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You can’t control the wind, but you can adjust your sails.

Yiddish proverb

This chapter assesses the nature and costs of water-related risks. Such disasters as floods and droughts take an enormous toll on human life, not to mention the social, economic and environmental losses they cause. Risk is growing, with human-induced emergencies now overtaking natural disasters. In 1999 alone, natural disasters accounted for at least 50,000 deaths. The burden of loss, of course, is greatest in poor countries, where thirteen times more people die from such events than in rich ones. Economic losses also tend to be larger as a proportion of the total economy in developing countries, and most are uninsured. Natural disasters may be unavoidable, but with better planning and prevention – risk management – their impact can be reduced.
There is a growing realization that the scale and frequency of water-related disasters is increasing, and that effective management and mitigation of water-related risk is an important issue. This is reflected in the resolutions of international meetings and in the priorities and programmes of United Nations (UN) agencies, such as in the International Conference on Freshwater (Bonn, December 2001):

- Floods accounted for half of the total disasters, waterborne and vector disease outbreaks accounted for 28 percent and drought accounted for 11 percent of the total disasters. Thirty-five percent of these disasters occurred in Asia, 29 percent in Africa, 20 percent in the Americas, 13 percent in Europe and the rest in Oceania (see figure 11.1). These factors are restricting the potential for improving socio-economic development and in many cases, lowered the Gross National Product (GNP) in poor economies by as much as 10 percent. It has been claimed that the economic losses from water disasters are currently equivalent to 20 percent of new investment needs in water.

The efficient and effective management of risk is fundamental to long-term prosperity. Risks arise from numerous human-made and natural phenomena, many of which relate in some way or other to various facets of water, including floods, droughts and pollution. The operation and management of water resources is not only exposed to extreme events generated as part of the natural weather cycle, but is also linked to economic and socio-political factors as well as human error.

Integrated Water Resources Management (IWRM), as the prevailing paradigm in water management, has been central to promoting the recognition that water meets a number of interrelated demands while forming an integral component of the economy and environment. Traditionally in the water sector, separate planning and operations strategies have been adopted for specific economic sectors, a practice that continues today. This narrow, sectoral approach, however, has probably limited the capacity for effective management of risk and uncertainty as well as

Figure 11.1: Types and distribution of water-related natural disasters, 1990–2001

- More than 2,200 major and minor water-related disasters occurred in the world between 1990 and 2001. Asia and Africa were the most affected continents, with floods accounting for half of these disasters.

obscuring certain types of risks inherent in the employed management measures (Delli Priscolli and Llamas, 2001).

The level of risk from sudden natural disasters is determined by the vulnerability of the society and the environment, combined with the probability that the hazard will occur. Climate change may exacerbate an existing vulnerability. For developing countries, the financial, human and ecological impacts are likely to be most severe, but their capacity to cope is weak. The floods in Bangladesh, Central America and Mozambique have illustrated the heavy human and environmental costs of extreme climate events. As such events become more frequent or more severe, the loss of life and livelihoods is likely to increase. The dimensions of social, economic and political vulnerability are equally related to inequalities, gender relations, economic patterns, and ethno-cultural divisions. It is also largely dependent on development practices that do not take into account the susceptibility to natural hazards.

Risk reduction refers to activities taken to reduce vulnerable conditions and, when possible, also the probability of occurrence. Vulnerability to disasters is a function of human action and behaviour. In the case of slow and unidentified disasters caused by environmental pollution, land degradation and climate change, risk reduction needs to focus on the source of the hazard.

Causes, Types and Effects of Disasters

General trends

A recent report by Munich Re (2001) notes that the number of major natural catastrophes has been increasing since 1950 (see figure 11.2). Along with this increase in the number of occurrences of floods, windstorms, earthquakes and volcanic eruptions, there has been a significant increase in overall economic losses and in uninsured losses in particular. According to Munich Re, natural disasters in 1998 caused at least 40,000 deaths around the world and 50,000 deaths in 1999. According to figures from the World Bank (2001), an estimated 97 percent of deaths related to natural disasters occur each year in developing countries.

Economic losses from the great natural catastrophes were estimated at around US$70 billion in 1999, compared with US$30 billion in 1990. In addition, more people were affected by disasters over the last decade – up from an average of 147 million per year (1981–1990) to 211 million per year (1991–2000). While the number of geophysical disasters has remained fairly steady, the number of hydrometeorological disasters since 1996 has more than doubled. During the past decade, over 90 percent of those killed by natural disasters lost their lives in hydrometeorological events such as droughts, windstorms and floods.

Figure 11.2: Trends in major natural catastrophes, 1950–2000

This figure clearly shows the increase of major natural catastrophes since 1950, leading to considerable human deaths (50,000 in 1999) and significant overall economic losses. Source: Munich Re, 2001.
Floods accounted for over 65 percent of people affected by natural disasters, while famine affected nearly 20 percent. Between 1973 and 1997 an average of 66 million people a year suffered flood damage, making flooding the most damaging of all natural disasters (Cosgrove and Rijsberman, 2000). According to a study by the United Nations (UN), about 44 percent of the flood disasters that occurred in the world during the period 1987–1996 affected Asia. These disasters claimed some 228,000 lives—corresponding to 93 percent of the total number of flood caused deaths in the world—and resulted in damage of US$136 billion to the Asian economy. In the 1990s alone, severe flooding devastated the Mississippi River basin (United States), and thousands lost their lives to flooding in Bangladesh, China, Guatemala, Honduras, Somalia, South Africa and Venezuela. Whether in loss of lives or property, the damage is enormous. Despite these figures, floods proved less deadly, accounting for 15 percent of total deaths from natural disasters, compared to famine’s 42 percent.

Several factors explain the increasing extent of disastrous flooding, among them the growing populations, denser occupancy of flood plains and other flood-prone areas, and the expansion of unwise forms of watershed land use. The hope of overcoming poverty drives many poor people to migrate. Frequently they move into places vulnerable to flooding and where effective flood protection is not assured. Informal settlements around megacities in developing countries are particularly at risk (see chapter 7 on cities). Massive deforestation and urbanization reduce water storage capacity and amplify flood waves (Kundzewicz, 2001). In Asia, where the majority of recent large floods have occurred, rapid growth of industry and services in the 1990s resulted in considerable change of land use pattern. In Thailand, for example, it caused a reduction of natural retention and storage in the lower Chao Phraya River basin, contributing to the downstream flooding by about 3,000 cubic metres per second (m$^3$/s), (see chapter 16).

Even countries located in dry areas, such as Algeria, Egypt, Tunisia and Yemen have not been safe from floods. Although counterintuitive, it is a fact that in dry areas, more people die of floods than from lack of water, as the dryness is a normal state to which humans have adapted, while floods strike unprepared populations suddenly.

Floods can have widely different characteristics. In major rivers, they rise and fall relatively slowly while in urban areas they can rise and fall in a matter of hours, even minutes, offering little or no time for response. The freezing and thawing of rivers can result in ice dams that cause widespread flooding upstream and then collapse with disastrous effects.

**Box 11.1: The Rhine Action Plan**

The global awareness of unanticipated high risk in international water courses was strongly influenced by the Sandoz Blaze in 1986, in the upstream section of the Rhine (western Europe). The accidental pollution incident had far-reaching consequences, triggering a successful and sustainable cooperation policy for protection of the Rhine by all countries bordering the river. The 1993 and 1995 major floods in the shared Rhine and Meuse Rivers forced the evacuation of 250,000 people, when flood protection dikes came close to collapsing. These events provided the impetus for the adoption of policies focused on mitigating risk and reducing vulnerability to pollution and flooding. They also drew attention to the risks of deterioration of both the ecosystem and groundwater resources, as well as increasing concern about more frequent extreme flooding and drought events, as a result of climate change.

The Rhine countries have adopted the 1998 Rhine Action Plan on Flood Defense. It involves spending up to approximately US$12 billion to reduce the exposure to risk of assets with a possible value of about US$1.5 trillion. The Action Plan marks a change from planned and defensive action to management of risk, and has opened the door to a wider range of measures for reducing risk in shared rivers. It also represents a first example of an international commitment to reducing shared risk based on the value of the assets at risk, as well as an agreed shared financial commitment to manage those risks. The Action Plan for risk mitigation builds on integrated risk management at the local, regional, national and supranational level and includes water management, physical planning and urban development, nature conservation and alternative improved practices in agriculture and forestry.

Source: Based on Worm and de Villeneuve, 1999.
Droughts

Droughts are undoubtedly the most far-reaching of all natural disasters. From 1991 to 2000 alone, drought has been responsible for over 280,000 deaths and has cost tens of millions of US dollars in damage. For example, sub-Saharan Africa suffered its worst dry spell of the century in 1991/92 when drought covered a region of 9.7 million square kilometres (km²) and affected about 110 million people. While droughts have always been a fact of life in Africa, the combination of drought with human activities such as overgrazing or deforestation may dramatically affect the desertification process and lead to a permanently or near-permanently degraded environment.

By the year 2025, the population projected to be living in water-scarce countries will rise to between 1 and 2.4 billion, representing roughly 13 to 20 percent of the projected global population. Africa and parts of western Asia appear to be particularly vulnerable.

Droughts have been categorized in three ways: as meteorological (due to a lack of precipitation), hydrological (lack of water in streams and aquifers) or agricultural (when conditions are unable to sustain agricultural and livestock production) (Houseran et al., 1975). The concept of what constitutes a drought varies between countries. In England, three weeks without rain is considered a problem; in many parts of the world much longer dry periods are normal. Duration and extents of droughts vary greatly. Examples of severe, persistent droughts over large geographical areas include the Sahel covering 7.3 million km² from 1970 to 1988, continental Europe covering 9 million km² from 1988 to 1992, and India covering 3 million km² from 1965 to 1967. There are other examples of extreme droughts in North America and Australia. Table 11.1 provides a summary of major drought events and their associated loss of life and economic losses as established by Munich Re. Extreme drought can affect large tracts of land and large numbers of people anywhere in the world and can persist from a few months to several years. The impacts of a drought hazard can have far-reaching social, economic and environmental consequences.

The effects of disasters

High stress results when many large disasters occur within a limited time span. The year 1999, for example, with several earthquakes, the Lothar storm in France, floods and mudslides in Venezuela and more than 50,000 deaths, still remains in political memory as the second most costly year in terms of global disaster and risk insurance indemnities. Stress is also high when one single region is hit by a sequence of several major catastrophes. One example is the Indian state of Orissa, which experienced massive flooding in 2000, followed in 2001 by the worst drought in a decade and new floods. Out of a population of 32 million, some 27 million people were affected. In poor countries, natural disasters generally result in larger economic losses in proportion to the economies. Depending on the robustness of the national economies, the negative consequences of disasters tend to be amplified as they erode the political and social stability of countries and upset the balance between the three necessary pillars for water resources management: economic development, environmental conservation and social stability (Appelgren et al., 2002). This is particularly the case when one disaster can virtually wipe out the investments made in infrastructure over the previous decade. Table 11.2 lists the severe natural disasters resulting in more than about 1,000 deaths in recent years. Most of these disasters occurred in developing countries, and the majority of the losses were uninsured.

The Zimbabwe drought of the early 1990s was associated with an 11 percent decline in Gross Domestic Product (GDP) and a 60 percent decline in the stock market; more recent floods in Mozambique led to a 23 percent reduction in GDP; and the 2000 drought in Brazil to a halving of projected economic growth. Even in developed countries, an extreme drought may cause considerable

---

Table 11.1: Major drought events and their consequences in the last forty years

<table>
<thead>
<tr>
<th>Date</th>
<th>Country or continent</th>
<th>Fatalities</th>
<th>Economic losses (US$M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1985–1987</td>
<td>India</td>
<td>1,900,000</td>
<td>100</td>
</tr>
<tr>
<td>1982–1985</td>
<td>Africa</td>
<td>250,000</td>
<td>500</td>
</tr>
<tr>
<td>1979</td>
<td>United Kingdom</td>
<td>1,000</td>
<td></td>
</tr>
<tr>
<td>1978–1980</td>
<td>Canada</td>
<td>3,000</td>
<td></td>
</tr>
<tr>
<td>April–June 1998</td>
<td>United States</td>
<td>15,000</td>
<td></td>
</tr>
<tr>
<td>June–July 1988</td>
<td>China</td>
<td>1,400</td>
<td></td>
</tr>
<tr>
<td>1983–1991</td>
<td>Angola</td>
<td>10,000</td>
<td></td>
</tr>
<tr>
<td>1982</td>
<td>France</td>
<td>1,000</td>
<td></td>
</tr>
<tr>
<td>Jan.–Oct. 1996</td>
<td>Greece</td>
<td>1,100</td>
<td></td>
</tr>
<tr>
<td>Summer 1996</td>
<td>Yugoslavia</td>
<td>1,000</td>
<td></td>
</tr>
<tr>
<td>Jan.–March 1997</td>
<td>African</td>
<td>1,000</td>
<td></td>
</tr>
<tr>
<td>May–Aug. 1998</td>
<td>United States</td>
<td>130</td>
<td>4,275</td>
</tr>
<tr>
<td>Jan.–Aug. 1999</td>
<td>India</td>
<td>3,000</td>
<td></td>
</tr>
<tr>
<td>Jan.–April 1999</td>
<td>Mauritius</td>
<td>175</td>
<td></td>
</tr>
<tr>
<td>Mar.–May 1999</td>
<td>United States</td>
<td>214</td>
<td>1,000</td>
</tr>
</tbody>
</table>

### Table 11.2: Severe natural disasters and their effects since 1994

<table>
<thead>
<tr>
<th>Year</th>
<th>Date</th>
<th>Event Type</th>
<th>Area</th>
<th>Deaths</th>
<th>Economic Loss US$M</th>
<th>Insured Loss US$M</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1994</td>
<td>Summer</td>
<td>Flooding</td>
<td>China, whole country</td>
<td>1,700</td>
<td>&gt;7,800</td>
<td></td>
<td>Landslide; broken dams; over 2 million dwellings destroyed; 40,000 km² of crops destroyed; 85 million affected.</td>
</tr>
<tr>
<td>1995</td>
<td>7 Jan.</td>
<td>Earthquake</td>
<td>Japan, Kobe</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6,348</td>
<td>108,000</td>
<td>3,000</td>
<td>782,000 buildings destroyed; 31,000 injured; 730,000 homeless</td>
</tr>
<tr>
<td></td>
<td>May–July</td>
<td>Flooding</td>
<td>China, south</td>
<td></td>
<td>1,980</td>
<td>6,700</td>
<td>Over 1.1 million houses destroyed; 3.8 million damaged; severe damage to infrastructure; about 3,420 injured</td>
</tr>
<tr>
<td></td>
<td>13 May</td>
<td>Earthquake</td>
<td>Russia, Sakhalin</td>
<td>1,041</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1995</td>
<td>27 June–</td>
<td>Flooding</td>
<td>China, central, north, west</td>
<td>2,700</td>
<td>24,000</td>
<td>446</td>
<td>Worst floods in 150 years, bridges, dams and over 5 million buildings destroyed; 8,000 factories affected (production stopped); damage to agriculture, infrastructure and supply facilities</td>
</tr>
<tr>
<td></td>
<td>13 Aug.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1997</td>
<td>10 May</td>
<td>Earthquake</td>
<td>Iran, north-east, Afghanistan west</td>
<td>1,573</td>
<td>500</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>15 July</td>
<td></td>
<td>Myanmar, central, north, west, south, east, Pagu</td>
<td>1,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dec.–Nov.</td>
<td>Flooding</td>
<td>Korea, central, south</td>
<td>1,050</td>
<td>2</td>
<td></td>
<td>Damage to over 5,000 buildings, roads and bridges; large areas cut off; food stores destroyed; water supply cut; over 250,000 people homeless</td>
</tr>
<tr>
<td>1998</td>
<td>4 Feb.</td>
<td>Earthquake</td>
<td>Afghanistan, north, Bamiyan</td>
<td></td>
<td></td>
<td>c. 4,600</td>
<td>95 S 1, affected region isolated; 28 villages destroyed</td>
</tr>
<tr>
<td>15 May</td>
<td></td>
<td></td>
<td>Afghanistan, north, Bamiyan</td>
<td>3,020</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 June</td>
<td></td>
<td></td>
<td>Pakistan</td>
<td></td>
<td></td>
<td>c. 4,500</td>
<td>95 S 1.1, 1,000 buildings destroyed or severely damaged</td>
</tr>
<tr>
<td></td>
<td>10 July</td>
<td></td>
<td>Bangladesh, eastern, north, south, 4,700</td>
<td>5,000</td>
<td></td>
<td></td>
<td>18,000 buildings destroyed; major losses to ports, storage buildings, oil tanks, salt factories and wind parks; severe losses to power supply</td>
</tr>
<tr>
<td></td>
<td>30 Sept.</td>
<td></td>
<td>Bangladesh, north, west, Barmal, 7,600</td>
<td>8,000</td>
<td></td>
<td></td>
<td>1.2 million houses damaged; severe losses to agriculture, livestock and infrastructure; epidemics (hundreds of deaths); 86 million people affected</td>
</tr>
<tr>
<td>1999</td>
<td>15 Oct.</td>
<td>Hurricane</td>
<td>Dominica, Puerto Rico,</td>
<td></td>
<td>5,000</td>
<td>3,300</td>
<td>500,000 feet of land damaged; houseboats, merchants and yachts, and to agriculture and forestry; major losses to the infrastructure, esp power supply</td>
</tr>
<tr>
<td></td>
<td>22 Oct.</td>
<td>Hurricane</td>
<td>Haiti, Nicaragua, Mexico, Costa Rica, 5,000</td>
<td>7,000</td>
<td>150</td>
<td></td>
<td>95 S 4, 250,000 houses damaged or destroyed; major losses to agriculture, systems severely affected; 10,000 missing</td>
</tr>
<tr>
<td></td>
<td>23 Oct.</td>
<td>Cyclone</td>
<td>Bangladesh, eastern, north, south, 9,200</td>
<td>7,400</td>
<td></td>
<td></td>
<td>95 S 4, 250,000 houses damaged or destroyed; major losses to agriculture, systems severely affected; 10,000 missing</td>
</tr>
<tr>
<td>1999</td>
<td>25 Jan.</td>
<td>Earthquake</td>
<td>Colombia, central, Quindio, 1,195</td>
<td>1,500</td>
<td>150</td>
<td></td>
<td>95 S 4, 250,000 houses damaged or destroyed; major losses to agriculture, systems severely affected; 10,000 missing</td>
</tr>
<tr>
<td>17 Aug</td>
<td></td>
<td></td>
<td>Argentina, central, north, west, 12,000</td>
<td>900</td>
<td></td>
<td></td>
<td>95 S 4, 250,000 houses damaged or destroyed; major losses to agriculture, systems severely affected; 10,000 missing</td>
</tr>
<tr>
<td>20 Sept</td>
<td></td>
<td></td>
<td>Taiwan, central, Tainan, 2,671</td>
<td>14,000</td>
<td></td>
<td>850</td>
<td>95 S 4, 250,000 houses damaged or destroyed; major losses to agriculture, systems severely affected; 10,000 missing</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>310,000 homeless; 11,000 injured</td>
</tr>
</tbody>
</table>
The 1988 drought in the United States may have caused direct agricultural losses totalling US$13 billion. The general view is that the recorded losses are underestimated and could be at least doubled when the consequences of the many smaller and unrecorded disasters that cause significant losses at the community level are taken into account. Devastation in the aftermath of the floods that ravaged many countries in Africa, Asia and elsewhere, and droughts that plagued all of Afghanistan, Africa, Asia and Central America are major setbacks for communities.

Table 11.2: Risk linkages and integration

<table>
<thead>
<tr>
<th>Sector/ sub-system</th>
<th>Natural, man-made disaster risk</th>
<th>Flow systems production risk</th>
<th>Social risk</th>
<th>Industrial risk</th>
<th>International risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural, man-made disaster risk</td>
<td>Reduced capacity to mitigate natural disaster impact</td>
<td>Chemical pollution disaster</td>
<td>Non-cooperation, conflict</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flow systems production risk</td>
<td>Affect strategic utilities and production</td>
<td>Multifunction, low production from social instability, collapse</td>
<td>Collapse of flow and production systems</td>
<td>Collapse of regional economic and environmental cooperation, food security, loss of economic resources</td>
<td></td>
</tr>
<tr>
<td>Social risk</td>
<td>Produce human loss, health, integrity out-migration, instability</td>
<td>High costs, economic collapse, instability, inequality</td>
<td>Health hazards</td>
<td>Out-migration, civil conflict, health hazards</td>
<td></td>
</tr>
<tr>
<td>Industrial risk</td>
<td>Insufficient investment for prevention and mitigation, chemical pollution</td>
<td>Pollution backlash, major industrial discharge and pollution</td>
<td>Labour instability and conflict</td>
<td>No access to technology, labour conflict</td>
<td></td>
</tr>
<tr>
<td>International risk</td>
<td>International impact, international conflict</td>
<td>International pollution, international instability, conflict</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(MRI=earthquake magnitude on the Richter Scale)

Mitigating Risk and Coping with Uncertainty

The first is knowing the risks. This means knowing the probability of the hazard to occur and establishing the vulnerability index and expected loss of life and possessions, injury and damage to the environment.

The second is defining and implementing the measures to reduce these risks. Such approaches can include 'structural' and 'non-structural' measures such as early warning systems and preparedness. However, for uncertainties and unidentifiable risks, the only option is for society to share the risks.

The third is in transference of risk, what is termed risk-sharing. It implies imposing risk on a wider group of people or in broadening the economic basis for support. In wealthy economies, this can be accomplished through insurance programmes¹ and other similar risk transfer mechanisms.

These instruments need to be used in combination with risk reduction, and are not themselves a solution to the cause of the risk.

Structural and non-structural measures

In attempts to mitigate the negative impacts of flooding, two general categories of measures or options exist: structural and non-structural. Structural measures include the building of physical works such as dams and dikes, but can also include channelization and dredging, creating additional artificial floodways, diversions and ponds, and armouring of channels to prevent erosion. Flood-proofing of existing structures has also witnessed rising popularity. Non-structural measures would include land use planning that promotes appropriate use of land within the floodplain and floodway and prohibits certain development and uses from occurring.

Acknowledging uncertainties

Risk identification and other risk management steps could provide invaluable indications and alert vulnerable groups, but could also establish perceptions of false security. As shown by the increasing number of unexpected large accidents, risk is often characterized by the uncertainty and incapacity of society to respond to early warnings. In this situation, there is an emergence of alternative approaches: the policy of fail-safe systems is now giving place to safe-fail ones. As stated during the International Conference on Water in Bonn: "It is impossible to design a system that never fails (fail safe). What is needed is to design a system that fails in a safe way (safe fail)" (Kuntzwerici, 2001). This acknowledges uncertainties and handles them through direct involvement of stakeholders as responsible managers and potential victims of the accidents, rather than through a technically refined analysis.

¹. Insurance of water risk is not attractive to the private insurance industry and the coverage has come from governments that possess neither the authority nor the resources, especially in developing countries.
Box 11.2: Methodology and terminology adopted by the ISDR

**Disaster**: A serious disruption to the normal functioning of a community or a society, which causes widespread human, material, economic or environmental losses that exceed the ability of the affected community/society to cope using its own resources. Disasters are often classified according to their speed of onset (sudden or slow), or according to their cause (natural or human-induced).

**Hazard**: A potentially damaging physical event or phenomenon that can harm people and their welfare. Hazards can be latent conditions that may represent future threats, as well as being natural or induced by human processes.

**Risk**: The probability of harmful consequences or the expected loss (of lives, people injured, property or environmental damage, and livelihoods or economic activity disrupted) resulting from interactions between natural or human hazards and vulnerable conditions. Conventionally, risk is expressed by the equation:

\[
\text{Risk} = \text{Hazard} \times \text{Vulnerability}
\]

The resulting risk is sometimes corrected and divided by factors reflecting actual managerial and operational capability to reduce the extent of the hazard or the degree of vulnerability.

For the purpose of economic assessments, risk is quantifiable and perceived in monetary terms. Taken from an economic perspective, risk is specified as the annual cost to the society from sudden accidental events and slow environmental degradation, determined from the product of the probability or frequency of occurrence and the vulnerability as social and economic losses in monetary terms:

\[
\text{Risk (economic cost per year)} = \text{Probability (once in n years)} \times \text{Vulnerability (economic cost/event)}
\]

**Risk assessment**: Investigates the potential damage that could be caused by a specific natural or human-induced hazard to people, the environment and infrastructure. The assessment includes hazard or multi-hazard analysis, probability and scenario; the vulnerability analysis (physical, functional and socio-economic); and the analysis of coping capacities and mechanisms. Risk assessment forms the necessary basis for the development of disaster mitigation and preparedness measures.

**Risk management**: The systematic application of management policies, procedures and practices that seek to minimize disaster risks at all levels and locations in a given society. Risk management is normally based on a comprehensive strategy for increased awareness, assessment, analysis/evaluation, reduction and management measures. The risk management frameworks need to include legal provisions defining the responsibilities for disaster damage and longer-term social impacts and losses.

**Uncertainty**: Different from quantifiable risks, uncertainty is defined as unidentified and unexpected threats and catastrophic accidents. Uncertainty often manifests as large unexpected ‘surprise’ threats and catastrophes and requires management approaches different from traditional risk management. Recent uncertainties are exemplified by the major floods in Europe and the United States in the 1990s, but also by the chemical pollution of the Sandoz Blaze in 1986 in the Rhine (Europe) and the non-water-related industrial incident in Bhopal (India) in 1984 which resulted in more than 10,000 deaths and 200,000 people injured. The main management issues of uncertainty concern the society’s incapacity to identify and react on weak signals; and as one consequence, the reluctance of decision-makers to assume related social responsibilities.

**Vulnerability**: A function of human actions and behaviour that describes the degree to which a socio-economic system is susceptible to the impact of hazards. Vulnerability relates to the physical characteristics of a community, structure or geographical area, which render it likely to be affected by, or protected from, the impact of a particular hazard on account of its nature, construction and proximity to hazardous terrain or a disaster-prone area. It also designates the combination of social and economic factors that determine the degree to which someone’s life and livelihood are exposed to loss or damage by a specific identifiable threat or event in nature or society.
Mitigating Risk and Coping with Uncertainty

Underlining the fact that risk forms a constraint on the willingness to invest and recognizing the large costs countries have to bear in adapting to the effects of water-induced shocks on their economies, the World Bank has emphasized the links between water resource variability and risk with the need for investments to mitigate the risks (World Bank, 2001).

Box 11.3: Initiatives coping with water-related risks

Underlining the fact that risk forms a constraint on the willingness to invest and recognizing the large costs countries have to bear in adapting to the effects of water-induced shocks on their economies, the World Bank has emphasized the links between water resource variability and risk with the need for investments to mitigate the risks (World Bank, 2001).

The United Nations Development Programme (UNDP) has assumed the operational responsibilities for natural disaster mitigation, prevention and preparedness within the UN system. Disaster reduction and recovery comprise essential components within development priorities, including poverty eradication and sustainable livelihoods, gender equality and the advancement of women, environmental and natural resource sustainability, and sound governance.

The World Health Organization (WHO), with mandated responsibility for emergency-related health hazards, has emphasized the consequences of water disasters and the growing risks such as inadequate drinking water and sanitation and uncontrolled spreading of toxic waste.

The Food and Agriculture Organization (FAO), under the food security programmes, is concerned with the development of agricultural systems that can sustain production during drought and flood. FAO has a long tradition of forecasts and early warning systems for regional agricultural droughts.

The UN World Food Programme (WFP) is focused on emergency and post-disaster food relief and rehabilitation support during and after natural and human-induced water disasters.

The Global Water Partnership (GWP) has noted that risk management practices are important to the realization of IWRM goals, observing however that there has been 'relatively little attention ... paid to the systematic assessment of risk mitigation costs and benefits across water use sectors and to the consequent evaluation of various risk trade-off options' (GWP, 2000b).

National governments are exposed to water risk and recognize in general its critical importance. Several countries have recently made moves towards integrated risk-based approaches in water resources management.

- The Netherlands planned on turning its watercourses into a fully integrated technical and economic system but cancelled the scheme because of considerations of national and local risk. With intensive economic development and growing vulnerability, the social and economic risk from the emerging threat of sea level rise, aggravated by increasing subsol subsidence and rainfall, is high. As a result, the country has adopted an integrated risk-based water management approach where water risks related to quality, flood control, ecosystems preservation and groundwater management form the guiding factors for the national spatial development policy.

- In the recent dialogue on the Swiss position at the World Summit for Sustainable Development (WSSD), the Swiss Government, together with Swiss Re, a private reinsurance company, emphasized risk mitigation as an important component of water resources management (Swiss Re and Swiss Government, 2002). The Swiss Agency for Development and Cooperation (SDC) ‘fosters sustainable water management, with the focus on rural water supply and sanitation, integrated water resource management and disaster prevention and relief’. The Swiss WSSD document position will be applied to risk assessment, awareness-building and development of water-related risk-mitigating activities in the country.

- The Giulia-Venezia region in Italy is under high social stress from flood hazards and serious health hazards from long-term freshwater and coastal water pollution, together with other non-water-related social stress. The regional authorities are reviewing the management of the joint risk-based approach.
Hazard mapping

The World Meteorological Organization (WMO) and the Scientific and Technical Committee of the IDNDR (WMO, 1999), have initiated a joint assessment of risk from a variety of natural hazards - especially meteorological, hydrological, seismic and volcanic disasters. They found the need for standard methodology in different sectors where composite hazard maps are generally recognized as an important tool for joint assessment. Mitigation of risks from natural hazards depends on the implementation of risk management measures and political will. Risk management requires a long-term view, while governments operate more on short-term objectives and limited annual budgets, and are sometimes reluctant to commit expenditure for proactive risk management measures that are based on weak indications of possible future risks. Governments are, however, generally responsive to short-term emergency relief requirements.

An iterative process

Figure 11.3 shows that risk assessment and risk management are iterative processes wherein various options are assessed and an optimal solution with acceptable risk is attained, for which the possible measures and the cost are defined. It requires an assessment of what level of risk is acceptable, given that it is not generally possible to reduce risk to zero. The acceptability of certain risks may vary both in different countries and in time.

The economic grounds

Decisions on risk management may be taken on economic grounds. The costs and benefits associated with managing the risk from a particular hazard can be compared to the returns from other investments, both within the water sector and other public health and safety areas, to maximize the effectiveness of public funding. It is also important to note that social acceptability is a contributing factor in making good decisions. It should be recognized that decisions about allocation of risk are often made more as part of political economic processes than through public consultation or participation (Rees, 2001). Establishing effective mitigation of risk and uncertainty therefore depends on the level and the strength of the political economy (see box 11.4).

While the impact of water disasters (mainly from flooding, drought and pollution) is apparent, there is an even greater impact in terms of future social costs. Appropriate investment strategies and a redirection of resources into prevention offer the potential for significant...
Mitigating Risk and Coping with Uncertainty

I common risk covering wide-ranging socio-economic factors that particularly great in the fragile developing and transition economies.

Private risk encompassing well-defined risks that can be covered into two categories:

- Private risk encompassing well-defined risks that can be covered by insurance policies; and
- Common risk covering wide-ranging socio-economic factors that ultimately must be borne by governments.

Box 11.4: Political economy

Politicians have the incentive to balance allocation of budgets in a way that preserves political support. Political sustainability is important, and security and stability, together with distributional goals, make up important aspects of political agendas and are often given higher priority than efficiency. Efficiency losses to society and the microcredits imposed on the public could therefore be substantial, but are often disregarded. In the political environment, therefore, policy often responds more to short-term concerns than to the long-term consequences to society. The objective of policy selection clearly differs from maximizing efficiency. One practical consequence is that, to be effective, policy analysis and formulation need to be adapted to the preferences of policy-makers.

Water sector risk management in terms of political economy is still based on reactive approaches and therefore has limited political currency. At the same time, however, the recognition of risk is sometimes already seen to be in contention with economic development and environmental conservation and could lessen economic prospects and competitiveness and repel investments.

Managing floods

Risk potential in flooding is expressed as the relationship between the magnitude of the flood and its probability of occurrence. Vulnerability is a function of the land use at the location at risk of flooding. Assessment of the probability of floods requires several years of high flow records and is also constrained by the uncertainty that the same high flow patterns might not persist into the future. There is evidence and growing concern that increased emissions of carbon dioxide and other greenhouse gases are producing changes in the world’s climate. The Intergovernmental Panel on Climate Change (IPCC) stated that ‘projections using the Special Report of Emission Scenarios of Future Climate indicate a tendency for increased flood and drought risks for many areas under most scenarios’ (IPCC, 2002). This raises the concern of uncertainty over the challenge of predicting future extreme runoff conditions and meeting the need for alternative approaches for managing flood risk under uncertainty.

Both droughts and floods impact directly on human well-being and health, especially in urban and rural areas where water supply and drainage facilities are inadequate. The most vulnerable are always the poor – those living in crowded, poorly protected peri-urban settlements, and subsistence farmers in rural areas – who cannot afford to protect themselves, or are ignorant about how to cope with the impact of changes in their environment.

Apart from the major threat of climate change, alterations to land use within the basin can affect the magnitude and frequency of floods. Urbanization of the land increases runoff and flood peaks, as observed in the Greater Tokyo region for example, where urbanized areas expanded from 13 percent to 20 percent between 1974 and 2000 (see box 11.5). Planning is an important non-structural measure for flood mitigation, covering the entire period from pre- to post-disaster. All parties, ranging from governmental and civil organizations to the local citizen, should know their roles and responsibilities. Everyone should also know exactly what is needed in terms of supplies and provisions, have them readily, and know how to respond when the hazard occurs. As part of this process, there should be a well-maintained contingency plan and vigilant flood forecast warning and alert programme. Experience has shown that local governments and citizens must be involved throughout the planning and implementation stages of such systems for them to be effective.
Losses from disasters do not cease once the flood has subsided. Post-disaster activities also decrease vulnerability and increase resilience. Relief during the first seventy-two hours of an event is critical in order to limit loss of life. Such relief requires the maximum possible lead time to enable pre-positioning and mobilizing of emergency assistance. Forecasts of non-significant events during periods of high alert are also important as they allow the re-assignment of human and other resources elsewhere. For example, according to the Chinese government, 90 percent of the 30,000 deaths from the floods in 1954 were a result of infectious diseases such as dysentery, typhoid and cholera, which struck in the period following the event (Worldwatch Institute, 2001). In contrast, after the 1998 flooding of the Yangtze, no such epidemics were reported. Additional post-disaster activities, beyond direct relief, include support to quickly restart the local economy and resume basic social services.

Flood control and mitigation is normally a high priority under International River Basin Commissions and in bilateral arrangements on transboundary rivers. Similar to the Rhine, flood management in the Lower Mekong basin will depend on being able to conserve the natural flood plain. Egypt and Sudan also have a long-established cooperation agreement for preparedness and operational management of the Nile summer floods.

Managing droughts

The onset of a drought is slow and very different from flooding with respect to the size of the affected area, the duration, the measures that can be taken to mitigate the impacts of the hazard and the ability to forecast the onset of the disaster. Nevertheless, many of the same principles put forth in the section on floods also apply to drought. Drought is associated with significant human and social economic losses, especially in poor developing countries where livelihood and food security depend on vulnerable rainfed subsistence farming and livestock production. It is also often claimed that drought results from a lack of distribution, know-how, and human and capital resources in poor regions (Delli Priscolli and Llamas, 2001).

From a risk management perspective the questions that arise are: how frequently can one expect a certain type of drought to occur? What are the vulnerabilities and expected losses? And what mitigation efforts or options are plausible and at what cost? It is then necessary to balance the cost of the mitigation efforts with the potential costs of the risks, and identify measures that will provide an ‘acceptable’ risk to society for the specific drought at the lowest cost.

Drought mitigation strategies may aim to reduce the vulnerability factor by, for example, altering land use and agricultural practices, or may modify the severity of the drought by flood control and mitigation measures that include improvement of the environment.

Box 11.5: Comprehensive flood control measures in Japan

Flood mitigation measures in Japan during the post-war rehabilitation period have both decreased the occurrences of major rivers overflowing their banks and limited embankment failures, reducing the severity of flood damage and the total area affected by it. In recent years, however, due to the remarkable shift of population and social assets into urban areas since the beginning of the period of high economic growth in the 1960s, urbanization has progressed in areas with a high risk of disasters: bracken marches, alluvial fans and cliffs. Today, 48.7 percent of the Japanese population and 75 percent of holdings are located within the flood-prone areas of rivers. The inflation of property values due to rapid economic growth and the continued concentration of urban property in floodplains have increased costs of flood damage in urban areas. Flood damage density (the ratio of damage to affected area) has risen sharply; and property damage due to river overflow and water collecting behind levees as a percentage of total damage has been on the increase as well.

River basins undergoing rapid urbanization are losing their natural water-retaining and retarding functions. At the same time, concentration of population and property in these urban river basins contributes to increasing ‘damage potential’ (the maximum amount of damage that could potentially result from a disaster). These problems are being dealt with through comprehensive flood control measures that consolidate the combined use of facilities to maintain the water-retaining and -retarding functions of river basins, the creation of incentives to use land safely and to build flood-resistant buildings, and the establishment of flood warning and evacuation systems.

Comprehensive flood control measures are implemented through the Council for Comprehensive Flood Control Measures, established for individual river basins and through the formulation of basin development plans that include improvement of the environment.

Source: Prepared for the World Water Assessment Programme (WWAP) by the National Institute for Land and Infrastructure Management (NILIM) and the Ministry of Land, Infrastructure and Transport (MLIT) of Japan, 2002.
Mitigating Risk and Coping with Uncertainty

Risk reduction is viewed as a technical problem, and often the responsibilities for mitigating disasters are fragmented. Geopolitical conflicts of the 1990s dominated the humanitarian agenda, pushing aside the problem of vulnerability to natural hazards.

Responsibilities for mitigating disasters are fragmented.

Risk reduction is not an integral part of water resource management and development.

Risk reduction is viewed as a technical problem, and often the underlying factors that compel people to live in insecure conditions are ignored.

Perspectives in the Management of Risks

Constraints to the achievement of effective risk management vary and include crop insurance and relief programmes to ensure water for basic needs and provide food supplements.

Mitigation efforts typically include contingency planning that might comprise arrangements for alternative supplies, putting into force water economy measures and protecting priority uses. The slow onset of drought combined with drought forecasting can enable such measures to be implemented in advance of the emergency occurring.

The improvement in recent years in seasonal and long-term climate predictions, such as those issued by many national and regional institutes, including WMO’s Drought Monitoring Centres in Africa, will assist effective implementation of contingency plans.

There are a variety of longer-term mitigation measures that can be taken. These include changing crop type, recognizing lands that are indeed marginal and appropriately changing agricultural practices, and constructing reservoirs. Populations will eventually have to build their security at a local and family level. An important requirement is, therefore, to identify and establish strategies that enable the community to cope with droughts, including revival of traditional customs for cultivation and livestock.

Relocation of populations is another possible long-term measure that is being debated. However, the social capacity to handle migration and resettlement are issues that warrant careful consideration.

Donors dedicate far fewer resources to risk reduction than to relief. While risk reduction technology and programmes are very important, the call is for enhanced responsibility for social water risk and recognition of a number of basic economic, institutional, legal and commercial constraints to the achievement of effective risk management.

Economic constraint: one major constraint to successful management and reduction of risk is that of recovering the costs from the beneficiaries. The dilemma, expressed in economic terms, is that management and risk reduction measures respond to a public good. Different from quantity and quality, risk mitigation responds to a public good that is non-exclusive and non-rival and economic practice suggests that it will be underprovided by private markets or not provided at all due to the free-rider aspect of the good. For the same reason, risk mitigation has no efficient marginal price and cost recovery becomes complicated especially in a market-based economy. If risk reduction is the only source of an investment pricing at marginal cost, some lump sum measure to allocate and recover costs is necessary. These non-separable costs are however not often included or recovered as part of land taxes. Faced with budget constraints and the trend of transferring water management responsibilities to the private sector, national governments are experiencing difficulties supporting increasing risk management from public budgets.

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Institutional constraint: water constitutes one of several risks under the responsibility of Prevention and Civil Protection outside of the water sector. As a consequence, management of water-related risk is often relegated to a technical side issue at a subordinate level and not integrated into the political economic allocation process in the water sector or other strategic sectors.

Legal constraint: for reasons already mentioned, risk is not always considered in project selection and resource allocation for economic development, notwithstanding that the responsibility of managing and mitigating natural and human-induced disasters is provided under the principles of precautionary and preventive action adopted in many national, regional and international water and environmental legislations.

Commercial constraint: the accommodation of hydrological risks as a calculated insurance risk is hampered by the fact that the vulnerable objects are spread over extensive common areas where a multitude of other risks are added up to a very large covered and uncovered total insured risk. In this case not even...
reinsurance companies accept the risk, and governments might not have the financial strength required to assume the ultimate financial responsibility.

Public and private responsibilities

In traditional systems, water users are accustomed to operating and sustaining production and social services under insecure and extreme climatic and economic conditions. As the systems grow more complex individual responsibilities to manage water-related risk are assumed by state administrations. Box 11.6 summarizes the evolution of responsibility for risk in the water sector over the last forty to fifty years as it has occurred in western Europe.

But deregulation, privatization and market liberalization, unless accompanied by a shift of responsibility for risk to the private sector, may leave the state with a responsibility that is not commensurate with its resources. For example, the community-based risk identification studies under the National Flood Insurance Programme (NFIP) in the United States amounted to about US$115 billion for 18,760 communities.

For a number of social, institutional and scientific reasons that range from climatic variability to economic globalization and liberalized market economies with their reduced roles of government, the management of risk and uncertainty has come to the forefront. Natural and human-induced hazards are becoming one of the major challenges to the management, protection and conservation of water. They risk undermining other efforts to attain development targets. While international organizations and in particular several national governments have adopted integrated risk-based management approaches, the institutional inertia and even resistance to full recognition of the wider scope of risk mitigation in the water sector persists. Risk and uncertainty continue to represent weak links in management of water systems. Parallel to the progress of traditional risk mitigation, there is a call to national governments and international organizations for alternative management approaches and adjusted governance responsibilities that need to be recognized, assessed and acted upon.

Citizens are becoming conscious of and affected by growing social costs of disasters such that the importance of risk management and uncertainty can be expected to emerge as major social and political challenges in water resources in the next decades. Figure 11.4 demonstrates the parallel and closely linked trend from natural to human-induced disasters in the causes of food emergencies. The evolution is towards wider social responsibility to control also the causes of disasters.

New challenges

New challenges have arisen in the control and mitigation of new and less well-known long-term risk and uncertainty, which are adding to the costs and problems of managing natural hazards. Traditional risks include unreliable or unsafe supplies for urban water supplies and irrigation, in particular for large urban settlements that depend on one source (hydrological risk) or one

**Box 11.6: Evolution of responsibility for risk-based water resource management**

- **Up to 1945**: Single-structured economies; traditional management system based on individual responsibilities.
- **1945–1980**: Management responsibilities, including prevention and civil protection assumed by the State.
- **1970–1990**: Often in conflict with reduced government role and resources, the functions are expanded to provide for IWRM.
- **1980–2000**: In conflict with a trend of growing risk and crisis, no-risk based and development-focused management is continued. Risks are dodged by integrated management and planning, with constructs for participation and far-reaching provisions for sustainable development, precaution and preventive action obscuring state responsibility.
- **Since 1990**: End of the no-risk era, with more frequent, severe human-induced and natural accidents including industry-, pollution- and health-related catastrophes, accompanied by civil accidents, violence, and civil and ethnic conflict at growing social costs. No-risk based integrated management and planning approaches become insufficient to manage increasingly frequent, large and long-duration accidents.
- **Today**: No-risk to high-risk change renders current approaches non-operational, initiating a decline towards broader social crisis; and risk-based management approaches are needed that build on defined responsibility and timely, risk-based decision-making to pro-act on unanticipated and invisible threats.

Source: Appelgren et al., 2002.
mitigate system (infrastructure risk). There are also localized risks from improper sanitation, risks of chemical and toxic pollution from industrial sites, as well as risks from accidental pollution of freshwater water bodies, coastal waters or aquifer systems. In addition to the sudden or relatively rapid-onset disasters, there are long-term environmental pollution risks such as accumulation of toxic agents in the water and the soil.

Data on the linkages between disasters and poverty are not always available, sometimes for political reasons. However, the statistics show that the victims of disasters in places where preparedness has been low are generally the poor and the marginalized, most of whom live in low-quality housing in flood-prone or drought-prone regions or along polluted watercourses. The poor are the most vulnerable to disasters, being exposed to the resulting health hazards but without the capacity to prepare for them or re-establish the life-supporting conditions after the catastrophes. Another tragic consequence is that flood and drought are also the main causes of poverty and the displacement and migration of poor populations.

Clearly, there is a close relationship between poverty eradication and the establishment of Comprehensive Disaster Risk Management (CDRM) strategies, which take account of economic, social and environmental dimensions in assessing risk and planning for preparedness measures in advance of water-related extremes. In making decisions about flood and drought management, it is important to broadly involve various stakeholders, even while devolving as much responsibility as is feasible to lower or community levels. There is an evident trend towards bringing together national and local governments, the private sector, non-governmental organizations (NGOs) and other representative groups of civil society in preparedness exercises. Such consultations build consensus about preparedness strategies and can help minimize risk. Encouraging public participation in self-protection strategies has been a successful strategy in some areas, as the Tokyo case study shows in chapter 22.

In many developing countries, women and female children are frequently the main providers of water for household use. Drought alleviation could reduce the annual expenditure of many million women years of effort to carry water from distant sources. Women

\[2. A\] unit of measurement based on a standard number of woman-days in a year of work.
play a central part also in management and safeguarding of water, which makes it critical to involve them at all levels of the decision-making process. In some cultures, it is important to recognize that response to flood warning is largely gender-dependent: there are examples of married women ignoring flood warnings in the absence of their husbands.

Risk and uncertainty may exacerbate existing tensions in other ways too. In transition countries in particular, risk and uncertainty can worsen political differences and regional instability arising from disputes over shared water resources. In this case, sharing the risks becomes just as important as allocating of water resources and its associated benefits. Box 11.7 presents the example of common risk in water resources and the prospect for sharing the common risk between the non-stabilized post-Soviet economies in transition in Central Asia.

Box 11.7: Shared regional water resources in economies in transition

The risk for unexpected crises in transboundary water systems, where regulation is based on voluntary cooperation between sovereign states, is generally high and complicated to manage, even in stable and industrialized regions. In transitional and unstable regions and economies that are experiencing emerging and unanticipated risk, social instability and conflict, the need for a risk-based approach to the management of water resources is even more important.

In the post-Soviet central Asia subregion where most of the water resources are shared between the new states of Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan, there is evidence of emerging undefined high risk and instability. This unstable and high-risk situation should allow for the development of joint management of common risk rather than engender further conflictive hydropolitical and development issues in the subregion. A joint risk-based approach for the management of the shared water resources will allow the central Asian countries to engage in joint preventive development and focus on identifying and managing emerging water risk to support and ensure regional stability.

Accountability, Monitoring and Indicators

In the present situation when the consequences of water-related disasters in all regions are severe, there is a need for practical indicators to support inter-regional comparison for the purpose of tracking trends and progress on management targets (policies) for reducing populations at risk from water-related hazards. In order to track progress and the sufficiency of policy, monitoring must be strengthened.

The indicators can be expected to foster country awareness and responsibility towards a coherent country-based approach to global and regional monitoring of water-related risk and uncertainty. Table 11.4 gives examples of low-cost indicators focused on risk losses and progress of risk reduction. The country values of losses and benefits need to be adjusted for local income and fluctuations in local currency.

Table 11.4: Examples of low-cost indicators focused on risk losses and progress of risk reduction

<table>
<thead>
<tr>
<th>Risk losses</th>
<th>Risk reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Past (10 years), present and future (25 years) losses (at different levels: basin, country, region, globally)</td>
<td>- budget and institutional provisions for risk-based management (total and by country established)</td>
</tr>
<tr>
<td>- in human life (number/year)</td>
<td>- budget allocation for water risk mitigation (total and percent of total budget/year)</td>
</tr>
<tr>
<td>- in real and relative social and economic values (total losses, percent of GNP, growth, investments and development benefits)</td>
<td>- risk reduction in flood plains (percent of total flood plain proportion)</td>
</tr>
<tr>
<td>- population exposed to water-related risk (number of people, income group)</td>
<td>- risk reduction and preparedness action plans formulated (percent of total number of countries)</td>
</tr>
<tr>
<td>- other than water-related risks (percent of losses from seismic, fire, industrial and civil stability risk)</td>
<td>- risk-based moisture allocation (country, international organizations, percent)</td>
</tr>
</tbody>
</table>

Conclusions

Global and local water-related risk is growing, resulting in an increasingly larger toll in human life and social, economic and environmental losses. Awareness of the enormous costs resulting from extreme events is encouraging decision-makers and water resource managers to give priority to the idea of integrating risk reduction and mitigation within normal management strategies.

The methodology and capacity to control natural disasters such as flood and drought have progressed in the last decades. However, as the trend is changing from natural to human-induced disasters and from known and manageable risk to higher uncertainty, the solutions based on engineering sciences are becoming increasingly ad hoc, fragmented and reactive and generally insufficient.

In the last decade, the debates on water governance and on management of water risk have increasingly been redirected to include ethical demands and management concepts based on political and economical realities. This change in governance responsibilities and attitudes has importance to the immediate victims of the disasters, who tend to be the poor and marginalized populations, but with special impact on women and children. The poor are exposed to the health hazards from natural and human-induced water disasters and lack individual capacity to prepare for or recover from them.

Agenda 21 emphasized the importance of mitigating floods and droughts. Eight years later, risk management, defined as ‘managing risks to provide security from floods, droughts, pollution and water-related hazards’, was given full recognition as one of the seven challenges listed at The Hague Ministerial Declaration in March 2000. The World Summit for Sustainable Development, held in Johannesburg in August/September 2002, reinforced this.

Combat desertification and mitigate the effects of drought and floods through such measures as improved use of climate and weather information and forecasts, early warning systems, land and natural resource management, agricultural practices and ecosystem conservation ... particularly in Africa, as one of the tools for poverty eradication (Plan of Implementation, 2002).

The risk is likely to grow in the twenty-first century, heralded as the age of water scarcity, while flood losses also show a rising tendency. Increasing vulnerability to water-related disasters is due to growing exposure, which in many cases cannot be matched by an appropriate adaptive capacity.

As a consequence, there is a call for alternative and more sustainable risk management approaches. The steps forward need to be scheduled as a period of smooth transition from current integrated management to pragmatic and straightforward risk-based management. The initial steps should be focused on:

- adopting a required incremental improvement approach to handle water problems within existing legislation and institutional structures to not waste time and efforts in trying to achieve ‘ideal’ water management approaches, laws and institutions;

Progress since Rio at a glance

<table>
<thead>
<tr>
<th>Agreed action</th>
<th>Progress since Rio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encouraging countries to set feasible and quantifiable targets for reduction in water related risks</td>
<td>Unsatisfactory</td>
</tr>
<tr>
<td>Facilitating the implementation of effective national countermeasures to climate change</td>
<td>Moderate</td>
</tr>
<tr>
<td>Recognizing the distinction between disasters resulting from natural hazards and those resulting from human action</td>
<td>Unsatisfactory</td>
</tr>
<tr>
<td>Improving collection of data and exchange information</td>
<td>Unsatisfactory</td>
</tr>
<tr>
<td>Improving forecasting systems, including early warning systems for the public</td>
<td>Satisfactory</td>
</tr>
</tbody>
</table>

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changing educational and research approaches to pragmatic decision-making instead of searching for perfection based on unachievable data bases;

invoking academics to build on the basis of the foundations they have constructed in IWRM, and allowing ethics to take a central role; and

invoking experts and officials with practical backgrounds in risk-based management from different sectors and disciplines (prevention and civil protection, legal and social medicine and public health, energy, financial and corporate sector, and the insurance and underwriting industry).

In order to achieve a more sustainable approach to managing risks, we must enhance recognition of water risks at political and economic level and entrench reduction and sharing of risk in development strategies. The management of risk and uncertainty to reduce social and stability uncertainty calls for integrated risk-based management approaches built on defined responsibilities at national and global levels.

References


Some Useful Web Sites*

- Secretariat of the United Nations Framework Convention on Climate Change (UNFCCC)
  http://www.unfccc.int/
  Part of the United Nations (UN) framework, this provides information relating to flood management and flood disaster reduction.

- World Meteorological Organization (WMO)/Global Water Partnership (GWP), the Associated Programme on Flood Management (APFM)
  http://www.wmo.ch/apfm/
  Site promotes flood management within the context of integrated water resources management.

- Secretariat of the United Nations Convention to Combat Desertification (UNCCD)
  http://www.unccd.int/
  Topics related to desertification, while staying in the context of sustainable development.

- United Nations Environment Programme, Floods and Droughts
  http://freshwater.unep.net/index.cfm?issue=water_flood_drought
  Strategies, links, documents and other resources for coping with flood and drought.

- United Nations International Strategy for Disaster Reduction (ISDR)
  http://www.unisdr.org/
  International site providing information, news events and training courses in order to increase awareness of the importance of disaster reduction.

* These sites were last accessed on 6 January 2003.