoes include early warning systems and evacuation.

Topographical phenomena

Disasters that occur due to natural phenomena at the Earth's surface can be summarized as follows.

Landslides.

- **Definition.** Landslides are defined as the down-slope transport of soil and rock resulting from natural phenomena or man-made actions. These can be different types of movements: falls, slides, topples, lateral spread, and flows (World Health Organization, 2003).

Landslides occur when masses of rock, earth, or debris move down a slope. Landslides may be very small or very large, and can move at slow to very high speeds. Many landslides have been occurring over the same terrain since prehistoric times. They are activated by storms and fires and by human modification of land. New landslides occur as a result of rainstorms, earthquakes, volcanic eruptions, and various human activities (Federal Emergency Management Agency, 2003a, b).

- Consequences. Landslides can severely damage properties, and cause high mortality and injuries. Landslides can cause trauma and suffocation by entrapment. Landslides also cause short- and long-term mental health effects (World Health Organization, 2003).

Avalanches. Avalanches are the rapid and sudden sliding and flowage of masses of usually unsorted mixtures of snow/ice/rock material (Centre for Research on the Epidemiology of Disasters, 2003).

Avalanches can happen wherever there is snow lying on ground of a sufficient angle. Snow is deposited in successive layers as the winter progresses. These layers may have dissimilar physical properties and an avalanche occurs when one layer slides on another (surface avalanche) or the whole snow cover slides on the ground (full-depth). An avalanche may be dry or wet, according to whether free water is present in the snow. It may be a loose snow avalanche, when the avalanche starts at a single point, or a slab avalanche, which occurs when an area of more cohesive snow separates from the surrounding snow and slides out (Sport Scotland Avalanche Information Services, 2003).

Meteorological/hydrological phenomena

Disasters that result from meteorological and hydrological phenomena can be summarized as follows.

Windstorms (cyclones, hurricanes, typhoons).

- Definition. Cyclones, hurricanes, and typhoons are large-scale closed circulation systems in the atmosphere above the Indian Ocean and South Pacific with low parametric pressure and strong winds that rotate clockwise. There is a maximum wind speed of 64 knots or more for the Western Atlantic and Eastern Pacific (Centre for Research on the Epidemiology of Disasters, 2003).
- Hazards. The primary health hazard from hurricanes or cyclones lies in the risk of drowning from the storm surge associated with the landfall of the storm. Most deaths associated with hurricanes are drowning deaths. Secondarily, a hazard exists for injuries from flying debris due to high winds.
- Mitigation. Cyclones, hurricanes and typhoons can be predicted several days in advance. Their onset is extensive and often very destructive. These disasters are usually more destructive than floods (International Federation of Red Cross and Red Crescent Societies, 2003).

In the case of cyclones, accurate landfall predictions can give only a few hours' notice to threatened populations. In addition, people generally opt to wait until the very last minute before abandoning their homes and possessions. Deaths from drowning in high tides and sudden flooding and material losses are therefore often very high (International Federation of Red Cross and Red Crescent Societies, 2003).

Hurricanes are expected within 24 hours or less. In regions where hurricanes may occur (e.g. Miami, Florida, in the USA), the National Weather Service issues information concerning the hurricane. The National Hurricane Center monitors hurricanes and broadcasts the information needed to track storms.

The active surveillance of hurricanes is one type of mitigation strategy. A mitigation strategy is an organized plan to attempt to reduce the impact of a

disaster. In epidemiological terms, it represents prevention. The primary prevention strategy in the event of a hurricane is to provide early warning and evacuation.

Tornados.

- **Definition.** A tornado is a violent windstorm characterized by a twisting, funnel-shaped cloud. It is spawned by a thunderstorm (or sometimes as the result of a hurricane) and is produced when cool air overrides a layer of warm air, forcing the warm air to rise rapidly. The damage caused by a tornado is a result of the high wind velocity and wind-blown debris (Federal Emergency Management Agency, 2003, b).
- **Hazards.** The primary hazard in a tornado from a health perspective is the risk of injuries from flying debris. The high winds and the circular nature of a tornado lead to the elevation and transport of anything that is not fastened down. Most victims of tornados are affected by head and chest trauma due to being struck by debris or being caught in a structural collapse. Some individuals are injured while on the ground. Others are lifted into the air by the tornado and dropped at another location (Songer, 2003).
- **Mitigation.** Mitigation strategies for tornadoes are primarily focused on providing the earliest possible warning of an approaching tornado. The warning system most widely used today is the issuance of tornado watches and tornado warnings by national weather services. A tornado watch is an advisory that the weather conditions are conducive to the development of a tornado. A tornado warning is an advisory that an actual tornado has been sighted. Early warning is important as it allows the public to seek shelter in protected areas. Most often this will be the basement of a home, or a culvert if driving along a road (Songer, 2003).

Floods.

- **Definition.** A flood is a significant rise in the water level in a stream, lake, reservoir or coastal region (Centre for Research on the Epidemiology of Disasters, 2003). Flash floods are a sudden and extreme volume of water that flows rapidly and causes inundation. Because of their rapid nature flash floods are difficult to forecast and give people little time to escape or to take food and other essentials with them (International Federation of Red Cross and Red Crescent Societies, 2003).
- **Hazards.** Floods can be predicted in advance, except in the case of flash floods. The impact of flooding can include the destruction of housing, crops, cattle and people.

The primary hazard from flooding is drowning. This is particularly evident for flash floods. A longer-term health concern from flooding is the development of disease from inundated sanitation stations. Large floods pose a hazard to existing sanitation and drinking water systems (Songer, 2003).

Factors influencing the severity of the hazard are the depth of water, the duration and velocity of the flood, the rate at which the water rises, and the frequency of occurrence and season (World Health Organization, 2003). Some of the floods to have occurred between 1969 and 1999 are summarized by Schneid and Collins (2001).

- Mitigation. Prevention strategies in flooding focus upon pre-event and post-event measures. Before a flood, one is concerned with providing early warning for flash flood events, as well as public education on flood hazards. The issue is one of maintaining proper sanitation systems and proper control of vector populations (Songer, 2003).

Drought.

- Definition. Drought is defined as an extended period – a season, a year, several years – of deficient rainfall relative to the statistical multi-year average for the region. Lack of rainfall leads to inadequate water supplies that are required for plants, animals and human beings. Droughts lead to other disasters, such as food insecurity, famine, malnutrition, epidemics and the displacement of populations from one area to another (International Federation of Red Cross and Red Crescent Societies, 2003).
- Consequences. The consequences of drought can be summarised as follows. *Desertification*: this is the processes by which an already arid area becomes even more barren, less capable of retaining vegetation, and progresses towards becoming a desert. This is often a cause of long-term disasters (International Federation of Red Cross and Red Crescent Societies, 2003).

Famine: a famine is a catastrophic food shortage affecting large numbers of people due to climatic, environmental and socio-economic reasons. The cause of the famine may produce great migrations to less affected areas. (For more on famine/food security, see International Federation of Red Cross and Red Crescent Societies, 2003.)

Food shortage or crop failure: these are abnormal reductions in crop yield such that it is insufficient to meet the nutritional or economic needs of community (International Federation of Red Cross and Red Crescent Societies, 2003).

Heat wave.

- Definition. Temperatures that hover ten degrees or more above the average high temperature for the region, last for prolonged periods of time, often accompanied by high humidity that the body cannot tolerate, are defined as extreme heat. A heat wave is a very dangerous situation (Federal Emergency Management Agency, 2003a, b).
- Consequences. Heat can kill by pushing the human body beyond its limits. Under normal conditions, the body's internal thermostat produces perspiration that evaporates and cools the body. However, in extreme heat and high humidity, evaporation is slowed and the body must work extra hard to maintain a normal temperature. Elderly people, young children, and those who are sick or overweight are more likely to become victims of extreme heat. Because men sweat more than women, they are more susceptible to heat illness because they become dehydrated more quickly. The duration of excessive heat plays an important role in how people are affected by a heat wave. Studies have shown that a significant rise in heat-related illnesses happens when excessive heat lasts more than two days. Spending at least two hours per day in air conditioning significantly cuts down on the number of heat-related illnesses (Federal Emergency Management Agency, 2003a, b).

The heat wave that scorched Europe in the summer (August/September) of 2003 resulted in a death toll in France of nearly 15,000 according to a government-commissioned report (*CBS News*, 2003), and also in the deaths of more than 4,000 elderly Italians (*Yahoo News*, 2003).

Biological phenomena

Biological events can be summarized as set out below.

Epidemics. An epidemic is an unusual increase in the number of cases of an infectious disease that already exists in a certain region or population. It can also refer to the appearance of a significant number of cases of an infectious disease in a region or population that is usually free from that disease. The International Federation of Red Cross and Red Crescent Societies (2003) pointed out that infectious diseases include cholera, dengue, ebola, malaria, measles, meningitis, yellow fever, HIV/AIDS (natural and man-made), SARS, and avian flu.

Experts warn that an avian flu pandemic is the most serious health threat facing the world today. Since December 2003, highly pathogenic H5N1 avian influenza viruses have swept through poultry populations across Asia and parts of Europe. The outbreaks are historically unprecedented in scale and geographical spread. Their economic impact on the agricultural sector in the affected countries has been large. The World Health Organization (2006) pointed out that the Western Pacific, South-East Asia and Europe now have H5N1 activity and poultry stocks. Outbreaks have recurred despite aggressive control measures, including the culling of more than 140 million poultry birds as of September 2005. Health experts have warned of a worldwide bird-flu pandemic that could kill millions of people and wreck the global economy (Walsh, 2005). The World Health Organization (2006) has pointed out that 173 laboratory-confirmed human cases have been recorded in Cambodia, China, Indonesia, Iraq, Thailand, Turkey, and Vietnam. These human cases resulted in 93 deaths. The World Health Organization estimates that in a best-case scenario, between two million and 7.4 million people would die worldwide, but the death toll could be considerably higher if the next pandemic virus turns out to be more virulent (Walsh, 2005).

Epidemics may be consequences of disasters of another kind, such as tropical storms, floods, earthquakes, draughts, etc. Epidemics may also attack animals, causing local economic disasters (International Federation of Red Cross and Red Crescent Societies, 2003).

Infestations. World Health Organization/EHA (1998) pointed out that the infestations disastrous events include locust invasions and mealy bug infestation.

Locust swarms. It was pointed out that tens of millions of square kilometers of crops and rangeland in North Africa, the Middle East, and Asia are within the reach of the desert locust. The livelihood of at least one-tenth of the world's population can be affected by the small insect with voracious appetite. A single swarm can cover 1,200 square kilometers (460 square miles) and can contain between 40 and 80 million locusts per square kilometer. With each insect capable of eating its own body weight (about two grams, or 0.07 ounces) in vegetation each day, a swarm that size could consume 192 million kilograms of vegetation each day, or more than 423 million lbs. In the last century, there were seven periods of numerous plagues, the longest of which lasted intermittently for 13 years.

Crop and rangeland damage due to locusts is a great threat to regional and global food security. Over the years since the Second World War, the United Nations Food and Agriculture Organization (FAO) has emerged as the leader in efforts to predict, prevent, and control locust plagues (Showler, 2003).

Man-made disasters

Man-made disasters are those catastrophic events that result from human decision. Man-made disasters include socio-technical and warfare disasters.

Socio-technical disasters

Richardson (1994) highlighted that socio-technical disasters occur in at least four types of organizational situations. These are:

- (1) technological disasters (plant and factory failures);
- (2) transport failures;
- (3) stadia or other “public place” failures; and
- (4) production failures.

Technological disasters.

- Definition. A major accident (technological disaster) is defined by the International Labor Organization (1988) as “an occurrence such as a major emission, fire or explosion resulting from uncontrolled developments in the course of an industrial activity, leading to a serious danger to man, immediate or delayed, inside or outside the establishment, and to the environment, and involving one or more dangerous substances”. The world has seen many technological disasters due to the operation of major hazard installations (MHIs). The definition, types, and characteristics of MHIs can be found in the ILO’s *Manual* (International Labor Organization, 1988). Examples of technological disasters are Seveso in 1978 (Lees, 1996), Flixborough in 1974 (Lees, 1996), Bhopal in 1984 (Shrivastava *et al.*, 1988), Piper Alpha in 1988 (Woolfson and Beck, 2002) and Chernobyl in 1986 (Meshkati, 1991).
- Hazards. The major hazards resulting from the operating of MHIs are fire, explosion, and toxic release. Of these three fire is the most common, but explosion is particularly significant in terms of fatalities and loss. Toxic release has perhaps the greatest potential to kill a large number of people, but large-scale toxic gas fatalities hardly occur. The factors which determine the scale of hazards are discussed in detail by Lees (1996).
- Prevention and mitigation. Most of the technological disasters to have occurred worldwide were due to the operation of major hazard installations. Control of major hazards differs from one country to another. The essential steps in major hazard control are outlined by the ILO’s *Manual* (International Labor Organization, 1988). The *Manual* highlights that a major hazard control system can be achieved through the identification of installations with potential major accident hazards. The *Manual* gives guidance about organizational and preventive measures against hazards, emergency planning and the implementation of major hazard control system. The International Labour Organization’s East Asia office recommends that

there are 20 steps to controlling major hazards (International Labor Organization/EASMAT, 2003).

Transportation disasters. Major rail/highway accidents can cause large numbers of casualties, hazardous materials incidents, and major disruption of vital transportation routes. An air crash involving a large passenger aircraft can occur anywhere, but the greatest risks are in and around airports. Any accident that produces numerous injuries could overwhelm local emergency medical resources.

Stadia or other public place failures. Stadia or other “public place” failures include fires, structure collapses and crowd crushing.

- Sports disasters. The world has seen many disasters due to sports activities. There are several internet websites that provide sports disaster databases. Sports disasters to have occurred worldwide from 1955 to 2001 are available at the InfoPlease site (InfoPlease, 2003).
- Fires. Urban fires occurring in structures such as high-rise apartment buildings, condominiums, etc., have always been serious to fire officials. Fire prevention codes, inspection programs, and installation of smoke detectors, can help to reduce this risk.

Production failure. Production failures include the following:

- computer system breakdowns; and
- production and distribution of defective products (for a review of product injuries and product sabotage, see Shrivastava *et al.*, 1988).

Warfare (conflicts)

Conflict is defined as the use of armed force between the military forces of two or more governments, or of governments, or of government and at least one organized armed group, resulting in at least ten battle-related deaths or 100 battle-related injuries in one year.

Inter-state conflict. State control conflicts obviously centre on struggles for control of the governing apparatuses of the state. State formation conflicts centre on the form or shape of the state itself and generally involve particular regions of a country fighting for a greater measure of autonomy or for outright secession. Failed state conflicts are conflicts about local issues and disputes involving violence in the absence of effective government control. The primary failure is an incapacity to provide minimal human security for individual citizens, compounded by weak governance and politics of exclusion that deny the majority of citizens any significant engagement in the political process.

International conflict. Conventional conflict includes border disputes, foreign invasion and other cross-border attacks.

Non-conventional war includes chemical, biological and nuclear wars. Chemical war is a warfare that employs chemical agents to intentionally inflict harm. Chemical agents are absorbed through the skin or by inhalation. Chemical agents include nerve agents, toxins, mustard agents and others (Public Broadcasting System, 2003). Biological war (BW) was defined by The Biological Weapon Convention of 1972 as “Microbial or other biological agents, or toxins whatever their origin or method of production, of types and in quantities that have no justification for prophylactic, protective or other peaceful purposes”. This

definition includes all living BW agents, including insects, as well as toxins produced from these agents (e.g. the botulinum toxin).

Hybrid disasters

There are disasters that result from both human error and natural forces. This type of disaster is known as a hybrid disaster. Examples of hybrid disasters can be summarized as follows:

- the extensive clearing of jungles causing soil erosion and subsequently heavy rain causing landslides;
- the location of residential areas, factories, etc., at the foot of an active volcano, or in an avalanche area; and
- floodplain disasters.

Throughout history, people have settled next to waterways because of the advantages they offer in transportation, commerce, energy, water supply, soil fertility, and waste disposal. In spite of these benefits, however, our historic attraction to settle along rivers is not without its drawbacks. Floods have caused a greater loss of life and property, and have disrupted more families and communities in the USA than all other hazards combined (Emergency Management Agency, 2006).

Alexander County in the USA experienced the effects of floods. It was pointed out that there were an estimated 417 residential or commercial structures in the flood plain, and the population was estimated to be 1,376. Estimates of the damage that could result from a catastrophic 100-year flood event were as follows:

- structural damage, \$37,530,000;
- non-structural damage (i.e. vehicles, boats, etc.), \$2,900,000;
- contents, \$550,000;
- relocation losses, \$24,000,000; and
- wages lost, \$2,500,000 (Yahoo!, 2006).

Subsequent disasters

The International Federation of Red Cross and Red Crescent Societies (2003) highlighted that subsequent disasters are those disasters that result from natural and/or man-made disasters. Subsequent disasters can be summarized as follows.

Flood subsequent disasters

Subsequent disasters that result from heavy rain and flooding are landslides and dam collapses.

Dam collapse. Dam collapse may be caused by a shifting of a dam's foundations due to earthquake, nearby oil drilling or faulty construction. Earth dams are more likely to collapse when excessive rainfall fills the reservoir to overflowing. The excess water then pours over the top of the dam, gradually washing it down and cutting deep channels into it. This weakens the entire structure so that it then gives way entirely. The result of a dam collapse is a sudden release of large amounts of water which sweep over low lying villages, causing many deaths and injuries (International Federation of Red Cross and Red Crescent Societies, 2003).

Haze

Forest or wild fires cause significant annual losses to timber, agriculture, and wildlife (Mid-Florida Area Agency on Aging, 2003). Forest fires may start by natural causes such as volcanic eruptions and lightning, or by man-made causes.

Haze is one of the subsequent disasters that can result from natural and/or man-made forest fires.

Haze is defined by IMPROVE (2003) as an atmospheric aerosol of sufficient concentration to be visible. The particles are so small that they cannot be seen individually, but they are still effective in scene distortion and visual range restriction.

The world has seen haze problems in several places. In September-November 1997, parts of several countries in South-east Asia, including Malaysia, Singapore, Brunei, The Philippines, Thailand and Indonesia, were affected by heavy air pollution, primarily caused by exceptionally large-scale forest fires in Indonesia. It was pointed out (*BBC News*, 2003) that the cause of forest fire in Indonesia was probably some farmers who had planted a few crops under the jungle canopy, or from the commercial plantation of rubber and palm oil. There are many economic, environmental and social costs associated with forest fire disasters (Relief Web, 2002).

Moving and displaced people

The number of displaced people around the world has increased consistently over the past ten years. The total number doubles every seven or eight years, and this upward trend shows no sign of declining. There are currently around 37 million uprooted people in the world, forced to flee their homes and seek shelter elsewhere, usually because of war or economic or natural disasters. Of these, more than 22 million are internally displaced within their country and approximately 15 million are refugees who have fled to another country (International Federation of Red Cross and Red Crescent Societies, 2003).

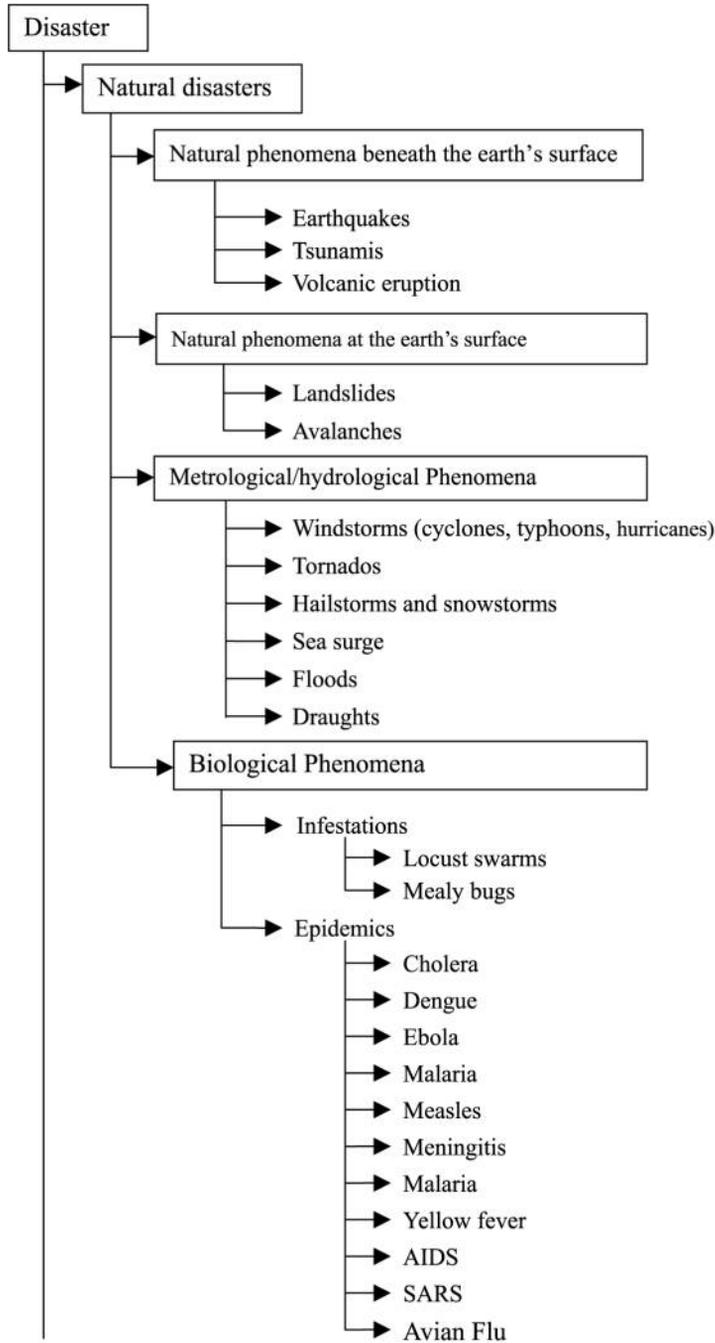
Refugees and asylum seekers. Refugees are people moving outside their country of origin – often in mass exodus – for reasons of conflict and now increasingly, natural disasters.

Internally displaced persons. Internally displaced persons (IDPs) are “persons or group of persons who have been forced or obliged to flee or to leave their homes or places of habitual residence, in particular as a result of or in order to avoid the effects to armed conflict, situations of generalized violence, violations of human right or natural or human-made disasters, and who have not crossed an internationally recognized State border” (International Federation of Red Cross and Red Crescent Societies, 2003).

Migrants. An often neglected but substantial moving population is made up of people displaced by factors other than armed conflict – people forced to move by a natural disaster, economic hardship, the formation of a new country or changing national boundaries. These people are migrants (International Federation of Red Cross and Red Crescent Societies, 2003).

Discussion

This paper has reviewed disaster types, definitions, hazards, and mitigation. Disasters have a common denominator: the severe impact they have on people’s lives, properties and the environment. Disasters have been classified as falling into one of three types, i.e. natural, man-made and hybrid (see Figure 1). Natural disasters are catastrophic events resulting from natural causes. They are often termed an “Act of God”. The author believes that everything happens with the will of God. Although natural disasters are beyond the



(continued) **Figure 1.**
Disaster tree

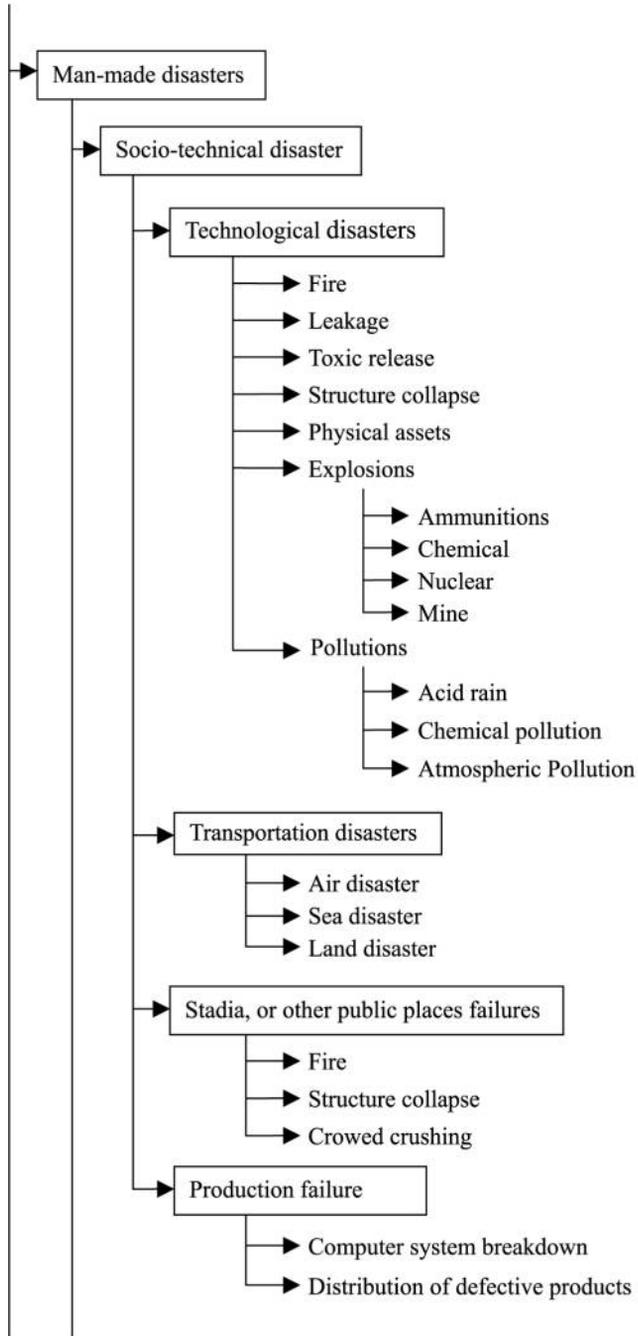


Figure 1.

(continued)

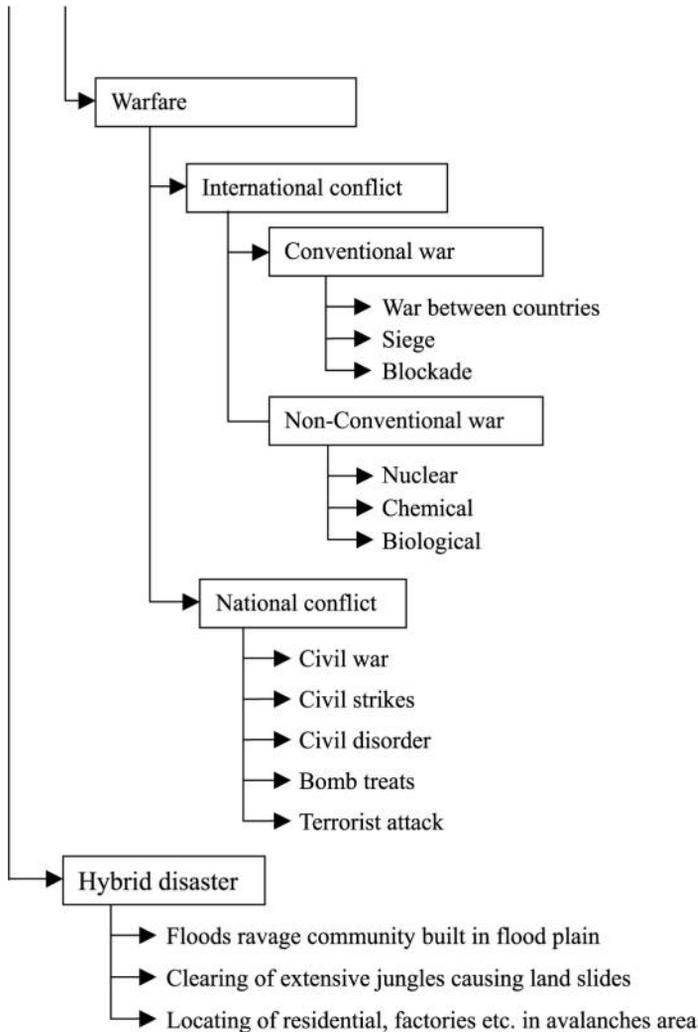


Figure 1.

control of human beings, the impact of natural disasters can be reduced by setting up advanced warning systems which forecast impending natural disasters. The consequences of natural disasters can also be reduced through effective disaster management. Man-made disasters include socio-technical and warfare disasters. Socio-technical disasters occur due to human, technical, and operational errors. Hybrid disasters are those disasters that result from natural forces and human error. Natural and/or man-made disasters sometimes lead to subsequent disasters. Subsequent disasters have social and economic impacts.

The disaster types can be arranged in the form of a disaster tree, as shown in Figure 1. The disaster tree does not include subsequent disasters, but can be utilized using a computer programme for training purposes.

Conclusions

This paper has briefly reviewed natural, man-made and hybrid disasters. The following have been noted:

- natural, man-made, and hybrid disasters cover all disastrous events;
- natural disasters are those disasters that result from natural forces;
- man-made disasters are those disasters that result from human decisions;
- hybrid disasters are those disasters that resulted from both natural and man-made causes;
- subsequent disasters are those disasters that resulted from natural and/or man-made disasters; and
- epidemics can be a disaster or a subsequent disaster.

Disasters have been classified into disaster types, sub-disasters, and disastrous events in the form of disaster tree. Therefore, an algorithm can be written utilizing the disaster tree. The algorithm can be used for training purposes to prevent or reduce disasters.

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