Natural Disaster Reduction and Global Change

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There are three types of global change that affect human and economic losses due to natural disasters. The three kinds of changes are

1) increasing economic development, especially along coastlines, in flood plains, and other hazard-prone areas;
2) changes in land surfaces and vegetation; and
3) variability and change in frequency and severity of natural hazards.

Any program for reduction of disaster losses must take these factors into account, and trends in losses are due to these changes.

1. Trends in economic losses

Economic losses from natural disasters have increased dramatically since the 1960s. Munich Re Insurance, Munich, Germany, makes estimates of total losses (Berz and Conrad 1993) based on adjustments to insured losses. In a 1993 press release, they estimated worldwide losses for 1992 at more than $60 billion, which is more than 10 times the average loss from large disasters of the 1960s. For meteorological disasters (windstorms), the Munich Re decadal loss estimates from the 1960s to the early 1990s are given in Table 1; the estimates increase fourfold from the period 1960–69 to the decade 1983–92.

2. Human losses

As an index of human suffering, loss of life from 1986 to July 1993 in proportion to total population indicates that Peru, Bangladesh, Honduras, Guatemala, Iran, Chile, Nicaragua, Colombia, Solomon Islands, Ecuador, Vanuatu, and the Philippines are the most vulnerable dozen countries, by this criterion. The ratio in Latin America of deaths to numbers of people injured in a disaster was 3 to 800 over the past two decades; thus, the enormous amount of human suffering from natural disasters is greatly understated by noting only the number of deaths.

Burton et al. (1978) pointed out that "about 95% of disaster-related deaths occur among the two thirds of the world's population that occupy developing countries." The trend in earthquake vulnerability illustrates the relative increase in exposure of developing countries. In the five decades to 1949, 70% of 700 000 earthquake fatalities were in developing countries. In the period 1950–92, this rose to 99% in developing countries (Tucker et al. 1993). These figures indicate that earthquake-resistant construction has saved many lives in developed countries, and with little extra cost much could also be achieved in developing regions.

3. Increased development

In countries with good warning and preparedness systems, especially for storms, floods, and droughts, significant reductions in disaster deaths can be achieved. For example, in the United States, while hurricane economic losses have increased, due in large measure to rapid increases in population and activity in coastal regions, deaths due to hurricanes have declined. Similar growth in coastal populations has been experienced over the world. Indeed, it is estimated that more than half of the world's population now lives within 60 km of the ocean coast. Population growth and increased economic development have resulted in increased exposure in other hazard zones as well. Known flood plains, earthquake-susceptible zones, and drought-prone regions have experienced development pressures, increasing the population

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TABLE 1. Major windstorm catastrophes during 1960–92. The number and extent of major windstorm disasters have increased dramatically in recent decades. In the period between 1983 and 1992, the number of such disasters and the economic loss they caused rose by a factor of 4 compared with the 1960s, while the increase in insured losses was almost tenfold (source: Munich Re 1993).

	Decade 1960–69	**Decade** 1970–79	**Decade** 1980–89	**Last 10 years** 1983–92	**Factor** 80s:60s	**Factor** Last 10: 60s
Number	8.0	14.0	29.0	31.0	3.6	3.9
Economic losses*	22.6	33.6	38.0	88.1	1.7	3.9
Insured losses*	5.3	8.3	18.9	52.1	3.6	9.8

*All figures in U.S. dollars (in billions) extrapolated to 1992 prices.

and property at risk. Does this account for all of the increase in disaster losses that have been experienced? World population from 1960 to 1992 has less than doubled, that is, from 3 to 5.5 billion, yet disaster losses appear to have increased four times or more. The reinsurance industry believes that other factors, such as environmental changes, are at work, and that economic activities sustain greater exposure. (Berz and Conrad 1993). What evidence is there for environmental changes that influence frequency and severity of hazardous events?

4. Environmental hazards

Which are the most serious of the environmental hazards in producing economic and human losses? Worldwide data from the U.S. Office of Disaster Assistance for the period 1960–89 are given in the Table 2. Data show that more than 90% of the affected people are visited by disasters of a hydrometeorological nature, including droughts and famine. When deaths are considered, earthquakes, droughts, and the storm–flood category are roughly equal in their devastation. Given these data on the relative importance of the various natural hazards, it is natural to look for any environmental changes that would influence disaster statistics for floods, droughts, and storms, that is, changes in climatic and hydrologic extremes and responses to them over land and sea areas.

5. Land-use changes

The relationship between floods and landslides and the removal of forests and other vegetation on the slopes of watersheds is well understood. Flood peaks and landslides are substantially increased by loss of vegetation on hillsides. This is especially true in smaller watersheds. In large basins the effect of land-cover changes tends to be masked by many other factors. However, this is a factor that has been cited, for example, as contributing to increasing flood hazards on the upper reaches of the rivers of Nepal (Russell et al. 1991).

In addition, the expansion of cities with accompanying increases in paved and roofed areas results in higher runoff rates and greater floods in urban and suburban areas. For example, in one study in southern Ontario, the percentage of rain and snowmelt that runs off increased from 10% to 43% with urbanization of the watershed (Organization for Economic Cooperation and Development 1986). Thus, with rapidly growing cities, human actions are undoubtedly increasing the percentage of rain or snowmelt that runs off quickly, causing floods.

In the case of droughts, studies in the Sahelian region and elsewhere have shown that while drought periods are caused by large-scale changes in the general circulation of the atmosphere, local actions can prolong the dry periods and make their effects more devastating. Removal of vegetation for firewood, or by grazing animals, changes the albedo of the land surface and the surface roughness, both leading to prolongation of dry weather and its adverse effects (Xue and Shukla 1993). Losses of vegetation can also reduce the penetration of water into the soil, accelerating runoff and leaving little flow for the dry season. From these examples it is evident that human actions in affecting land uses and vegetation are already having significant effects on severity of floods and droughts.

The growth of cities results in vegetation loss and soil changes in their area of urban sprawl, and large cities can cause devastation far beyond their boundaries. For example, urban demand for fuel wood often leads to clear cutting of nearby forests that had served local populations for generations. To illustrate, Delhi, India, needs 612 tons of firewood per day, and much of this wood now comes from forests as far as 700 km away (Kreimer and Munasinghe 1992).

6. Climate trends and change

Is there any evidence of recent trends in climate that would contribute to the disaster loss trend? And what are the prospects for changes in climate extremes with increased radiative forcing due to greenhouse gases?

There are a number of datasets that indicate trends toward increasing frequency of climatic- and ocean-level extremes. A simple analysis by Yamamoto of Yokohama University (Takedo 1993) took the three largest daily precipitation amounts for each of 55 long-term stations in the Japanese Meteorological Agency network and plotted the two-decade period in which each occurred. The two-decade totals expressed as a percentage of the total number of occurrence show a rising trend of from 13% to 14% in the decades centered on 1900 and 1920 to 27% in the two decades of the 1970s and 1980s. A similar analysis for the three largest amounts of monthly rainfall for 14 U.S. stations, plotted by decade, shows an upward trend; further, the chance of the highest amounts occurring in the decade 1975–84 is double that of the decade centered on 1920. Similar analyses should be done for other regions since it is these heavy rainfalls that result in floods and are the basis for design of many hydraulic structures. Engineering design criteria have often been set by various jurisdictions several decades ago and may need review.

The small rise of some 10 cm in mean sea level observed over the past century and, in some areas, evidence of increased storminess are sources of concern in coastal communities. Between Cuxhaven and Hamburg in northwestern Germany, the "safe" height of the protective dikes along the lower Elbe River from river floods and from storm surges in the North Sea is affected by both human interference with the river regime and storm surge frequency. In reexamining the storm surge aspects, Plate (1992) concluded that the Cuxhaven 100-yr, high-water data series could be considered stationary until 1980. Since then, high-water periods, due to combinations of storm-driven surges with tidal effects, have greatly increased. In the period 1980–90 weather patterns that produce high storm surges have increased by 45%. This has turned the 100-yr return period design value of 1980 into the 63-yr value by 1990, with signs of this trend continuing into the early 1990s.

Wave heights are also a reflection of over-ocean storminess. The 1990s have seen, in the North Atlantic off the east coast of Canada, the record-breaking Halloween storm of 31 October 1991 with the highest recorded wave of 30.7 m, and the "storm of the century" on 15 March 1993. Similarly, off Canada's west coast, the North Pacific has produced wave heights exceeding the 100-yr value, as calculated in 1990, four times since then. Experiences of remarkable recent increases in extreme wave heights have also been felt in Iceland and the west coast of United Kingdom (Swail 1993).

Data on tropical cyclone frequency show both positive and negative trends. For the southwest Pacific, the World Meteorological Organization (WMO) Regional Cyclone Warning Centre in Fiji shows a gradual increase in numbers of tropical cyclones from the 1940s to the 1980s with decadal numbers, respectively, of 58, 64, 72, 91, and 107 (R. Prasad 1993,

TABLE 2. Worldwide disaster statistics by disaster classification.

	Number	Percent	Killed	Percent	Affected	Percent
Civil strife	137	5.8%	2 912 612	62.2%	117 493 613	5.6%
Drought and famine	308	13.1%	636 583	13.6%	1 085 563 917	51.8%
Geophysical*	315	13.4%	497 500	10.6%	42 023 615	2.0%
Hydrometeorological**	1109	47.1%	536 820	11.5%	845 462 237	40.3%
Fires and epidemics	486	20.6%	96 843	2.1%	4 811 138	0.2%
Total	2355	100.0%	4 680 358	100.0%	2 095 354 520	100.0%

* earthquakes, volcanoes; ** storms, floods (source: Office of U.S. Foreign Disaster Assistance 1991).

personal communication). Some of the increase may be due to better detection by satellites, beginning in the 1960s. On the other hand, the trend in numbers of hurricanes in the Caribbean has been distinctly downward (Tol 1993). Both datasets appear to be more influenced by the periodic El Niño–Southern Oscillation phenomenon than by any long-term global trend.

These data and other climatic and oceanic evidence tend to lend some credence to the insurance company's concern about both the increased exposure to risk due to population and development growth and recent increase in risks. The insurance industry at a meeting in London in 1993 noted that they had no disasters between 1966 and 1987 with losses in excess of $1 billion (constant 1992 dollars). Since 1987 they have had 15 disasters. Ten of these were "windstorms," which accounted for 85% of the losses in the 15 cases.

7. The climate future

Are such observed changes part of a trend induced by greenhouse gas increases, or are they a vigorous manifestation of natural climate variability? It is, of course, impossible to decide with any real confidence. However, it is instructive to compare recent climatic experience with some results of climate projections from modeling studies of the past few years.

From the point of view of heavy rainfalls, a 75-yr run of a coupled ocean–atmosphere model of the Hadley Centre, United Kingdom, assuming 1% per year increase in CO_2 equivalent (transient model), gave increased rainfall amounts in Europe but no more rain days, that is, larger daily rain amounts by 20%–60% (Rowntree 1993). CSIRO (Australia) studies show a marked increase in frequency and scope of heavy rain from "penetrating convection" over Australia, India, western Europe, and the midwestern United States in a doubled CO_2 atmosphere.

D. Rind studied drought frequency and severity using the Goddard Institute for Space Studies model projections. Using a supply–demand drought index (SDDI), involving the difference between evapotranspiration and precipitation, the model shows that a doubled CO_2 atmosphere would result in a large increase in drought over the central United States. Rind believes that this has been generally underestimated in model studies (Rind 1993). Meehl (1993), from studies of increased radiative forcing, equivalent to a doubled CO_2, interacting with ENSO events, concluded that in general ENSO-affected drought areas would become drier and wet areas wetter.

On the matter of storminess, the U.K. Meteorological Office (Hadley Centre) model indicates that with increased radiative forcing, "indicators of storm activity such as eddy kinetic energy are shifted northward and intensified downstream, particularly with the North Atlantic storm track." A doubled CO_2 atmosphere is projected to increase gale frequency around the Atlantic seaboard of Europe (Houghton 1994).

As is the case with the data, the climate model indications on tropical storm frequency and severity are inconclusive. Most models have too coarse a grid scale and do not model sufficiently well the vertical temperature profiles in the Tropics. For example, the models neglect effects of changes in vertical distribution of ozone. Changes in both sea surface temperatures and stability of the tropical atmosphere would have an effect on tropical cyclone frequency, but on neither issue is agreement good between models or theoreticians.

From this brief review, it can be seen that model projections of a future climate with a CO_2- and aerosol-enriched atmosphere are consistent with some observed changes in climate extremes of the recent past, which suggests the real possibility that the observed changes are part of a trend.

8. Conclusions: The International Decade for Natural Disaster Reduction

This short overview of the impact of global environmental changes and of changes in economic developments and their locations suggests that population and economic changes, increasing the exposure to risks, is a major factor in increasing disaster losses and human suffering over time. However, recent environmental changes affecting the frequency and severity of the risks appear to be by no means negligible. Future projections of both land-use changes and of climate change suggest that these recent signs of increasing risk of floods, storms, and droughts may well continue and increase.

What kinds of responses are then needed? The first should be to vigorously address the forms and nature of economic development that greatly increase the exposure to disaster risks. This means that the following three conditions are needed:

1) vigorous effort to ensure that buildings and urban infrastructure are built to be safe in extreme events,
2) land-use planning and zoning to keep unsafe developments out of high-risk zones, and
3) good warning and preparedness systems that can greatly reduce loss of life and limit property damage.

International cooperation toward these actions can now be undertaken within the framework of the International Decade for Natural Disaster Reduction (IDNDR) of the 1990s. Indeed, the IDNDR provides all countries with the opportunity and means of cooperation that could help to reverse the terrible trend toward ever greater losses in natural disasters. And within the IDNDR, national preparations by 130 countries or more for the United Nations declared World Conference on Natural Disaster Reduction in Yokohama, Japan, May 1994, provide a stimulus to create plans for the second part of the decade. These could lead to significant reduction in disaster losses, both human and economic.

At the same time, actions must be supported to assist those attempting to maintain forest and vegetative cover that would reduce flood and drought incidence. On the climate front, purposeful adaptation to extremes seems increasingly imperative. Adaptation measures are needed whether the recent run of disasterous events is part of a long-term, anthropogenically driven trend toward increasing risk of climatologically related natural hazards, or simply part of the variability of the climate system.

From the limited information available, it is entirely possible that the human-induced changes in radiative forcing of the climate system is resulting in greater climate extremes. However, this aspect of studies of climate change has received relatively little attention. Much more definitive and peer-reviewed research is needed. The Intergovernmental Panel on Climate Change should focus more attention on this topic in its second assessment report due in 1995. Indeed, it is probable that climate changes induced by greenhouse gases will not be felt through long slow rises in mean temperature, but through increased frequency of extreme events (Houghton 1994). Thus, it would be prudent, as a third preventative action to reduce disaster losses, to lend support to those working to limit anthropogenic climate change through the now-ratified international Framework Convention on Climate Change.

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