



# *Water and Ethics*

## ETHICS OF WATER-RELATED DISASTERS

*James Dooge*



UNESCO International  
Hydrological Programme



World Commission on the Ethics of  
Scientific Knowledge and Technology



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# Preface

This essay is one of a series on Water and Ethics published under the International Hydrological Programme of UNESCO. A Working Group on the Use of Fresh Water Resources was established under that programme in 1998. Preliminary drafts on fourteen aspects of this topic were prepared under the guidance of this Working Group.

An extended executive summary was prepared by J. Delli Priscoli and M. R. Llamas and was presented to the first session of the World Commission on the Ethics of Scientific Knowledge and Technology (COMEST) held in Oslo in April 1999. At the latter meeting, COMEST established a sub-commission on the Ethics of Fresh Water under the Chairmanship of Lord Selborne. The first meeting of this sub-commission was held at Aswan in October 1999. A 50-page survey by Lord Selborne on the Ethics of Fresh Water, based on the above meetings and documents, was published by UNESCO in November 2000.

Since then, the original draft working papers have been revised under the editorship of James Dooge and published on CD ROM as an input to the Third World Water Forum held in Kyoto in March 1993. These are now being published in printed form as the first fourteen titles in a series of Water and Ethics

These essays are written from the point of view of experts on different aspects of the occurrence and use of fresh water who are interested in the ethical aspects of this important subject. They do not purport to be authoritative discussions of the basic ethical principles involved. Rather, they aim at providing a context for a wide-ranging dialogue on these issues between experts in diverse disciplines from the natural sciences and the social sciences.

James Dooge  
John Selborne

This essay discusses the nature and impacts of water-related disasters and the scope for the mitigation of the vulnerability of communities to such disasters.

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# 1. Hazards and disasters

## 1.1 *Problems of terminology*

The first difficulty encountered in the study of disasters is the profusion and confusion in relation to definitions. The first step in seeking to resolve the confusion is to distinguish between the concepts of (a) a hazard, natural or man-made, and of (b) a disaster, in terms of deaths, injuries, disruption, damage etc. The link between the two is the concept of vulnerability which is a measure of susceptibility to injury or damage. Blaikie et al. (1994) have defined this concept as follows:

By vulnerability we mean the characteristics of a person or group in terms of their capacity to anticipate, cope with, resist, and recover from the impact of the natural hazard.

The variation of vulnerability between countries and between socio-economic groups in a given country is a vital factor in considering the ethical problems arising from disasters.

Accepting that the risk in any situation is a function of both the hazard and the local vulnerability, it is necessary to agree on some definitions for all three elements. For our purpose, the most useful source for such definitions is the UN Department for Humanitarian Affairs (DHA) whose terminology was used in the International Decade for Natural Disaster Reduction 1990–2000. In this terminology (DHA, 1992), hazard is defined as:

a threatening event, or the probability of occurrence of a potential damaging phenomenon within a given time period and area.

This definition is appropriate for both man-made hazards such as technological hazards and hazards arising from armed conflict as well as for natural disasters. The complementary factor of vulnerability is defined as:

degree of loss (from 0% to 100%) resulting from a potential damaging phenomenon.

Finally, the resulting risk is defined as (DHA, 1992):

expected losses (of lives, persons injured, property damaged and economic activity disrupted) due to a particular hazard for a given area and reference period.

In mathematical calculations and in risk mapping, risk is frequently taken as the arithmetical product of hazard and vulnerability.

## 1.2 Classification of disasters

In order to place water-related disasters within the context of disasters in general, it is necessary to consider the various types of hazards and disasters that have the potential to afflict mankind at the present time. In planning national programmes for disaster mitigation, experience arising from dealing with man-made disasters can be useful in preparing to cope with natural disasters and with integrating the programmes for both types of disaster where appropriate. There is a clear distinction between cataclysmic disasters with a rapid time scale and long-term disasters that develop over a much longer time scale. Cataclysmic disasters include floods, cyclonic storms, earthquakes and volcanic eruptions; long-term disasters include droughts, crop failures and prolonged war or civil conflicts. Both types of disaster are increasing in time at a rate well above the rate of increase of population.

Floods account for over a quarter of disasters as indicated by Table 1 (Hagman, 1984) which relates to the decade of the 1970s. Droughts accounted for over one-half of the numbers affected by disasters over the same period. More recent statistics for sudden natural disasters (i.e. excluding droughts) indicate that flooding accounted in 1997 for 26% of such events, 43% of deaths, 46% of economic losses and 36% of insured losses (Munich-Re, 1998). Accordingly, it is clear that water-related disasters represent a large segment of the total global picture of disasters and their human impacts.

**Table 1 . Water-related disasters**

<i>Type of event</i>	<i>Disasters per year</i>	<i>No. affected per year</i>
Floods	22	15,400,000
Tropical cyclones	15	2,800,000
Droughts	10	24,400,000
Earthquakes	8	1,200,000
Others	20	500,000
<b>Total</b>	<b>75</b>	<b>44,300,000</b>

### 1.3 Phases of a typical disaster

Disasters differ widely in regard to the causal hazard, the vulnerability of the local community and the time scale of the disaster impacts. Nevertheless there is a common morphology which allows us to identify various phases in a typical disaster. These can be described as:

- the anticipatory phase
- the warning phase
- the impact phase
- the relief phase
- the rehabilitation phase

and they apply to all types of disaster. Of necessity the time span of each of the phases will naturally vary with the type of disaster as will the relative importance of the phases and the relative importance of different types of activity within each phase. Nevertheless the structure is useful as a basis for the discussion of local problems and for the integration of appropriate measures for disaster reduction into a national development programme, as recommended by the 1994 World Conference on Natural Disaster Reduction in Yokohama (IDNDR 1995a and 1995b).

The anticipatory phase includes risk assessment involving both hazard probability and local vulnerability, codes of practice for buildings and services, structural measures for hazard reduction, special planning controls, training of emergency staff, and promotion of public awareness.

The first element of the warning phase is the continuous monitoring of hazard indicators that give advance warning of a hazardous event to the appropriate specialist staff. A second element is an advanced warning system that alerts local authorities and emergency services of a possible disaster situation. The third element is a public alert.

During the impact phase, the response in the case of cataclysmic disasters is completely dependent on the local community. In the case of slowly developing disasters, such as droughts or the annual Bangladesh flooding or prolonged civil conflict, support and relief from other parts of the country or from abroad may be available. The impact phase involves activities such as search and rescue efforts, emergency repairs, evacuation, etc. The relief phase, which involves external help, is concerned with such matters as emergency supplies, restoration of services, temporary housing, etc. (Arthur, 1977).

The final and prolonged phase is that of rehabilitation. This includes many activities of which some of the most important are physical reconstruction, personal rehabilitation, and post-hoc evaluation of the procedures under each of the five phases. The latter element of thorough post-hoc evaluation and recommendations for

the future has only recently emerged even in developed countries. A good example of such a process is the Interagency Floodplain Management Review Committee (IFMRC, 1994) and the associated Scientific Assessment and Strategy Team (SAST, 1994) established following the 1993 Mississippi Flood.

## 2. Types of water-related disasters

### 2.1 *Precipitation-induced floods*

A flood is the occurrence of too much water in the wrong place. It may range in scale from an overflowing basin in a bathroom or a blocked drain that floods a single street or a single field to the Great Flood of 1993 which covered 15% of the contiguous land area of the United States (NOAA, 1994). Torrential rain over a small catchment area may produce without warning a flash flood which within a period of a few minutes or a few hours may produce damage that is quite disruptive to the local community. In the case of prolonged and widespread rainfall or snow-melt over a large catchment, the onset of flooding in lower reaches of the main river is more gradual but the volumes of water involved may become enormous.

Floods result in loss of life due to drowning, in damage to human settlements, in the destruction of most crops, and in increased soil erosion as well as secondary effects such as outbreaks of water-borne disease and damage to the environment. While the deposition of silt in a downstream area may be beneficial in some cases, it has the effect of reducing the capacity of flood control reservoirs and of changing the course of the river. Major floods on the Yellow River in China, which at times has a silt content of 40%, has had the effect of moving the mouth of the river by a distance of over 400 kilometres.

### 2.2 *Droughts and their consequences*

It is not only an excess of water that can cause a disaster. Lack of water can also have serious consequences for human beings and their economic activities. This was well described by Gaius Plinius Secundus (Pliny) in 77 AD in reference to the Nile Flood in his *Natural History*. The nilometers, which were erected to facilitate use of the extent of the Nile flooding as a basis of taxation, were calibrated in ells which corresponded to a unit of about 1.1 metres. Pliny characterised the normal flood levels between 14 and 16 ells as corresponding to the three outcomes of happiness (14 ells), security (15 ells), and abundance (16 ells). He equated an abnormally high level of

18 ells with disaster and the levels below normal as corresponding to suffering (13 ells) and hunger (12 ells).

Everyone agrees that a distinction should be made in the definition of the basic hazard between a climatological drought and a hydrological drought. However, there is little unanimity of agreement in relation to the definition within each category. Similarly there are differences in definition of the consequent agricultural drought and socio-economic drought. Finally there are differences in regard to the relative importance to be given to drought itself and to socio-political factors as contributors to disastrous famines (see e.g. Sen, 1981).

Of particular concern is the persistence of drought conditions over a number of years. Arid and semi-arid areas are characterised by high variability of rainfall throughout the year. Often the yearly rainfall is confined to a very small number of storms which produce flash floods in the dry wadis. Munich-Re (1998) comments that the resulting rise of water level by several metres in a few minutes 'gives rise to the well-known paradox that in the desert drowning is more common than dying of thirst.' The high variability of rainfall is a factor in such areas as the Sahel in North Africa where several hundred thousand died as a result of drought between 1968 and 1973. The basic underlying hazard was the failure of the Intertropical Convergence Zone (ITCZ) in certain years to move sufficiently far North to produce heavy rain in June and July over the six Sahel countries. This was aggravated by a number of social, political and economic changes whose effects were masked by a run of wetter than average years in the 1950s and the 1960s (Frampton, 1996).

### **2.3 Other water-related disasters**

While floods and droughts are the most serious types of disaster to be considered, there is a third category of water-related disasters which should be allowed for in any guide-lines on the ethics of water problems. These phenomena may for convenience be divided into four groups: (a) wind and water interaction; (b) instability of natural materials; (c) structural failures; (d) major incidents of water pollution. Only categories (a) and (b) are discussed below because the other two are essentially man-made disasters. All of these problems were discussed at a Technical Conference on the Hydrology of Disasters organised by the World Meteorological Organisation in 1988 in preparation for the International Decade for Natural Disaster Reduction 1990–2000. Over half of the resulting publication dealt with disasters other than floods or droughts and provides a good review of such problems (Starosolszky and Melder, 1989).

Storm surges occur in coastal areas and associated gulfs and estuaries due to the constant blowing of strong winds in an on-shore direction. A combination of such

storm surges with a high tide can result in devastating damage to such coastal areas comparable to or greater than that from major river floods. Similar damage can be caused by tsunamis which are immense sea waves generated in mid-ocean due to underwater geophysical events such as earthquakes, volcanic eruptions or landslides.

In the case of large bodies of inland waters, the same type of geophysical phenomena (wind, earthquakes, landslides or rockfalls) can set up periodic fluctuations of water surface which may be potentially dangerous. An example of a disaster arising from such an interaction of factors is that of the Vaiont Dam in Italy in 1963. A massive rockfall of 250 million cubic metres of rock, (possibly triggered by changes in sub-surface water conditions) into the reservoir upstream of the dam initiated a seiche which rapidly built up through resonance. Though the dam did not fail structurally, a spillway was eventually over-topped resulting in a flood wave which devastated the valley below the dam and claimed 2,500 lives.

Earthquakes, volcanic eruptions, and landslides of all types can create the potential for a disastrous flash floods by the creation of temporary barriers to the flow of streams and rivers which eventually fail due to the build-up of the water stored behind them. Yoshino (1989) lists seven earthquakes in Japan between 1331 and 1984 in each of which the mass of debris from slope failures exceeded 10 million cubic metres. A similar hazard exists in relation to the sudden release of water enclosed by or within glaciers, and to a lesser extent due to ice jams in rivers. The contributions to river flow in lowland areas from high mountain regions arise from both snow melt and glacier ablation. The variation in these two components, each of which can show up to 30% variation from year to year, are commonly out-of-phase with each other but occasionally coincide to produce potential conditions for either an exceptional flood or an exceptional drought (Hewitt, 1989).

## 3. Impact of droughts and floods

### 3.1 *The context of disaster impacts*

It was mentioned earlier that there are difficulties in the definition of various types of natural disasters and these are accompanied by further difficulties in obtaining objective, and reliable data in regard to natural hazards and their impact. Accordingly, it is not possible to present a complete quantitative picture in relation to either a single type of natural disaster or its comparison with other natural disasters.

Even if we confine ourselves to comparisons based on percentages and trends, the picture differs in some respects from one data set to another. Nevertheless it is useful

**Table 2. Impact of natural disasters (1960–79)**

<i>Type of disaster</i>	<i>Percentage of events</i>	<i>Percentage of persons killed</i>	<i>Percentage of persons affected</i>
Floods	30	5	29
Droughts	10	18	60
Windstorms	24	33	8
Earthquakes	14	33	2
Others	22	11	1
<b>Total</b>	<b>100</b>	<b>100</b>	<b>100</b>

to make certain comparisons and draw tentative conclusions. Table 2 shows the distribution in the twenty year period from 1960 to 1979 among types of natural disaster of number of events, number of persons killed and number of persons affected by that type of disaster. The percentages in Table 2 are based on figures assembled by the League of Red Cross and by the US Office for Foreign Disaster Assistance (Hagman, 1984). The table shows a clear dominance of water related disasters (89%) in the figures for number of persons affected but much less prominence in respect of number of persons killed.

Table 3 is based on figures from the 1997 Annual Review of Natural Catastrophes produced by Munich-Re Insurance (Munich-Re, 1978); it should be noted that droughts are not included in this compilation. In this table covering almost three

**Table 3. Impact of natural disasters (1960–79)**

<i>Type of disaster</i>	<i>Percentage of events</i>	<i>Percentage of deaths</i>	<i>Percentage of economic loss</i>
Floods	31	58	33
Windstorms	34	8	29
Earthquakes	15	26	28
Others	20	8	10
<b>Total</b>	<b>100</b>	<b>100</b>	<b>100</b>

decades from 1960 to 1997, the measure of economic loss due to water related disasters remains high (62%) and the percentage of deaths (58%) increases sharply. On the basis of either table the impact of droughts and floods is seen to be an important element of the total disaster picture. All sets of data on reported disasters agree that there is a marked increase in disaster impacts over time which cannot be ascribed entirely to wider and more careful reporting of such events. Taking the decade of the 1960s as a base, Wijkman and Timberlake (1984) estimate the following percentage increases for the following decade of the 1970s over the 1960s: 48% increase in number of events, 451% in numbers killed, and 66% in persons affected by the disasters. Munich-Re (1978) for the same period estimate an increase of 81% in number of events and a 92% rise in economic losses. For subsequent decades, Munich Re (1978) estimate a further rise of 140% in the number of events in the 1980s followed by a fall in the 1990s combined with a further rise of 59% in economic losses during the 1980s maintained into the 1990s.

### ***3.2 Impact of droughts***

The drought-prone areas throughout the world can be relatively easily predicted on the basis of large-scale meteorological phenomena. The general large-scale circulation of the atmosphere results in regions of descending air close to the tropics of Cancer and Capricorn resulting in low rainfall over such areas as the Sahara and the Arabian Deserts. Mid-continental areas remote from moist oceanic air masses may become deserts as in the case of the Gobi Desert. Areas in the rainshadow of a large mountain range obstructing the prevailing flow of air masses may become deserts because of the depletion of moisture from these air masses. The best example of this type of arid zone is the Atacama Desert in Northern Chile, said to be the driest area in the world. Because of their perennial condition of high aridity, such areas have sparse populations, usually with a nomadic life style.

More vulnerable to drought disaster are the semi-arid regions with alternating runs of wetter years in which herds are increased and more land cultivated followed by a run of dry years in which this level of activity cannot be sustained. In many of these cases, the mean annual rainfall is highly seasonal and may depend on the annual movement of the Intertropical Convergence Zone (ITCZ) which moves northward reaching the limit of its movement in June and July before reversing its motion and moving southward until January. It is the failure of the ITCZ in certain years to remain at its northern limit for a sufficient time that initiates a drought hazard in the sub-Saharan region of the Sahel. An aggravating feature of such dry periods is the persistence of the drought period for a number of years suggesting the existence of some positive feedback in the micro-climate system that intensifies the drought

susceptibly following an initial rainfall deficiency. There is increasing concern that, beyond a certain threshold of global warming, these large scale movements could be perturbed by an amount that could refresh the Gobi Desert at the expense of famine in more populated regions.

The impact of a drought on a vulnerable population depends on the interaction between a large number of factors: climate, environment, social conditions, technology, economics and politics. Famines do not occur simply because there is a lack of rain or even because there is a lack of food in a given locality. The other factors will vary from country to country but in all cases they are complex and significant in determining the extent of the impact of the drought condition on the local population (Sen, 1981).

The 1968–73 drought event in the Sahel is an interesting case study on which a large amount of information is available. Six countries were affected – Burkina Fasso, Chad, Mali, Mauritania, Niger and Senegal. The Sahel has experienced three major dry spells in each century since the 1680s. The pastoral nomads of the region mitigated the effects by their traditional customs and culture. In the past 50 years, a number of new factors – most of which would be approved of as progress towards development – have resulted in an increased fragility of the economic and social structure. These were aggravated by political factors and in many cases by armed conflict. Some authors regard the drought hazard as little more than the trigger that sets off a pre-existing social instability (Glantz, 1987; Frank and Chasin, 1980). These considerations are of vital importance when we come to consider the possible means of disaster mitigation and the ethical issues involved.

### **3.3 *Impact of floods***

The course of most well-developed rivers may be divided into three parts each with their particular flood problems: an upper reach with steep slopes subject to the sudden onset of flash floods, a middle reach with moderate slopes in which there is some time for flood warning but where the volume of water to be handled creates special problems and a lower reach where the slopes are gradual and the ground low-lying and where the flooding may be augmented by high tides or by wind-induced storm surges. The underlying causes of a flood hazard are: (a) heavy localised rainfall on an upland catchment or warm rain on a snow field or prolonged rain over a wider catchment; absence of vegetation due to either climatic condition or destruction by fire or deforestation; soils that are impermeable due to their heavy nature or to freezing or saturation or crusting. Urbanisation increases the magnitude of floods through such factors as increased impermeability of the surface, quicker runoff by artificial drainage systems, and constriction of natural waterways and flood plains.

This has led to an increase in flood insurance in developed countries (Swiss Re, 1998 and 2002).

Flash floods can occur in many types of climate region. Typical examples are the 1979 and 1990 floods in arid Northwest India (Sharma, 1997) and the 1997 flooding in the upper Odra in Poland (Kundzewicz, 1997; Kundzewicz et al., 1999). A well-documented example of a catchment wide flood involving the middle reaches of large river is the Great Flood of 1993 on the Mississippi and its tributaries (NOAA, 1994).

The perennial flooding in Bangladesh is a typical example of lowland flooding. It is necessary to distinguish between river flooding which is slow in developing but lasts a considerable length of time and coastal flooding intensified by sudden storm surges. (Frampton, 1996).

## 4. Vulnerability to disasters

### 4.1 *Variations in vulnerability*

As mentioned earlier the study of disasters and their impacts can be facilitated by separating the concepts of the causal incident (geophysical or technological or man made) and of the vulnerability of the affected individual or group. It is the combination of these two that determines the scale of the impact of the resulting disaster. In the case of natural disasters, a useful definition of vulnerability (already quoted in section 1.1 above) is that given by Blaikie et al. (1994) which reads:

By the vulnerability we mean the characteristics of a person or group in terms of their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard.

It is for the scientist and the engineer to explore the nature and evaluate the probability of the natural hazard itself and to propose solutions both structural and non-structural to the problem of reducing the hazard itself. Since such measures involve substantial costs, the question of the most economic option to pursue immediately arises. There has been a growing realisation in relation to disaster impact that we need to go beyond such an approach based on hazard and exposure factors and include considerations of the effect of social structures and political action on individual and group vulnerability.

The two most common measures of disaster impacts are loss of life and damage to property. A plot of the number of disasters in a country versus annual income

**Table 4. Variation of impact with income**

<i>Annual income per capita (US\$)</i>	<i>Annual number of disasters</i>
0–600	270
600–1,000	130
1,000–1,400	20
1,400–1,800	30
1,800–2,200	10
2,200–2,600	60
2,600–3,000	30
3,000–3,400	20
3,400–3,800	20
3,800–4,200	20
4,200–4,600	0
4,600–5,000	0
5,000–5,400	0
5,400–5,800	280

per capita as shown in Table 4 gives a U-shaped distribution with the one local maximum for extremely poor communities (270) and a second local maximum for rich communities (290) almost equal and the intermediate communities showing a much reduced number of disasters (Susman et al., 1983).

This arises because the poorest countries have the greatest loss of life and the rich countries have the highest level of damage to property. Haggmann (1984) found that middle and high-income countries tended to have on average 500 fatalities or less per individual disaster while low-income economies had on average 3,000 fatalities per disaster. For example, over the period 1960 to 1981, Japan suffered 43 disasters with an average of 60 deaths per disaster, Spain suffered 12 disasters with 250 deaths per disaster. In contrast, Ethiopia over the same period suffered 16 disasters with 6,440 deaths per disaster, Bangladesh suffered 63 disasters, with 10,050 deaths per disaster, China suffered 20 disasters with 12,350 deaths per disaster.

The effect of economic inequality within countries and within localities on variations in vulnerability has been well analysed by Sen in the case of famines (e.g. Singer, 1972; Sen, 1973 and 1981). We have an ethical duty not only to help the poor affected by water-related disasters but to help them to help themselves as a community. It might be thought that with time the vulnerability of a poor community

would be reduced through economic development. However, this is often an interactive process. Richards (1975) comments:

Just as natural processes such as lack of rainfall affect social structures, so social processes such as economic 'development' can affect natural systems causing famine and soil erosion for example.

In many cases, such economic development may increase vulnerability unless policies are in line with the principles of sustainable development (Anderson, 1995). The high vulnerability due to poverty and inequality is aggravated by degradation of the environment due to poor practices of land use and to the high rates of rapid population growth and urbanisation.

Vulnerability may be characterised as complex, dynamic, cumulative, sometimes irreversible, and frequently very difficult to contain (Anderson, 1995). Complexity is due to the fact that vulnerability to any type of hazard is specific to particular location, to particular groups in that location, and to the special circumstances of the particular place at a particular time. Vulnerability results from interactions between natural forces, environmental conditions, and socio-economic constructs. All of these factors vary in time and some of the interactions involve non-linearity and feedback mechanisms (both negative and positive). Accordingly, rapid changes may occur as well as long term trends. There is also the cumulative effect that a serious disaster may leave the community affected by it even more vulnerable to future hazards. Vulnerability may be irreversible due to the exhaustion of a resource such as the loss of fertile soil during a major flood which will increase the vulnerability to a subsequent rainstorm of the same magnitude. It may be impossible to confine the effects of natural hazard as in cases of the spreading of epidemics beyond the area of immediate impact of a flood or a drought. Only recently has the fact of the psychological impact of disasters become a subject of systematic study (Saenz, 1998).

The definition of vulnerability by Blaikie et al. (1994) quoted earlier covers coping, resisting and recovering from disasters. Accordingly, it follows that there is naturally a difference in the vulnerability of a rich farmer and a poor farmer in the same locality. The rich farmer can evacuate his family using his own truck and return after the event, repair the damage to his well-built house and replace lost livestock from his savings. The poor farmer is dependent on others for evacuation and has no savings to replace his flimsy home or his few livestock. His losses may be less in economic terms but to resume production he must borrow at a high rate of interest thereby increasing his vulnerability. These social differences are added to by differences in psychological perceptions and responses to disaster situations (Salas, 1998).

## 4.2 Vulnerability assessment

The nature of vulnerability to droughts and floods is fairly well established although reliable quantitative assessment is still a matter of difficulty. Vulnerability to droughts is influenced as much or more by social factors as by loss of crops (Blaikie et al., 1994). Mapping of drought impact at a local scale reveals anomalies such as those between data on famine deaths and crop deficits in Bangladesh (Currey, 1981) and in Ethiopia (Kumar, 1987). The lack of a clear causal link between drought and famine arises from inequity in the sharing of available food complicated by disparity in security and resources within the population. In the case of floods, there is the question of the dependence of vulnerability on class structure and other social factors including ethnic and gender issues (Blaikie et al., 1994).

The general structure of a vulnerability assessment procedure is the same for any type of natural disaster and for man-made disasters as well (Anderson, 1995). This may be divided into four steps:

- (a) identifying the nature of the hazard and estimating the probability of events of given magnitude and frequency;
- (b) identifying the degree of exposure of individuals, groups and communities;
- (c) identifying the causes of variation in vulnerability arising from socio-economic-political structures and practices; and
- (d) allowing for interaction between factors and in space and time and thus clarifying some of the anomalies found earlier and providing a basis for future planning.

To apply the above procedures requires expert staff, money and time. The geophysical data on hazards required under step (a) are available in many countries but there is wide-spread concern about the drastic deterioration in meteorological and hydrological networks in developing countries because of budget difficulties. Preliminary assessments under step (b) can in the case of floods and droughts be based on existing registers of land use. This is done by using average loss functions based on land use determined by special local studies and continually updated as more information is obtained. Steps must also be taken to inform the public of the facts in relation to risk (Lee, 1981).

Further problems arise in relation to the estimation of changes in vulnerability due to major changes of land use such as urbanisation. Mathematical modelling of the changes in hydrological regime and the associated changes in the risk of flooding and the possibility of mitigating potential disasters are being increasingly used. Riccardi et al. (1997) applied such an approach to the Rosario region in the Argentine province of Sante Fe. Subsequent legislation on planning and non-structural measures of flood control took account of the results of this study.

The above considerations of the relative contributions of hazard and of vulnerability to disaster impact lead to the conclusion that the vital factor in the reduction of such disaster impact is the mitigation by various means of the most severe types of vulnerability. This attitude is clearly reflected in the message from the World Conference on Natural Disaster Reduction held in Yokohama in May 1994. Paragraph 3 of the Affirmation reads (IDNDR, 1995a):

Disaster prevention, mitigation, and preparedness are better than disaster response in achieving the goals and objectives of the Decade. Disaster response is not sufficient, as it yields only temporary results at a very high cost. We have followed this limited approach for far too long. This has been further demonstrated by the recent focus on response to complex emergencies which, although compelling, should not divert from pursuing a comprehensive approach. Prevention contributes to lasting improvement in safety and is essential to integrated disaster management.

In implementing this approach, it is necessary to include in the anticipatory phase of our strategy for certain activities that will enhance the effectiveness of later actions taken in the warning phase, the relief phase, and the recovery phase.

## 5. Scope for mitigation

### 5.1 *Hazard assessment and reduction*

The first requirement in planning for disasters is to know the extent of risk and of its two main components – hazard probability and specific vulnerability. A second requirement is to establish a basic procedure for arriving at an optimum solution in a given case that involves input both from expert professionals and from local interests and is capable of receiving support from local communities, regional authorities, and central government.

Structural measures have been taken to mitigate flood damage to human settlements over the past three millennia. The construction of large dams to provide flood control has grown greatly during the past century and this has accelerated, particularly in the developing countries, over the past forty years. This has given rise to a huge debate about environmental effects and social consequences which is relevant to the topic under discussion but outside the scope of the present text. It is, however, pertinent to comment that in the Mississippi flood of 1993 the reservoir storage was rapidly taken up during the early part of the event so that there was no modification of the reservoir inflows during the later stages of the flood.

Recent decades have seen a greater involvement by those affected by reservoir construction in the planning and design of hydroprojects in developed countries as illustrated in Table 5 (Goodland, 2001). This tendency needs to be encouraged and extended.

**Table 5. Co-operation on design of hydroprojects**

<i>Period</i>	<i>Design team</i>	<i>Post-design evaluation</i>
Pre-1950	Engineers	Economists
1950–70	+ Economists	
Late 1970s		Environmentalists
Late 1980s	+ Environmentalists	
Early 1990s	+ People	NGOs
Late 1990s	+ NGOs	

An objective basis is necessary for rational discussion in the above process and for rational decisions by appointed arbitrators on unresolved questions. In the case of the comparison of structural and non-structural measures of flood control in a given catchment area, a number of such methods based on computer simulation have been developed. Typical of these is the ‘inundabilité’ method developed in France which in effect superimposes (1) a vulnerability map based on depth/duration/frequency relationships of flooding derived from local surveys and (2) a hazard map based on flow-frequency/duration relationships for river flow derived from a hydrologic model and combines these to produce a synthetic map showing areas that are under-protected in red, those that are over-protected in green, and those whose risk level is zero in yellow (Gilard, 1995; Gilard and Givane, 1997).

## **5.2 Disaster preparedness**

The first large scale effort to understand the linkage of drought and famine dates from over a hundred years ago when the British Administration in India issued Famine Commission Reports and drew up Famine Codes. There were detailed instructions in these Codes about early warning signs of famine, the duties of local officials, famine relief works, and many other practical issues (Blaikie et al., 1994). Despite the ideological preconceptions of that era, the reports contained sound observations and gave

rise to reasonably effective policies. Since that time there has been a confused debate about the causes of famine and other disasters with an undue emphasis on natural hazards as a substantial cause of disasters rather than as a trigger. About a hundred years after the introduction of the Famine Codes in India, writers such as Hewitt (1983) criticised the emphasis on the natural hazard as undervaluing the social factors promoting vulnerability and as productive of an undue reliance on structural and technological remedies.

The persistence in reliance on high-tech solutions by some experts and some governments is well illustrated in the case of the co-ordinated international effort to solve the problem of flooding in Bangladesh following the disasters of 1987 and 1988 referred to earlier. The two contrasting approaches are well summarised by Blaikie et al. (1994).

One aspect of preparedness for disasters is the ability of decision makers to learn from past disasters. In the case of the Upper Odra in Poland, an expert assessment in 1993 pointed out the inadequacy of the flood protection for large areas of agricultural land and for several large towns in the upper catchment (RZGW, 1993). Despite this there was a widespread lack of public awareness which was rudely shattered by the flood of July 1997 which killed 55 people, inundated 1,358 towns and villages, flooded almost half a million hectares of agricultural land, destroyed 480 bridges and in all was responsible for material damage in Poland amounting to US\$3 billion. This flood revealed many weak points both structural and non-structural in the flood mitigation system (Kundzewicz, 1997; Takeuchi and Kundzewicz, 1998; Kundzewicz et al., 1999).

The Japanese experience with floods over the past hundred years has been described as 'a series of painful adaptation processes with many surprises' (Takeuchi and Kundzewicz, 1998). In the post-war period in Japan, (1945–59) more than a thousand people were killed by floods in almost every one of the 15 years including 3,000 in 1956 and 5,600 in 1959. The climate during this period was wetter than average but other factors were more decisive. During the war, the flood control system was neglected and no money was allocated to channel and dike maintenance. After 1960, the annual toll of deaths due to floods was less than 600 except in 1962. Takeuchi and Kundzewicz state:

This is partly because the climatically wet period was over and few strong typhoons hit Japan since the big one in 1959. But more important reasons would be the progress of flood control works such as levees, channel improvements and dam construction and the changes in social behaviour and spirit of respecting human lives. Another most decisive reason was that better weather forecasting information became available and made public through radios and TVs.

The authors attribute these factors to 'the overall improvement of national strength, a reward of the peace.'

Preparedness for disasters involves both the establishment of monitoring procedures and planning of warning systems together with the raising of the awareness of vulnerable communities so that they will take advantage of such warnings. Even in the case of slow-onset disasters such as droughts, an objective monitoring of the hazard risk is required. In Australia, a country-wide network of rainfall stations, mainly operated by volunteer observers, forms the basis for a systematic drought watch service (Zillman, 2003). A Drought Watch Statement accompanied by maps is issued every month to relevant authorities and to the media.

### ***5.3 Planning for relief and rehabilitation***

Further aspects of preparedness requiring close co-operation with the local community are the planning of emergency procedures to be activated during the direct impact phase of a sudden disaster and the planning of the recovery and rehabilitation phases, particularly in regions subject to recurrent disasters. The emergency phase is almost totally dependent on local reaction to save lives and mitigate disruption. It involves such actions as search and rescue operations, first aid and medical assistance, restoration of essential services and, in some cases, emergency evacuation. It has been noted in past disasters that during this initial phase the local people show a resilience and a liveliness that only gives way to depression during the transition from the emergency phase to the recovery phase. An essential feature in maximising the potential for disaster mitigation during this phase is the promotion of awareness and some basic training during the anticipatory phase.

Advanced planning is also necessary in order to promote maximum benefit during the recovery and rehabilitation phase. Blaikie et al. (1994) discuss the general principles to be followed in this phase on the basis of a discussion of the handling of the recovery phases of the Peruvian Earthquake of 1970 and the Sudan Famine of 1983 onwards. They based their conclusions on the following twelve principles:

1. Recognize and integrate the coping mechanisms of disaster survivors and local agencies;
2. Avoid arbitrary relief assistance;
3. Beware commercial exploitation;
4. Avoid relief dependency;
5. Decentralize decision making when possible;
6. Recognize disasters as political events;
7. Recognize pre-disaster constraints;
8. Balance reform and conservation;

9. Avoid rebuilding injustice;
10. Accountability – the key issue;
11. Relocation is the worst option.
12. Maximize the transition from relief to development.

In the application of such principles the interests of the local community must be paramount and their views taken into account. For transient international experts and aid workers the event is one incident in their lives. For the national politician or administrator it is one problem among many. For the local people, the problem is a major determinant in their lives and the lives of their children.

Blaikie et al. (1994) end their broad study of vulnerability to disasters by setting out a further set of twelve principles reflecting their general conclusion that the environment cannot be made safer by technology alone. These merit quotation in full:

1. Vigorously manage mitigation;
2. Integrate the elements of mitigation;
3. Capitalize on a disaster to develop mitigation;
4. Monitor and modify to suit new conditions;
5. Focus attention on protection of the most vulnerable;
6. Focus on the protection of lives and livelihoods of the vulnerable;
7. Focus on active rather than passive approaches;
8. Focus on protecting priority sectors;
9. Measures must be sustainable over time;
10. Assimilate mitigation into normal practices;
11. Incorporate mitigation into specific development projects;
12. Maintain political commitment.

These principles based on the recognition of the key role of vulnerability in disaster impact point to the way forward to the development of a consistent and effective strategy for disaster management. A disaster ethic must concern itself with the obligations of governments, social groups and individuals to develop such a strategy.

The emergence of a debate about disaster ethics was almost certainly inhibited in the past by the overuse of the term 'disaster prevention' in earlier discussions of disaster policy. The assumption, conscious or unconscious, that most natural hazards could not be prevented led to an implicit assumption that no action except huge expenditure on structural measures could be effective in disaster mitigation. The growing use in the last two decades of terms such as 'disaster mitigation' or 'disaster reduction' has facilitated a more realistic analysis. The modern analysis based on mitigation of vulnerability to disaster impact provides a suitable background for consideration of the ethical problems that arise for individuals, special groups, and government authorities in relation to disasters.

## 5.4 Role of governments

The Yokohama message on Natural Disaster Reduction (IDNDR, 1995a) states:

The adopted Yokohama Strategy and related Plan of Action for the rest of the Decade and beyond will note that each country has the sovereign responsibility to protect its citizens from natural disasters.

The responsibilities in this regard are similar to those dealt with in Agenda 21. In the area of water resources, the Rio Conference on Environment and Development identified four specific objectives based on an interactive multisectoral approach: integration within national economic development policy, projects based on defined strategies and on full public participation, mechanisms for sustainable social progress and economic growth (UN, 1992). Similar principles should apply in the case of national programmes for natural disaster reduction.

The responsibilities of governments in relation to risk analysis in water resources management has been highlighted over the past decade. The Dublin Conference on Water and the Environment, (Young et al., 1994) which provided the official input to the Rio Conference on water problems, in dealing with the institutional support of water resources assessment stressed the need to 'establish and maintain effective co-operation at the national level between the various agencies responsible for the collection, storage and analysis of hydrological data'. Unfortunately, the past decade has seen a catastrophic decline in such hydrometric survey work in many undeveloped countries due to severe budget difficulties. This is an example of the effect of the international debt crisis on increasing the vulnerability of disadvantaged communities.

Clear guidelines for natural disaster, prevention, preparedness and mitigation are presented in the Yokohama Strategy and Plan of Action for a Safer World (IDNDR, 1995b). Unfortunately, financial support from groups or from countries which becomes available following a disaster is not forthcoming for disaster mitigation under which the return in human terms would be increased by a substantial factor. Implementation of the recommendation of the Yokohama strategy (IDNDR, 1997) would require a substantial shift in attitude on the part of political decision makers. However, the process has been initiated since its inclusion in a UN-sponsored Declaration and this deprives governments of the initial defence that they were unaware of the requirements of the situation.

Governments have a responsibility to promote awareness and provide timely warnings. The Dublin Conference on Water and the Environment in January 1992

included disaster preparedness and warning systems in its recommendations on the monitoring and surveillance of water resources (Young et al., 1994):

Establishment and enhancement of effective flood and drought warning and preparedness systems within the framework of the International Decade for Natural Disaster Reduction.

The same Conference included disaster awareness as part of environmental awareness when it recommended (Young et al., 1994):

7. Increase environmental awareness through education and public relations campaigns to stimulate behavioural change to conserve water, combat pollution, and increase disaster preparedness.

This was followed by the inclusion in the Yokohama Assessment of the status of disaster reduction in 1994 of the following comment as the first item on its list (IDNDR, 1995a):

A. Awareness of the potential benefits of disaster reduction is still limited to specialized circles and has not yet been successfully communicated to all sectors of society, in particular policy makers and the general public. This is due to a lack of attention for the issue, insufficient commitment and resources for promotional activities at all levels.

Again the responsibilities of governments have been clearly identified in the international arena.

The Yokohama Plan of Action is quite specific in regard to the need for political commitment (IDNDR, 1995a). It called on all countries to:

A. Express the political commitment to reduce their vulnerability through declaration, legislation, policy decisions and action at the highest level, which would require the progressive implementation of disaster assessment and reduction plans at the national and community levels.

The Plan of Action stresses that disaster mitigation should be incorporated in socio-economic development planning based on the assessment of the risk. It also recommends:

G. Give due consideration to the role of local authorities in the enforcement of safety

standards and rules and strengthen the institutional capacities for natural disaster management at all levels.

Basic structures and programmes can be set in place relatively easily but there remains the problem of financing some substantial activities.

While ethical considerations may require the redistribution of resources to reduce inequity within a given society, the position in regard to an existing inequality arising from scarce water resources or from above average disaster vulnerability in a given location is less clear. What is clear is that traditional methods of economic evaluation must be broadened to include indirect benefits and external values. The change in attitude in regard to sustainable development following the Brundtland Report (1987) and the Rio Conference (1992) has started the broadening process required. The radical new departure required to incorporate disaster vulnerability will require substantial discussion at all levels in society in order to reach a consensus. Essential requirements for success are a realistic assessment of hazard risk and local vulnerability and a clearer appreciation of the ethical considerations involved. Based on this knowledge a solution is possible and is most efficiently achieved through the involvement of local interests. This participatory principle is vital in relation to water-related disasters and is essential if the impact of such disasters is to be mitigated to the extent possible with a minimum diversion of resources.

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