NATURAL HAZARDS-INTERNAL AND EXTERNAL PROCESSES

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Summary

Natural hazards are among one of the major causes for concern on Earth. The economic losses caused by natural hazards are about 40 billion US dollars per year, or 100 million dollars a day. Worldwide, 100,000 souls perish each year from such cause. Natural processes (surface's or internal) that become a hazard have highly variable causes and effects. In order to help mitigate the effects, it is necessary to understand the dynamics of the processes involved and to suggest ways that preventative measures can be executed within the socio-economic framework of the area threatened. There were 755 natural hazard loss events in 1999. The most losses of life (98% of total) and damages of properties (93% of the total) came mainly from earthquakes, floods and windstorms. Generalized characteristics of various natural hazards, i.e. the geographic distribution, magnitude- frequency relation etc., is given firstly in present topic, then, the detailed descriptions of several main natural hazards are followed.

1. Earth's process

The Earth is a dynamic, evolving system with complex interaction of internal and external processes. The processes that shape and change the earth can be broadly divided into "surface processes" and "internal processes".

1.1 Surface processes

The more familiar heat source is the external hear of sun. The part of the sun's radioactive heat is retained within the atmosphere each day. Because low latitudes receive more heat than the high latitudes, average atmosphere temperatures decrease from the equator toward the poles. Thus differential heating, plus the rotation of the earth, cause air masses to move around and creates our weather and climate.

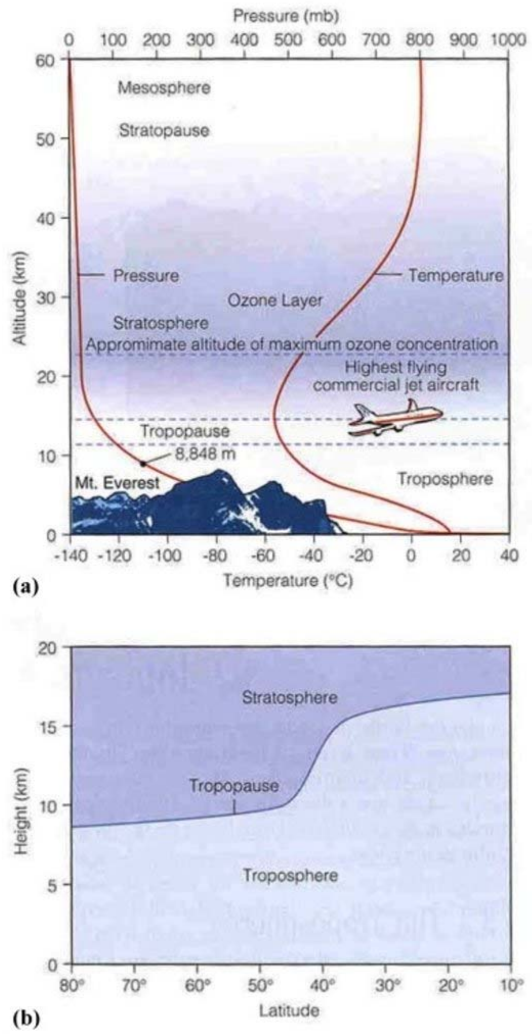

Figure 1. (a) Layers of the atmosphere in relation to the average profile of air temperature above the Earth's surface. Pressure decreases drastically with increasing elevation above the surface;
(b) Variations in the thickness of the troposphere with latitude. A jet steam, known as the polar jet, is typically located between 40 and 45 latitude where there is a sharp change in the altitude of the tropopause. Most atmospheric hazards occur in the troposphere

Part of sun's heat is used to evaporate water, principally from oceans, thus putting water vapor into the atmosphere. When the vapor is extracted as rain, it cause erosion and promotes rock weathering. It also fills rivers and ground water basins, and most of the rainwater makes its way back to the sea within a few years of falling on the ground.

Most changes on the earth's surface (surface processes) are caused by the external heat engine. Some of these changes, essential to human survival, are slow and imperceptible; some are fast and terrifying. Among the slow events is erosion by the water. Newly exposed rocks weather to provide essential nutrients to soil and to release other chemicals to rivers and streams to buffer the composition of the atmosphere and ocean. On the fast scale like the fast movements of air, such as hurricanes, that are rapid enough and cause sufficient coastal flooding to be potential catastrophic. Fluctuation in the amount of water delivered to river systems may cause floods. Most atmospheric hazards occur in the troposphere (Figure 1).

1.2 Internal process

The earth's internal heat causes earthquake and volcanic hazards. This heat results both from the accumulation of the earth and the radioactive elements that it acquired as it forms. Approximately 4.5 billion years ago the solar system "cloud" condensed into discrete bodies – the sun and planets. The earth grew from a dispersed set of particles and gas that constituted the primitive solar system. As the protoearth attracted particles into its gravity well, both its size and temperature increases. The heating resulted from the impact of particles.

The more important additional heat source is the continuing decay of radioactive elements, principally uranium, thorium, and potassium. The earth forms an effective blanket for its internally derived heat, permitting only slow escape into space. For this reason, the interior of the earth remains hot, and temperatures increases downward from the surface to the earth's center. The increase is sufficient to make the earth's mantle thermally unstable. Hot mantle rises from the deep interior and cools below a rigid outer skin of mantle and crust (known as lithosphere), which has a thickness in the range of 150 to 300 km. This cold mantle then descends back to the interior, and the rising and descending areas combine to form a convection cell. This convection stirs the mantle in the same fashion that a pot of soup is stirred by a rolling boil as the bottom is heated and the top cools.

Mantle convection cells create stresses in the nearby surface, rigid lithosphere on the earth, causing it to deform. The zones of deformation are generally narrow and serve as the borders between broad oceanic and continental areas. The stable areas are referred as plates, and the concept of stable plates moving around the earth and deforming on their margins is called plate tectonics. It is a dominating principle of modern geology.

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The concept of plate tectonics also permits us to distinguish two types of continental margins, which are important in our discussion of coastal line process. “Active” margins are plate boundaries, where subduction cases mountain buildings. “Passive” continental margins are not plate margins; they occur where oceans growing and pulling continents on either side apart. Almost all of the Pacific Ocean is surrounded by active margins, and almost all of the Atlantic by the passive margins.

Mantle convection is the fundamental cause of earthquakes and volcanoes. Earthquakes result from the fact that none of the various types of plate deformation occur smoothly. The lithosphere is strong enough to resist fracturing, and this resistance causes strain to build up in the lithosphere. Thus, when fracturing does occur, the energy releases rapidly and the earth shakes. Most, but not all, earthquakes occur along the plate margins. As with earthquakes, volcanism occurs along plate margins. Volcanoes are the most obvious surface expression of the release of the earth’s internal heat. Rising hot mantle either melt itself as it nears the surface or, more commonly, distributes sufficient heat to cause melting of some part of the adjacent lithosphere. Also, descending mantle release water and other volatile materials that promote melting of overlying lithosphere. Some volcanoes, however, develop above a narrow (100-200 km diameter) “plumes” of hot mantle that appear to rise independently of the major convection cells. Volcanic eruption not only create local disasters, they may also affect the earth’s climate for period of several years.

Many of the continental slopes, including most of the slopes surrounding continents facing the Atlantic, Indian, and Arctic oceans, have very few earthquakes, and thus they, together with the continents and ocean basins adjacent to them, are inherently stable. We refer to such slopes as passive continental margins. Other continental slopes, including most of those bordering continents facing the Pacific Ocean, have many earthquakes. These continental margins are flanked by high mountains and deep trenches, departing from the mean elevations of continents and ocean basins, and they also contain active volcanoes. We refer to these slopes as active continental margins, active because of the presence of large earthquakes, active volcanoes, and extreme variations in topographic relief.

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1.3 Consequences of change

The Earth’s internal and external heat sources create a dynamic, rather than static, earth. Many rapid earth’s and atmospheric processes cause changes are risky – hurricanes, floods, earthquakes, and so on. We do, however, adjust to slower changes and, in fact, benefit from them. For example, we build cities on riverbanks to use the following water for transportation, municipal water supplies, industrial purposes, and waste removal. Slow downhill movements were not present in rivers, they would erode their banks downstream. The movements of sand along the coastlines create beaches for our enjoyment. The debris from volcanoes develops into rich soils for agriculture.

Our task is not to prevent change, which is usually important, or to deny the accompanying risks. What we must do is accept and understand the changes and the dangers that they may pose and then prepare for them.

Any infrequent natural change that is fast enough to threaten life and limb is refers to as a natural hazard. Examples of such hazards include floods, landslides, earthquakes, volcanic eruptions, tsunamis and so on.

2. How big problem are natural hazards

2.1 Natural catastrophes 1999

The natural catastrophe statistics 1999, in Figure 2, is given by Munich Re (Munich Re, Topic, 2000).

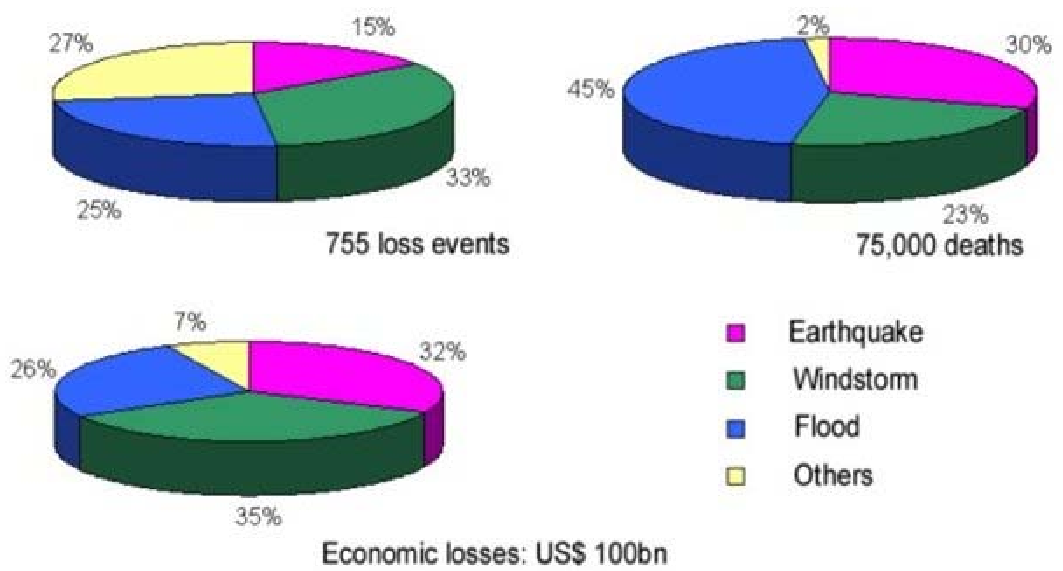

Figure 2. Percentage distribution worldwide: Natural catastrophes 1999 (Courtesy of Munich Re)

There were 755 loss events in 1999. Table 1 shows the top ten events in 1999. It can be seen from Figure 2 and Table 1 that most losses of life (98% of total) and damages of properties (93% of the total) came mainly from earthquakes, floods and windstorms. It can also be seen that the economic losses caused by natural hazards is about 40 billion US dollars per year, That is about $100 million dollars a day. Worldwide, 100,000 souls perish each year from such cause. It is hard to say that natural hazards are someone else’s problem.

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Date	Event	Region	Fatalities	Economic Loss (US $ million)	Explanation, description
Jan 25	Earthquake	Colombia	1,185	1,500	M_w 6.2; 80,000 houses damaged or destroyed; severe damage in infrastructure
April 14	Hail	Sydney, Australia	1	1,500	Hailstones the size of baseballs; 45,000 houses, businesses, 63,000 cars, 23 aircrafts damaged; numerous boats damaged.
May, 3~7	Tornadoes	Oklahoma, USA	51	2000	7,000 houses, 60 business, 30,000 cars damaged or destroyed; 900 injured
June. 15	Floods	China	800	8,000	480,000 houses, hundred of thousands of farms, 1,600 factories badly damaged or destroy; 113,000 arc land flooded; 15,600 km^2 harvest crops destroyed.
Aug. 17	Earthquake	Izmit, Turkey	>17,200	12,000	M_w7.4; 270,000 houses, businesses damaged; heavy damage in industrial sector; thousands missing, 44,000 injured, 600,000 homeless.
Sep. 20	Earthquake	Taiwan, Chichi	2,474	14,000	Thousands of aftershocks, landslides; more than 50,000 buildings badly damaged or destroyed; semi-conductor industry without electricity; 6 million households severe damaged; 310,000 homeless, 11,000 injured
Sep. 22-25	Typhoon	Japan Korea	26	5,000	Gusts reaching 240 km/h; thousands of houses damaged/destroyed; agricultural, industrial, and infrastructural damage; more than 100,000 claims.
Oct. 28-30	Cyclone	India	10,000-30,000	2,500	Worst storm for 100 years, torrential rain; 18,000 villages destroyed; harbor badly destroyed; 17,000 km^2 paddy fields devastated
Dec. 13-16	Floods	Venezuela	20,000	15,000	Devastating landslides and debris flows after landslides; 9 days of rain; villages, towns destroyed; thousand injured or missing
Dec. 25-27	Winter gales	France Switzerland Germany	>130	11,000	Wind speeds exceeding 180km/h; hundred year storm in France. Severe tree losses; million without electricity

Table 1 Top ten significant natural hazard event in 1999 (Courtesy of Munich Re, modified)

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2.2 Geographic distribution of natural disasters

Figure 3 gives the geographic distribution of 1999’s natural disasters in Africa, America, Asia, Australia/Oceania, and Europe. It can be seen from Figure 3 that the America and Asia are the natural disaster prone regions.

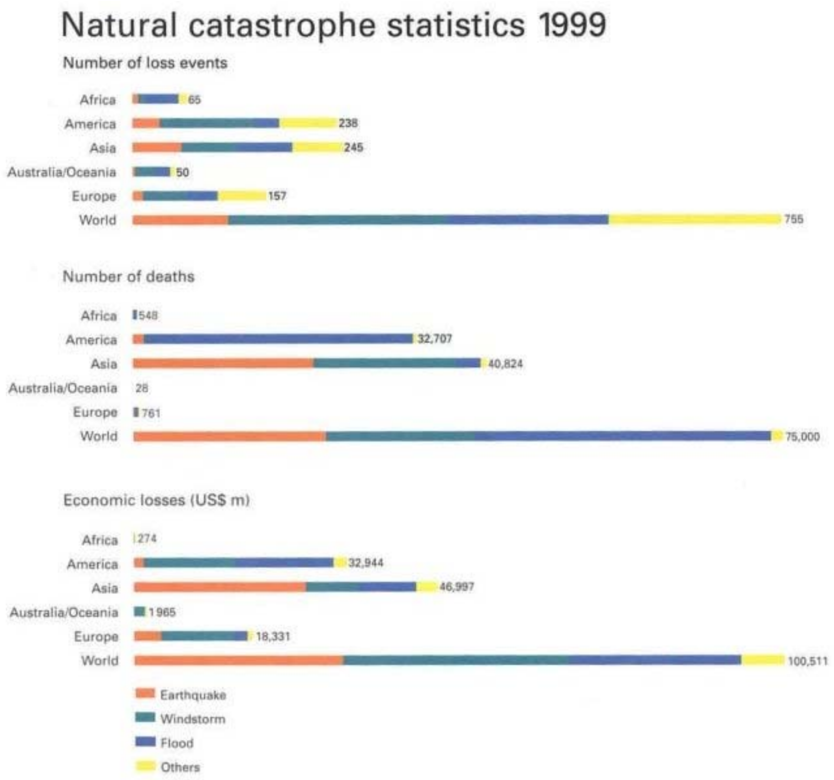

Figure 3. Geographic distribution of 1999's natural disasters in various continents (Courtesy of Munich Re, 2000). A, Number of loss events. B, Number of death caused by natural hazard. C, Economic losses (US$ million) caused by natural hazards

The another task in geographic distribution study was to find a way of comparing the various economies. We adopt the same basis as that used in the World Bank study (classification of economies), which addressed the question of world development indicators. The World Bank looked at 210 countries, diving them into four groups according their gross national product (GNP) per capita (Figure 4). Figure 5 shows the percentage distribution (natural catastrophes 1985-1999) in economies at different stages of development. In Figure 5, the different income groups are divided like this:

	Income group 1	Income group 2	Income group 3	Income group 4
GNP 1998 – Purchasing power parity (US$ bn)	20,774	4,874	3,736	7,483
GNP 1998 – Nominal (US$ bn)	22,560	2,816	1,705	1,811
Economic losses (US$ bn) from natural catastrophes 1985~1999	564	77	86	240
%(share of overall loss)	57.3	7.8	8.7	24.4
%(purchasing power parity – US$ bn)	2.7	1.6	2.3	3.2
% (GNP nominal)	2.5	2.7	5.0	13.3

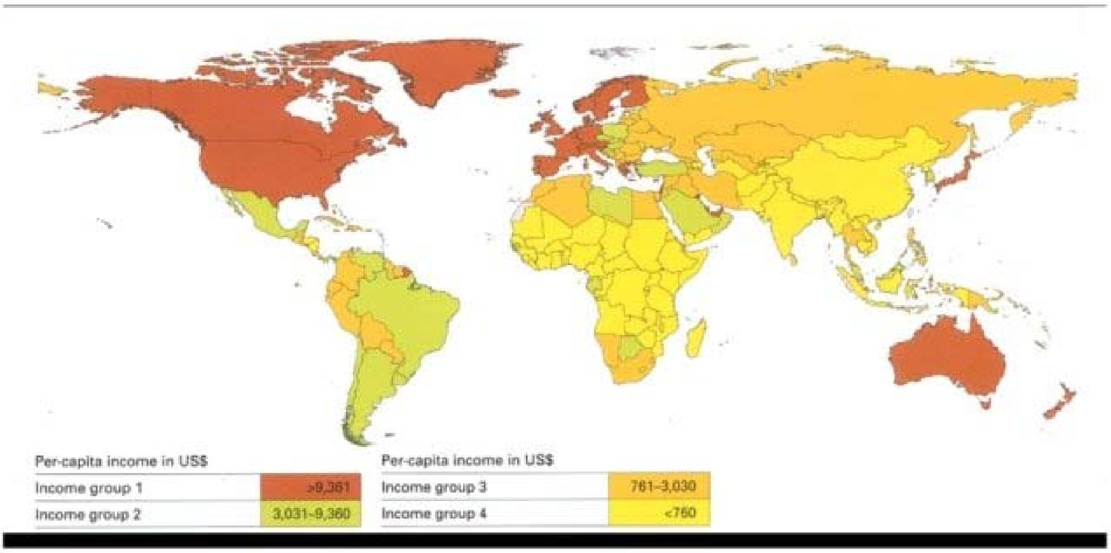

Figure 4. Countries distribution in economies at different stages of development: Income group 1: per-capita income in US$ >9,361; Income group 2: per-capita income in US$3,031-9,360; Income group 1: per-capita income in US$ 761-3,030; Income group 1: per-capita income in US$ <760

The countries with the highest frequency of natural catastrophes are the rich countries; it is here that 4,200 of approximate 9,200 events were registered. The country with the most catastrophes is unmistakably the United States with 1,200 events. The countries in Group 2 (such as Mexico, Brazil, Turkey, and Chile) were hit 1,000 times. Group 3 and 4 – each with some 1,900 events – were led by South Africa and China.

As far as loss of human life is concerned, however, the countries with a high per-capita income come off much lighter. Only 4% of the 586,900 fatalities were registered there. Also, the majority was caused by one single event – the Kobe earthquake of 1995 with a toll of 6,348. The picture is quite different in the countries most severely hit (income Group 4 with a total of 380,000 fatalities). The number of victims roughly reflects the stages of development reached in the regions affected. Many industrialized countries already have efficient disaster management systems and modern early-warning facilities which have a major bearing on whether counter-measures can be adopted in time so that people are exposed to the immediate danger.

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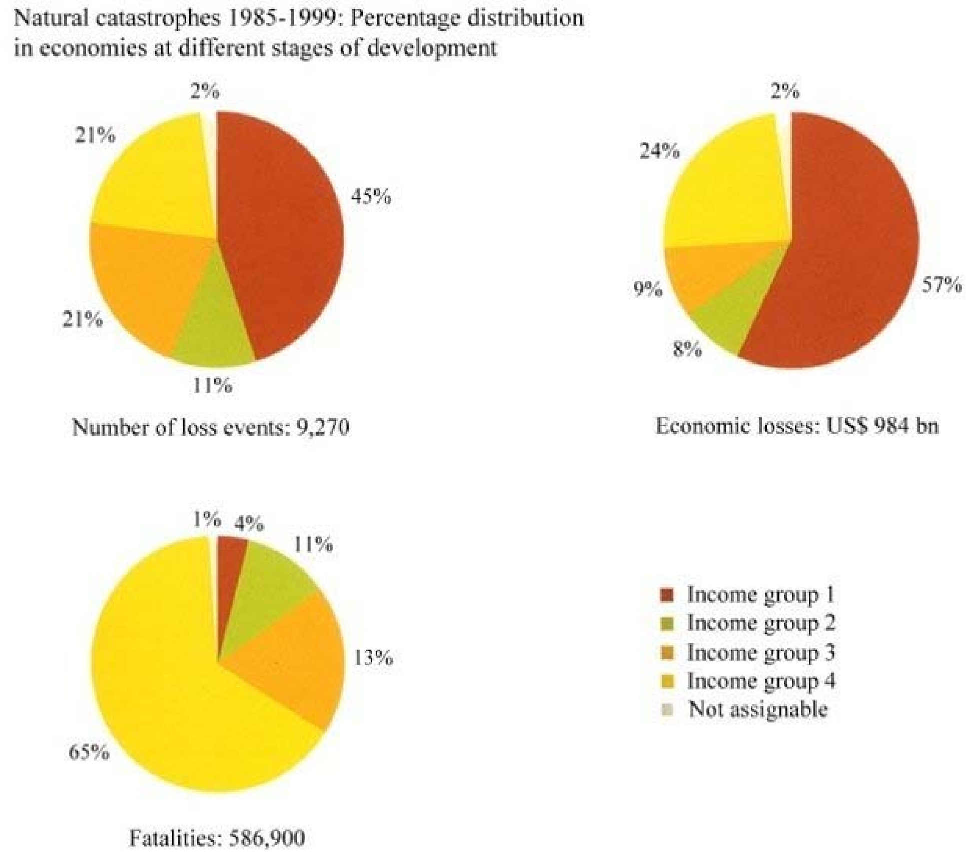

Figure 5. Natural catastrophes 1985-1999. Percentage distribution in economies at different stages of development (Courtesy of Munich Re, modified). A, number of loss events: 9,270, B, Economic losses: US$ 984 billion, C: Fatalities: 586,900

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Looking at the economic losses caused by natural hazards from 1985 to 1999, the rich countries bear the main burden in absolute terms. These countries registered more than half (57%) of the worldwide total of around US$984 billion, mostly as a result of earthquake and windstorms. In Group 4, which was confronted with losses of around US$ 240 billion, floods (US$ 140 billion) were the main cause, particularly the great floods in China on the Yangtze and in the Dongtian Lake area.

2.3 Natural Hazards Statistics of 1963-1992

Hazardous processes have always existed. Earth processes that we term "hazardous" – flood, earthquakes, volcanic eruption, droughts – are natural geological processes. They operated, for most part, since early in Earth history, although in some cases the magnitude or timing of the events may have changed. The mentioned above mainly deals with the natural hazards of 1999. The World Conference on Natural Disaster Reduction gave the results of natural hazards statistics of 1963-1992 (Table 2 and Table 3).

Number of major hazards, as defined by type	>1% of the total annual GNP lost	>1% of country's population affected	>100 deaths caused
Floods	76	162	202
Tropical storms	73	100	153
Drought	53	167	21
Earthquakes	24	20	102
Landslides	1	2	54
Volcanoes	2	9	12
Tsunamis	1	1	9

Source: disaster Around the World – A Global and regional View: World Conference on Natural Disaster Reduction, Yokohama, Japan, May, 1994, U.N. Information paper DHA/94/132.

Table 2 The number of major hazards around the world during the period 1963-1992, as defined by type, damage, persons affected, and the number of deaths

Number of major hazards, as defined by five years periods	>1% of the total annual GNP lost	>1% of country's population affected	>100 deaths caused
1963-1967	16	39	89
1968-1972	15	54	98
1973-1977	31	56	95
1978-1982	55	99	138
1983-1987	58	116	162
1988-1992	66	139	205

Source: disaster Around the World – A Global and regional View: World Conference on Natural Disaster Reduction, Yokohama, Japan, May, 1994, U.N. Information paper DHA/94/132.

Table 3 The number of major hazards around the world during the period 1963-1992, in five year period, as defined by damage, number of persons affected, and number of deaths. The Table shows a steady increase in the number of hazards in each category over the time period.

It can be seen from Table 2 and Table 3 that most losses of life and damages of properties came mainly from earthquakes, floods and windstorms.

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Biographical Sketch

Prof. Chen Yong graduated from the University of Science and Technology of China in 1965. Member of Chinese Academy of Sciences. Vice president of Chinese Geophysical Society. Vice president of Chinese Seismological Society. He is now engaging in: geophysical characteristics of active continental tectonics, fractal analysis of seismicity, the simulation of natural disasters and rock physical property study.

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