CHAPTER 1

Environmental Risks

1.1 WHAT IS AN ENVIRONMENTAL RISK?

The word 'risk' has two distinct meanings. It can mean in one context *a hazard* or *a danger*, that is, an exposure to mischance or peril. In the other context, risk is interpreted more narrowly to mean the *probability* or chance of suffering an adverse consequence, or of encountering some loss. Thus 'flood risk' can refer to the presence of a danger of flooding — a flood hazard, or more narrowly, a specific probability such as a 0.01 probability flood event (a 100-year flood).

Because the word 'risk' can be used in these different ways the term has led to some confusion. Three distinct views which emerged in the Tihany Workshop are recorded here because they reflect the present divergent state of informed scientific opinion.

1.1.1 Risk As Hazard

One school of thought sees risk as more or less synonymous with hazard; that is, an event or act which holds adverse *consequences*. In this view the degree of risk is related both to its probability and to the magnitude of its consequences.

1.1.2 Risk As Probability

Another school of thought would like to retain the word risk to apply solely to probabilistic statements. This school defines 'environmental risk' as the probability value of an undesirable event and its consequences that arise from a spontaneous natural origin or from a human action (physical or administrative) that is transmitted through the environment. According to this view the difference between 'impact assessment' and 'risk assessment' is that impact assessments are concerned with events that are reasonably *certain to occur,* while risk assessment is concerned with events that *may possibly occur.* Upon closer inspection the difference between 'certain' and 'probabilistic' events appears not in the *nature* of the events themselves but in the human understanding and description of the processes involved.

1.1.3 An Evolutionary View

In the third perspective the use of the term *risk assessment* is seen as an historical phenomenon. The first assessments dealing with evaluating effects or impacts did not employ probabilistic techniques. Termed *impact* assessments, they are used to describe the known impacts of various events, and employ rather straightforward quantitative techniques to estimate the magnitude of the impacts.

As the problems being assessed become more complex (which is in part due to our increased understanding of the interrelationship of events), the area of uncertainty concerning both the *nature* of the impacts and the *possibility* of occurrence became more important. To deal with these uncertainties, assessments began to make use of mathematical techniques, and in particular probabilistic theory and models of stochastic processes. Thus the assessments themselves became more sophisticated and complex. With the growing use of probability, the term risk assessment came into being to differentiate the new type of assessments from the earlier '*impact*' assessment that did not focus upon the conditional or probabilistic aspects of the event. In this view therefore risks are hazards in which the probabilistic element is important either for reasons of the state of knowledge, mode of analysis, or management, or all three.

1.1.4 Risk As Used In This Report

In this report, *risk* is taken to mean the probability times the consequence of an adverse or hazardous event. A broad meaning of risk is retained here because the report is concerned with the incorporation of risk assessment into environmental management. For the purposes of management, environmental risks have other relevant characteristics in common as well as their probabilistic nature. These characteristics justify an approach which treats environmental risks as a set of related phenomena. They include:

(1) The risks involve a complex series of cause and effect relationships. They are connected from source to impact by pathways involving environmental, technological and social variables which need to be modelled and understood in concert. There are thus common elements in the systematic approaches required for the study of risk.
(2) The risks are connected to each other. Usually several or many risks occur simultaneously within the same country, region, or city and this requires an ability to compare them and make trade-offs or balancing decisions about how much of one risk to accept in relation to another.
(3) The risks are connected to social benefits so that a reduction in one risk usually means a decline in the social benefits to be derived from accepting the risk. The social benefits of different risks are related to each other or may be very similar.

(4) The risks are widespread over the globe and concern many countries, both developed and developing. They occur in both industrial and agricultural sectors of the economy. There are advantages to nations therefore in comparing approaches to risks in the context of environmental management.
(5) The risks are not always easy to identify and sometimes identification occurs long after serious adverse consequences have been felt. There is merit in comparing the ways in which different risks arise and are recognized.
(6) The risks can never be measured precisely. Because of their probabilistic nature it is always a question of estimation. The methods for risk estimation have underlying similarities that can be described and improved.
(7) The risks are evaluated differently in social terms. Thus a risk considered serious in one place may be considered unimportant in another. It is important to understand why similar processes of risk evaluation can give rise to such dissimilar conclusions.

When used in this report 'risk' therefore means a hazard or danger with adverse, probabilistic consequences for man or his environment. When only the probability component of risk is meant, expressions such as 'risk probability' or 'probability of risk' are used. When used in 'risk assessment', the concept of risk includes not only probability and consequences but also how societies evaluate them.

1.1.5 Environmental Risks

The risks with which this report is concerned are all in some way 'environmental'. They arise in, or are transmitted through, the air, water, soil or biological food chains, to man.

Their causes and characteristics are, however, very diverse. Some are created by man through the introduction of a new technology, product or chemical, while others, such as natural hazards, result from natural processes which happen to interact with human activities and settlements. Some can be reasonably well anticipated, such as flooding in a valley or pollution from an industrial smelter. Others are wholly unsuspected effects at the time the technology or activity was developed, such as the possible effects on the earth's ozone layer of fluorocarbon sprays or nitrogen fertilizers.

While being diverse in themselves, environmental risks, as defined here, share a second common feature in addition to being transmitted through environmental media. They cause harm to people who have not voluntarily or specifically chosen to suffer their consequences, and thus they require regulation on the part of some authority above that of an individual citizen — that is, they require managing. These consequences can fall on other groups in

the future as well as today, as for example in the mismanagement of natural resources. In this report, environmental risks *exclude* personal choices such as smoking, rock-climbing or tampering with electrical circuits. The immediate consequences of this latter group fall upon the individual who is voluntarily accepting such risks and the government role is usually to educate the public rather than to regulate or control the risks. Even in these cases, the transmission of risk to others through environmental media can be of concern. The risks of smoking to non-smokers present, for example, is probably small but it *is* the subject of current risk assessment and changes in public policy.

The boundaries between environmental and other risks can never be hard and fast ones and there are always marginal cases. As well as the personal risks which are excluded here, other risks are considered marginal to the central focus. These include accidents in the home, traffic accidents and food additives. While arguments can be made to include these as environmental risks they are less germane to our discussion than are risks such as soil erosion, natural hazards and water pollution.

1.1.6 Which Environmental Risks Are Important?

Many of the environmental risks that have received public attention follow on the heels of urbanization and industrialization; they are the risks of economic development. Not surprisingly these risks have been most associated with those countries, or those regions within countries, that are already highly industrialized. While it is quite possible that risks such as air pollution and toxic metals in food chains, are more severe in developed countries they are rapidly increasing in the urban-industrial regions of developing countries. Other risks are more widespread in the poorest countries — those stemming from malnutrition, inadequate housing and sanitation and the like, but they are not absent in the richer nations. Some risks — e.g. unsafe water supply — are serious in both developed and developing countries but for somewhat different reasons: contamination with small amounts of carcinogenic industrial effluents in the one case, and bacteriological contamination in the other.

There are insufficient data on the incidence and impacts of different risks to quantify their relative magnitudes and severity in the world. Even if there were such data they would not give a reliable indication of priorities on a global scale, because it is in the nature of risks and benefits that their relative values are very differently appraised from country to country. One surrogate measure for risk magnitude is expectation of life. Since expectation of life is known to be much lower in some countries than others, it may be inferred that the chief risks in those countries should be accorded some international priority.

One indication of where the important risks are thought to lie is to be gained from a list of international monitoring activities. The list in Table 1.1 therefore gives an idea of priority risk areas from the viewpoint of what it is considered

Table 1.1 International Monitoring Activities

ECOLOGICAL MONITORING	
	Soil degradation — global
	Tropical forest cover
	Rangelands
	River and sediment discharge
	World Glacier Inventory
	Isotope concentration in precipitation
BIOSPHERE	
	Wildlife sampling and monitoring
	Impact of pesticide residues
	Living marine resources
POLLUTANTS	
	Air quality monitoring — global
	Transmission of air pollutants in Europe
	Water quality — global
	Eutrophication in inland waters
	Food and animal feed contaminants
	Pollutants in body fluids and tissues
	Human milk composition
	Pollutants in human hair
	Ionizing radiation
CLIMATE	
	Climatic variability
	World Weather Watch
	Solar radiation
	Atmospheric Ozone
	Climate change
	Glacier mass balance and fluctuation
	Atmospheric pollutants
OCEANS	
	Pollutants in regional seas — Mediterranean
	— North Sea
	— Baltic
	— NE and NW Atlantic
	Open ocean waters
	Marine oil pollution
	River discharge to sea
	Background levels of selected pollutants
NATURAL DISASTERS	
	Tropical cyclones
	Tsunami information
	Flood forecasting

Source: Martin and Sella, 1977.

Table 1.2 Priority Pollutants

Substances and environmental stress indicators that are potentially important with respect to their direct and indirect effects on man and the biosphere: (Munn, 1973)

1. Airborne sulphur dioxide and sulphates
2. Suspended particulate matter
3. Carbon monoxide
4. Carbon dioxide and other trace gases that affect the radiative properties of the atmosphere
5. Airborne oxides of nitrogen
6. Ozone, photochemical oxidants and reactive hydrocarbons
7. Polycyclic aromatic hydrocarbons
8. Toxic metals, especially mercury, lead and cadmium
9. Halogenated organic compounds, especially DDT and its metabolites, PCB, PCT, dieldrin and short-chain halogenated aliphatic compounds
10. Asbestos
11. Petroleum hydrocarbons
12. Toxins of biological origin (from algae, fungi, and bacteria)
13. Nitrates, nitrites and nitrosamines
14. Ammonia
15. Selected indicators of water quality: biological oxygen demand (BOD), dissolved oxygen (DO), pH, coliform bacteria
16. Selected radionuclides
17. Airborne allergens
18. Eutrophicators (e.g., nitrates and phosphates)
19. Soluble salts of the alkali metals and the alkaline earth metals
20. Other substances that have caused significant local environmental problems in the past such as arsenic, boron, elemental phosphorus, selenium, and fluoride
21. Noise
22. Waste heat

to be important to monitor on an international level. This may be compared with the list of 'priority pollutants' shown in Table 1.2. Here again a group of scientists at the international level has attempted to list substances and environmental stress indicators considered to be of priority concern.

Another approach is to ask national governments what they consider to be problems of environmental risk that affect them. A survey has been carried out by the International Union for the Conservation of Nature and Natural Resources (IUCN) in collaboration with UNEP. Sixty-three developing countries (see Table 5.1 for the complete list) were asked in which risk categories they considered problems to exist in their own country. The information produced therefore relates to the *number* of national governments

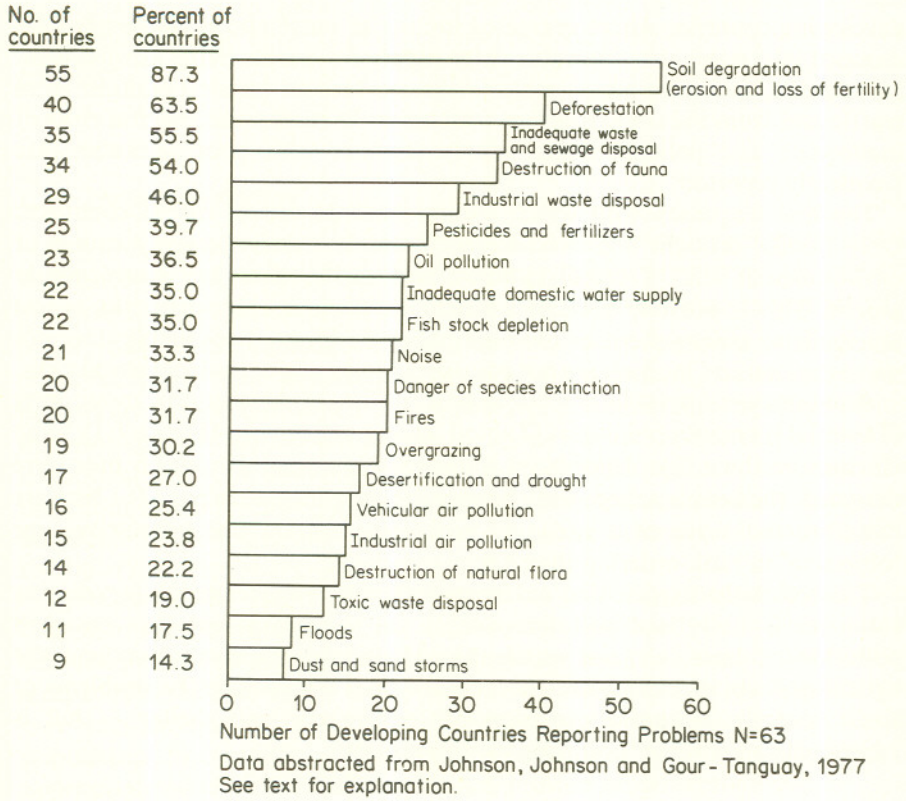

Figure 1.1 Major Environmental Risks in 63 Developing Countries
(for list of countries see Table 5.1)

recognizing these problems and not to their overall magnitude either in extent or socio-economic impact.

The twenty most frequently reported causes of environmental risk are listed in Figure 1.1. Loss of soil through erosion or depletion of fertility is reported in almost all countries, with deforestation ranking second. The most common risks therefore, in the eyes of national governments are primarily those of *resource depletion* (such as loss of fauna, fish stock depletion, soil erosion, overgrazing, deforestation and the like), habitat (inadequate waste and sewage disposal, domestic water supply), and *pollution* risks (air pollution, water pollution by oil and industrial and toxic waste disposal).

These are all risks that can be exacerbated by the development processes of agricultural expansion, industrial development, and expanding populations in cities and on the land.

Water pollution is by implication a frequent subject of concern in

1.2.4 Man-induced And Natural Disasters

Where the environment is subject to natural catastrophies, the decision maker's role has tended to be restricted by and large to *post facto* corrective measures and rehabilitation. More recently, especially as a result of lessons from the Sahelian experience, for example, there is a pressure on decision makers to look into early warning systems which may be used to reduce the effects of environmental hazards and to institute damage reducing measures such as land use zoning and appropriate building regulations. In many areas where disasters strike, the local resources are too poor to pay for these improvements and the task falls to the national government, either alone or with the help of bilateral and international aid and disaster relief programmes.

1.2.5 Introduction of New Products

Perhaps one of the more well known risk management systems in any country is that designed to regulate the introduction into the market of processed food and drugs, chemicals such as pesticides, and consumer products, of both local and imported origin. Most countries have a regulatory system which requires sampling for quality control and toxicity, and has provisions for initiating legal proceedings against offenders. The risk assessment problem is usually one of inadequate facilities for the size of the task, whether in an industrial country or in one of the least developed nations. More products, drugs and chemicals are introduced into countries than they can adequately test, monitor and regulate and significant time lags develop between the introduction of new products and the assessment of their risks. The management task is generally one of trying to increase the scientific and administrative resources to keep pace with the need for regulation.

The problem is exacerbated in some fields by the speed with which products are dropped and replaced by new ones which are only slightly different. This is notoriously the case with drugs, which are frequently replaced by new products by the time regulatory tests have 'caught up'.

1.3 THE MANAGEMENT OF RISKS

Environmental risk management involves the search for a 'best route' between social benefit and environmental risk. It is a balancing or trading-off process in which various combinations of risks are compared and evaluated against particular social or economic gains.

In a previous volume in this series by Kates *(Risk Assessment of Environmental Hazard:* SCOPE 8) risk assessment was described as having three interrelated components: *risk identification, risk estimation* and *risk evaluation*. This volume follows Kates' nomenclature and uses his work as a starting point for a discussion of questions surrounding the implementation of a risk assessment approach.

1.3.1 Risk Identification

Risk identification simply means recognizing that a hazard exists and trying to define its characteristics. Often risks exist and are even measured for some time before their adverse consequences are recognized. In other cases, risk identification is a deliberate procedure to review, and it is hoped anticipate, possible hazards.

1.3.2 Risk Estimation

This is the scientific determination of the characteristics of risks, usually in as quantitative a way as possible. These include the magnitude, spatial scale, duration and intensity of adverse consequences and their associated probabilities as well as a description of the cause and effect links. Both risk estimation and identification can involve modelling, monitoring, screening and diagnosis (Kates, 1978, pp. 14-19) which are discussed in Chapters 2 and 3 of this report. The main purpose of these two management functions is to understand the environmental system and its complex pathways and processes through which risks occur.

1.3.3 Risk Evaluation

The third component of risk assessment is *risk evaluation* in which judgements are made about the significance and acceptability of risk probabilities and consequences. This stage is central to policy determination. Evaluation techniques seek to compare risks against one another, and against benefits, as well as providing ways in which the social acceptability of risks can be judged. Indeed, any judgement about social acceptability combines both political and managerial decisions since it inevitably involves a calculation of who is likely to benefit and who to suffer, and what compensation, if any, should be paid.

After a risk has been identified, estimated or evaluated (or any combination of the three) there comes a point where some kind of intervention (or deliberate decision *not* to intervene or to delay action) takes place. The nature of the intervention varies greatly depending not only on what the risks are (and are perceived to be) but upon the particular policymaking 'style' and the constitutional and administrative framework. But before that point of implementation has been reached, a great deal of risk assessment has already taken place, and has profoundly affected the course of events that will follow.

1.4 WHY WE NEED ENVIRONMENTAL RISK MANAGEMENT

The focus of scientific research on problems of the environment has highlighted many gaps and inadequacies in present knowledge. The pressure of events requires, however, that important decisions about environment and

development be made now rather than at some indefinite time in the future. To do so involves making decisions under conditions of risk and uncertainty. The concept of risk has therefore become central to the environmental management process. How can a course of development be chosen which is 'safe enough'? A safe enough, or less risky, course of development would be one which would avoid the dangers of collapse through unsupportable or unsustainable development. In other words, it would be development compatible with the environment — or ecodevelopment. It would also minimize or reduce to acceptable levels undesirable side effects, for those subject to risk, but also for those who create risks and those responsible for managing them.

The choice of a 'best path' for development involves not only questions about the total amount of risk that is acceptable in any one area, but also the distribution of risks among the population. Thus risk management is central to the ecodevelopment process in two ways. First, it is necessary to ensure that the risks taken will not undermine or negate the aims of development. Second, both the benefits and the risks should be distributed in a socially acceptable way.

Societies differ widely in the spectrum of risks that they encounter and in their view of the priorities to be favoured in dealing with them. In some countries there is major concern over cancer, birth defects and mutations and their possible causes in man-made and man-modified environments. Elsewhere the societal priorities are more centered on those risks associated with the lack of basic needs — water that is safe to drink, housing and nutrition that permit the healthy growth of individuals, families, and the community, and the development of natural resources that does not result in the irreversible destruction of soil, forests and wildlife.

The dichotomy that is sometimes implied when the population risks of high and low income societies are set in contrast, can often be misleading. It is increasingly becoming apparent that the assessment of all environmental risks is as serious and important a responsibility in developing countries as in the more heavily industrialized and higher income nations.

Indeed, countries now undergoing rapid industrial development or large scale expansion of commercial agriculture, are confronted by an especially difficult situation. They combine in a demanding fashion some of the traditional risks of natural hazards and resource depletion with the new pollution and technological hazards associated with industrial development and modern agriculture. Paradoxically, the more successful the economic development process, the more likely there is to be generation of new risks at the same time that unprecedented pressures are arising in the more 'traditional' risk areas of soil erosion, deforestation, desertification and natural hazards.

Furthermore, as rapidly developing nations are drawn more strongly into the pattern of international trade and commodity flow they find that standards

and regulations established elsewhere for the protection of the environment and human health can have a deep and lasting effect on their development. Sometimes these regulations are appropriate to their needs, but often they are not.

Environmental risk management therefore raises questions for all nations, both in their own internal or domestic affairs and in relation to others in the family of nations. This report is not therefore addressed exclusively to one group of nations or another. It attempts to elucidate the problems of environmental risk assessment especially in its international dimensions, and to show how it relates and fits into decision-making in economic development.

There is a great deal of scientific information about some environmental risks. This originates largely from countries rich in scientific and technical manpower and from research institutes established to look closely into environmental risks. In addition, international organizations draw upon this wealth of scientific information to set or suggest international standards and guidelines. It is not wise, however, for a national government to assume that because a risk has been identified, assessed, and a standard established in one or more countries, that this evaluation will automatically apply to their own country. The *consequences* of risk vary from place to place, both as measured in scientific ways and as perceived by local populations. However, when scientific manpower, management skills, and institutional capability are in short supply, it may be a misallocation of resources to invest a large effort into research on the toxicity of industrial effluents or the ecological affects of pesticides, if this has been done elsewhere. Independent risk evaluation does not necessarily require replication of all the scientific work required for risk estimation.

The management of risks does require resources — money, skilled manpower, and time — and is itself associated with the risks of cost, delay and inaction. Risk management is not, however, an entirely new or unfamiliar exercise. Governments already weigh the risks of the exhaustion or depletion of a fishery while building new fishing boats, and farmers have long appraised the risk of a drought or a pest infestation while planting a crop.

Environmental risk management is only part of a much larger governmental set of national needs and priorities. Social and economic development often lead to the introduction of new processes and products, and to the development of hazard prone areas without any consultation with risk assessors or environmental scientists. The environmental risk manager, whether at a high Ministerial level or as an individual technician, has to compete with other demands in a nation's resources and attention. Often he will be faced with risks whose origins lies deep in social customs and history, and thus cannot be improved without more far-reaching changes than can be encompassed by environmental management alone.

It is not the purpose of this report to suggest that no risks be taken. However, they should be understood as fully as possible. This means that the

factors that are taken into account in any decision need to be expressed clearly and where appropriate in terms of the risks involved. Consequences need to be explained and understood both by the authorities and by those at risk, before they are (knowingly) accepted. Only in this direction lies the way to more effective risk management and to a safer and more prosperous future.