Disasters: lessons from the past 105 years

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Abstract

Purpose – The purpose of this paper is to study and review some major impacts of the disasters during the past 105 years and develop a new theoretical classification of disasters.

Design/methodology/approach – A detailed study of disasters in the world during the period (1900-2005) has been obtained from the recent published sources. In that period more than 40 lessons have been reported based on statistical data analysis of disasters. Furthermore, a two-dimensional probability density function is developed to categorize the different types of disasters. This paper studies and reviews some major impacts of disasters during the past 105 years and summarizes some major lessons for the future. Furthermore, a new scaling system is presented to determine the actual damage of disasters to human life.

Findings – There is no doubt that the impacts of future disasters will not be the same as previous ones but lessons from the past can be very helpful for improving one's knowledge about disasters and providing better response programs for local and international organizations. A new scaling system will also be a useful guide for the development and evaluation of national and international disaster planning, mitigation, and hazard reduction efforts.

Originality/value – Important lessons have been reported based on statistical data analysis of disasters. Moreover, a new classification of disasters is presented to relate the vulnerability factors of a society to the magnitude of the natural disasters.

Keywords Disasters, Classification, Natural disasters, Response time, Emergency services

Paper type Research paper

1. Introduction

The word disaster came into the English language in the sixteenth century through the Latin root meaning "bad star". The word's roots imply that when the stars are in a bad position, a disaster is about to happen (Encyclopedia Britannica Corporation, 2003). Disaster in the history of the human race is estimated to have brought about the loss of a billion lives (DCW, available at: www.disastercenter.com).

There is no precise definition for a disaster. In fact some experts believe that the definition of a disaster can be different based on the geographic, economic and political situations of the disaster-prone countries. However, a disaster is a natural or man-made event that negatively affects life, property, livelihood or industry often resulting in permanent changes to human societies, ecosystems and environment (Quarantelli,

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1998). Disasters are relatively sudden, highly disruptive and in most cases time limited (although the effects may be longer lasting).

The cause of a disaster may be due to:

- natural causes, such as a hurricane or an earthquake;
- a failure of technology, such as airplane crash or the collapse of a bridge; and
- an act of human violence, such as terrorism or an act of war.

The University of Delaware's Disaster Research Center (DDRC, available at: www.udel.edu/DRC /preliminary/ pp304.pdf) differentiates disasters from emergencies and catastrophes as follows:

(1) *Emergency:* An event that may be managed locally without the need of added response measures or changes to procedure.

(2) *Disaster:* An event that:
   - involves more groups who normally do not need to interact in order to manage emergencies;
   - requires involved parties to relinquish the usual autonomy and freedom to special response measures and organizations;
   - changes the usual performance measures; and
   - requires closer operations between public and private organizations.

(3) *Catastrophe:* An event that:
   - destroys most of a community;
   - prevents local officials performing their duties;
   - causes most community functions cease; and
   - prevents adjacent communities from providing aid.

In general, we can say that there are many items to be considered to define an event as a disaster. The definition of a disaster is highly related to the quantity and quality of its impact on human life, human society, economy and environment. In this paper, first we will study and review some major impacts of the disasters during the past 105 years and then we will present a new classification of disasters. Finally, we will summarize some lessons for the future.

2. Initial classification of disasters

Since there is a wide variability in the description of disaster events and their impacts, it is not unusual to have different initial classifications for disasters. Some experts believe that there are two major types of disasters: natural disasters and man-made disasters. A natural disaster is the consequence or effect of a hazardous event, occurring when human activities and natural phenomenon (a physical event, such as a volcanic eruption, earthquake, landslide etc. that does not affect human beings) become enmeshed (Leon Abbott, 2005). In areas where there are no human interests, natural phenomena do not constitute hazards, nor do they result in natural disasters. This understanding is crystallized in the formulation: "disasters occur when hazards meet vulnerability" (Blaikie, 1994). Vulnerability is influenced by factors such as location, state of housing, level of preparedness and ability to evacuate and carry out emergency

operations. Different populations have different levels of vulnerability, this is one reason why hazards of a similar type and intensity can have quite varied effects on different populations.

Man-made disasters are disasters having an element of human intent, negligence, error or involving a failure of a system. Man-made disasters like power or telecommunication outages may be caused by thunderstorms, tornados or earthquakes and though the root cause is a natural phenomenon, they are still considered to be man-made disasters.

The Canadian Disaster Database (CDD, available at: www.ocipep.gc.ca/disaster/search.asp) categorized disasters in five different types as follows:

(1) biological, such as epidemic;

(2) geological, such as earthquake;

(3) meteorological and hydrological, such as drought;

(4) human conflict, such as terrorism; and

(5) technological hazardous, such as chemicals materials.

The Disaster Database Project (DDP, available at: learning.richmond.edu/disaster/index.cfm) conducted by University of Richmond, categorized the disasters in three major classes as follows:

(1) conflict based disaster, such as bombing and massacre;

(2) human systems failure, such as dam collapse and mine accident; and

(3) natural disaster, such as earthquake.

It should be mentioned that sometimes natural disasters are man-made such as damage to ozone layer. There is also a long list of some hypothetical natural disasters such as asteroid impact or mass extinction on earth by hyper nova disaster. It is also important to know that, many times, one natural disaster is accompanied by another. For example, earthquakes and volcanoes sometimes occur together because they are both caused by geologic movements. Epidemics may also be the consequence of disasters of another kind, such as earthquakes, tropical storms, floods, etc.

3. The frequency of disasters

The frequency of disasters and their effects seem to be increasing. The total number of disasters in the world, excluding some human-made disasters like war and genocide, during the period (1900-2005) is reported by EM-DAT in Table I. Since 1988 the WHO Collaborating Centre for Research on the Epidemiology of Disasters (CRED) has been maintaining an Emergency Events Database (EM-DAT, available at: www.em-dat.net/). EM-DAT contains essential core data on the occurrence and effects of mass disasters in the world from 1900 to present. A disaster is defined by EM-DAT as an event or act resulting in great loss and widespread destruction and at least two of the following criteria to be fulfilled by its consequence:

(1) ten or more people reported killed.

(2) 100 or more people reported affected.

(3) A call for international assistance or a declaration of a state of emergency from government.

Duration	1900-1909	1910-1919	1920-1929	1930-1939	1940-1949	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2005
Number of disasters	93	149	124	197	258	359	690	1,237	2,870	4,817	4,850

Source: EM-DAT (available at: www.em-dat.net/)

Table I.
The total number of disasters in the World: 1900-2005

We use this definition for the rest of this paper until section 6 where we will present a new categorizing for disasters.

The number of disasters has also been shown in Figure 1.

Furthermore, of the 100 most costly natural disasters of the twentieth century, 65 occurred in the 1990s, 25 in the 1980s and 10 in the 1970s, and much fewer in the previous decades.

Although the first look at these numbers shows that there is a shocking increase in the number of disasters during the past few decades, it is not enough to jump the conclusion that our world is becoming a more dangerous place to live. It should be note that many experts believe that by developing modern technology, communications and media, we can detect more disasters now and this is one of the major reasons for the perceived increase in disasters. For example, quakes that were undetectable – either because of intensity or distance – now are recorded. This explanation is logical when we compare the number of disasters of the first and last decades of the previous century to each other. However, this reason cannot explain why the number of disasters during the past five years is higher than the ones during the period 1990-1999.

On the other hand, natural disasters represent the intersection of two sets: nature and population (Leon Abbott, 2005). As the population continues to grow, so does the area of intersection, leading to costlier and deadlier disasters. Human population entered the twentieth century with 1.6 billion people then reached two billion in 1927 and 60 years later, in 1987, the world population was five billion, and 12 years later, in October 1999, it passed six billion (UNPD, available at: www.un.org/esa/population/unpop.htm). Unfortunately, a considerable population growth has occurred in the areas that are more vulnerable to hazards. Asian and Africa's share in the world population have been increase 3.4 percent and 4.1 percent respectively during the last centaury and as we will see later in this paper, more than 90 percent of affected people by disasters lived in these areas.

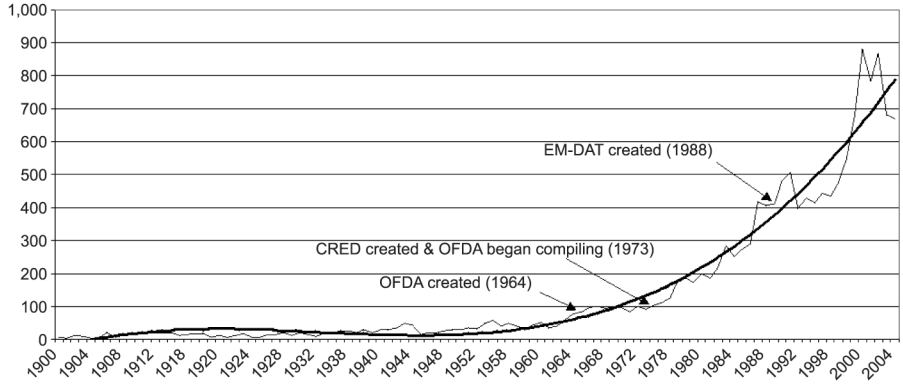


Figure 1.
The total number of disasters in the World: 1900-2005

Note: Equation for time trend line:
$y = 0.0023x3 - 0.2311x2 + 6.6707x - 29.376$; R2 = 0.9564

Source: "EM-DAT. The OFDA/CRED International Disaster Database, www.em-dat.net – Université Catholique de Louvain – Brussels – Belgium"

Another major reason for increasing the number of disasters is climate change due to the damage to ozone layer (HIP, available at: www.nws.noaa.gov/oh/hic/flood_stats/index.html). The number of meteorological and hydrological disasters has been climbed rapidly during the past three decades as it is shown in Figure 2.

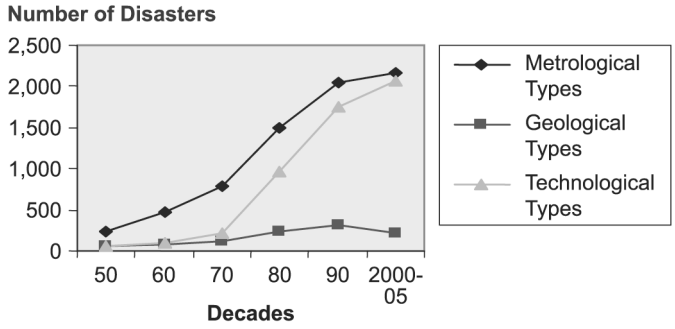
The number of technological types of disasters has also climbed dramatically due to the rapid growth of technology and travel industry during the past 30 years. Hopefully, the growth of increasing the number of geological types of disaster is not as fast as technological types.

There is another good news in this matter as the rate of increasing the number of all types of disasters was decelerated during the last decade as it is shown in Figure 3.

Unfortunately, the frequency of disasters in many major parts of the world is also increasing dramatically. For example, the number of disasters in the USA has been increased as it is shown in Figure 4 and reported in Mileti (1999) and Steinberg (2000):

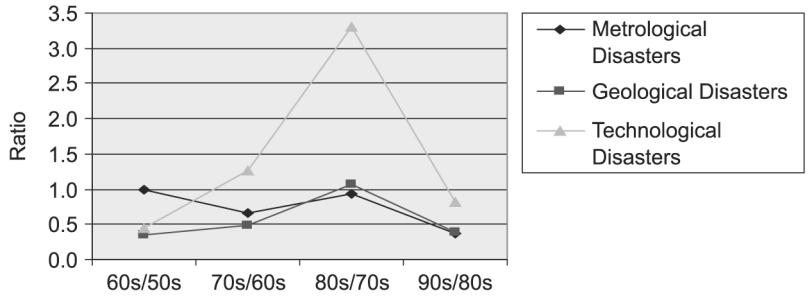
There is no doubt that disasters can threaten every part of the world. However, the distribution of disasters among the five large continents is not uniform. In Table II, the distribution of disasters, excluding war and genocide, in different parts of the world during the period 1905-2005 is reported.

The initial impact duration of most disasters is short and can last from seconds to days. Natural examples of this type are earthquakes and hurricanes. However, there



Sources: [EM-DAT], [US-NHC], [DDP]

Figure 2.
The disaster trend: 1950-2005



Sources: [EM-DAT], [US-NHC], [DDP]

Figure 3.
Increasing ratio in the number of disasters in the World

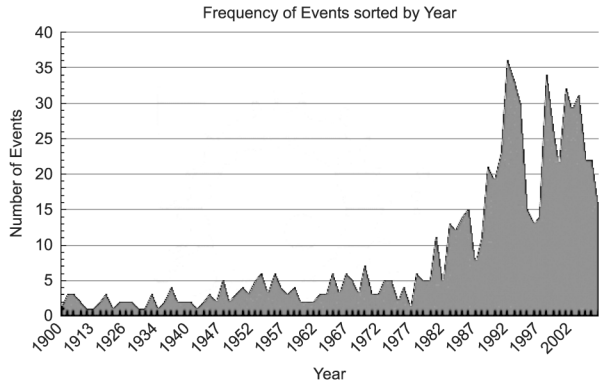


Figure 4.
The frequency of disasters in the USA

Source: "EM-DAT. The OFDA/CRED International Disaster Database, www.em-dat.net – Université Catholique de Louvain – Brussels – Belgium"

are other types of disasters such as epidemics whose initial impacts can last from weeks to months and even years.

4. The human casualties of disasters

During the past five years, disasters like 9/11 attack or Tsunami shocked the world. After watching live coverage of those disasters, many people start realizing that a disaster can be a very dangerous and terrible event. The list of the most infamous disasters in the world during the past five years can be seen in Table III.

As we can see only during the past few years millions of people have been affected by the disasters. In Table IV, the most famous types of disasters have been listed. In the last column of this Table, the worst case occurred during the past 105 years has been reported. It should be mentioned that many figures are only rough estimates. Unfortunately, in many cases government authorities have tried to hide the true figures. Furthermore, many cases involve more deaths from the "aftermath", so there are different reports given by different sources. In Table IV, the cause of biological, geological or meteorological disasters is nature. Human conflict is a man-made disaster. The cause of Technological disaster is either human or system failure. However, in some natural disasters the main cause of death is human. For example, at least 20 million died in Chinese famine of 1959-1962 as a result of homicidal government policy (Yang, 1996).

According to the above data, the deadliest disasters in the last century were Genocide and War. More than 100 million people were killed in war or genocide in the twentieth century. This fact shows that one of the most dangerous types of disasters to humanity comes from humanity itself. Since this type of disaster occurred when human beings or governments purposely start it to harm the others, it is completely different from the other types of disasters which are basically stochastic or accidentally events. Therefore, we will exclude human conflict types of disasters from further consideration in this research.

The total number of dead and affected people per disaster type is also reported in Table V. In this Table, affected people are people are either dead or requiring immediate assistance during a period of emergency including injured, displaced or

Table II. The total number of disasters in the World (1900-2005)

	Type of disaster	Name of disaster	Africa	America	Asia	Europe	Oceania	Total
1	Biological disaster	Epidemic (excluding AIDS)	533	112	284	55	13	997
		Infestation	66	3	11	1	2	83
2	Geological disaster	Earthquake/tsunami	71	239	492	217	42	1,061
		Landslide/mudslide	22	142	236	75	16	491
		Volcanic eruption	13	64	78	10	18	183
3	Meteorological disaster	Drought	476	131	170	31	22	830
		Famine	48	4	21	2	1	76
		Flood	489	724	1,155	397	92	2,857
		Heat/cold weather	10	78	96	117	5	306
		Hurricane/typhoon/tornado	157	891	1,147	263	251	2,709
		Wild fire	19	106	69	83	29	306
4	Technological disaster	Industrial/hazardous chemicals accident	82	174	566	208	5	1,035
		Transportation accident	980	673	1,509	598	30	3,790
	Total		2,966	3,341	5,834	2,057	526	14,724

Source: EM-DAT (available at: www.em-dat.net/); DDP (available at: learning.richmond.edu/disaster/index.cfm)

Table III.
The list of the most infamous disasters in the World (2000-2005)

Date	Type	Location	Disaster characteristics	Casualties
11 September 2001	Terrorism	USA	A series of coordinated terrorist attacks upon the USA	At least 2,986 people were killed in total
26 January 2001	Earthquake	Gujarat, Bhuj, India	6.9 magnitude earthquake	20,000 dead and over 160,000 injured
August-September 2003	Heat wave	European countries	The summer of 2003 was one of the hottest ever in Europe; this led to a health crisis in France, Italy and UK	14,847 people, mostly elderly, died in France and 20,000 people died in Italy and 907 people were estimated to have died in the UK
26 December 2003	Earthquake	Bam, Iran	6.6 magnitude earthquake	43,200 dead and over 20,000 injured
26 December 2004	Tsunami	Indian Ocean	8.6 magnitude earthquake and resulting tsunami affected many countries in Southeast Asia and beyond	283,100 killed, 14,100 missing, and 1,126,900 people displaced
25 August 2005	Hurricane	South Florida, USA	Hurricane Katrina was Category 5 hurricane and the most destructive and costliest natural disaster in the history of the USA	1,383 killed and over 1.2 million people were under an evacuation
8 October 2005	Earthquake	Kashmir, Northern Pakistan	7.8 magnitude earthquake	More than 90,000 dead and over 105,000 injured in Pakistan and india

Sources: *World Disasters Report* (2005); US-NHC (available at: www.nhc.noaa.gov/pastdeadlya1.html); DDP (available at: learning.richmond.edu/disaster/index.cfm); WFE (available at: en.wikipedia.org/wiki/Disaster)

	Type of disaster	Name of disaster	Worst case (1905-2005)
1	Biological disaster	Epidemic/infestation	Spanish Flu killed some 20 million to 40 million people world-wide over about a year in 1918 and 1919 (WHO, 2005). AIDS is responsible for an estimated 25 million deaths to date (UNAIDS, 2004)
2	Geological disaster	Earthquake	242,000 dead in Tangshan earthquake (China, 1976) (Zeilinga de Boer, 2004)
		Landslide	More than 12,000 dead in Kahait landslide (Tajikistan, 1945)
		Mudslide	More than 15,000 dead in torrential rains and mudslides in Venezuela (Venezuela, 1999)
		Volcanic eruption	29,025 dead in Nevado del Ruiz volcano eruption (Colombia, 1985)
		Tsunami	228,000-310,000 dead in Indian Ocean earthquake with tsunami (2004)
3	Meteorological disaster	Avalanche	Nearly 4,000 people were killed in Andes Mountains avalanche (Peru, 1962)
		Drought	5 million people starved to death in Sichuan (China, 1936)
		Famine	1,000,000-43,000,000 dead in the Period of Three Difficult Years (China, 1958-1961) (Smil, 1999)
		Flood	1,000,000-3,700,000 dead in Huang He flood (China, 1931)
		Snowstorm/storm surge	669 dead in heavy storms ("Winnie") (and 695 missing), (Philippines, 2004)
		Heat/cold weather	35,000 dead in European Heat Wave of 2003 (Europe, 2003)
		Hurricane/typhoon/ tornado	500,000 dead in Bhola cyclone (Bangladesh, 1970)
		Wild fire	1,000 people killed in wild fire in Minnesota Wisconsin (USA, 1918)
4	Human conflict	Genocide	30,000,000-50,000,000 dead in Stalin's regime (USSR, 1924-53) (Adler, 1993), (McLoughlin, 2002)
		Terrorism	2,994 dead in September 11, 2001 attacks (USA, 2001)
		Mass casualty	1,426 pilgrims were trampled to death in the Mina tunnel during the hajj (Saudi Arabia, 1990)
		War	More than 50,000,000 dead during World War II (1939-1945) (Keegan, 2005).
5	Technological disaster	Industrial/hazardous chemicals accident	More than 15,000 dead in Bhopal Disaster India (India, 1984)
		Transportation accident	583 dead in Tenerife Air disaster (Tenerife, 1977)

Sources: US-NHC (www.nhc.noaa.gov/pastdeadlya1.html); DDP (available at: learning.richmond.edu/disaster/index.cfm); DCW (available at: www.disastercenter.com); WFE (en.wikipedia.org/wiki/Disaster); NCDC (www.ncdc.noaa.gov)

Table IV.
The list of the worst disasters in the World (1900-2005)

Table V.
The total number of affected/dead people per disaster type (1905-2005)

	Type of disaster		Africa	America	Asia	Europe	Oceania	Total
1	Biological disaster	Epidemic (Excluding AIDS + Spanish Flu)	431,419	67,193	6,524,981	2,501,053	7,002	51,531,648
		AIDS	11,746,473	4,009,724	13,616,935	20,894,379	15,812	612,283,323
			AIDS (22,000,000 dead + 62,000,000 affected) (UNAIDS, 2004)					
			Spanish Flu (20,000,000 dead + 500,000,000 affected) (Taubenberger, 2006; WHO, 2005)					
2	Geological disaster	Earthquake	21,316	214,637	1,611,290	366,228	2,882	2,216,353
			1,786,589	25,018,354	68,261,692	12,308,594	100,910	107,476,139
		Landslide/mudslide	721	20,589	16,265	16,152	541	54,268
			20,461	4,690,980	5,352,290	57,682	11,556	10,132,969
		Volcanic eruption	2,196	67,836	21,456	757	3,665	95,910
			502,549	873,999	2,634,894	12,981	250,866	4,275,289
3	Meteorological disaster	Drought	1,046,543	74	7,761,408	1,200,000	688	10,008,713
			325,605,625	62,017,094	1,806,626,422	16,462,575	8,234,323	2,218,946,039
		Famine (1931-2002)	37,539	0	2,120,760	5,000,000	0	7,158,299
			51,020,840	1,003,000	21,120,760	5,010,000	0	78,154,600
		Flood	19,071	100,480	6,764,153	9,733	361	6,893,798
			39,355,591	52,759,726	2,770,670,481	13,164,094	555,413	2,876,505,305
		Heat/cold weather (1936-2005)	218	6,598	17,505	51,362	23	75,706
			1,000,436	4,096,516	942,800	847,470	4,600,807	11,488,029
		Hurricane/Typhoon/Tornado	5	4,577	1,092,300	6,988	1,884	1,105,754
			6,005	13,719,882	606,196,208	8,143,431	6,015,979	634,081,505
		Wild fire	147	1,465	437	347	314	2,710
			22,719	395,349	3,254,822	282,046	87,440	4,042,376
4	Technological disaster	Industrial/hazardous chemicals accident	8,875	22,195	52,551	17,969	137	101,727
			388,366	3,885,125	2,272,462	923,244	29,685	7,498,882
		Transportation accident	41,148	31,309	84,342	27,670	1,313	185,782
			112,067	66,339	164,129	46,132	1,698	390,365
		Total	1,609,198	536,953	26,067,448	9,198,259	18,810	79,430,668
			431,567,721	172,536,088	5,301,113,895	78,152,628	19,904,489	6,565,274,821

Source: EM-DAT (available at: www.em-dat.net/)

evacuated people. The upper and lower numbers in each cell are referred to dead and affected/dead people respectively.

Now we define the average fatality rate of a certain type of disaster as the ratio of the total dead to the total affected/dead people during a specific period of time. In Table VI, the fatality rate of each type of disaster among 1,000 affected people during the period 1900-2005 has been reported:

5. The economic damage of disasters

The real costs of disasters are not particularly well understood, especially the hidden costs which extend deep into the community. The cost to the community from a disaster like hurricane can run into billions of dollars. Although it is difficult to measure, the biggest cost of disasters, both natural and technological, is the human cost of lives lost, shattered and changed. For survivors, the effects may last a lifetime. For the same reason, the economic and environmental impacts of these disasters to the whole world are uncountable and extremely difficult to answer.

The most expensive disaster recorded in history is the Kobe earthquake (Japan, 1995) with the estimation of 131.5 billion dollars damage (Guinness, 2005). The estimation of economic damage of the major disasters in USA during the past 15 years can be seen in Table VII.

According to the above source, the cost of disasters during the past 15 years in USA is more than $21.200 billion. Unfortunately, even for many major disasters in the world no accurate official record in economic damages has been reported. The lowest estimation of the economic damages of different types of disasters during the past centaury is reported in Table VIII.

Table IX shows the total number of disasters in different continents together with their area and the population and the average Gross Domestic Product (GDP) per population are summarized.

6. Categorization of disasters

In this section, we want to present a scaling system to categorize the different types of disasters. There are different numerical systems to describe the strength of certain types of disasters and measure their potential power. In Table X, some famous scaling methods for measuring the strength of different types of disasters has been shown.

The main object of the above scaling systems concentrates on measuring the physical strength of the disasters. Therefore, disasters of a similar type and intensity have the same scale in these methods but may cause quite wide-ranging losses and damages on different populations. This fact is our first motive to construct a scaling system to determine the actual damage of disasters on human life. On the other hand, a general scaling system of disasters provides a quantitative basis to categorize the disasters and differentiates them from the other types of events such as emergencies and catastrophes. This scaling system will also be a useful guide for the development and evaluation of national and international disaster planning, mitigation, and hazard reduction efforts.

There is no doubt that the economy damage of natural disasters is a very important issue but as we mentioned before the actual dollar loss is extremely difficult to calculate due to numerous items involved. Moreover, it is assumed that some parts of

	Biological disaster	Geological disaster			Meteorological disaster					Technological disaster		
	Epidemic	Earthquake/ Tsunami	Land/ mudslides	Vol. eruption	Drought	Famine	Flood	Heat/cold weather	Hurricane/ typhoon/ tornado	Wild fire	Ind. accident	Trans. accident
Ave. fatality rate	84	21	5	22	5	92	2	7	2	1	14	476

Table VI.
The fatality rate among 1000 affected for different types of disasters

Event	Year	FEMA funding (billion dollars)
Northridge Earthquake	1994	6.961
Hurricane George	1998	2.251
Hurricane Ivan	2004	1.947
Hurricane Andrew	1992	1.813
Hurricane Charley	2004	1.559
Hurricane Frances	2004	1.425
Hurricane Jeanne	2004	1.407
Tropical Storm Allison	2001	1.387
Hurricane Hugo	1989	1.307
Midwest Floods	1993	1.140

Source: FEMA (available at: www.fema.gov)

Table VII. The estimation of economic damage of the major disasters in the USA (1990-2005)

the economy damages of a disaster can be compensated by the help of international community.

The most devastating and irretrievable part of a disaster is its impact to human life. To measure the actual impact of a disaster on population, we consider the fatality rate and the number of people affected by a disaster as the basic factors in our scaling system.

First, let us assume that x be the number of deaths caused by a disaster. Table XI shows the distribution of disasters during the past 105 years due to the different values of parameter x:.

Furthermore, let us define y as the total number of people affected by a disasters. Table XII shows the distribution of disasters during the past 105 years based on different values of y.

In our scaling system, a single number, ψ, is assigned to a disaster to quantify the size of its impact to human life. For a given disaster, first we will find the appropriate ranges of x and y in Tables XI and XII respectively. Now suppose that parameters L_X and L_y are defined as the lower bounds on x and y in their appropriate ranges in Tables XI and XII respectively. Furthermore, suppose that U_x and U_y are their upper bounds on those ranges. The parameter ψ is defined as follows if $10 < x \leq 1{,}000{,}000$ and $100 \leq y \leq 10{,}000{,}000$:

$$\psi = \text{Maximize}[((x - L_x)/U_x) + LogL_x, ((y - L_y)/U_y) + (LogLy) - 1]$$

If $1{,}000{,}000 < x$ or $10{,}000{,}000 < y$ then we will assume that $\psi = 6$.

Then the disasters can be categorized and defined in six different types according to the values of the parameter ψ in Table XIII.

For example, the great Tsunami in 2004 caused 300,000 deaths and affected 1,126,900 people. Therefore, its ψ value is calculated as follows:

$$\psi = \text{Maximize}\,[((300,000 - 100,000)/1,0000,000) + Log\,100,000,\ ((1,126,900 - 1,000,000)/10,0000,000) + (Log\,10,000,000) - 1]$$

$$= Maximize(5.2, 5.01) = 5.2$$

Table VIII.
The estimation of total economic damage of the major disasters

Type	AIDS	Earthquake/ tsunami	Land/mudslides	Vol. Eruption	Drought	Flood	Heat/cold weather	Hurricane/typhoon/ tornado	Wild fire
Total damage (billion dollars)	514	323	5	4	61	346	26	477	2

Therefore, the Indian Ocean's Tsunami is categorized as a major disaster in our scaling system. Hurricane Katrina is also considered as a major disaster since its ψ is equal to 5.02.

Our scaling system is highly related to vulnerability factors of a society when a disaster strikes. For example, Northridge earthquake struck a part of California in 1994 with magnitude 6.6 in Richter scale. Northridge earthquake caused 57 deaths and 1,500 injured. Although this earthquake was one of the most expensive natural disasters in US history, it is categorized as a crisis situation in our scaling system because it did not

Continent	Africa	America	Asia	Europe	Oceania	Total
Total number of disasters	2,966	3,341	5,834	2,057	526	14,724
Area (million sq. miles)	11.6	16.2	17.2	3.8	3.3	52.1
Population (million)	885	881	4,000	728	33	6,527
GDP($)/population	2,364	19,382	5,376	19,566	22,340	

Sources: World Bank (2003); UNPD (available at: www.un.org/esa/population/unpop.htm); DDP (available at: learning.richmond.edu/disaster/index.cfm); WFE (available at: en.wikipedia.org/wiki/Disaster)

Table IX. The number of disasters, population, area and GDP of different continents

Disaster	Scaling method
Hurricanes	Saffir Simpson scale
Tornadoes	Fujita scale
Earthquakes	Modified Mercalli scale or Richter scale
Volcanic eruptions	Volcanic explosivity index

Table X. Famous scaling methods in disasters study

x	Number of disasters	%
$10 < x \leq 100$	7,599	0.781
$100 < x \leq 1{,}000$	1,752	0.180
$1{,}000 < x \leq 10{,}000$	269	0.028
$10{,}000 < x \leq 100{,}000$	73	0.008
$100{,}000 < x \leq 1{,}000{,}000$	22	0.002
$1{,}000{,}000 < x$	13	0.001
Total	9,728	1

Table XI. Distribution of disasters due to the different values of parameter x

y	Number of disasters	%
$100 \leq y \leq 1{,}000$	1,988	0.329
$1{,}000 < y \leq 10{,}000$	1,448	0.240
$10{,}000 < y \leq 100{,}000$	1,292	0.214
$100{,}000 < y \leq 1{,}000{,}000$	882	0.146
$1{,}000{,}000 < y \leq 10{,}000{,}000$	351	0.058
$10{,}000{,}000 < y$	84	0.014
Total	6,045	1.000

Table XII. Distribution of disasters due to the different values of parameter y

cause a severely damage on human life in a heavily populated area. On the other hand, Bam earthquake in 2003 had the same strength in Richter scale but the total death toll was given as 43,200 and the total number of injured or evacuated people was 50,000 – 100,000. The Bam earthquake is a moderate disaster in our scaling system due to the vulnerability of the city of Bam.

7. Lessons from the past disasters

In this section, we summarize some lessons from the facts described in the previous section.

Data in Table I show that:

- the number of disasters in the past five years is more than the ones in the 1990s;
- the number of disasters recorded in the first half of the last century is only 6 percent of the total disasters in the past 105 years;
- 62 percent of the disasters in the past 105 years occurred in the past 15 years;
- 80 percent of the disasters recorded in the past 105 years happened in the past 25 years; and
- the curve corresponds to the number of disasters in each decade of the last centaury is a strictly increasing function after the 1950s.

There are some interesting results as follows derived by the facts reported in Table II:

- In every month during the past 105 years at least 12 disasters, in average, occurred around the world.
- Disasters are threatening every part of the world particularly poor countries.
- Transportation disasters have the first rank among all types of disasters by 26 percent of total number of events. Flood and hurricane/typhoon/tornado disasters have the second and third rank by 19 percent and 18 percent respectively.
- The distribution of the disasters in the different continents around the world is shown in the following Figure. As we can see in Figure 5, more than 60 percent of disasters occurred in Asia or Africa.
- Transportation accidents in Africa, Asia and Europe, hurricane/typhoon/tornado in America and Oceania are the most frequently types of disasters.

Table XIII.
Categorizing of disasters

ψ	Disaster type
$1 \leq \psi < 2$	Emergency situation
$2 \leq \psi < 3$	Crisis situation
$3 \leq \psi < 4$	Minor disaster
$4 \leq \psi < 5$	Moderate disaster
$5 \leq \psi < 6$	Major disaster
6	Catastrophe

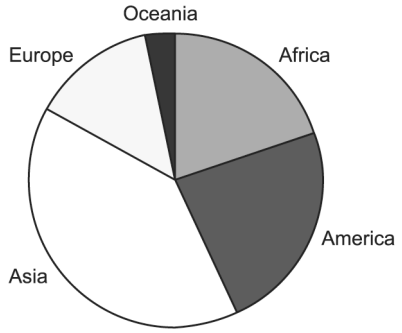


Figure 5.
Distribution of disasters in the World

- Almost 50 percent of the disasters is metrological, 30 percent is technological and 12 percent is geological. The rest comes from biological disasters by 8 percent.
- Although an average frequency of famines is 1/14 of earthquakes, it caused more than three times deaths in compare to earthquakes.

According to the data reported in Table III and Table IV, we know that:

- the worst case of earthquake, drought, famine and flood during the past 105 years occurred in China;
- the worst case of wild fire and terrorism occurred in the USA;
- the worst case of mudslides, volcanic eruption and avalanche happened in Latin America;
- south east of Asia was the place where the worst case of industrial accidents, hurricanes and tsunami happened;
- the worst geological disaster was Indian Ocean earthquake with Tsunami (2004); and
- during the past five years, the worst cases of mudslide, Tsunami, snowstorm, heat weather and terrorism occurred in the world.

According to the data in Table V, we can conclude the following facts:

- In every hour on average during the past 105 years at least 87 people have been killed and 7,137 people have been affected by one of the natural or technological disasters.
- The total number of dead people by natural or technological disasters during the past 105 years is more than the current combined population of France and The Netherlands.
- The total number of affected/dead people by disasters during that period is more than the current population of the world.
- Epidemics are the most dangerous worldwide type of natural disasters by causing 65 percent of the total deaths. Drought and famine are in the second and third place by causing 13 percent and 9 percent of the total deaths respectively.

- The most devastating type of disasters based on the total affected/dead people is flood (43 percent), followed by drought (33 percent) and hurricane/typhoon/tornado (10 percent).
- The deadliest types of disasters based on the average number of dead people per event are famine (94,188 per event), epidemics (47,714 per event) and drought (12,059 per event) respectively.
- The most destructive types of disasters derived from the average number of affected/dead people per event are drought (2,673,429 per event), famine (1,028,350 per event), flood (1,006,827 per event) respectively.
- More than 95 percent of all affected/dead people was Asian or African.
- Although only 40 percent of disasters occurred in Asia, more than 70 percent of the total deaths and 87 percent of all affected/dead people was living in this region.
- In average, each disaster caused 5,395 deaths and 435,100 affected but alive people.
- Epidemics, meteorological and geological disasters caused 65 percent, 31 percent and 3 percent of the total deaths by disasters respectively.
- Drought in Africa and Asia, earthquakes in America, famine in Europe, epidemic in Oceania are the deadliest types of local disasters.
- People in America, Africa, Europe and Oceania are affected the most by drought. Asians are affected the most by flood.
- Each earthquake as the most dangerous geological type of disasters caused 2,089 deaths and 101,297 affected in average.
- Each transportation accident as the most common type of disasters caused 49 deaths and 54 affected but live people.

Figure 6 shows the distribution of disasters in five continents in comparison to their population and area according to the data of Table IX. As it is shown in this figure, there is a high correlation between the number of disasters in a continent and its population but there is no direct relation between the number of disaster in a region and its area.

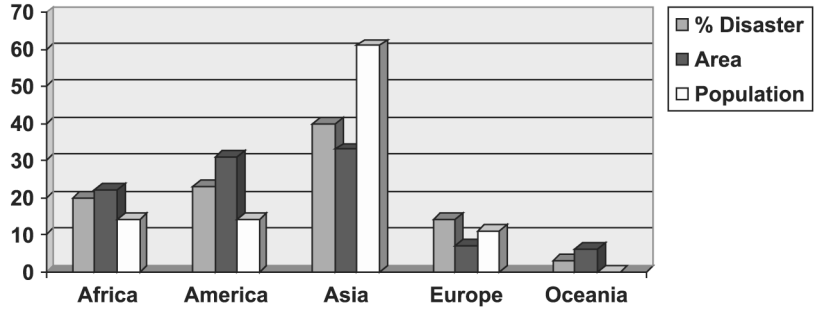


Figure 6.
distribution of disasters in five continents in compare with their population and area

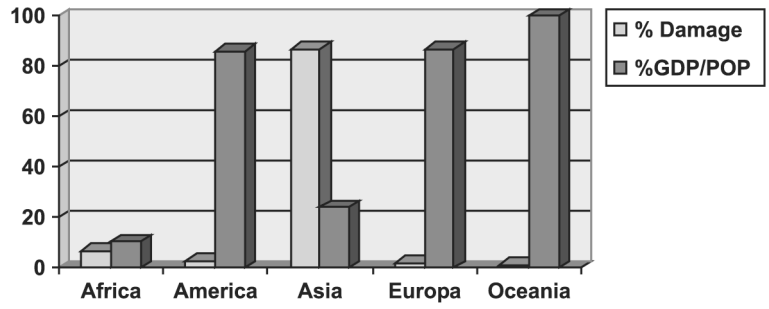


Figure 7. distribution of disasters in five continents in compare with their average GDP

Figure 7 shows the distribution of disasters casualties to human in five continents in in comparison to their average GDP. As a result, it shows that there is an essential relationship between damage reduction and poverty eradication. Poverty is a major factor, as it places people at greater risk of injury and death during a natural disaster. Unfortunately, the number of poor individuals living in high-risk disaster areas is likely climb dramatically in the coming years.

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