Risk is more than just a number

Reflections on the development of the environmental
risk management approach

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Health Council of the Netherlands: Committee on Risk measures and risk assessment

to:

the Minister of Health, Welfare and Sports

the Minister of Housing, Spatial Planning and the Environment

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Contents

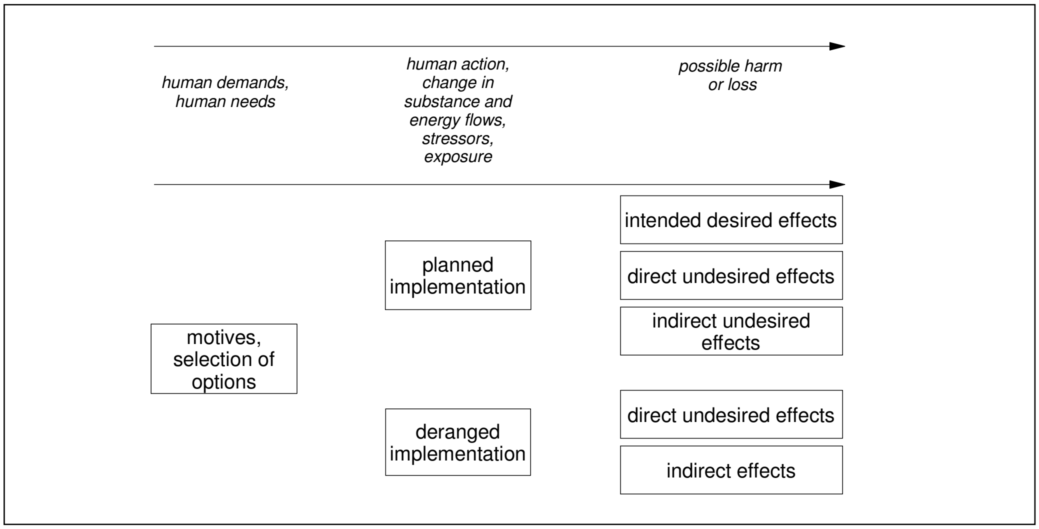
Executive summary

1995 saw the publication of ‘Not all risks are equal’. This report contained the comments of the Committee on ‘Risk measures and risk assessment’ about the ‘environmental risk management approach’ of the Netherlands Government. In the present report the committee arrives at recommendations for the further development of this policy for the protection of human health and the environment.

The committee argues in favour of an effective and efficient approach based on the nature of particular risk problems. It summarizes the framework it proposes in three sections: ‘risk and the origin of risks’, ‘the process of risk assessment and risk management’ and ‘not all risk problems are equal’.

Risk and the origin of risks

The committee defines risk as the possibility, with a certain degree of probability, of damage to health, environment and goods, in combination with the nature and magnitude of the damage. Risks are ultimately caused by human demands and needs which generate human action. Examples of human action are developing and operating a chemical plant, living below sea level, alcohol drinking, and traveling by car to the place of work. These activities will result in changes in substance and energy flows. This can lead to a situation in which humans and the environment are subjected to stressors (‘exposure’). The effect can be damage or loss involving human health, the environment or goods. The aim of human activities is to produce benefits but the

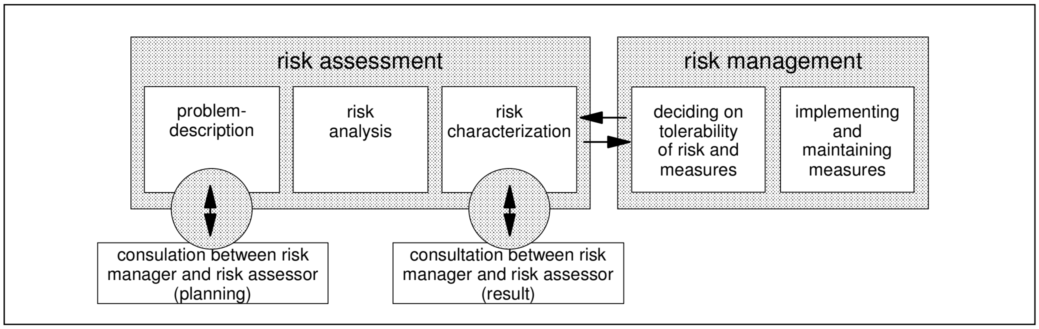


inevitable side-effect is the creation of risks. This is why risks cannot be viewed separately from benefits and it is for this reason that the figure above shows both benefits and possible undesired effects.

When assessing the risks for human and ecological health, it is important to distinguish between activities which proceed as planned and activities which do not do so. This makes it possible to make a further distinction between the risk of (unplanned) accidents and risks of a less incidental nature (e.g. the risks associated with licensed emissions). Finally, the committee asks for attention to be paid to the indirect undesired effects, such as economic damage and employment loss after a serious accident. These are often neglected in risk analyses even though they can be the most important aspect of the risk. These indirect effects are also related to the fact that only limited resources are available for risk management. Resources can be deployed for reducing one risk instead of another. However, the choice for risk reduction competes with deploying the same resources for satisfying other needs instead of health promotion and environmental protection. In risk management one should take into account ‘opportunity costs’, i.e. costs (including risks) that are generated because resources which have been deployed once can no longer be used for other objectives.

The process of risk assessment and risk management

The committee advocates coping with risks by means of a process of risk assessment and risk management. This makes it clear for all those involved when and why a decision has been proposed or taken, and by whom. The terms ‘risk manager’ in the above figure denotes the person or institution that is responsible for deciding on the tolerability of risk and for taking risk reduction measures (in this report the



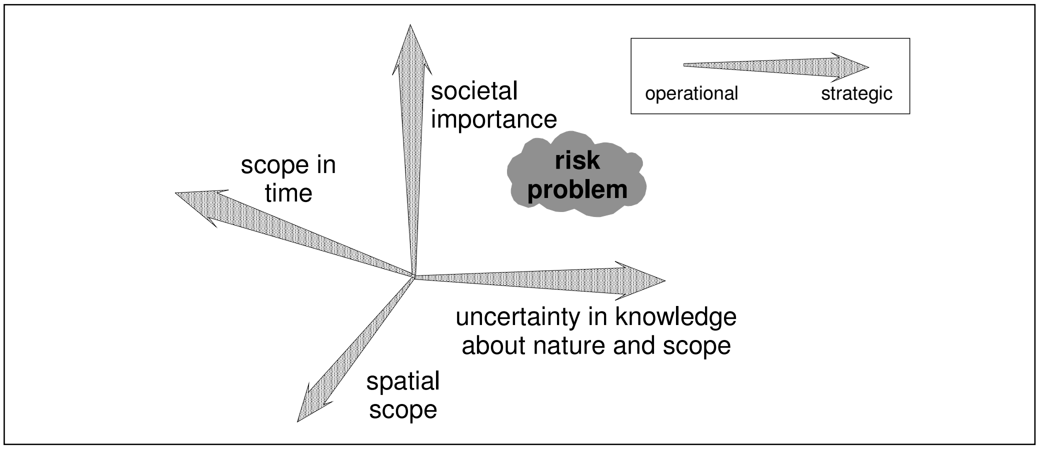
authorities). ‘Risk assessor’ is the person or institution that is commissioned by the risk manager to analyze the risk.

Risk assessment encompasses: problem description, risk analysis and risk characterization. During problem description, the scope and nature of the problem are determined. Social preferences inevitably play a part here. This makes consultations between risk managers and risk assessors necessary with the risk manager expressing the preferences of the parties involved in the risk assessment. The outcome of the risk analysis is a risk estimate, which is expressed in the form of a risk profile. During the risk characterization process, the question arises: which characteristics should be used to represent the risk? This selection process cannot be left to the risk assessor, but requires consultation between the risk manager and the risk assessor. Here again, the risk manager should represent the preferences of the parties involved. Examples of characteristics are: probability of disease or death and reduction of species in ecosystems, but also level of training of industrial operators.

During the risk management stage, a decision is taken about the tolerability of the risk. In the context of this report, that decision is taken by the government. Measures will be taken on the basis of the decision to keep the risk within acceptable limits and the effectiveness of these measures will be monitored.

The committee advocates a dynamic process of risk assessment and management. In the risk assessment stage one may conclude that the scope of the problem is different, usually more extensive, than originally determined. Also one may wish to study alternative risk measures. Parts of the process are than again passed through. Feedback from actual practice my lead to renewed risk estimates and adaptation of risk measures.

The dynamic nature of the risk assessment and management process is also due to external interferences. Parties with a say in the decision making may ask for additional analyses. Also gaps in knowledge and uncertainties in the risk estimates may reinforce the back and forth character of risk assessment and risk management.



Not all risk problems are equal

The committee believes that a number of factors have a considerable influence on the way risk problems are assessed and how decisions are taken about them:

- the scope of the risk in time
- the spatial scope of the risk
- uncertainty in knowledge about the nature and scope of the risk
- the societal importance of the activity which causes the risk.

Together with the jurisdiction of the authority which takes the decisions, these facets determine the status of the problem: is it strategic, tactical or operational? The higher the problem 'scores' on one of the four dimensions, the more it shifts from operational to strategic (see figure above). The status of the problem is not a rigid one: each problem has strategic, tactical and operational aspects. The development of the port of Rotterdam with its industrial operations may be viewed as a strategic problem, the construction of the socalled Betuwe railway-line for the transport of goods to the German hinterland as a tactical choice and noise reducing measures in houses along the railway-line as operational.

Different risk problems require different risk management strategies. The latter will have to be adapted to how risks arise. They are—at least in the case of problems which have arisen previously—set down or referred to in environmental legislation and regulations. The committee points to the necessity—especially in the case of problems of strategic importance—of creating an 'environment' in which justice is done to a variety of political views and cultures, i.e. a variety of risk perceptions. This makes fruitful discussion possible between the parties involved before government takes decisions about accepting certain risks and about associated conditions.

In the committee's view, the main criteria when deciding about the tolerability of risks and about the measures to be taken are:

	from operational	to	strategic
a	fits in with all established decision methods and criteria?	⇨	results in new decision methods and criteria?
b	accords with scientific knowledge?	⇨	consistent arguments? well thought-out vision?
c	risk attributes adequate for protection objective?	⇨	various protection objectives taken into account?
d	risk within previously established tolerability limits?	⇨	does the societal benefit outweigh the risk according to various parties?
e	risk management for lowest costs?	⇨	efficient after consideration of opportunity costs?

As stated above, the intended benefits of activities play a role in arriving at a decision. A possible problem here is that those involved can differ in their assessments of the social importance of the activity, depending on their vision of society and their position with respect to the activity and the risk (risk-takers, beneficiaries, victims or combinations of the three). This is especially true for strategic questions, as is demonstrated by the discussions on the energy policy and on public transport systems (expansion of Schiphol airport, high speed trains). In the case of risk problems with a marked operational nature, social benefits are often not discussed explicitly since the usefulness of the activities which cause risk is often thought to go without saying.

Risk management

Risks do not come about on their own. An analysis of the cause-effect sequence shows that there are various opportunities for risk management. This summary is limited to the discussion of the 'quality of the organization' and 'priority setting and risk comparison'.

Quality control In effective and efficient risk management, the way activities which cause risk are organized plays a central role: risk management should be a part of a system of quality control. In the case of industrial processes, this system starts 'on the drawing board', implies thorough training for employees at the managerial and practical levels and is related to maintenance and to disposal of waste products etc. The feedback mechanism is important: experience in the control system should result in alterations and improvements which should also include risk management measures.

Quality control should also be the motto for government with respect to its involvement in the process of risk assessment and risk management. This leads to an organization of the process that is transparent, appropriate to the nature of the risk problem and grant a central position to information activities and risk communication.

Risk management through quality control and communication are particularly applicable if diversion is an important cause of the risk. Diversion onto other parts of the world or future generations means that risk-takers no longer perceive the possible harmful effects of their activities in those terms: an important motive for risk reduction is lacking. Another diversion mechanism is the one which shifts risks from the individual to the collective; many individuals or bodies believe that they can quite reasonably take the risk on their own but the combined risk can increase to intolerable proportions.

Priority setting and risk comparison How should environmental funds be spent? This is the question faced by the government in tackling the various environmental risk problems which they encounter. There are two problems in priority setting: what do we not do if we deploy the available resources for a particular problem and what risks does that involve? And how do we compare the efforts involved in one problem with those involved in another?

When answering these questions, it can be helpful to make a link between the costs of risk management measures and the level of risk reduction which those measures aim to achieve. The committee recommends that the following risk attributes should be taken into account: reduction in life expectancy and worsening of health, nuisance, negative appreciation of the environment, reduction of biodiversity, reduced functioning of ecosystems and reduction of environmental functions. Comparative risk analysis may provide a solution for the comparison of problems of different kinds. Here, 'experts', representatives from social groupings and government officials rank risk problems in consultation.

Different approaches to dissimilar risks

How can government manage risks and take the individual nature of various kinds of problems into account during the process? For matters of a mainly operational nature, the committee proposes choosing between:

- strict standardization
- balancing risk reduction against reduction costs
- self-regulation with requirements for the organization of the activity.

'Standardization' includes government decisions about conditions for the acceptance of risks, about the form of risk management measures and about the desired level of risk reduction. An example is setting environment quality objectives on the basis of the

Environmental Management Act. The second point relates to the application of the ALARA principle: the reduction of risks to a level that is as low as is reasonably achievable. Risk reduction may also be ‘unreasonable’ if other beneficial activities may not be carried out because of a lack of resources. The third point, self-regulation, can improve the quality of the organization of the activity which causes the risk. At the same time, it imposes stringent demands on the monitoring role of government, to which the ‘self-regulated’ is accountable. Risk communication plays an important role in this respect.

There are no generally-accepted approaches in current Dutch government policy for problems with a less operational, more strategic nature. The committee lists the following possibilities:

- breaking down the problem into parts for which there are acceptable risk management approaches
- taking measures which are on the safe side, particularly if the consequences are irreversible
- searching for measures which stimulate risk reduction (bonuses) or encourage the acceptance of risks (insurance-policies)
- determine the extent to which, and the conditions in which, compensation can play a role in controlling risk distribution which is judged to be unfair.

In problems of major strategic importance, government must initiate and follow procedures which create conditions for good understanding among all those involved of the particular risk problem, of how the different parties approach the problem and of the decision-making criteria which will be followed. Measures will primarily consist of encouraging some developments and discouraging others in order to manage risks without creating excessive obstacles to the functioning of the society. It may be helpful in this respect to classify measures according to the costs of the estimated level of risk reduction on relevant risk attributes. The committee believes that the following points deserve particular attention:

- Strategic problems are complex in nature and generally unique. They cannot therefore be tackled using standard approaches. A failure to recognize the need to look for new approaches—generally a mixture of various tactics—can interfere with efficient risk management. Global climate change is an example.
- All the parties involved can be expected to indicate how the activities which cause the risk advance the public interest. They should also state whether this benefit off-sets the risks and, in particular, how the risk is distributed across the various parties. Each party should clarify which distribution of risk and benefits it considers just.

Strategic risk problems make it necessary to look for new forms of coping with risks: who decides when about the tolerability of what part of the risk and who is responsible for keeping the risk at an acceptable level?

Risk is more than just a number

Risk management questions are questions about the structuring of the society. Opinions about the vulnerability of nature, about concern for future generations and about freedom of action determine the answers. Supplying milk in plastic bottles and the construction of a network of high-speed train tracks are both types of human activities which, in addition to serving meaningful objectives, also threaten human health and the environment. Milk supply and fast trains are, however, different in nature, scope and societal importance and the risks involved cannot therefore be assessed in the same way. The nature and extent of the risk management measures will, in both cases, be different and partly dependent on the importance which groupings in society attach to particular types of milk packaging and to fast trains.

A transparent, orderly approach to risk assessment and risk management can lead to a result which the people involved can live with. In many cases, this requires meticulous analysis, communication and consultations. After all, risk is much more than just a number.

Chapter 1

Background

1.1 Regulatory risk management

’Who dares, wins’. This is one of the many sayings which expresses the importance of taking risks in everyday life. In the present report, a Health Council committee discusses how *government* can deal with threats to human and ecological health which result from human activities. These threats can be extremely varied in nature. Examples are possible health problems as a result of the inhalation of substances generated by traffic or discharged by an industrial installation, the risk of falling victim to the side-effects of an accident with an oil tanker on a river and the destruction of ecosystems by harmful substances (with the possible subsequent damage to human health).

Risk is related to the possibility of a reduction in the quality of life, death, damage to—or loss of—ecological assets or goods as a result of human activities or natural processes. Examples of activities of this kind are the location and operation of a chemicals factory, living below sea level or below the level of a river, drinking alcohol and going to work in a car. All activity involves a certain risk. Decisions about allowing or accepting risks are always taken against the background of a certain freedom of choice in terms of stopping, continuing or adapting the activities which cause the risk. This is true of individuals who live next to dikes which are too low and who are faced with what they consider to be an excessive risk. It is also true of the government which, when it decides not to raise dikes, takes up a *de facto* position about the tolerability of certain risks in the public domain.

The government has the authority and the power to impose restrictions on people's behaviour. In the context of this report, these powers are related to behaviour relating to risk. In this respect, the government has statutory responsibilities, for example the prevention of the unfair distribution of financial burdens or disproportionate damage. These duties are grounded in the Constitution. For this report, sections 21 and 22 are particularly important. They stipulate that government is responsible for keeping the country habitable, improving the living environment and promoting public health. The last duty involves protecting individuals and the population as a whole. The aim of the government when carrying out this duty is to further the public interest. This also involves the protection of citizens against dangers when they cannot do so themselves.

There are fixed procedures for government with respect to evaluating and deciding about risks. In our legal system, the government can be called to account for the procedure which is followed as well as for the substance of a decision and the nature of measures taken.

1.2 Committee and task

In 1991, the President of the Health Council established the Committee on Risk Measures and Risk Assessment', to be referred to hereafter as the committee. He asked the committee to report on the possibilities and limitations of an assessment system for the risks of a variety of activities as proposed in the 'Premises for risk management' policy memorandum (TK89b). He was of the opinion that, now that the policy which had been set out in the memorandum (and its predecessor, TK85) had been in place for some time, there was sufficient reason to subject the principles and suppositions to scientific appraisal.

The committee published its first report in April 1995, stating reservations about the basis of the 'environmental risk management approach' which was defined in 'Premises for risk management' and in later letters from the Minister of Housing, Spatial Planning and the Environment to the Lower House (GR95b). The present report represents the completion of the committee's work.

The committee's instructions are set out in detail in annex A. Annex B contains a list of the members of the committee.

In section 5.8 of its previous report, the committee gave a point-by-point summary of its reservations relating to the environmental risk management approach (see annex C). Here, the committee will elaborate the following issues (text taken from pp. 54-55 of GR95b):

- The other side of the coin [of positioning the risks to humans and the environment which are associated with human activities at the centre of the political stage] is that, as a result of simplification, the wide-ranging nature of the risk concept has been lost from view. This effect has in part been enhanced because of the range of meanings which have been attributed to ‘risk’ during the elaboration of the risk approach: risk as the possibility of damage, risk as the possibility of a particular effect on health and risk as a unit, such as the concentration of a substance, for describing exposure.
- Deciding about the tolerability of risks on the basis of testing against numerical limits which are founded on a few quantitative measures requires justification based on the nature of the risk problem, since a limited range of numerical standards often fail to do adequate justice to a complex reality.
- Testing against generally applicable numerical limits in association with the rule ‘failure to meet the numerical limit is not permitted or means that decontamination is required’ makes it formally impossible to include the assessment of economic and social benefits in deciding about the tolerability of risks. If one wishes to allow for this, the result will be a more differentiated system of standards which will sometimes be stricter or less strict than those currently in force.
- The link with the (dynamic) processes which are at the root of the development and management of risks is often weak. A stronger link would also result in a more differentiated system of standards, both in terms of decision rules and risk measures, with the application of the ALARA principle occupying a more central position.
- The risk approach in its current form provides insufficient instruments for dealing with the phenomenon of risk accumulation.

1.3 Working methods and structure of the report

The committee drew up its findings in a series of meetings. In annex D, it sets out how it drew on scientific literature in its considerations. Here, the committee was faced with the problem that it is practically impossible to give a complete picture of the ‘state of the art’. Risk and risk evaluation can be found in a variety of social contexts; in each of these contexts, people draw on their ‘own’ approach and this results in a variety of descriptions and analyses. The committee concentrated primarily on the threats to human and ecological health posed by environment factors.

In the chapters which follow, the committee discusses the process of risk assessment and risk management. In the course of that discussion, the assessment and characterization of risk are examined, as is the origin of risk. The evaluation of risks is linked directly to the objectives of government policy. These objectives therefore determine, together with the available resources, the methods for arriving at a decision about the tolerability of risks, the nature and effectiveness of numerical limits and of other tools of risk management, all subjects which will be discussed here also. The committee's point of view is that a transparent procedure for deciding about accepting risks is of primary importance. It believes that a procedure of this kind is a pre-condition for creating support among those involved for the decision which is taken.

The intention of the committee is not to provide a blueprint for a new risk policy. This would have been beyond its capabilities and it is not part of the duties of the Health Council. The committee's objective is, on the basis of the findings of scientific research, to give the best possible description of the complex issue of dealing with environmental risks. That description results in proposals for improving the effectiveness and efficiency of the process of risk assessment and risk management. The committee hopes that this will provide ingredients for the further development of the environmental risk policy.

Chapter 2

Definition

2.1 Risk

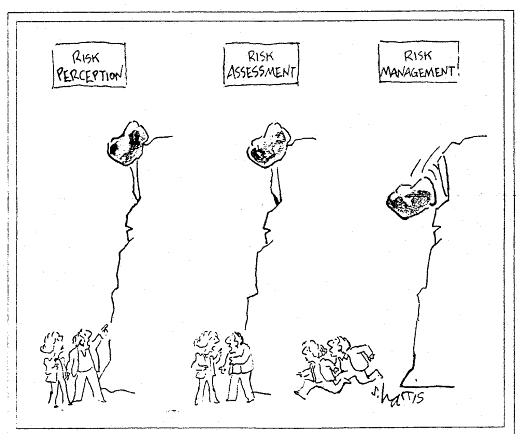


Figure 1 It is thought that the word 'risk' is derived from the name for the rocky coast of Crete. It can be traced back to the Italian 'rischiare' which in turn comes from the Greek word 'rhiza', meaning root. This word acquired the metaphorical meaning of everything which sticks out like a root. On Crete, the cliffs came out on the coast like roots from the mountains. They represent a possible danger or risk. (Taken from Mathieu-Rosay J. Dictionnaire Etymologique. Alleur, België: Marabout, 1985. Quoted in Dro91.) Even now, there are risks associated with rocks, as the illustration here shows.

2.2 Definition

A dictionary definition of the concept of risk is ‘the danger of damage or loss’. Here, ‘danger’ is interpreted as the ‘chance that something may go wrong’ (Dal92; see also figure *1*). Two central elements in risk are ‘the possibility or probability of undesired consequences’ and ‘the nature and severity of those consequences’. The committee agrees with this dictionary definition and defines risk as (GR95b):

the possibility, with a certain degree of probability, of damage to health, environment and goods, in combination with the nature and magnitude of the damage.

The committee has deliberately chosen a definition which is broader than ‘the chance of damage or loss’. When deciding about the tolerability of the risk associated with human activities, it is not only the possibility of damage or loss but also the level of probability, as well as the nature and extent of the damage or loss, which play a role. The committee believes that it is desirable to include these aspects in the definition of risk.*

Risk includes both direct and indirect components (see, for example, Bur93). Direct components include the effect of load factors on humans and on the environment. Indirect components include the influence of possible or actual effects on social processes, such as loss of production or the consequences of restrictions imposed as a response to an accident. Examples of restrictions of this kind are supplementary licensing procedures, stricter licensing conditions, prohibition of certain activities etc. A special component of risk are ‘opportunity costs’. Investments in certain forms of activity and in measures to manage the risk associated with that activity mean that other things are left aside, that potential benefits are not realized and that other risks might not be adequately contained.

The scientific literature contains a variety of definitions of ‘risk’ which differ in terms of their conceptual basis. In technical circles, a commonly-held view is that risk is the probability of a certain effect of a certain size or the accumulation of such probabilities (Kap81). A range of researchers in the social sciences define risk principally in terms of voluntariness (how free are those who may be affected directly or indirectly by the stressor in terms of escaping the risk?), familiarity (how familiar are the potential victims with the possible effects?), objectives (what is the aim of the activity which causes the risk and what are the objectives of the people who are responsible for that activity?), reparability (can the damage be repaired and how

* The social usefulness of the activity also plays an important role in the assessment process. See, for example, Chapter 7.

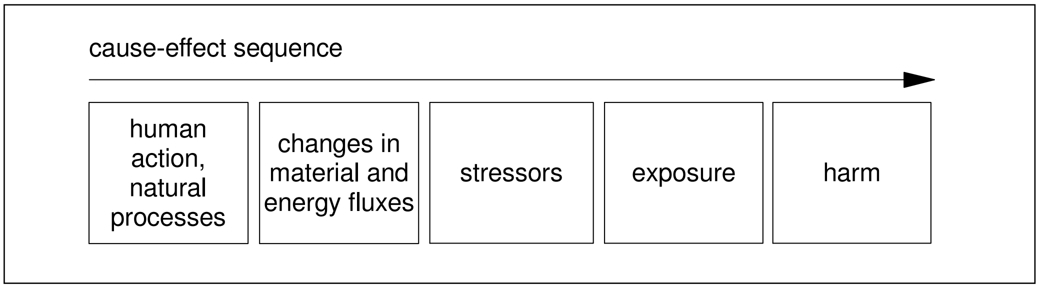


Figure 2 Cause-effect sequence for describing and analyzing risks. Human action or activities, the ‘first link’ in the chain, are driven by needs and desires.

quickly?) etc. (Mor81, Vle90). The committee does not see these approaches as being diametrically opposed. Which factors are most suitable for characterizing risk depends on the nature of the risk problem. The committee will discuss this issue in greater detail below.

In annex E, the committee lists a number of common definitions of risk.

From cause to effect

Actual damage or loss result from a process which can be described as a cause-effect sequence (see figure *2*). A sequence of this kind starts with human activities and natural processes which, in some cases interacting with each other, influence substance and energy flows. The aim of the activity is to meet human needs and desires (Hoh83; see also figure *7*). However, it also generates stressors—load factors—which have effects on humans and the environment. The figure introduces stressors as the results of changes in substance and energy flows (Nor92). The stressors involved include noise levels and concentrations of substances in water, soil and air which, given exposure, constitute a threat to, or actually damage, health and the environment. Human activities as such can also be perceived as threatening and subsequently have an influence on health. In that case, they constitute the stressor. Examples of this are technologically complex installations and traffic.

A characteristic of the concept of risk is that uncertainty shrouds how damage and loss occur as a result of human activities* as well as the nature and extent of the damage or loss. One stage of the sequence in figure *2* does not always result in the next, or does not always do so to the same extent. All this is dependent on processes within the sequence and on external factors. For example, human activities almost always result in small-scale or large-scale changes in substance and energy flows but they need not always be a threat to humans or the environment. In addition, damage

* Here, human activities play a central role as a source of risk. Natural processes do play a role but as factors which influence the risk involved in particular activities.

can only occur if there is exposure and even this does not apply in every case and generally only then after various intermediate stages. The sequence in figure *2* contains other simplifications. For example, feedback loops are not shown; changes in substance and energy flows can initiate processes which counteract changes and result in a reduction of the risk.

Delimitation

Cause-effect sequences are suitable models for the description and analysis of the generation of risks. They should include answers to the following questions:

- which activities?
- what forms of damage or loss?
- what spatial scale level?
- what time scale?

Delimiting the activities is important for the outcome of a risk assessment. For example, in an analysis of the operation of an oil refinery, different results will be obtained if the risk assessment includes or excludes the transportation of raw materials and finished products. In addition, the question which will be asked from the point of view of government is: is the installation unique (for example, one particular LPG station) or does the assessment cover similar activities in a lot of other places (for example, all the LPG stations in the Netherlands). Human activities can have an influence on the global level—such as the effect of CFCs on the ozone layer—or on the local level—such as the raising of a polder using polluted harbour mud. The time scale is also important for the risk assessment: what time span does one examine for the activities and what time span for possible harmful effects?

Delimitation is also required at the end of the cause-effect sequence: what forms of damage or loss—and therefore what property—will be looked at? Is one concerned with the local, national or global population? What ecosystems do we want to protect and which endangered species? Are valuable goods involved?

The committee will return in detail to these delimitation issues.

Risk attribute

A variety of attributes are linked to the concept of risk as defined by the committee. Some can be expressed as measures and numbers; others are more qualitative in nature. The chance of death, the probability of illness, the reduction in fertility of a species and drops in fish catches are quantitative risk attributes. The degree to which people believe they can avoid the risk ('voluntariness') and the degree to which a risk is thought to be manageable are more qualitative attributes.

The risk attribute 'possibility of death' can be described numerically using quantities such as age-specific probability of death, chance of death irrespective of age or reduction in life expectancy*. The selection of one metric or another is not without importance. For example, the result of a comparison between the risk associated with working on a scaffold and with exposure to a small dose of radiation will be different when using the metric probability of death irrespective of age' than when the metric used is 'reduced life expectancy (GR91b, Ber95).

Risk attributes are sometimes introduced as risk *definition*. This implicitly results in a limitation of the concept of risk (for example: risk *is* the possibility of death or risk *is* the possibility of an accident multiplied by the number of casualties). Within the context of a single problem or a group of similar problems, this need not necessarily result in difficulties as long as there is unanimity about the definition to be followed. However, in a comparison of the risks generated by a variety of types of activity, an implicit limitation of this kind can easily result in difficulties with risk management**.

2.3 The process of risk assessment and risk management

The committee has already referred to the government's constitutional duty to make judgements in the *public* domain about the tolerability of risks and the measures which have to be taken in order to manage risks. In so doing, the government must weigh the range of claims made by various lobby groups on public resources and establish legal criteria and procedures for this process of evaluation. The Environmental Management Act is an example of this (Wmb79). The management of risks is preceded by their evaluation. In its previous report, the committee proposed the model of risk assessment and risk management*** as an instrument for this purpose. This model is shown again here in figure *3*.

* Quantities of this kind are sometimes referred to as risk measures. The stated measures for possible death can be mutually converted if complete mortality data is available.

** If one uses the probability of death to describe the risks associated with smoking, with passive smoking and with the inhalation of benzene at the workplace in the Netherlands, smoking comes out on top. However, the strictest rules apply to occupational exposure to benzene (numerical limits with sanctions) whereas with smoking the government concentrates on risk communication. The rules for smoking are principally based on the notion of annoyance (smoke-free rooms). This differentiation in risk management measures is not easy to understand if risk is only the probability of death.

*** The term 'risk management' is used in different senses in the literature. In annex C of its last report, the committee gave an explanation of the usage of the American Environmental Protection Agency and National Academy of Sciences. That usage corresponds to the definition of risk management in this report. Among experts in the field of working conditions, 'risk management' generally only refers to the last stage in figure *3*, namely the implementation and enforcement of measures. Some people use 'risk management' to refer to the entire process of risk assessment, risk evaluation and the

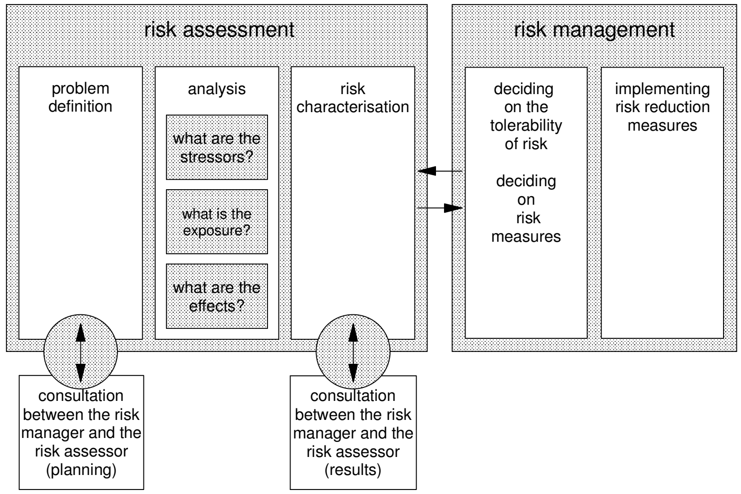


Figure 3 Model for risk assessment and risk management. The arrows between the two blocks show that the process is a dynamic one.

In its previous report, the committee explained the figure as follows (GR95b, p. 27-28):

Risk management by the government involves an appraisal by those responsible for policy of the social and economic cost of possible harm to people and the environment and of damage prevention, as opposed to the possible benefits of the activities causing the risk. Here, the government will have to take into account risk perception among groups of the population, that is to say assessments of the risks in question made by the population. In order to achieve risk management in a rational way, it is necessary to 'map out' the risk. By 'risk assessment', the committee means the analysis of risk, the estimation of the extent of the risk and the presentation of the results in a form appropriate for risk management. Risk assessment also encompasses the analysis of the effect of a range of alternative risk management strategies and measures. It usually will take place in stages. On the basis of an initial risk estimate, the risk manager will need a prediction of the effectiveness of certain measures. In the case of complex problems, the approach to the process of risk assessment and risk management can be iterative.

Risk assessment is generally an activity confined to experts which, as far as the definition of the problem and risk description are concerned, must take place in close collaboration with risk managers since the risk managers or the governmental agencies which are responsible for policy are the ones who bring up the problem. Furthermore, it is important that risk assessors describe the risk in a practicable form. Here, there must clearly be consultation: some problems are not amenable to analysis and some risk attributes are not compatible with the results of the risk analysis.

implementation of measures.

The term 'risk manager' in figure *3* refers to the person or organization responsible for deciding about the tolerability of the risk and for implementing and enforcing appropriate measures. In this report, the risk manager is the government. The 'risk assessor' is the person or organization who conducts the risk analysis on behalf of the risk manager.

Figure *3* provides the basis for a conceptual framework for evaluating and deciding about risks. In concrete cases, this means determining which social actors are involved in the activities which generate risk and what the broader context is of the risk problem. The latter includes the socio-political dimensions of activities and the associated risk, as well as the economic and other social benefits of a certain form of industry. It is also necessary to state which causes and which possible effects one wishes to include in the appraisal. During the risk management stage, an important procedural element is the way in which government decides about tolerability and how it involves social actors in that procedure.

The concrete course of the process of risk assessment and risk management therefore depends upon the problem concerned. With global problems, such as possible climate changes because of the large-scale use of fossil fuels, extensive studies are conducted by panels of experts during the risk assessment stage and the risk management stage typically involves negotiations between parties—often states—with a range of interests. During efforts to improve interior climates, analyses generally follow established rules and, at work, decisions are taken according to statutory criteria. In the latter case, the parties involved are employers, employees, the works council which represents the employees, the safety adviser, the company doctor and the government inspection agency. Many problems relating to threats to the environment or environmental damage are characterized by numerous individual decisions which are in themselves justified but which, taken together, can result in serious damage to human and ecological health. Obvious examples are private car use and skiing holidays. The management of risks like these require a complex arsenal of measures.

The process of risk assessment and risk management starts with the problem description and delimitation. This requires agreement between those involved. Generally, the government has the last word (in risk management) with respect to the environmental risk problems under discussion here. However, the involvement of individuals and organizations who implement or are affected by the measures which need to be taken can contribute to support for government decisions. A lack of agreement about the content and delimitation of the problem under discussion results in dissatisfaction about decision-making. For example, if the government brings up the problem of the building of a nuclear power plant and participants in the process bring up the matter of energy supply, the two parties will not arrive at any agreement about the location or the method of energy supply*. In the case of complex problems like the example given in the previous sentence, expert help is called in for risk assessment. When this happens, the experts will also be involved in the formulation of the problem since it must be expressed in terms of questions which can be answered at later stages in the process.

The committee would wish to point out the possibility of altering the character of the problem during later stages of risk assessment and management. Usually, what is involved is a widening of the scope. An example is the decision-making process relating to the extension of Amsterdam Airport. The airport and the government have described the risk problem in terms of spatial planning and environmental effects. However, environmental groups also raised the question of air traffic as such. Nevertheless, this point never became a genuine subject of discussion and this has meant that, for certain groups at least, the decision-making process was unsatisfactory.

The risk analysis in the flow-chart in figure *3*—in principle: determining the stressors, exposure to stressors and the effects of that exposure—is a job for experts in the case of more complex problems. However, this does not mean that no value judgements have to be made during risk analysis. Where scientific knowledge falls short, risk analysts make plausible suppositions. The selection of a linear exposure-response relationship for low levels of exposure to genotoxic substances is one example. An argument in favour of this choice is that, given the lack of empirical data, it can possibly lead to the over-estimating, rather than the under-estimating, of the risk. The committee emphasises the importance of consultation between those who carry out risk assessment ('risk assessors') and those who are responsible for decisions about the tolerability of risks and the measures which are to be taken ('risk managers', in this case the government). This renders transparent the choices which are made in order to make up for gaps in knowledge. This is all the more important because there are differences of opinion among experts, precisely about the validity of such decisions. These differences of opinion can not only be traced back to differences in knowledge and experience. They are also linked to factors such as position in society and views regarding society (Kra92, Shr95, Slo94).

The committee believes that this sort of decision (known as 'science policy' decisions in America; San94) should be stated in the comments which accompany the results of the risk characterization (see figure *3*). This enables the risk manager or ultimate decision-maker—as well as all other concerned parties—to determine whether the choices made have taken sufficient notice of the objectives which the risk

* Another consideration is that those involved in the consultation process will sometimes bring up the problem of energy supply during discussions about a location when the energy supply method has already been decided upon. That can mean that the earlier decision-making process is felt to be unsatisfactory, not only in terms of the result but also in terms of the procedure. However, a party can sometimes deliberately take up a position 'off the agenda'.

assessment should serve. In addition, during the risk assessment stage, the discussion will cover the selection of risk attributes and how uncertainties in the description of the risk will be presented using the selected risk attributes.

The need for this interaction between the ‘risk assessor’ and the other parties involved (the people who decide about the tolerability of a risk, who are affected by the risk management measures and who have to undergo the effects of damage to human and ecological health) is the result of the decision to structure society on democratic lines and of the not-entirely objective nature of risk assessment (Shr95).

The process of risk assessment and risk management will be iterative. The result of a risk analysis will often raise questions about alternatives. The committee emphasises the dynamic nature of the process (Vis94). How effective and efficient measures are will, after all, only emerge in practice. Despite all efforts to estimate and characterize risks as well as possible, ‘trial and error’ is an unavoidable element when it comes to establishing actual risk management.

2.4 Risk perception and risk communication

Parties and positions

A range of ‘parties’ are involved in the process of risk assessment and risk management. Even though these are matters about which government decides, there are individuals, groups and bodies which have a direct interest in the method of risk management which is chosen, who are responsible for the activity which generates the risk or for the implementation of risk management measures or who are—or may be—subjected to risks. The involvement of all those parties in the process of risk assessment and risk management can be awkward because they adopt different positions (figure *4*), while in practice, those involved can also occupy several positions simultaneously. Parties who generate risk as a result of their activities do so in order to gain an advantage and they are therefore also the ones who benefit. If the activities are commercial, employees benefit in the sense that they earn their living, but they may also suffer damage to their health and in this sense they are potential victims. The government, which decides about the tolerability of a risk, can also fulfil one or more of these roles. In addition, there are positions of indirect involvement, the main ones being (see figure *4*): the government as regulator, the government as supervisory body, the managers of means of communication (media) and the public, including a variety of people and bodies who provide the various parties with advice, whether requested or not.

Each position gives its own point of view as the risk is being assessed. They generate their own objectives, responsibilities and options for action while the

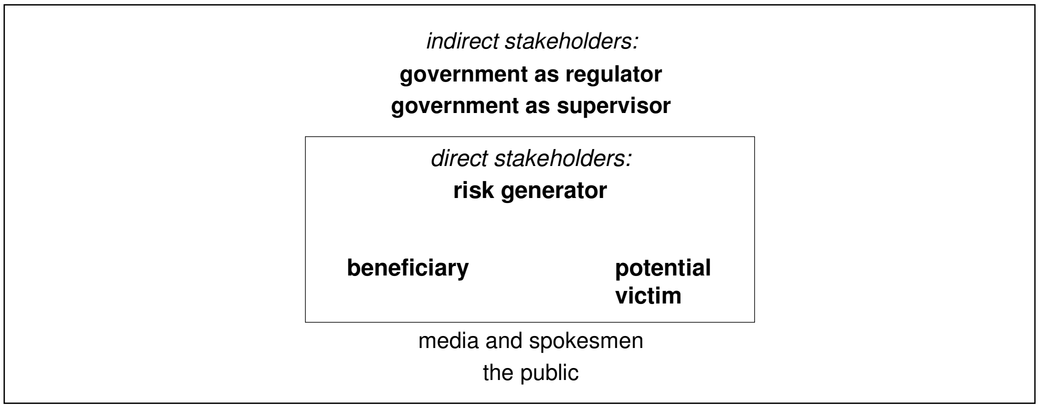


Figure 4 Positions of stakeholders in risk management decisions. Taken from Vle94.

availability of information is not the same for each position. Positions and interests are rooted in a range of deeper beliefs about the values which society should maintain, about the degree to which nature is vulnerable to human intervention and about how it is possible to deal properly with questions relating to the management of risks (Dou82, Smi96). As the committee will describe in detail below, it believes that the procedures for assessing and deciding about risks should take this range of positions into account more than they do at present*.

Risk perception

The range of value judgements, insofar as they are related to risk, are referred to as ‘risk perception’. In principle, this differs from individual to individual and from group to group. This personal and institutional weighting of judgements about risks is found among ‘experts’ as much as it is among ‘lay people’, and among ‘decision-makers’ as much as ‘stakeholders’ (Shr95).

Differences in risk perception increase the number of attributes which are important in characterizing risk. In practice, selection is inevitable in order to keep decision-making about the tolerability of risk reasonably ordered and clear. Considerations relating to selection are: Does the process involve protecting lives or particular social structures? Does the first case involve the reduction of the chance of death, an increase in life expectancy or an increase in the number of healthy life years? If it involves the chance of death, should a distinction then be made between more and less vulnerable people or between people who also benefit from the risk-bearing activity and people who do not? Especially in the assessment of ecological risks, major

* During the risk assessment stage, this will primarily be seen in problem delimitations and risk characterization. During the risk assessment stage, it will make itself felt in the decision criteria used (standards) and in the nature of the measures to be taken.

problems occur here because any sort of precise determination of what is to be protected is often still impossible given current scientific understanding*.

Differences in the selection of risk attributes result in the use of various definitions of risk. The committee has already drawn attention to this fact. In addition, the importance attached to the attributes varies from individual to individual and from group to group. Death and illness, for example, are rated differently depending on the cause (influenza, a car accident, a crime etc.).

In a number of fields of social industry—gambling, for example, civil engineering and insurance—there are few differences of opinion among those involved about what is meant by risk. There is a large degree of internal consensus with regard to risk perception. Judging risks here is traditionally the domain of a professional group of experts and other parties seem to be happy with this situation. However, where there is variation in the assessment of the importance of activities—the advantages and the risks—then more than just a few risk attributes will be involved. A complicating factor here may be the role of the media in stressing the importance of some attributes. The approach to risk by the experts with a preference for a one-dimensional definition of risk—such as the anticipated number of deaths in a given unit of time or the anticipated loss of species in an ecosystem—will therefore soon come into conflict with the approaches of the public or lobby groups who take more attributes into account in their risk perceptions (Mor93). The committee would not consider it correct to dismiss this difference in approach as simply the difference between 'objective judgement' and 'subjective perception'.

With issues of major social complexity where major interests are also at stake, the varied and generally fundamentally differing risk perceptions, in addition to equally different assessments about the social usefulness of the activities which cause the risk, play a dominant role. The reason for this is that what is meant by 'risk' is closely intertwined with the social relationships which people prefer and with the importance which is attached to the activity which generates risk (Sch90). The originators of this concept summarize it concisely: "common values lead to common fears" (Dou82). Some people, for example, fall back on the 'probability times effect' definition of risk in cases of considerable uncertainty and social controversy. This definition is very suitable for negotiation purposes**. In this case, these people's concern with social ideals is no less intense than that of people who, in similar circumstances, think that a risk approach based on the 'precautionary principle' ('Vorsorgeprinzip') is appropriate.

* See, for ecotoxicological risk assessment, the Health Council publication 'Ecotoxicology on course' (GR94). This report has been translated into English (1994/13E).

** As shown by the following: an effect with a wider scope is admissible if the probability of its occurring is smaller. In other words if the product of probability times effect does not increase.

The committee refers to the confrontation between different risk perceptions in an open dialogue as risk communication. This type of communication can increase support for risk management measures. A major problem in risk communication is that the parties who exchange information assign a variety of meanings to the concept of risk. If the parties are unable to arrive at a conceptual consensus, the communication will be doomed to fail from the start. The committee is in agreement with the following quotation: (Dav95): “If officials and experts involved in dealing with the public can at least establish a common meaning of ‘risk’ that is shared between them and their audience then the chances for meaningful communication will be greatly enhanced.”

A second major condition for successful risk communication is: trust. If people with something to say do not take their listeners seriously, and if those who come to listen and ask questions or to set out their own point of view have no confidence in the official spokesperson or the experts who have been called in to assist, the most that can be achieved is an exchange of opinions*.

The committee already mentioned that involving stakeholders in the process of risk assessment and management is a condition for obtaining broad support for risk reducing measures. Risk communication, *i.e.* ‘dialogue’, plays a central role in the consultations between the parties involved.

* In the US in particular, a lot of research has been conducted in recent years into the factors which play a role in risk communication and into effective forms of risk communication. Cf. Mor93.

Chapter **3**

Protection

3.1 The environment policy of the Netherlands Government

The environment policy as it has grown up in the course of time can be described as: ‘this is where we draw the line’ and ‘trying to get better’. The environmental risk management approach, as set out in ‘Premises for Risk Management’ (TK89b) is an example of this. Using maximum tolerable risk levels, the government indicates what maximum level of threat to human and ecological health it considers to be tolerable. ‘Negligible risk levels’ are an additional measure for the intended environmental quality. As the committee stated in its previous report (GR95b), the maximum tolerable risk levels are not explicitly based on considerations of social benefits or feasibility.

According to the Dutch government (TK89a), considerations of environmental hygiene and environmental protection should in the first place be seen as pre-conditions for human activities. This position is set out in greater detail in the discussion between the cabinet and the Lower House about ‘negligible risk level’ (TK93a, TK93b, TK93d). It was argued in the Lower House that in cases where risk levels under a maximum tolerable limit are accepted, this level should be determined after a consideration of costs and benefits.

In this chapter, the committee briefly discusses the objectives of the environmental policy. This results in a position for a further appraisal of questions relating to risk assessment.

3.2 Sustainable development

In the first National Environmental Policy Plan (TK89a), the Dutch government chose sustainable development as the basic principle for its environmental policy. Sustainable development includes the attempt to balance economy, culture* and ecology in such a way that there will be an end to the systematic destruction of ecosystems and environmental functions as well as the exhaustion of resources. It emerges from the report 'Our common future' published by the World Commission on Development and Environment (WCDE87) that sustainable development is linked to a reasonable distribution of the—finite—possibilities for the exploitation of 'Mother Earth'. The purpose here is to avoid saddling up future generations with an exhausted and severely unbalanced biosphere. Those generations should also have access to options which allow them to provide for their needs.

A mechanism in our non-sustainable approach to the environment is the diversion of problems to other, often less developed, parts of the world or to other scales, to the future or from the individual to the collective. This diversion is linked to the tendency of numerous individuals, groups and organizations to maximize 'economic' benefits in the 'here and now' at the cost of risks for the collective on a larger scale or in the longer term (TK89a, Vle93). It is precisely for this reason that the translation of the objective of 'sustainable development' into concrete measures is not simple.

3.3 Human health

According to the World Health Organization, health is a condition of complete physical, mental and social well-being and not just the absence of any illness or deficit. This description of health is not practical when assessing whether a particular level of exposure to an environment factor is justified in terms of health. The concept requires further elaboration. The committee agrees with the interpretation of the Health Council's Committee on Air Quality Guidelines that health can be seen as a dynamic balance between, on the one hand, biological and mental properties of the individual and, on the other hand, stimuli and factors in the physical and social environment (GR77). This point of view can also be found in 'Public Health Status and Forecasts' (RIVM93). The authors of that document discern five elements in the concept of health:

- health is an optimal adjustment to given circumstances or optimal functioning

* In the sense of civilization and the social relationships within society.

Table 1 Factors which determine health. Source: RIVM93.

exogenous factors	
	environmental factors
	lifestyle
	social environment
endogenous factors	
	genetic factors
	acquired characteristics
health policy	
	prevention
	health information
	health care

- health exists if there is a dynamic balance or interaction between endogenous and environment factors
- health includes physical, psychological and social components
- health has organic, functional and social levels
- health includes subjective and objective components.

Any statement about a reasonable situation from the health point of view will therefore include individual, social and cultural components as well as physical ones (see table *1*). Environment factors such as substances in the air, water and food, radiation, noise, bacteria and other micro-organisms, can have an influence on health, in addition to other exogenous factors such as behaviour, eating and drinking habits, smoking and medicine use and the social environment. The exogenous factors, the endogenous factors and public health policy interact to determine the health of individuals (RIVM88, RIVM91). This also means that it is generally difficult to make a precise prediction or measurement of the effect of a reduction in exposure to an environmental factor or stressor which is thought to be harmful.

For the risk attributes which describe effects on human health, the committee cannot make a recommendation which applies to all situations. It is of the opinion that the probability of illness and the probability of death, taken together with the number of life years and the number of healthy life years, are relevant risk attributes. In a variety of environmental problems, annoyance and a negative appreciation of the environment are important.

3.4 Ecosystem health

'Healthy' ecosystems are essential for the sustainable operations in the world and they are therefore one of the conditions for the continued existence of mankind. It is even more difficult to define what constitutes the health of an ecosystem than it is to define good health in humans. First of all, a variety of ecosystems are rated differently on the basis of attributes such as complexity, diversity, spatial differentiation, succession trends, self-regulating ability, naturalness and carrying and production functions (examples are the regeneration of oxygen, the bonding of carbon dioxide and the production of all kinds of natural resources). In addition, scientific insight into the interaction between environmental conditions and ecosystems, as well as changes in them, is generally very limited, especially on the higher organizational levels of populations and ecosystems.

'Ecological' risk evaluation has developed furthest for toxic substances. Here, the assumption has been made that, if there is quantitative protection of the species present, the structure and the functions of ecosystems will also be safe. Dutch government policy aims to protect populations of flora and fauna, not individual plants or animals.

3.5 Classification

Objectives

During the development of the objectives of health and environmental policy, it emerges that threats to health and the environment can differ widely in scope. The risk associated with gambling in a casino is not of the same type as that involved in mountain-climbing; the risks of transporting LPG in tankers are different from those of generating electricity in a power station. Equally, the risks involved in large-scale pig-breeding for export (manure disposal) are not the same as those for mass air travel. These differences in scope can be described in various ways, some overlapping and some complementary. Classification criteria are:

- the spatial scale of risks
- the time scale of the risks
- uncertainty about the nature and scope of the risks
- social importance of the activities which cause the risk.

Another important factor is the authority of the government organ which takes the decision.

Table 2 Spatial levels of the possible effects of human activities (from RIVM88).

level	keywords for purpose of illustration
global	- greenhouse effect, damage to 'ozone layer', reduction in biodiversity
continental	- air pollution, acid rain, deforestation,
fluvial	- pollution of rivers and lakes, upstream discharge of substances
regional	- air pollution, habitat fragmentation, tanker disasters with pollution of coastal waters
local	- factory accidents, traffic noise
domestic	- pollution of inside air, DIY equipment

Spatial scale of the effects

A classification according to the spatial scale of possible effects is shown in table *2*. The management of risks which have, global, continental and fluvial implications generally requires supranational consultations. Regional, local and domestic risks, on the other hand, come under the jurisdiction of national or more local government. Both the social importance and the scientific complexity of a risk assessment generally increase with the spatial scale of the problem.

Time scale of effects

If one concentrates on threats to health, one can think in terms of generations. A year, for example, or 30 years, a century and so on. However, if the assessment is to include natural processes, typical times will vary widely in terms of both effects and recovery. Annex F (figure *11*) contains some examples of this.

An additional consideration of importance is whether the effects are continuous, sporadic or delayed. Releasing a hazardous substance into the environment will, to an extent which depends on the dispersal pattern, the exposure pattern and the distribution of susceptibility in the population, pose a continuous threat to human health. An accident with a petrol tanker, on the other hand, only occurs very occasionally. It is possible that the population of a particular area will not be affected by an accident of this kind for several generations. Exposure to radioactive substances provides an example of delayed effects: an increased incidence of cancer only becomes apparent many years after exposure when the people who have been exposed have already reached an age at which cancer is common anyway. Damage to the ozone layer by anthropogenic emissions is another example of activities with delayed effects since the consequences only become apparent many years after the actual emissions.

Public interest and uncertainty about nature and scope

Risk problems can also be classified by reference to (Sta93, Fun85):

- the area where there is consensus about the nature and scope of the problem and where there is a limited, simple public interest
- the area where the boundaries of a single professional domain are crossed, with public interests becoming more complex and extensive
- the area of major social commitments; there is a national interest or an interest of even greater scale and scientific expertise is hardly available, if at all.

This classification involves two aspects of risk problems which the committee refers to as: ‘public interest’ and ‘uncertainty about the nature and scope of the risks and benefits’ of activities. These aspects cannot be viewed independently of the spatial and time scales referred to above. For example, considerable uncertainty surrounds the prediction of possible effects on the health of the world’s population and the global ecosystem. However, the social importance of the management of such risks is very great since the consequences of the drastic measures which may be required are considerable.

The committee sees ‘social importance’ as a major aspect of risk problems. This fits in with its earlier comment that risks must be evaluated against the background of the intended benefits of activities. The committee is aware that, just like risk, social benefit has many attributes: nature, scope, uncertainty about outcome (this involves economic risk), who benefits? etc. The committee will not be discussing these aspects of social benefit further.

Government jurisdiction

Government decisions can be broken down into the following levels:

- supra-national
- national
- regional (provincial)
- local.

The assessment and decision-making procedures will vary from level to level. On the supra-national level, treaties between states will constitute the basis for multi-national efforts to manage risk. The extent to which these treaties are binding can vary. In the EU, multinational cooperation results in legislation which is binding for all the member states.

Regional and local governments will generally have to operate within guidelines laid down by national government. In the Netherlands, there is a tendency to give these guidelines a more general character than was the case in the past in order to increase policy freedom for local governments.

The committee would wish to point out that the interests of local and national governments need not always be matching, in particular when it comes to weighing the benefits of activities against the risks caused by those activities. Conflicting interests of this kind can, for instance, make themselves felt during infrastructural developments. National decisions about forms of transport and routes need not necessarily meet local preferences. This is also true on the international level. A continuing increase in the amount of carbon dioxide in the atmosphere would appear to have disastrous consequences for large areas and populations but, initially, the consequences for Dutch agriculture might be favourable (GR86, Wol93).

This classification might be extended to include a personal level. In a variety of problems, individuals have extensive powers to decide about the risks which they accept. Examples of this are smoking, eating, drinking and exercise.

Administrative classification

The four aspects referred to—spatial and temporal scope, uncertainty about nature and scope and public interest—determine to a considerable extent the administrative character of risk problems. This administrative character can be described in terms of the three levels commonly used in decision theory (GR84a, Vle90): strategic, tactical and operational. As a risk scores higher for one of the four aspects, the problem will become less operational and more strategic. The committee would express two reservations here. The administrative classification is not rigid: every problem has strategic, tactical and operational aspects. The development of Rotterdam harbour with its industrial sites can be seen as a strategic problem, the construction of a railway line for goods transport to the German hinterland can be seen as a tactical choice and measures to reduce noise along the line can be seen as operational. In addition, the classification ‘strategic—tactical—operational’ depends on the decision-maker. Strategy for the United Nations is not the same as for a municipal council. The concrete spatial arrangement of a polder, for example,—an operational detail for national government’s spatial planning policy—can be a central issue of municipal politics. The classification of risk problems given here is shown in figure *5*.

Strategic decisions left to national government* are decisions about multi-faceted and far-reaching activities of major social importance. Examples are selections of

* ‘Management tasks’ are mostly delegated to governments at lower levels.

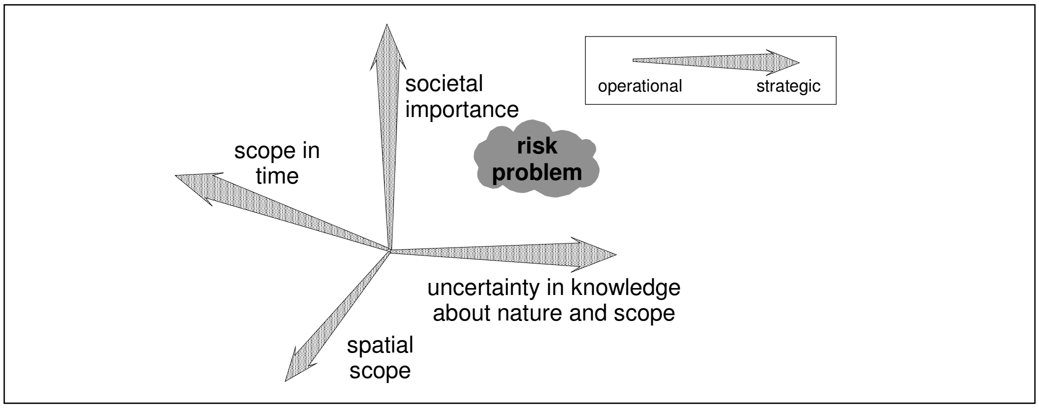


Figure 5 The main aspects or dimensions of risk problems. The higher a risk problem scores for each of the four dimensions, the more the nature of the problem shifts from operational to strategic.

methods for energy supply (nuclear energy as opposed to energy from fossil fuels or energy savings or 'alternative' sources of energy) and mobility in the Netherlands (private as opposed to public transport). The choices are located on the regional scale or higher and can have consequences which reach far into the future. Tactical problems relate to the choices which have to be made—and the measures which are necessary—in order to achieve tactical objectives such as the location of a power station and the routing of roads or railway lines. Numerous decisions are continuously required on the operational level to keep processes or developments on track: what requirements need to be met by a valve in a chemical processing plant, by a car or by the air quality in a street or district?

With risk problems of any size, it is not always clear whether the decision-making process is concerned (or should be concerned) with strategy, tactics or implementation. The concrete health and environmental objectives only become clear from the choice of resources for managing risks. It can also emerge that one party thinks they are dealing with a strategic problem while others think that they are answering tactical or even operational questions. This can result in a divergence in the opinions of the parties involved in the decision-making process, something which can in turn lead to conflicts. The discussion about nuclear energy provides a range of examples of this: are we trying to decide upon the most suitable location for a nuclear power station in the Netherlands or are we deciding about the acceptability of the use of nuclear energy for electricity production? Equally, during the decision-making process about extending Amsterdam Airport, the government's attention was fixed on, among other things, the prevention of excessive noise levels. Environmental campaigners, on the other hand, wanted to turn the discussion to the acceptability of air transport.

3.6 Choices for protection

The statement of objectives for environmental and health policy and of the nature of the risk problem does not mean that questions about the tolerability of the risk associated with specific types of activity have been settled. A variety of interests play a role in the evaluation of, and decisions about, these risks. In addition, there is no certainty about the benefits and risks of the various forms of human activity. The government needs to make a reasoned selection from the multitude of objects which require protection and from relevant opinions.

The process of risk assessment and risk management proposed by the committee (see figure *3*) includes a structured discussion of the central questions which have to be answered during government decision-making about risks. These central questions are:

- What is the risk involved in the activity or situation? (What is the object which requires protection? To what extent is it threatened and by what?)—*risk assessment*
- Is the risk which is linked to the activity or situation adequately limited? (What level of protection is required?)—*criteria for the decision about the tolerability of the risk*
- How can the accepted risk level for an activity or situation be ensured or reduced? (What is the value of certain protection, how can that level of protection be maintained or achieved?)—*what measures are possible, what influence do they have on the risk assessment and the decision about tolerability (repetition of process)*

These central questions can be broken down into sub-questions like: What risk-reduction measures are available and at what cost? Who has to pay the costs or; what claim on public resources can be justified? What are the benefits of the activities which require management and who benefits directly, indirectly or not at all? At what level of cost for risk reduction should the activity—and therefore the benefits—be brought to an end? Can these benefits also be generated in other ways and what will the risks then be? What freedom does the public have in their choice of a place to live, of work environment, of degree of mobility and mode of transport, or of medical care?

When answering these central questions, the government will turn to cost and benefit considerations and to established legal principles. When formulating government concern for safety and the environment in laws and other regulations, the chosen instruments should be in reasonable proportion to the goal in question (Ano92). Examples of criteria for determining this reasonableness are: adequate attention for the prevention of side-effects and the link-up to existing efforts for risk reduction. Formal approaches such as cost-benefit analyses can be useful in achieving the required clarity with respect to facts and valuations.

When choosing the instruments for the management of risks to human and ecological health, the negative effects are therefore not the only criterion. The government will also have to take into account the potential benefits and the wishes of the parties involved. This will then lead to differentiation in regulations relating to risk management and the levels stated in those regulations. Beforehand, it is not possible to select a single level of government concern or a single level of protection which can be described as reasonable for all circumstances. Which risks will, as a rule, be seen as tolerable, will depend on the specific web of interests, on the justification of the associated claims and on the force of the accompanying arguments.

Chapter 4

Origin

4.1 Activities, direct and indirect effects

Damage and loss as a result of human activities do not simply happen. They are the possible result of a sequence of successive actions and events (see figure *2*). Causes of actual damage or loss can be located in human goals and ambitions, in the design or plan for an activity, in the selection from a variety of options for the implementation of that plan, and—last of all—in the way in which casualties are cared for and treated and in the way in which damage to the environment and goods is repaired.

Three stages can be seen in the sequence which describes the origin of risks. At the beginning, there are needs and wishes. Then there is the activity which can result in exposure to stressors which, in turn, can be a source of damage or loss (figure *6*). During the transformation of human needs into wishes and concrete activities, there are choices between respecting varied—and sometimes conflicting—wishes and fulfilling options for the implementation of the wishes. The committee makes a distinction in the activities which take place between ‘implementation according to plan’ and ‘deranged implementation’ (see figure *6*). Accidents, although they are expected and accepted to a certain extent, are the possible result of implementation difficulties. The licensed discharge of polluted waste water is an inevitable by-product of implementation according to plan. The boundary between these two categories is, incidentally, not altogether clear-cut*.

* Should a leak in a flange gasket in a chemical processing plant be classified under implementation according to plan or under deranged implementation? If one takes the view that some leaks are inevitable in a large plant but that they can be

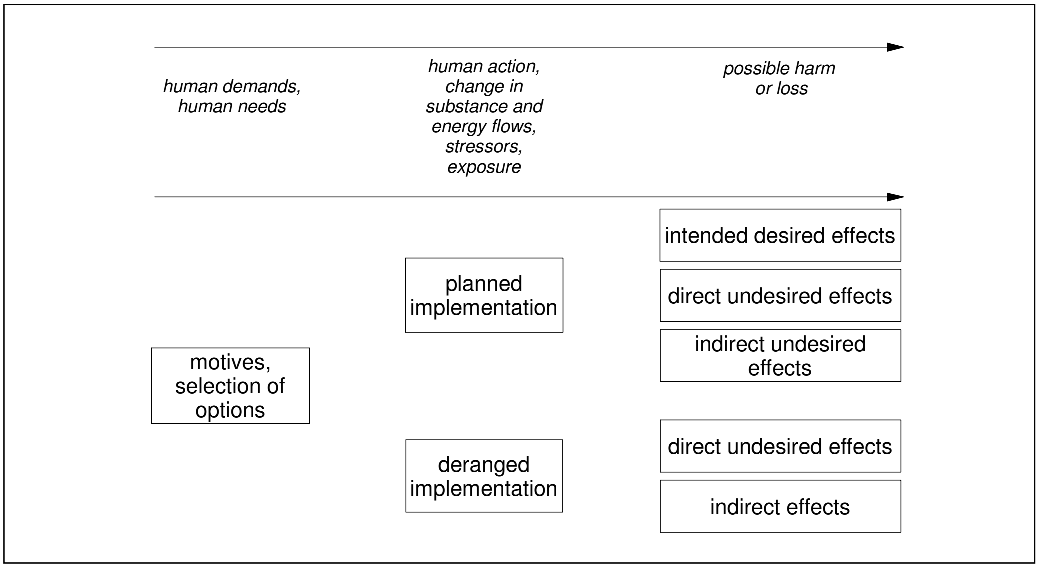


Figure 6 Elaboration of the cause-effect sequence for the generation of risk. Human activities result in the desired effects and directly and indirectly in undesired effects.

Implementation according to plan leads to the intended effects but is therefore inevitably accompanied by undesired effects. The effects of deranged implementation are generally unpredictable (when?, what nature and extent?) and generally undesired.

The intended effects are also shown in figure *6*. In decisions about the tolerability of risks, the benefits of activities play an important role (Dav94; see also last chapter). There are more than enough examples of this. The committee would here wish to refer to the distinction in levels for the protection of radiotherapy patients and of radiotherapy staff against ionizing radiation. In the case of the patient, the benefit of the treatment determines the accepted potential damage; for staff, there are exposure limits which may only be surpassed in very exceptional cases (see annex L).

In figure *6*, a distinction is made between direct and indirect effects. The direct harmful effects occur as the result of the action of physical stressors—such as substances and radiation—on humans and the environment. However, in the assessment of the possible consequences of human activities, other factors play a role. Examples are the fairness of the distribution of benefits and risks and the frightening nature of the possible effects. These factors can sometimes play a dominant role and, if the activity be considered tolerable, determine risk management measures.

All this can lead to considerable economic effects. This can in turn have an influence on the protection of human and ecological health. In some cases, the indirect

kept within limits by design, servicing and supervision measures so that accidents are prevented, the phenomenon can be seen as part of planned implementation. If the leaking gasket is seen as the start of a sequence which will end in a serious accident, it belongs to 'deranged implementation'.

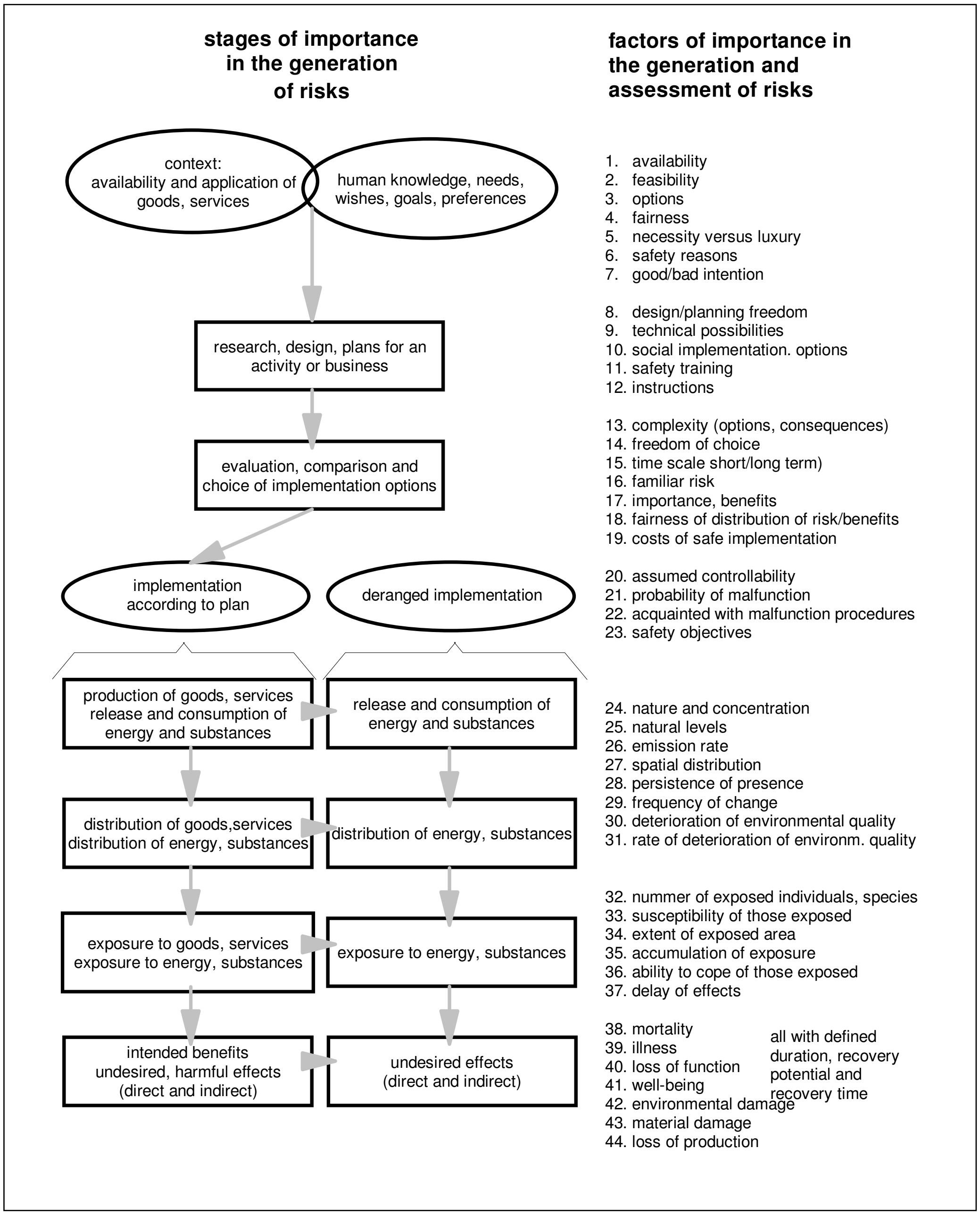


Figure 7 Elaboration of the cause-effect sequence for the generation of risks. On the right of the figure, we see the factors which are important in the generation and assessment of risks. These factors, which describe occasionally overlapping aspects of risk, are discussed in annex G.

effects may entirely dominate the risk assessment (Bur93). In addition, there are the indirect effects to which the committee has already referred in the shape of ‘opportunity costs’, the costs (including risks) which arise because resources which have been deployed can no longer be used for other purposes.

4.2 Factors

The chart in figure *6* is elaborated in figure *7*. The factors which can be important for the assessment of risks and for decisions about risk management measures are shown for the various stages on the right in figure *7*. The 44 factors in the figure constitute a list of possible candidates with the lower numbers primarily describing context attributes and the problem of selection. As one progresses towards the higher numbers, one increasingly finds attributes of substance and energy flows and of stressors, exposure and effects. The figure also indicates that implementation according to plan can change into implementation difficulties at every stage. For example, a malfunction in a reaction process or an accident with a tanker need not necessarily result in damage to human and ecological health if safety provisions work as they should. However, complete or partial failure of these provisions means that the process shifts from the left-hand to the right-hand sequence in figure *7**. An analysis according to the model in figure *7* makes it possible to select attributes which are important for the risk problem in question and to achieve agreement about that selection with those involved.

Generally, it is necessary to elaborate particular parts of the sequence in figure *7* in order to answer questions posed as part of a risk assessment. For example, detailed knowledge about the availability and practicality of certain products is relevant for determining target groups and the nature of information activities about risks. A closer understanding can also be needed of the needs, wishes and preferences of various types of users of goods and services. In addition, it may be important to know the problems which can occur during the evaluation and selection of activities with the same objective, management options for example. The detailed cause-effect sequence can be worked out further for a well-defined activity or product, as in a complete life-cycle assessment (Kra93).

The ordered list of factors in the figure constitutes, in the committee’s opinion, a good starting point for characterizing certain aspects of the risk. It is then possible, against the background of the intended benefits of the activities in question, to ask which measures would be the most effective in adequately managing the risk at what stages in the process.

* Here, once again, we see that the demarcation line between implementation according to plan and deranged implementation is not clear-cut. Is the deployment of safety provisions ‘according to plan’ or does this automatically mean that there is a ‘derangement’?

4.3 Diversion onto the collective level

In 3.2, it was stated that 'diversion' is one of the main causes of the non-sustainable exploitation of the environment. In many cases, this involves diversion from the 'individual'* to the collective. If someone decides to subject his decision to do his shopping in the car to a risk assessment, the most probable result would be that *his* activity is not so harmful to human and ecological health that *he* should leave the car at home, especially in view of the benefits which accrue to *him*. The fact that numerous others follow his example, however, results in an environmental problem of considerable proportions: damage to the living environment as a result of air pollution and noise, damage to ecosystems as a result of road-building (not to mention accidents; see, among others, Wal91). Other examples are the problem of waste and the effects on the global biosphere as the result of the release of certain substances into the atmosphere.

Risk problems of this kind are based on conflicts between individual needs for security, comfort and relaxation in the short term and collective and longer-term requirements for prosperity, liveability and environmental quality. A characteristic feature is that individuals make independent decisions which are directed towards improving well-being. However, all these choices involve material and immaterial 'costs'. In part, these are diverted onto others and onto society as a whole. If large numbers of people divert their costs, a situation will be created which is considered by everybody to be threatening and therefore undesirable.

The risk management methods in this type of situation vary from those used, for example, when new materials are put onto the market or for external safety of railway yards. A characteristic feature here is that there are many parties involved (individuals and lobby groups) whose goals are different and who therefore represent varied points of view. It is then difficult to arrive at a consensus, whether about framing the question, about which risk attributes to select or about decision-making criteria. In turn, this means that it is difficult to reach agreement about risk assessment or the measures to be taken. The committee believes that an analysis based on the model in figures *6* and *7* can be helpful in arriving at a consensus and therefore in establishing the necessary support for the decisions which have to be taken.

* 'Individual' can refer to individual people as well as to organizations.

4.4 Risk accumulation

In general, the population and the environment are exposed to a variety of stressors caused by many types of activities (in the terminology used here: cause-effect sequences). Exposure to a particular substance can result from a variety of causes, while, in addition, there can be simultaneous exposure to radiation, noise and accidents from the same—or other—sources. There are two sides to the problem of accumulation. First of all, on the strategic level, it is a question of fairness: how are the benefits and risks of activities distributed? In addition, there is the question of the concentration of a variety of stressors which, precisely when they are present together, lead to a risk which is considered to be serious.

The degree of risk accumulation emerges when the risk is characterized using attributes at the end of the cause-effect sequence, *i.e.* exposure and effect attributes (see figure *7*). In addition, it is necessary to consider factors from outside the cause-effect sequence which are associated with particular types of activity, as well as the distribution of the risk in space and time. In situations where risk accumulation plays a role—situations which are by definition complex—the government will mainly follow policy codes (see 6.2) in decision-making about the tolerability of risk. Environmental quality standards* can be used here as measures for the effectiveness of the policy.

Issues of fairness arise in cases where there is an uneven distribution of risk across groups of the population. In effect, what is involved here is diversion from the collective to individuals. In the USA in particular, pleas have been made in favour of devoting explicit attention to 'environmental equity' during decision-making, for example in the form of a separate section in Environmental Impact Statements (see Cal94). In order to make accumulation problems visible in relatively simple ways, aggregated risk attributes have been proposed. However, they have not yet been used in Dutch environmental policy. One example is the 'integrated environmental exposure index' for integrated environmental zoning which another Health Council committee reported on (GR95a). An additional problem is that, precisely in situations where the phenomenon of risk accumulation plays an important role, socio-economic factors can also exert a negative influence on health (where human health is concerned, see Mac94).

* Numerical standards for stressor or exposure attributes (for example, the concentration of a substance in an environmental compartment).

Chapter 5

Characterization

5.1 Example

At the start of this chapter, the committee wishes to provide a summary of a study relating to attributes which play a role in judging risks.

Hester and his colleagues (Hes90) asked groups of people to choose a route for a high-voltage power transmission line on the basis of information which included construction costs and possible effects on health (cancer) as the result of exposure to electric and magnetic fields generated by the line*. It emerged that participants included numerous attributes in their decision. The researchers report ten 'major factors'. The top three were the costs of risk-reduction measures, building and operation costs and the increased risk of cancer. The study also showed that the choice depended on the risk attributes which were selected. The participants tended to prefer a more expensive route with fewer exposed people if they had to base their choice on information about the additional costs of electricity consumption per person than if they had to base their choice on the total additional construction costs (the numerical value of the first measure is considerably lower than the second). Another interesting finding was that participants interpreted information about the upper limit for the risk of cancer as the most probable estimate. The respondents based their statements about the limits for the health risk on, among other things, the number of people exposed, the number of deaths per year, the voluntariness of the risk, the benefits of the technology and the individual possibility of controlling the risk.

* In 1992, a Health Council committee concluded that, on the basis of published research results, it was not possible to conclude that exposure to electric and magnetic fields generated by power transmission lines has an influence in the development of particular malignant disorders (GR92).

The committee has gone into this example of the selection of risk attributes and the use of those attributes to evaluate risk in some detail because the results match a lot of other findings, both from experimental studies and from studies relating to concrete government decisions. It would add that a range of individuals and groups grant different levels of importance to risk attributes and, partly in the light of the benefits associated with the activities which generate risk, arrive at different choices which reflect their standards and values as well as the interests which they represent (see, for example, a 'classic' study by Slovic, Fischoff and Lichtenstein involving students, politically-interested women, business people and professionals and experts in the field of risk assessment: Slo79).

5.2 The selection of risk attributes

A government which tries to establish support for its decisions about risk management will have to take account of the varied perceptions of risks which are present in different groups of society. This means that making a meticulous selection of the attributes which determine risk perception and acquiring an understanding of the importance granted to each of those attributes. A single attribute will often be enough for operational decisions: the relevant measure for the choice of a filter in a ventilation shaft is the fraction of the substances which is left on the filter. With problems of strategic importance, single attributes are generally inadequate. For example, when new substances are being introduced, establishing the acute chance of death for the people who may be exposed is inadequate. Equally important are attributes relating to various forms of illness and handicap, to any influence on the health of future generations, to the effects on flora and fauna and to the effects on local, regional or even global ecosystems*.

The committee does not believe that fixed rules can be given for the selection of risk attributes. As the social importance of questions increases, or as their scientific complexity and uncertainty increase—with a corresponding shift from operational to strategic—selection will be increasingly dependent on the individual circumstances of each case. In the case of problems which transgress national boundaries, international consultations will be required in order to achieve risk characterization and assessment which does justice to the scope of the problem. The committee refers to the example of the 'Harmonization of approaches to the assessment of risk from exposure to chemicals' project of the International Programme on Chemical Safety (IPCS)** in which the Netherlands also participates.

* The committee refers the reader to its earlier comment that a quantitative attribute can be expressed numerically in various ways. For example, there will be a difference between appraising the environmental burden of particular substances for a particular year and appraising the integrated burden over a period of time.

Table 3 Attributes which play a role in the evaluation of risks (Vle92).

- potential degree of harmfulness or deadliness
- physical extent or range of possible damage
- social extent of possible damage (number of people concerned)
- distribution in time of possible damage (direct, delayed effects)
- probability/ambiguity of undesired events
- supposed manageability of consequences (by subject and/or expert)
- experience/familiarity with, and conceivability of consequences
- voluntariness of exposure (freedom of choice)
- importance and clarity of expected benefits
- harmful intention of risk creator (in cases of crime, sabotage)

Figure *7* and annex G can be helpful when choosing risk attributes. The analysis and hierarchical breakdown of the goals of environmental and public health policies also provide a starting point for determining risk attributes which are relevant to policy. In addition, the scientific literature about the comparative assessment of the risks generated by a variety of activities and products provides some approaches (see, for example, Slo84). Table *3* lists attributes which can play a role when evaluating risks (Vle92). In annex F of its previous report, the committee provided an even more comprehensive list (Sjö94). Most of these attributes are also included in figure *7*.

The cluster of risk attributes which are used to characterize the risk should be transparent. This means that the attributes must be meaningful for experts and non-experts alike. In addition, the cluster should be subject to methodological requirements. The reader is referred here to Keeney and Raiffa's work (Kee76), the conclusions of which are thought by the committee to be applicable to the selection of risk attributes. A selection of risk attributes must be complete, practical, analyzable and independent. In addition, these authors consider it to be desirable to keep the number of independent attributes ('dimensions') to a minimum. The four criteria can be explained as follows:

Complete Leaving aside attributes which describe relevant facets of the risk problem almost inevitably results in decisions which are felt to be unsatisfactory by the parties involved.

Practical In practice, it often emerges that risk attributes selected previously are criticized during assessment, for example because they leave too much room for different interpretations. Clearly, then, they were not really practical. Risk attributes must also fit in with the chosen management system.

* A joint venture of the United Nations Environment Programme (UNEP), the International Labour Organisation (ILO) and the World Health Organization (WHO).

Analyzable Taking decisions about risk problems which require a variety of attributes (for example, ten or more) in order to characterize the risk, is generally complicated. The process of decision-making can be made more transparent if the attributes can be broken down into groups which can be considered independently.

Independent It is undesirable for two or more risk characteristics to describe the same aspect of a risk problem. However, in practice, it is not always possible to avoid this. In these cases, it is possible in principle to derive two new independent attributes by means of combination. However, these attributes may not be very transparent. For example, there is the chance of contracting a particular illness and the chance of dying from that illness. The number of days of sick leave and the reduction in life expectancy are two characteristics which are more independent (and, in this example, also reasonably transparent).

5.3 Risk profile

Using the selected risk attributes, the risk can be characterized. A characterization or risk profile of this kind means that an attempt will be made to give the risk a score for the various attributes. The result can be expressed numerically (for example, the concentration of a substance in the air, or the costs of safety measures) or as a particular ordinal representation (for example according to the severity of the illness on a scale from 'very serious' to 'harmless' and 'absent' or according to the level of manageability on a scale from 'unmanageable' to 'easily manageable'). Aggregation—the combination of risk attributes and the associated scores—can be used to simplify the characteristic*. Annex J contains two practical examples of risk profiles. In the first example, four possible routes are compared for oil pipelines in the Wadden Sea (figure *12)*. By stating for each route the possible influence on natural and ecosystem attributes which are thought to be relevant, it is possible to compare the various routes. If one wishes to use the risk profiles for classification purposes, rules are needed for the evaluation of the individual attributes with respect to each other and aggregation.

The second example is taken from the work of a research group at Leiden University (Gro92, Gro95). They have developed a method for rating companies in terms of safety (see figure *13*). Where the risk characteristic in the previous example principally consisted of effect attributes—in other words attributes located lower down the sequence in figure *7*, the selected attributes in this example are primarily related to the organization of the activities higher up in the cause-effect sequence of figure *7*.

* Here, an inevitable consideration is the relative weighting of the risk attributes involved in the aggregation.

To draw up a risk profile based on a cluster of risk attributes, one can look for support from the multi-attributive utility theory. This theory was originally developed for modelling choices between options which are described with diverse attributes. Choices like this will, for example, be involved in job application procedures, labour relations or the purchase or rent of accommodation (see, for example, Edw82 and Win86). This first means, as stated in the previous section, the generation of relevant risk attributes followed by the 'scoring' of activity or situation in terms of these attributes (see the examples in annex J). Some risk problems are suitable for two additional stages, namely:

- weighting: assigning a weighting to each risk attribute
- aggregation: determining a weighted combination of all scores.

This results in a simple, quantitative risk profile. Weighting and aggregation are recommended by, among others, Fischhoff, Watson and Hope (Fis84). These authors state that risk problems using this method are more practicable and amenable to discussion but they also point out that the result depends on the problem in question and on those who make the assessment.

Sometimes, scoring and weighting risk attributes can be justified on the basis of empirical scientific research, as with exposure-response or exposure-effect functions from research in epidemiology, toxicology or experimental psychology. Other cases may involve 'expert judgement' or group judgements from informed lay panels who have been introduced beforehand to the method as a whole and who are aware of the objectives of the risk assessment. Characterizing risk using a number of attributes, including the selection of those attributes, involves empirical natural science as well as empirical social sciences.

An example of an aggregate risk attribute meant for the classification of risk problems has been included by the committee in annex H (Cla93). An entirely different example of an aggregate measure is the 'disability adjusted life year' (DALY) which is used in a World Bank study into the illness burden in various regions (WB93). This measure is based on:—a standard survival table for the calculation of 'lost' life years;—an age-dependent evaluation of lived time which takes into account that young people and old people are dependent on adults for social functioning;—a correction for state of health using a definition of a weighting according to six categories of severity of invalidity;—and a discount rate of 3% per year. The committee has no prior answer to the question of whether this measure is also adequate on the local or regional level in the Netherlands for the assessment of the consequences of risk management measures for public health; it is possible that alterations will be needed for the Dutch situation. A much more simple measure, which is obtained by leaving aside some of the considerations mentioned, is the measure based on death in terms of lost life years, possibly with a correction for state of health. This measure is used in a

Table 4 Costs of 'saving' a life year (prolonging life expectancy by one year) for various interventions. Taken from Ten95. The figures should be seen as indications. Indirect costs have been left aside and a reduction of 5% has been applied for costs and additional life years.

intervention	US$ (1993)
car safety systems	
Driver automatic (vs. manual) belts in cars	≤0
collapsible (vs. traditional) steering column	67.000
airbags (vs. lap belts)	120.000
dual master-cylinder braking system	450.000
hazardous substances	
reduction of lead content in petrol from 1.1 to 0.1 g per gallon	≤0
chlorination of drinking water	3.100
ban on asbestos in brake systems	29.000
ban amitraz pesticide in pears	350.000
radionuclide emission control at coal-fired industrial boilers	2.600.000
medicine	
cervical cancer screening every 3 years for women age 65+	≤0
heart transplantation for patients age 55 or younger and favourable prognosis	3.600
anti-hypertensive drugs for patients age 40 and 95-104 mmHg	32.000
annual mammography for women age 55-64	95.000
intensive care for very ill patients after cancer operations	820.000

lot of medical cost-effectiveness studies. When used in the context of environmental policy, measures of this kind should be complemented by an ecological measure.

As shown by the pipeline example in annex J, it can be desirable to determine the risk profiles of various risk management alternatives. This provides a basis for the comparison of the effectiveness and efficiency of the measures*. An example of a way of doing this is provided by the committee in table *4*. This table shows the costs of various measures per additional life year. The committee emphasises that table *4*, which is a selection from a list of five hundred measures, is not the only basis for taking decisions. A reduction in life expectancy is, after all, only one attribute. Furthermore, the analysis on which the table is based involves all sorts of limiting suppositions such as not including indirect costs.

In concluding this chapter, the committee warns against excessive quantification and subsequent aggregation of the selected risk attributes with the aim of arriving at a single risk figure. This can be counter-productive because it results in more questions

* Another example is the purification of drinking-water. Chlorination in order to prevent bacterial infection leaves behind traces of organic chlorine compounds which may harm health. Not chlorinating water is as much, if not more, of a threat to health.

than it answers. A good qualitative description with sound quantification in certain areas provides more room for policy considerations and input, precisely at the point where science makes no further contribution. If there is agreement about the use of aggregation, for example in the classification of options, it makes sense to accompany the results with an explanation of how the aggregates have been drawn up.

Chapter 6

Standardization

6.1 Testing the risk profile

During the risk management stage, a judgement is made about the risk of activities. As the committee stated in 2.2, the criteria followed by the government when arriving at its assessment are laid down in laws and regulations. An exception are the problems, generally strategic in nature, which can only be tackled on an *ad hoc* basis (in these cases, the law will usually state the decision-making procedures).

This chapter provides a generalized discussion of the criteria used for testing the risk characteristics (standards). Not all criteria consist of numerical limits. Some are of a more procedural nature, examples being the ‘optimization principle’ and the ‘quality control principle’ (for example, a risk is not tolerable if the business processes fail to meet quality standards such as ‘good manufacturing practice’).

6.2 Risk standards

The committee uses the term ‘risk standard’ to refer to a general rule relating to a risk attribute or a risk characteristic. This rule is, to a certain extent, binding and is framed in qualitative or quantitative terms. Here, the committee follows the definition given by the government in the Policy Document on Environmental Standards (TK76) and by the Committee on Ecological Standards for Water Management (GR84b). A numerical limit is linked to a quantitative risk attribute. If the numerical value of this measure is higher than the limit, rule A will apply. Otherwise, rule B will come into effect.

As part of the environmental risk management approach, numerical limits are used by the government for a range of effect-oriented risk attributes (TK89b, GR95b). For example, the government has introduced a 'maximum tolerable risk' for 'exposure' to industrial installations of 1 per million per year. The limit applies to the chance, during a year spent at a particular location near the installation, of death as a result of the presence of the installation. The rules linked to this limit are that the government considers the risk intolerable if the limit is exceeded (choice A) and that it should be brought to a level below the limit which is as low as reasonably possible (B).

One finds numerical limits in the various environmental policy documents under the names 'limit value', 'target value', 'intervention value' and 'indicative value'. These different standards imply different decision rules. Exceeding the *intervention value* means that the situation is unacceptable and that intervention is needed. Exceeding the *limit value* is equally unacceptable but intervention is less urgently required*. New applications which result in exposure above the limit value are not allowed. The concept of *target value* has been particularly subject to diverse interpretations in successive policy documents. Its meaning has varied from a sustainability level to an objective to be achieved within a period of 10 or 20 year**. The rule associated with exceeding the target value is: risk reduction is desirable. Between limit value and target value, one or more indications or reference values can play a role. For example, an *indicative value* can constitute a measure for an exposure level which can be achieved with good risk management organization and adequate technology***.

In addition to numerical limits, the government also draws up qualitative standards. These are also referred to as policy codes (Ano83). Policy codes state the government's position on questions such as:

- Is the risk inevitable and has this been adequately demonstrated?
- Has the risk been reduced to a level which is as low as reasonably possible?
- Has the 'most feasible' or the 'best available' technology been used?
- Has risk reduction taken place as early as possible in the cause-effect sequence?
- Have the consequences of exceeding the limits been charged to those responsible? (the principle of 'the polluter pays')

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* This is an example of a distinction between standards relating to new applications ('preventive standards') and standards relating to the risks in existing situations or activities ('intervention').

** The committee is of the opinion that the latter meaning should be preferred since the concept of sustainability would appear to be too complex to be described in terms of numerical limits.

*** Here, the committee refers the reader to the 'tolerability of risk' approach of the British Health and Safety Executive which was discussed in annex D of its last report (see figure 11 in GR95b).

- What does a risk add to existing risks in the area in question? (In assessing the answer to this question, the government can follow the 'stand-still' principle.)
- Are the benefits and drawbacks fairly distributed?

The second rule in this list—reduce the risk to a level which is as low as reasonably achievable (ALARA)—plays an important role in Dutch environmental and working conditions policies. ALARA can also be linked to a numerical limit. The word 'reasonably' refers to the fact that, in addition to effects on human and ecological health, economic and social factors also play a role in risk management: how great are the benefits, who benefits, what are the 'opportunity costs' of drawing up a risk limit here, what is fair etc.?

In addition to standards for a risk profile, procedure standards can be distinguished which relate to the assessment and decision-making process. An example of a procedure standard is the obligation to draw up an Environmental Impact Statement for activities with major negative effects on the environment (Wmb79).

Standards can be subject to conditions. First of all, a risk standard must be valid: there must be a reasonable degree of certainty that enforcing the standard will serve the objectives of environmental and public health policies. In addition, a risk standard must:

- be clear and consistent, in other words be expressed in terms of an appropriate quantity which, in the case of a numerical limit, must be measurable
- be enforceable; testing against standards should make it possible to arrive at the required decisions (sanctions where appropriate)
- have enough political and social support.

In addition to requirements which relate more to the content of standards and requirements relating to the process of standard-setting, these conditions can be found in the general rules drawn up by the government for regulations (Ano92).

6.3 Setting numerical limits

In Dutch environmental policy, especially relating to problems on the national (or, in another classification system, fluvial) scale or on an even more limited scale, numerical limits play an important role (TK89a,b). These limits are set along the lines of the risk assessment and risk management model in figure *3*: the problem for which the standard is intended is described, the possible effects of exposure are studied, the relevant exposure situation is described in terms of risk attributes and a standard is then set using the selected risk attributes. Standards can, in principle, differ according to the type of case involved.

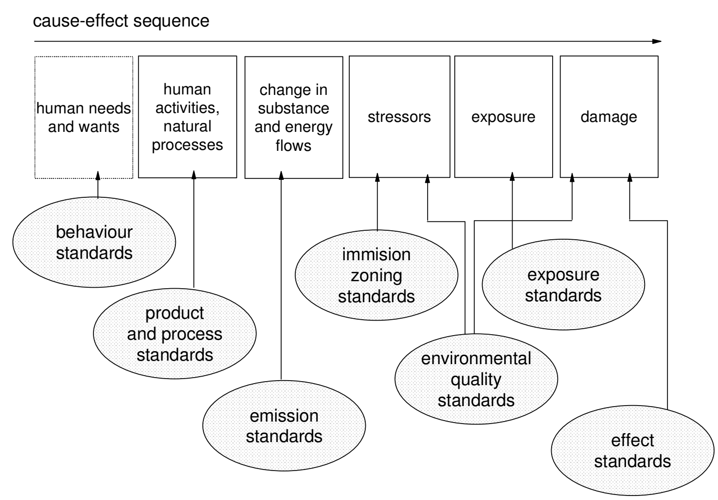

Figure 8 Various types of standard classified according to the stages of the cause-effect sequence. Standards for environmental quality can relate to the stressors (concentration of a substance in soil, for example) as well as to effects (or their absence). Adapted from Rag94.

Standards, and therefore numerical limits, can in principle be set for every stage in the cause-effect sequence. Figure *8* shows types of standards classified in accordance with the sequence. Numerical limits for risk attributes linked to various stages of the cause-effect sequence are, in principle, mutually convertible. Figure *9* gives an example for exposure to a substance. Assuming an individual chance of death or of an effect on health, it should be possible to calculate what level of ingestion corresponds to that probability. The level of ingestion can be linked to concentration in food. In turn, this can be linked to concentration in plants, and so on. This approach makes it possible, assuming a desired level of protection—*i.e.* an effect standard—to derive standards for stages earlier in the cause-effect sequence. This is the path which has been taken in the 'environmental risk management policy'. For every conversion, models are needed which contain suppositions which are difficult to verify. In addition, an evaluation problem is involved at every level in figure *9*. What is the contribution of the substance in question to the effect on health, what is the contribution of ingestion through food to ingestion as a whole, what is the contribution of the concentration in plants to the quantity in the usual diet etc.

Numerical limits (and qualitative standards) can also be derived using considerations such as: what can reasonably be achieved in situations of this kind?, what resources are available?, how ready are people to alter their behaviour? do the standards fit in with traditions? All this will, in part, depend on the point of the cause-effect sequence where the standard is expected to apply. By estimating the risk

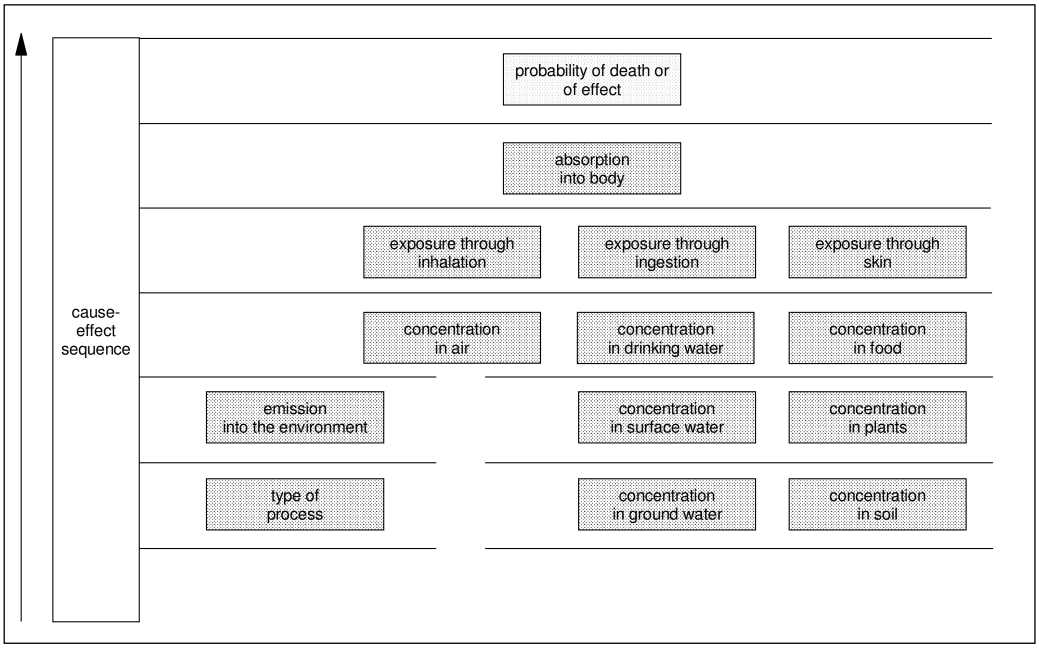

Figure 9 Classification of risk attributes for human exposure to a substance in accordance with the cause effect sequence.

involved in maintaining the standard, one obtains an understanding of the significance of the standard for achieving the objectives of environmental and public health policies.

Numerical limits with general validity play an important role in the Dutch government's environmental policy. One example are the 'environmental quality standards' in the form of concentrations of substances in water, soil and air (Wmb79). The generalized validity of these standards means that, as such, they are generally inadequate for taking decisions which take local circumstances into account. Soil decontamination policy is an example. Exceeding the general limit for the concentration of a substance in soil leads to the conclusion that decontamination is needed. However, urgency depends on additional considerations*, for example because of the use to which the particular stretch of ground will be put.

6.4 Optimization

The committee already referred to the ALARA principle at the beginning of this chapter. In the environmental risk management approach, this principle is linked—as a decision rule—to a numerical limit: if the numerical limit which corresponds to a

* These additional considerations can take the form of standards linked to additional risk attributes.

‘maximum tolerable risk level’ is not exceeded, the risk must be reduced to a level which is as low as reasonably achievable (above this level, it is not considered to be tolerable). The principle can also be interpreted as an optimization rule: an option with a risk profile which is thought to be more favourable than the risk profiles of the other options is preferable, unless the additional costs involved in implementing that option are disproportional to the additional risk reduction. A problem with the implementation of the optimization rule is accounting for the indirect costs and benefits for society of a particular option, as well as the standards and values of the parties involved.

In the field of radiological protection, the optimization rule (ALARA) is an accepted standard for testing the efficacy of a coherent package of protection measures. For example, the International Commission on Radiological Protection (see, among others, ICRP91), and, subsequently, the Dutch government (TK90, TK93c), have recommended ALARA as a method for limiting exposure to radiation expressed in terms of the radiation dose. Every measure for the further reduction of the radiation dose in a group exposed to radiation is justified if the associated health benefits off-set the costs of the measure. What is at issue here, therefore, is the optimization of a chosen protection strategy, with attempts being made to achieve improvements in one or more risk attributes (individual and collective radiation dose, for example) without doing worse in terms of other attributes. Whether the use of radiation sources as such is preferable to other alternatives is therefore no longer under discussion.

Attempts have been made, using mathematical models like differential cost-benefit analysis, to determine the ALARA level of packages of protection measures. A requirement here is that damage to health has to be converted into a monetary value in order to make it possible to compare the avoidance of the damage with the costs of protection measures (for a recent example, see Lef93). An approach of this kind means that all relevant risk attributes are grouped under the same denominator so that subsequent use of the principle becomes simple. In the previous chapter, it was stated that such extreme aggregation will generally not be satisfactory for problems of a strategic nature.

6.5 Organization of activities which generate risk

The organization of activities which generate risk determines, to a considerable extent, the nature and extent of the risk. The cause-effect sequence which describes the generation of risks illustrates this (see figure *7*). For example, the ‘quality’ of the organization emerges as a decisive factor in the prevention of serious accidents (see, for example, Gro92). Organizational data is included implicitly in risk analyses, for example in the form of failure frequency derived from historical data, but the quality of the actual organization is difficult to integrate in the analysis. The Norwegian government saw this as a reason—with a view to the prevention of accidents with serious consequences for workers and the marine environment—to place the emphasis in the licensing of off-shore industry on the presence and maintenance of a quality control system*. See annex E in GR95b.

The committee considers it advisable to determine the conditions in which an approach of this kind might be fruitful, both in risk management relative to serious accidents and elsewhere. The quality of an organization includes management organization, staff training, the selection of production resources and production processes, the assessment of the results obtained and the use of that information to introduce changes in the organization. The emphasis on quality control for risk management at all stages of the cause-effect sequence fits in with current developments in the commercial sector. Quality control based on ISO 9000 standards and the associated certification are now widespread. Following the example of the ISO 9000 series, another series of standards for integrated environmental and safety management (ISO 14000) is now at an advanced stage of development. Here, the committee refers the reader to the EU's Eco-Management and Audit System (EMAS) which includes a certification program for environmental management systems and in which companies can participate on a voluntary basis. The implementation of strategies of this kind does, incidentally, take time. At least, this was the tentative conclusion about the actual introduction of environmental management systems in the Dutch paint industry (Pep95). In a quality control approach of this kind, numerical limits set by government can impose conditions relating to the policy freedom of entrepreneurs with respect to certain risk attributes. In Great Britain, the Health and Safety Executive has opted for an approach of this kind in certain industrial sectors (oil and gas exploration, the chemical industry, the nuclear industry; Pap92). This emphasis on organization can also be found in the EU's imminent revision of the 'Post-Seveso' directive (EU95).

Even when the risk is caused by many individual behaviours, quality control relating to the 'organization of activities which generate risk' can contribute to risk management. Examples are changes to product design, to the production process, transportation patterns and transport mode, nature of the service or the removal and processing of waste substances.

6.6 Influencing behaviour

Organizations consist of, and are run by, people. The promotion of 'good behaviour' is therefore an essential component of quality control. This applies particularly to the sort

* At the same time, the government stopped imposing numerical limits for risk attributes—such as the chance of an accident—and obliged the companies themselves to draw up reasonable standards for accident risks.

of risk problems described at the end of the previous section. These problems arise as a result of diversion from the individual to the collective. The following is a summary for the purposes of illustration of the possibilities for influencing behaviour as a risk management measure:

The provision of physical or technical alternatives High-efficiency boilers, automatic light switches and bio-degradable packaging for food are examples of technical and physical alternatives which make environmentally-friendly behaviour possible.

Legal regulations and enforcement This area involves orders, prohibitions, standards and regulations, as well as agreements and covenants. The assumption in this approach is that official laws, regulations and standards will ultimately be 'internalized' as self-evident codes.

Financial/economic stimulation This strategy includes subsidies for more environmentally-friendly activities, funding levies such as refuse collection and sewerage charges, fiscal provisions such as the deduction of environmental investments, credits and guarantee arrangements for more sustainable production processes, discounts, tolls and other regulatory charges for discouraging activities which generate risk.

Information, education and communication This involves informing, educating and convincing target groups, as well as encouraging discussions about causes of threats to human and ecological health. This approach includes far-reaching respect for citizens' and businesses' rights to choose.

Setting a good example This strategy is based on the example set by important people or organizations. Here, behaviour modelling is achieved using task and role examples. Individual citizens or companies who behave correctly are supported by loyal 'companions' in their social environment. This approach is based on the assumption that social factors have a strong influence on behaviour.

Chapter 7

Assessing and managing dissimilar risks

7.1 Insight and differentiation

Central to the ‘environmental risk management approach’ are numerical limits for exposure to physical stressors which are derived from universal effect standards (TK89b, GR95b). The background to this approach is a ‘principle of equality’ which is expressed as follows: “Regardless of the agent or source, the same limit must be applied for the same harmful effect” (TK89b). In its previous report, the committee stated that a system of risk management based on a few quantitative risk attributes and on the standards linked to those attributes is not appropriate for tackling all the risk problems which government encounters.

In its previous report, the committee called for the use of an ordered, transparent process of risk assessment and risk management (see figure *3*) in which all the relevant aspects of the risk problem are discussed. It repeats that call here. Such a process gives all those involved the opportunity to determine which suppositions have been used during risk assessment, who has made what choices or decisions (and when), and what criteria have been used when deciding about the tolerability of the risk and the introduction of risk management measures. This is important because the framing of the problem and the choice of risk attributes for characterizing the risk have a major influence on the decision about the tolerability of the risk and the nature of the risk management measures which will be taken.

This approach makes an analysis and assessment process possible which does justice to the differences in the nature of risk problems. Within this pattern, there is also a place, for particular types of problem, for an approach based on a few risk attributes and the numerical limits based on these attributes. The committee describes its approach as 'equal treatment for equal cases'. In 3.5, it discussed the dimensions which determine the distinctions between risk problems: administrative level, spatial scope, temporal scope, social importance and uncertainty about nature and scope.

Incidentally, in decisions about the tolerability of risks, the same considerations play a role as in policy decisions in general. For example, in the case of problems of a strategic nature, the benefits and drawbacks of the activity which generates the risk (or the failure to implement that activity) play a central role against the background of established rights. In questions of a more operational nature also—such as the establishment of environmental quality objectives*—administrative considerations continue to play a role. For example, the Environmental Management Act requires government to take account of 'the financial and economic consequences which can be reasonably anticipated as a result of the implementation of the requirement which is to be made' (section 5.1(2e))**.

In preceding chapters, the committee discussed the 'ingredients' of the process of risk assessment and risk management. In this final chapter, it will combine them into an approach with the differentiation of environmental risk problems as the nucleus.

7.2 Framing the problem

Making distinctions between types of risk problems starts with the framing of the problem (see figure *3*). The factors in 3.5 constitute the basis for a classification of this kind. The committee set this out in figure *5*. As problems become more strategic, more parties have an interest in the outcome of the process of risk assessment and risk management and therefore in the framing of the problem. The unavoidable question is then: what will one be forced to leave aside during investment in the activity and in measures for limiting the risk associated with that activity?***

7.3 Risk characterization

The conclusion of a risk assessment is the characterization of the risk (see figure *3*). The committee discussed this in chapter 5. The distinction between diverse groups of

* For example, numerical limits for the concentration of substances in an environmental compartment (see the Environmental Management Act).

** The committee is of the opinion that the differences in standards for drinking water, swimming water, fishing water etc. (Pollution of Surface Waters Act) and in standards for industrial noise, traffic noise etc. (Noise Abatement Act) are examples of this general rule.

*** The issue of 'opportunity costs' which the committee discussed in 2.1.

risk problems is expressed in the choice of the risk attributes. In its previous report, the committee noted that this is not adequately recognized in the 'environmental risk management approach'. For example, the risk attribute 'individual death' often fails to provide an adequate characterization of the risk; other qualitative and quantitative attributes are also of importance in ensuring that the risk characteristic is consistent with values considered to be politically important.

One way of expressing differences between risk problems is to analyze the risk-reduction effect of measures and to estimate the costs and benefits of those measures. One can then determine how the costs relate to the social usefulness of the activities which generate the risk. The committee gave an example of this in chapter 5 (table *4*). Here, the committee believes that it is sensible, in any case, to include the following risk attributes in the analysis and characterization of the risk:

- loss of life expectancy and health
- annoyance
- negative appreciation of the environment
- loss of biodiversity
- loss of environmental functions.

To distinguish between risk problems, the distribution of benefits and drawbacks among the parties involved is important. The risk profile will, in the opinion of the committee, have to show this distribution.

7.4 Procedures

Environmental rules and regulations include procedures which guarantee and regulate the contributions of interested parties in government decisions. In addition to the usual political consultations, the reader is referred to the appeal procedures for licensing, the consultation procedures for Environmental Impact Statements and the procedure for key planning decisions. In addition, during preparations for decision-making, the government sometimes establishes sounding board groups of stakeholders, asks for advice from organizations such as the Social and Economic Council in which social groupings are represented and makes use of the media to inform groups of the population about proposed decisions.

Once again, the committee would emphasize the importance of a meticulous and transparent assessment and decision procedure. It considers a procedure of this kind to be important, especially with wide-ranging problems of major public importance which involve considerable uncertainties. The procedure allows for the simultaneous discussion of the benefits and risks of the activities which generate risk, as well as of uncertainties in the risk estimates (and in expected benefits)*.

	from operational	to	strategic
a	fits in with all established decision methods and criteria?	⇨	results in new decision methods and criteria?
b	accords with scientific knowledge?	⇨	consistent arguments? well thought-out vision?
c	risk attributes adequate for protection objective?	⇨	various protection objectives taken into account?
d	risk within previously established tolerability limits?	⇨	does the societal benefit outweigh the risk according to various parties?
e	risk management for lowest costs?	⇨	efficient after consideration of opportunity costs?

Figure 10 Criteria for deciding about risk problems, broken down according to the nature of the risk problem.

It is not possible to fall back on legal rules in every case. In that case, an *ad hoc* approach will be needed. However, as is generally the case, it will be necessary to state who is involved at what stage of the process of risk assessment and management and why. In addition, it should be clear to those involved which criteria are used during decision-making or how criteria are derived and whether, and if so how, the question of social usefulness is involved in the risk assessment.

7.5 Balance

During the risk management stage, a judgement is given about the tolerability of the risk (figure *3*). For problems with a clear operational nature which are subject to government regulation, the emphasis here is on the nature and extent of the risk. As the problem becomes more strategic, the varied ideas about the social objectives which are served by the activities which generate risk come to play a more important role. The discussion about the tolerability of the risk is then conducted in terms of the desirability or undesirability of the activities with respect to alternatives. An example of this is the discussion about energy supply in the seventies (Vle86).

Any decision about risk management generates a certain level of precedence. If a risk problem is similar to others, there will be a tendency to fall back on previous decisions about tolerability and the measures required (for example by comparing the

* The classification of judgements and decisions is desirable because the considerations of the various parties involved are generally different (differences in risk perception). For example, on the basis of uncertainty about the long-term effects of low environmental concentrations of chlorine compounds with a hormonal mechanism, one person will wish to limit the intended or unintended production of compounds of this kind. On the basis of the benefits associated with ‘chlorine chemistry’ and the supposed inevitability of waste incineration (the compounds can be released into the environment in flue gases), others will want less rigorous measures, or even no measures at all.

costs of risk reduction for one or more attributes, see table *4*). This means that there is an institutionalization of the decision methods and criteria. Whatever the spatial and temporal scope, the problem becomes less strategic and more operational. If there is little institutionalization, tradition and culture relating to how risk questions are viewed will determine how the judgement is formed. In view of the fact that the parties involved can differ (see figure *4*), precisely in terms of tradition and culture, achieving consensus is therefore often difficult.

The criteria for the considerations which play a role in risk management will, depending on the nature of the risk problem, be expressed in specific forms. In figure *10* the committee states five criteria in the form of questions. For example, for a typical implementation or operational problem, such as the building of a bridge, considerable expertise will be available for conducting a risk analysis. Uncertainties here can be severely limited and, to a reasonable extent, be mapped out (b in figure *10*). This also means that the ultimate decision can be taken using quantitative limits linked to a few risk attributes. In the case of the bridge, an example of this might be the chance of collapse given a certain load (c). The choice of the implementation method will be largely determined by whether the risk is less than the stated limit (d) and whether this situation is achieved at the lowest cost (e). This approach is characterized by an established assessment procedure: there is no discussion about who is involved in the various stages of assessment and what contributions they will make (a).

The situation is different for risk problems of a highly strategic nature, for example decision-making about the extension of Amsterdam Airport. It is true that established—judicial—procedures are used here, examples being environmental impact statements, together with consultations and parliamentary debate about government subsidies. However, the decision-making process as such could not fall back on any fixed criteria (a in figure *10*). Choices were mainly made using the criteria which are stated as questions in the right-hand column of figure *10*. Here, the reader is referred to the comments made by another Health Council committee in 1984 about external safety (GR84a). In its report, that committee summed up ‘decision-making principles’ for various types of external safety problems. A summary can be found in annex K.

The priority issue which plays a role in various risk problems is: does the risk demand urgent intervention? In other words: which problems require closer and intensive study? Mainly, the risks involved here are those associated with the consequences of current and historical activities. Risk comparison is a way of determining this priority. Risk characteristics for a variety of problems are, however, difficult to compare since they are based on varied groups of risk attributes. A method which is creating something of a furore in the United States in this area is ‘comparative risk analysis’ (see annex C.3 in GR95b). In this approach, a group of experts and representatives from influential lay groupings and administrative organs studies all the data as well as possible and attempts, in the course of a structured discussion, to classify a variety of environmental problems. The committee believes that it is worth studying whether elements in this approach can also be used successfully in Dutch risk policy in order to establish widely-supported priorities. Aggregated measures are proposed for the classification of risks, either as a tool for use in comparative risk analysis or elsewhere. The committee has enclosed a proposal in this area in annex H (Cla93). Annex H clearly shows that, during a classification of this kind, the discussion turns to the selection of relevant attributes and the assignation of value judgements to the various attributes, in this case as an initial step towards aggregation.

7.6 Different approaches to dissimilar risks

How can the government manage risks and at the same time take the individual nature of various types of problems into account? In this final section, the committee sums up its ideas about this question.

In the case of matters of a mainly operational kind (left-hand column in figure *10*), the committee believes that it is possible, depending on the type of decision, to choose between the following forms of regulation:

- strict standardization
- weighing ‘risk benefit’ against costs
- self-regulation with requirements for the organization involved in the activity.

‘Standardization’ includes well-defined statements from the government about the conditions in which risks can be accepted, about the nature of risk management measures and about the extent to which additional risk reduction is possible and desirable. The second point—weighing ‘risk benefit’ against costs, or the implementation of the ALARA principle—was discussed in 6.4. The committee would again refer to the necessity of involving ‘opportunity costs’ in an ALARA appraisal. Chapter 6 also discussed the organizational quality of activities which generate risk (6.5). Self-regulation can benefit that quality. At the same time, it imposes strict requirements on the supervisory role of government to whom the self-regulating organization has to answer. Supervision here is less easy than, for example, in the case of strict standardization since parts of the quality of the organization cannot be tested using simple numerical criteria. Integral assessment is required here. Risk communication plays an important role in this context*.

* Government needs to make it clear what its protection objectives are and the entrepreneurs who engage in the activity which generates risk have to make it clear how they serve those objectives.

For more strategic, less operational, problems—the central position in figure *10*—the available approaches are only partially institutionalized in Dutch environmental policy. The possibilities stated by the committee are:

- breaking down the problem into parts for which there are accepted risk management approaches (something which can, incidentally, be counter-productive because one loses sight of how the parts are related)
- following an approach which, if at all possible, assumes the worst, certainly when the consequences are possibly irreversible; this approach requires further investigation; the ALARA principle will play an increasingly important role in the management strategy as uncertainties are reduced
- looking for measures which encourage risk reduction (bonuses, quota trading*) or which encourage risk acceptance (insurance**)
- determining the extent to which, and the conditions under which, compensation can play a role in managing a distribution of risks which is judged to be unfair.

In order to arrive at decisions, planning groups, decision conferences and the social decision analysis can be appropriate tools (see annex I).

In the case of problems of major strategic importance facing government (on the right in figure *10*), questions such as large-scale environmental damage, population growth and lifestyles, economic organization and technological development are involved, generally together. The procedures which the government has to initiate and follow here must create conditions for a good understanding among all those involved of the risk problem in question, of the way in which the different parties approach the problem and of the decision-making criteria which will be used***. This involves negotiations between the parties involved. Measures will mainly consist of encouraging some developments and discouraging others in order to manage risks without creating excessive obstacles to social functioning. The committee believes that the following points require special attention:

- Strategic problems are complex in nature and generally unique and they cannot therefore be tackled using standard approaches. However, as stated above by the committee, those involved will have a marked tendency to search for solutions from their own point of view (the government, for example, will want to use the

* A system of transferable quotas, possibly linked to a reduction over time of the total amount covered by those quotas, would make better use of the innovative potential of the business community and result in better environmental quality than the prescription of emission limits in licenses. However, others have claimed that an approach of this kind changes pollution from a crime into a right and that the 'real' polluters will move elsewhere. Another point which has been made is that the approach is in conflict with the wish to ensure equal environmental quality for all citizens in the vicinity (Lig95).

** Insurance reduces the risk of financial damage so that people tend to accept the remaining risk more easily.

*** Clarity also implies that the government will not shift the goalposts, at least not without consulting the other players.

introduction of numerical limits). The failure to recognize the need to search for new approaches—usually a mixture of various approaches—can interfere with effective risk management.

- The inevitable question in these cases is: does the social usefulness of the activity which generates the risk serve the public interest adequately and does this furtherance of the public interest match the risks and, in particular, the distribution of risks among the various parties?* All the parties can be expected to come up with an answer to this question.

Strategic risk problems make it necessary to look for new forms of dealing with risks on the administrative level: who decides what and when about the tolerability of which part of the risk and who is responsible for limiting the risk to an acceptable level?

* Examples taken from the decision-making process relating to the routing of the High-Speed Railway in the Netherlands are: Is an increase in mobility in the public interest and does this justify environmental damage? Is a reduction in travelling time between Rotterdam and Amsterdam of a few minutes in the public interest and does this justify building a railway line through one of the Netherlands' most important natural areas?

The Hague 31 March 1996,
Signed, on behalf of the committee

dr WF Passchier, scientific secretary	AEM de Hollander, scientific secretary	ir WC Reij, chairperson

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TK93a Minister van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer. Nader uitwerking van het externe veiligheidsbeleid. Brief van 25 oktober 1993 aan de Tweede Kamer; DGM/SVS/18o93017.

TK93b Minister van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer. Omgaan met het verwaarloosbaar risico in het milieubeleid. Brief van 25 oktober 1993 aan de Tweede Kamer; DGM/SVS/14o93005.

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Annexes

Annex **A**

Task of the committee

A Letter of invitation from the President of the Health Council

The letter from the President of the Health Council (U2314/dH/mr/346-B) relating to the establishment of the committee included the following passage:

A range of Health Council reports in the fields of external safety, radiation hygiene or environmentally-hazardous substances have concentrated on—as far as possible—quantifying and assessing risks to human and ecological health which result from human activity.

In this context, the Health Council published a background study ‘Deciding about risk acceptance’ (A90/10) which was drawn up by professor CAJ Vlek at the request of the President of the Council. Among other subjects, this background study examined the various definitions of ‘risk’, the problems associated with estimating and assessing risks, the possibilities for risk comparison and the basic principles which play a role in deciding about the acceptability of risky activities.

The government has already presented its policy relating to risk-bearing activities in a policy memorandum entitled ‘Premises for risk management’. The definitive version of this document appeared in 1989 as an annex to the National Environmental Policy Plan. It emerges from this document that, from the point of view of legal certainty and policy transparency, the aim is to arrive at a comparable approach to risky activities with varying negative effects on humans and the environment. In addition, quantitative risk analysis plays a significant role as a tool for measuring generally dissimilar risks as much as possible using the same ‘measure’.

Although ‘Premises for risk management’ is generally considered to be an important step forward, there has also been criticism. In his background study, Vlek states a number of objections, such as the use of a too limited or too technological definition of risk, the lack of attention paid to the benefits of risky activities and the absence of decision-making rules for the weighing of risks against the usefulness of activities, the inevitable simplification of reality in quantitative risk analysis, the omission of socio-psychological factors which play a role in the perception of risks and in risk communication and the fact that the management of risk-bearing activities is a dynamic activity, not a static problem of selection.

The method of risk management proposed in ‘Premises for risk management’ now plays an important role in government policy for environmental management. One comes across a variety of limitations in this approach in its design and implementation. There are therefore enough reasons to subject the basic principles and assumptions to scientific appraisal. A good start has been made here in the background study ‘Deciding about risk acceptance’ referred to above.

I propose that, pursuant to this, a Health Council committee will provide the relevant ministers with an advisory report about the possibilities and limitations of an assessment system for a variety of risky activities as proposed in the policy memorandum.

B First report: ‘Not all risks are equal’ dated 20 April 1995

After consultation with the President of the Health Council, the committee decided in September 1994 to record its findings in two reports. The first was published on 20 April 1995 and its title was ‘Not all risks are equal’ (1995/06)*. In this report, the committee also answered the questions which the Minister of Housing, Spatial Planning and the Environment had put to the Health Council in his letter of 28 October 1991 (DGM/DS/S/MBS no. 23o91005).

In his letter of submission accompanying the report of 20 April 1995, the President of the Health Council wrote, among other things, the following:

In consultation with myself, the committee decided to record its findings in two advisory reports. The first of these has been completed. It contains the reservations of the committee with regard to the environmental risk management approach and also responds to the request for a report from the Minister of Housing, Spatial Planning and the Environment. (...)

Finally, I would wish to make one comment about the questions in the request for a report from the Minister of Housing, Spatial Planning and the Environment. These questions take the principles of the environmental risk management approach as given facts. However, the committee makes some critical observations about those principles. This did not make answering the questions any easier. However, the committee expects that its advisory report and the answers to the minister’s questions will provide

* The report has been translated into English (1995/06E).

openings for the further development of environmental risk policy. In its subsequent advisory report, the committee will make further recommendations in this regard.

Annex **B**

The committee

During preparations for the present report, the following sat on the Committee on Risk Measures and Risk Assessment:

- WC Reij—*chair*
  civil engineer, Voorschoten
- Dr WFJPM ten Berge
  industrial toxicologist, DSM, Geleen
- Dr W Biesiot
  nuclear physicist, University of Groningen
- Prof LA Clarenburg
  chemist, Pijnacker
- Dr HJP Eijsackers
  ecotoxicologist, National Institute of Public Health and the Environment (RIVM), Bilthoven
- Prof JDF Habbema
  medical management scientist, Erasmus University, Rotterdam
- Dr G de Mik
  toxicologist, National Institute of Public Health and the Environment (RIVM), Bilthoven
- Dr CM Plug—*advisor*
  Ministry of Housing, Spatial Planning and the Environment, The Hague

- Prof U Rosenthal—*advisor*
  management scientist, Leiden University
- Dr WA Smit
  physicist, University of Twente, Enschede
- Dr PJM Stallen
  biochemist/psychologist, Arnhem
- Dr JP Visser
  chemical engineer, Shell International BV, The Hague
- Prof CAJ Vlek
  psychologist, University of Groningen
- AEM de Hollander—*scientific secretary*
  National Institute of Public Health and the Environment (RIVM), Bilthoven and Health Council, The Hague
- Dr WF Passchier—*scientific secretary*
  Health Council, The Hague

The President of the Health Council, Prof L Ginjaar, attended a number of meetings of the committee.

Mrs MFC van Kan provided the committee with administrative support. AB Leussink, a member of the Health Council staff, provided editorial assistance.

Annex **C**

Reservations relating to the environmental risk management approach

Section 5.8 (pp. 54-55) of 'Not all risks are equal' of 20 April 1995 states (GR95b):

The committee would summarize its comments about the environmental risk management approach as follows:

- The environmental risk management approach, with its relatively simple system of limits, has given a strong impetus to interest in the influence of environmental factors, including industrial activities, on human health and on the structure and functioning of ecosystems.
- This has meant that the risks associated with human activity for human and ecological health have entered into the centre of the political arena.
- The other side of the coin is that, as a result of simplification, the wide-ranging nature of the risk concept has been lost from view. This effect has in part been enhanced because of the range of meanings which have been attributed to 'risk' during the elaboration of the risk approach: risk as the possibility of damage, risk as the possibility of a particular effect on health and risk as a unit, such as the concentration of a substance, for describing exposure.
- Deciding about the tolerability of risks on the basis of testing against numerical limits which are founded on a few quantitative measures requires justification based on the nature of the risk problem, since a limited range of numerical standards often fail to do adequate justice to a complex reality.
- Testing against generally applicable numerical standards in association with the rule 'failure to meet the numerical limit is not permitted or means that decontamination is required' makes it formally impossible to include the assessment of economic and social benefits in deciding about the

tolerability of risks. If one wishes to allow for this, the result will be a more differentiated system of standards which will sometimes be stricter or less strict than those currently in force.

- The link with the (dynamic) processes which are at the root of the development and management of risks is often weak. A stronger link would also result in a more differentiated system of standards, both in terms of decision rules and risk measures, with the application of the ALARA principle occupying a more central position.
- Meeting equal numerical limits for a risk measure like individual risk does not simply mean that the level of protection will be the same. This is because the risk measure does not adequately represent the risk in all cases and also because the risk measure for non-carcinogenic substances, carcinogenic substances, radiation or the possibility of large accidents is worked out in different ways.
- Group risk should express some of the multi-dimensionality just referred to, that is to say 'social disruption' following on from serious accidents as a result of the deaths of a certain number (more than ten) of people within a short time. However, the committee is of the opinion that this measure is an inadequate reflection of a complex phenomenon such as social disruption.
- The numerical limit associated with group risk, which changes according to the number of victims (inversely quadratic relationship with the number of victims) is not justified on empirical grounds. It is therefore unclear to what extent this standard takes perception factors into account.
- In the elaboration of the risk approach, it appears that the government has a preference for carrying out risk estimates with a few models which it has 'approved'. This position fails to do justice to the variations which there will be in reality. The committee supports attempts to establish a 'quality hallmark'. However, the application of a particular model will always have to be justified in the light of the aim of the risk estimate.
- The risk approach in its current form provides insufficient instruments for dealing with the phenomenon of risk accumulation.

Internationally, a variety of 'risk management approaches' are *en vogue*. The committee has taken a close look at approaches in the United States, the United Kingdom and Norway. This choice was principally based on the fact that information about these approaches was found in the literature, that it proved possible to obtain personal explanations of various aspects and that the approaches included aspects which fitted in with the nature of the committee's line of reasoning. It is certainly not the intention to suggest that there are, either beyond or within the borders of these three countries, no other ways of dealing with risks from which lessons can be learnt.

In the further development of the risk management approach in the Netherlands, elements could be adopted from approaches used elsewhere. An example might be the interest in the quality of the organization of human activity with risk management as an integrated part (Norway, Norwegian Petroleum Directorate, Annex E [in GR95b]), the flexible link between risk limits and corresponding limit values for other units (UK, Health and Safety Executive, Annex D [in GR95b]) and the classification of risks ('comparative risk analysis', USA, Environmental Protection Agency, Annex C [in GR95b]).

Annex **D**

Selection of scientific literature

Prior to the establishment of the committee and in response to a request from the President of the Health Council, Prof CAJ Vlek drew up a survey of knowledge about risk measures and risk assessment. His report appeared in 1990 as 'Deciding about risk acceptance' (Vle90). This report was seen by the committee as a summary of literature from the seventies and eighties about the subjects referred to. In addition, the scientific secretaries have, between the publication of Vlek's background study and mid-1995, continually consulted the databanks MEDLINE and TOXLINE in order to keep abreast of new publications about the assessment of risks. The search profiles used were:

MEDLINE, TOXLINE[a]
1 risk adj assessment[b]
2 risk adj management
3 risk adj perception
4 risk adj analysis
5 risk adj evaluation
6 risk adj estimation

[a] The search terms were combined using 'or', i.e, 'risk assessment' or 'risk management' or ...

[b] 'adj' means an article with 'risk assessment' in the title, the summary or the keyword list.

Much of the literature collected in this way was related to the assessment of risks associated with exposure to specific substances or groups of substances. The scientific secretaries selected those publications which were of general interest and distributed them among the members of the committee. Other publications were obtained as the result of contributions from the members of the committee, from references in articles studied and through contacts between committee members or the scientific secretaries with scientists elsewhere.

In the assessment and processing of the literature about risk assessment, there was a problem: there are relatively few publications about original research and a relatively large number in which known data is reanalyzed and assessed for its use in practice. In addition, there are risk appraisals in many applied science fields which are relevant to this report. The committee would wish to refer to the following examples: insurance, law, medical management, economy, political sciences etc. Tracing all this data—not to mention processing it—was not possible for either the committee or the secretariat.

Annex **E**

Definition of ‘risk’

The report ‘Deciding about risk acceptance’ states the following 20 definitions of ‘risk’ (table 3.2 in Vle90). The definition stated by the committee in chapter 2 fits in well with the informal definitions 1, 2 and 3.

	global, informal definitions
1	possibility of an undesired consequence (loss, damage, injury, death)
2	accumulation of possible undesired consequences
3	lack of perceived controllability
	personal versions of 8-11
4	probability of an undesired consequence
5	seriousness of (maximum) possible undesired consequence
6	product of probability and seriousness of an undesired consequence ('expected loss')
7	function of the probability and the seriousness of an undesired consequence
	objective versions of 4-7
8	observed relative frequency of an undesired consequence
9	extent of a (maximum) possible undesired consequence
10	observed relative frequency times the extent of an undesired consequence
11	function of the observed relative frequency and the extent of an undesired consequence
	distributive ('multiple-loss') definitions
12	variance of all possible consequences about mean expected consequence
13	variance for the possible undesired consequences with respect to average anticipated undesired consequences
14	probability distribution of possible—where appropriate multi-dimensional—undesired consequences
15	collection of points in a graph relating probability to extent of consequences
16	probability-weighted sum of possible undesired consequences (average 'expected loss', cf. definition 6)
17	form of the chance distribution of results (with parameters: the average, the variance, the bias and the kurtosis)
	weighted combination functions
18	weight of possible undesirable consequences ('loss') in relation to the comparable possible desired consequences ('gain')
19	multi-attributive weighted sum of components or aspects of possible undesired consequences ('damage dimensions'; compare definition 5)
20	weighted sum of the anticipated value and the variance of all possible consequences

Annex **F**

Time scales of processes

The time scales for natural processes vary widely. Figure *11* provides an overview. When assessing the risks of human activities, it is important to determine which processes play a role and to adjust the 'time horizon' of the risk assessment accordingly.

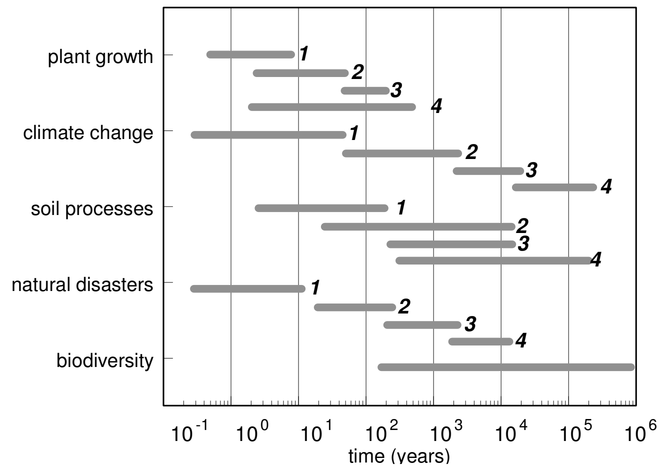

Figure 11 Time scales for processes which influence sustainable development. The processes on the vertical axis are: *Plant growth* - (1) duration of the growth cycle of annual varieties, including crop rotation during a period of no more than 5 years, (2) duration of the growth cycle without crop rotation, (3) duration of the growth cycle of a production forest, (4) average turnover rate for biomass in a tropical rain forest. *Climate change* - (1) time scale for meteorological fluctuations, (2) historical climate changes (compare Little Ice Age AD 1500-1850), (3) holocene, (4) pleistocene. *Soil processes* - (1) length of time taken for complete erosion of top-soil, (2) length of time taken for severe exhaustion of nutrients as a result of the leaching of soil in damp tropical areas, (3) the same in temperate areas, (4) time for the formation of a complete top layer. *Natural disasters* - (1) time intervals between moderate flooding of alluvial areas, (2) the same for severe flooding, (3) time interval between successive volcanic ash falls, (4) time interval between destructive volcanic eruptions. *Biodiversity* - time which macroflora and macrofauna need to recover from a disaster-like disturbance.

Annex **G**

Risk attributes

One might describe risk attributes as the words of the language of risk assessment and management. They crop up as early as problem formulation, risk assessors assign values to them during risk analysis and the risk characteristic is the resulting accumulation of attributes and their associated values.

A list of risk attributes can be found in a report from Norberg-Bohm and colleagues (Nor92) who compared environmental problems in the United States, the Netherlands, India and Kenya. Their work is based on previous studies carried out by Hohenemser et al (see Vle90). It is rooted in the natural sciences and concentrates on disturbances of the physical environment and on biological damage. The committee has extended the list, adding risk attributes which take account of varied risk perceptions (see figure *7*). The list does not pretend to be comprehensive. It does not, for example, include attributes which are particularly related to non-sustainable development.

The risk attributes which will be discussed below can, in many cases, be seen as groups of attributes. For example, 'illness' can be broken down into a long list of illnesses and handicaps.

Needs, desires and the planning of activities

Whether human needs and desires are transformed into particular types of activity, thereby resulting in risks, depends on the *availability (figure 7, no 1)* of resources, the *feasibility (figure 7, no 2)* of the plans and the *choices* which can be made for meeting the need in other ways *(figure 7, no 3)*. In addition to these attributes, *fairness* (is the use of resources acceptable to society?; *figure 7, no 4)* plays a role, together with the question of whether the activity is a *necessity or a luxury (figure 7, no 5)*.

Intention of the causer of the risk (figure 7, no 7) The judgement of groups of the population about risks depends on the intentions which they suppose the causers of the risks to have. Natural disasters are the 'will of God' (although, in part, more and more often the result of poor 'stewardship'). There are social dangers such as terrorism, crime and civil war and there are technological dangers. In the last of these, there can be a difference between the institution which is legally responsible for the activity which generates risk and the person who is called to account. An example might be the construction of a railway line or a power line. In commercial activities, a comparable attribute—*safety motivation (figure 7, no 6)*—will play a role.

Freedom in design or planning (figure 7, no 8), technological (figure 7, no 9) and social options (figure 7, no 10) In the implementation of the proposed activities are attributes located at the beginning of the cause-effect sequence which can determine the nature and extent of the ultimate effects and the chance that they may come about.

In commercial activities, *safety training (figure 7, no 11)* and *the availability of instructions (figure 7, no 12)* are of importance.

Complexity (figure 7, no 13) In activities which take the form of complicated processes, different options continually emerge for the design of the process, with each option being associated with its own set of possible consequences.

Freedom of choice (figure 7, no 14) It is not always possible to determine objectively whether those exposed to risks have freedom of choice—in other words whether exposure to a stressor is voluntary or involuntary. Driving is often described as a 'voluntary' activity but it is often the case that people have no choice but to drive from A to B. An important factor in this criteria is whether people believe they have freedom of choice.

Time horizon of activities (figure 5, no 15) Risk assessment depends in part on whether the activities only last a brief time or whether they will be spread out over a long period. This attribute is linked to the attributes which describe the time span of the exposure and of the effects.

Familiarity with the risk (figure 7, no 16) The importance granted to this attribute makes it possible to make a distinction between known and unknown risk problems. It mainly involves familiarity with the stressor and with the consequences of exposure.

Importance, expected benefits (figure 7, no 17) The assessment of the risk is not as severe if people perceive that there are also benefits associated with the activity which is the source of the stressor.

Fairness of the distribution of benefits and risks (figure 7, no 18) It is unfair if the benefits are distributed in a way which is very different from the way the risks of human activities are distributed.

Costs of risk management (figure 7, no 19) The costs of risk management ('safe implementation') play an important role, particularly for the 'risk-taker'. In certain cases, however, the costs can be diverted onto other parties, consumers, for example. In that case, 'costs' will also be an important risk attribute for this group.

Assumed controllability of consequences (figure 7, no 20) This attribute includes the confidence which people have in themselves, government or other organizations in terms of limiting the consequences of a risk. With this attribute, a distinction could be made between consequences for human health and consequences for ecosystems. This attribute also includes uncertainty about the nature and extent of consequences and about the question of whether there is damage as a result of exposure to a stressor (scientists with conflicting opinions). Whether models describe reality is uncertain by definition, although not always to the same extent (depending on the opportunities for validation).

Substance and energy flows and stressors

Attributes which characterize substance and energy flows are *nature and concentration (figure 7, no 24), natural levels (figure 7, no 25)** and *the rate at which those levels change (figure 7, no 26).* Taken together, these attributes describe the change in the natural quantities of substances, energy or resources as a result of human activities or natural processes (substance and energy flows). A difficulty is how to determine the

* The term 'natural levels' is linked to the term 'natural ecosystem'. The Health Council's third report about ecological standards for water management discusses the latter concept (GR89b). The definition given there was: "ecosystem which was present on the earth before the start of human development or which was (or is) found thereafter and which is not controlled by humans. An ecosystem of this kind is influenced by people and can therefore become distanced from its natural condition."

natural level or the natural ‘background’. A legitimate question is whether, in the Netherlands, there is still ‘background’ which is not influenced by humans. These attributes are associated with *disruption of environmental quality (figure 7, no 30)*, and *the rate at which that disruption takes place (figure 7, no 31).*

Spatial scale (figure 7, no 27) This attribute is a description of the extent or scale of the area in which the stressor is ‘at work’. The National Environmental Policy Plan (TK89a) makes a distinction between five scale levels: local, regional, fluvial, continental and global.

Persistence of disruption (figure 7, no 28) This attribute expresses the time involved in a return to natural levels after the disruption has ceased. This attribute must not be confused with ‘recovery time’ which is concerned with effects.

Frequency of change (figure 7, no 29) Some stressors are present continuously, others for just a brief time or intermittently. This attribute is an expression of this phenomenon. It can also be used to refer to the probability of natural disasters such as earthquakes and of accidents with installations or transportation.

Exposure

Number of exposed individuals and species (figure 7, no 32) This attribute states how many individuals or species are exposed to the stressor. It can, of course, not be viewed separately from the ‘spatial scale’ attribute.

Susceptibility of exposed persons and species (figure 7, no 33) This attribute expresses the severity of the effect for a given exposure.

Extent of the exposed area (figure 7, no 34) This attribute corresponds to the previous one but is concerned with the exposed area or the ‘exposed’ resources.

Accumulation of exposure (figure 7, no 35) This attribute describes the build-up (spatial or otherwise) of exposure to various stressors. The presence of other stressors can increase sensitivity to the stressor being studied. It can affect human populations, examples being inhabitants of old city areas where there is a concentration of a lot of traffic, localized air pollution, noise, smell, insecurity, and low-quality facilities and housing. It can also affect ecosystems. An example may be an agrarian environment which is under threat as the result of a combination of excessive fertilizer use, acidification, water depletion and the spread of pesticides.

Self-reliance (figure 5, no 36) It makes a difference whether or not the exposed people or organisms can do something about the exposure on their own or whether they are dependent on the efforts of others or on external circumstances. In the case of species in ecosystems, this attribute relates to, among other things, acclimatization and adaptation.

Latency period (figure 5, no 37, 'delayed effects') This attribute shows how much time elapses between exposure and the manifestation of the consequences.

Effects on humans

Death (figure 7, no 38) A variety of measures can be chosen for this attribute. Examples are total mortality, illness-specific mortality (per year, for example) and the reduction of average life span ('lost years of life').

Illness (figure 7, no 39) One can look at all illnesses together or at individual disorders. Here also, a variety of measures are possible: total attributive illness burden, incidence of an illness (per year, for example), absenteeism, medical service utilization (visits to GPs, medicine consumption) or period of unhealthy life.

Loss of function (figure 7, no 40) This attribute includes all the effects of environmental pollution which can be described as a deterioration in physical functioning.

Well-being (figure 7, no 41) This risk attribute is felt to include annoyance and negative appreciation of the environment. In view of the fact that annoyance can result in physical symptoms, this attribute cannot be separated from the attributes of illness and loss of function.

It is true of all the effects referred to in this section that the duration and the possibility of recovery influence how the risk is evaluated. *Recovery time* describes the recovery period after the exposure has ceased. If exposure results in death or chronic illness, there is no recovery on the individual level. On the level of the population as a whole, recovery is complete when mortality rates and morbidities have dropped back to normal levels. *Delayed health effects* are found a long time after exposure. This attribute can of course be specified in terms of the nature of the effect on health. *Consequences for the health of later generations* can occur in two ways. Damage to reproductive cells or to the foetus can result in harm to progeny. In addition, stressors which have high scores in terms of the persistence attribute will influence later generations. These consequences can, in turn, be broken down in terms of attributes such as death, illness etc.

Effects on ecosystems

Environmental damage (figure 7, no 42) This attribute describes the consequences of the exposure of natural, abiotic and biotic components of an ecosystem to a stressor. These are attributes of ecosystems of a physical, chemical and biological nature such as energy level, primary production, nutrition richness, salinity, acidity, complexity, diversity, spatial differentiation, succession trends and self-regulating potential. Damage to production functions is covered by a separate attribute *(figure 7, no 44).*

Here also, recovery and the duration of the effects are important. *Recovery* describes the recovery period after the exposure has ceased. It is not easy to evaluate this attribute. After exposure has ceased, an ecosystem can result which differs from the previous one but which need not necessarily be of inferior quality. Can this be described as recovery? As in the case of the consequences for human health, an attribute for *delayed consequences to ecosystems (figure 7, no 36-44)* can be introduced. However, what is a delayed effect for one species or one process can be an acute one for others. See annex F.

Economic effects

Material damage (figure 7, no 43) and *loss of production (figure 7, no 44)* are attributes which describe economic losses. Here also, recovery and duration are important.

Annex **H**

Ranking of environmental problems

Clarenburg has drawn up a proposal for the ranking of environmental problems on the basis of risk attributes (Cla93). The risk attributes which should be used in the ranking can be broken down into two groups, one for human health and one for the environment (effect on the composition, structure and functions of ecosystems)*. Each of these groups includes attributes which relate to

- the 'severity' of the effect on human health
- 'scale' and 'relaxation time' (or recovery time), attributes which refer to the extent and the continued action of the effect over time
- 'irreparability' (or persistence) and 'unmanageability' of the possible harm to health.

In order to draw up a ranking, it is necessary to evaluate each attribute. This can be done 'ordinally' in terms of: serious (5), considerable (4), moderate (3), minor (2), negligible (1), not applicable (0). The table below shows how an evaluation scale of this kind can work out in practice. It must be stressed that assigning figures does not mean, for example, that a serious risk is five times as great as a negligible risk. Clarenburg then adds up the various evaluations and obtains a final score which can, in turn, be evaluated in terms of serious, considerable etc.

* The classification proposal in this annex makes no distinction between 'humans' and 'ecosystems', although both differ in terms of the level of biological organization (individual—population—community—ecosystem; with humans, the two highest levels are absent).

The use of a scale as proposed here is only possible and useful if there is a consensus. Consensus is required about the risk attributes used, about the evaluation of each attribute, and about the aggregation procedure (in this case, the addition of the individual scores). Environmentalists, policy-makers and representatives from social groupings can participate in the drafting of a scale.

Examples of scores *s* for attributes for the ranking of environmental risks			
human health criteria	*s*	ecological health criteria	*s*
severity		*severity*	
- acute and/or latent death and/or severe genetic and/or somatic effects as the result of:		- acute and/or latent death and/or severe genetic and/or somatic damage or severe ecological damage (species extinction); severe damage to spatial structure and stability of ecosystem as the result of:	
disturbance radiation balance	4	disturbance radiation balance	4
an accident	3	an accident	2
delayed	3	delayed	3
- slight to moderate psychosomatic and/or somatic harm and /or annoyance on group level as the result of:		- (non-fatal) interference's or damage of physiological and/or morphological nature or effects on numbers and quantities of species, reduction in species diversity as the result of:	
(probability of) an accident	2	existing situation/accumulation	3
existing situation	3	an accident	2
accumulation	3	- changes in behaviour and slight changes in physiological/biochemical processes	1
- psychological and/or social effects on individual level (annoyance); slight functional disorders resulting from:		- not applicable	0
(probability of) an accident	1		
existing situation	2		
accumulation	3		
- not applicable	0		
scale and relaxation time		*scale and relaxation time*	
number of people within sphere of influence			
- global scale, long relaxation time (>10 yrs)	5	- global, long relaxation time (>10 yrs)	5
relaxation time shorter (<10 yrs)	4	relaxation time shorter (<10jr)	4
- continental scale	4	- continental/fluvial	4

Examples of scores *s* for attributes for the ranking of environmental risks			
human health criteria	*s*	ecological health criteria	*s*
- national/regional scale:		- relative very large area/national	3
10E4—10E6[a]	4	- larger area	2
10E3—10E5	3	- smaller area	1
10E2—10E4	2	- not applicable	0
10 —10E3	1		
- not applicable	0		
irreparability and unmanageability		*irreparability and unmanageability*	
- recovery impossible; unmanageable	4	- recovery impossible; unmanageable	4
- very long term (> 10 yrs)	3	- extensive and/or expensive measures needed and/or very long term (> 10 yrs)	3
- extensive and/or expensive measures needed	3	-	
- some measures needed	2	- some measures needed	2
- spontaneous recovery will take some years	2	- spontaneous recovery fairly long-term (some years)	2
- recovery spontaneous and fast	1	- recovery spontaneous and fast	1
- not applicable	0	- not applicable	0

[a] 10E4 means 10^4, and so on

Annex I

Models for societal decisions

In complex problems, consultations between those involved in the risk problem play a central role. In this annex, the committee describes a few models which help in reaching decisions in such cases. There are no ‘watertight’ methods for taking decisions in situations which require consultations, discussions and negotiations with a variety of parties. This is the result of the incompatibility of three ‘fair’ principles for decision-making:

- jointly arriving at a rational decision
- decisiveness
- equal participation of those involved.

This problem arises in board and committee meetings and, in addition, everywhere where a variety of people or groups need to arrive at a joint final ranking of the same system of options. Examples may be deciding about investment plans, selecting job applicants and deciding where to go on holiday. The practical solutions for this ‘trilemma’ in social choice theory (see Bla83, Bez89) are:

- search for a consensus, something which can take a long time
- benevolent dictatorship of one of the parties, an undemocratic approach
- deciding by majority voting, something which can result in laborious decision-making when there are more than two options.

The discussion now turns to a number of approaches which are based on a combination of searching for a consensus and deciding by majority voting. In preparations for decision-making about projects or activities with risks which are thought to be considerable, such as the location of an industrial enterprise, the construction of a waste incineration plant or the extension of an airport, 'planning groups' (Die89), 'decision conferences' (Phi89) and 'social decision analyses' (Che89) can be organized. Such forms of organized participation in the assessment of, and decisions about, risks go a lot further than traditional consultation sessions or the work of 'sounding board groups'. The latter generally remain on the level of the exchange of information and relatively unstructured opinions. They may even be limited to 'one-way traffic'.

Planning groups

Planning groups (Die89) are small, representative groups of the population which, during one-day or two-day meetings, work out a plan for a particular project or activity with consequences for third parties. They do this on the basis of a certain amount of homework relating to a problem which is formulated beforehand. They can be helped by experts who provide explanations and provide answers to questions which crop up. A planning group can make extensive use of visual and material resources. This means that, when necessary, planning drawings and models can be set out and judged on their merits. The groups work under the direction of coordinators whom they choose themselves and they conclude their work with a recommendation which is supported by the individual groups as a whole.

Depending on the nature of the project or the activities, one or more planning groups can be formed. If the work is to be efficient, it is important for the size of the groups to be limited to 10 or 15 people. It is also important that, after the work has been concluded, a reliable picture can be established of the ideas and preferences of all the planning groups together.

Decision conferences

Decision conferences (Phi89) are meetings of small groups which last one or two days. By contrast with the approach just described, more formal evaluation and decision procedures are followed. During a decision conference, the basis is, as much as possible, rational decision analysis: the problem description, the listing of 'appropriate' options and the description of relevant pros and cons must reflect a 'shared social reality'. On the basis of the agreed problem description, the participants then make a systematic evaluation of the possible positive and negative consequences of the listed options. Here, a probability or probability distribution can be assigned to uncertain factors.

The analysis as a whole is, as a rule, conducted using graphical and visual aids and with computer programs for, among other things, multi-attributive utility evaluation or a sensitivity analysis to deal with uncertainties. The fact that the decision analysis is conducted step by step makes it possible, *for each step*, to attempt to arrive at agreement about the 'content' of the relevant component of the analysis. However, this attempt to achieve a consensus for each stage and, ultimately, for the problem as a whole, means that, in practice, the success of a decision conference will depend on the extent to which the aims of the participants coincide: more agreement means a greater chance of success.

Social decision analysis

Social decision analysis (Che89) is an approach which is close to the 'decision conference'. However, in this method, the *individual* viewpoints and opinions of various involved parties—individuals, homogeneous groups and organizations—are mapped out and respected until the very end. A social decision analysis is therefore primarily intended to clarify and exchange points of view and to improve mutual understanding between those concerned. This takes place in the context of rational decision analysis, in other words in terms of options, uncertain factors and probabilities, consequences and their utility (or non-utility), concluding with optimization. The social decision analysis is conducted step by step and the individualized results of every step are passed on to all those involved on each occasion. It can emerge during this process that initial differences of opinion lose their justification. This can make it clear what the real differences of opinion are. At the end of the analysis process, it can emerge that a decision is possible which has no adverse effects on any of those concerned, with at least one party deriving a benefit.

Because of its concern with individuals and communication, the social decision analysis, unlike the decision conference, is primarily suited for 'decision counselling' for groups with differing goals and interests. Social decision analysis can conclude with structured reporting on the viewpoints and preferences of all the participants. Where possible, conclusions can also be drawn about the extent to which certain 'central' decisions can count on broad societal acceptance.

Annex J

Examples of risk profiles

In this annex, the committee provides two examples of the drafting of risk characteristics. The first relates to the risk assessment for the laying of an oil pipeline through the Wadden Sea (Wet92). A part of the risk characteristic sketched a picture of the possible effects on flora and fauna near the proposed pipeline. The committee has

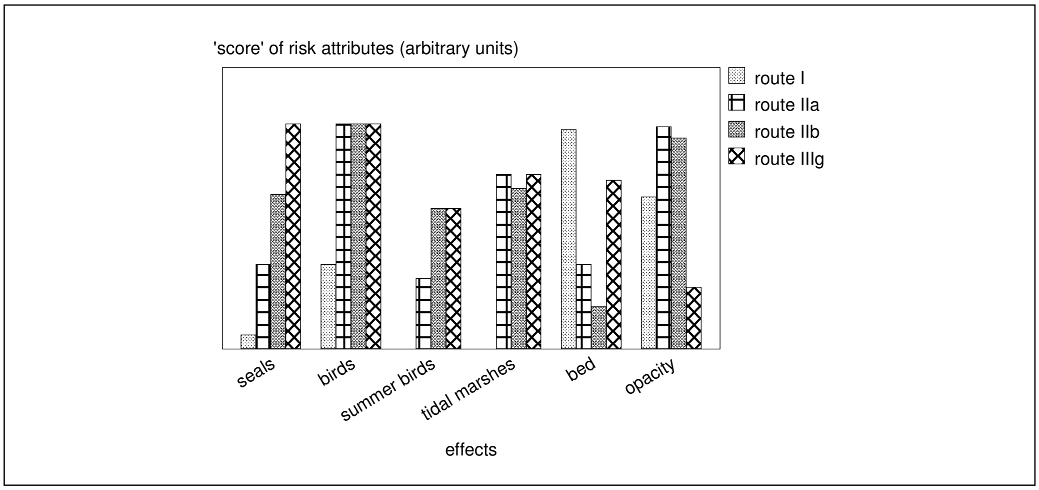

Figure 12 Part of the risk profile for the laying of an oil pipeline in the Wadden Sea. The risk attributes referred to by the keywords in the graph are (left to right): disturbance seals, disturbance of birds, loss of summer birds, loss of tidal-marsh vegetation, loss of sea-bed fauna, increase in opacity. Source of data: Wet92.

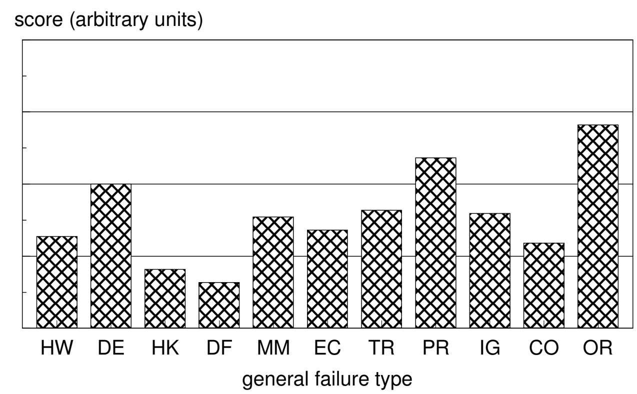

Figure 13 Example of a 'safety profile' made up of 11 general failure types (in the terminology used in this report: a risk profile based on 11 risk attributes). HW: poor state or unavailability of equipment and tools (HardWare) - DE: poor design of a whole plant as well as individual equipment (DEsign) - HK: poor housekeeping (HouseKeeping) - DF: poor quality of the protection against hazardous situations (DeFences) - MM: poor quality of the maintenance procedures regarding quality, utility, availability and comprehensiveness (Maintenance Management) - EC: poor quality of the working environment, regarding circumstances that increase the probability of mistakes (Error enforcing Conditions) - TR: inadequate training or insufficient experience (employee TRaining) - PR: poor quality of the operating procedures regarding utility, availability and comprehensiveness (PRocedures) - IG: poor way safety and internal welfare are defended against a variety of other goals like time pressure and a limited budget (Incompatible Goals) - CO: poor quality or absence of lines of communication between the various regions, department or employees (COmmunication) - OR: the way the project is managed and the company is operated (ORganization). Sources: Gro92, Gro95.

summarized the data for four different routes in a graph (figure *12*). The risk attributes 'disturbance seals' and 'disturbance birds' were scored on a ordinal risk scale (negligible, minor, moderate, serious). The others were expressed quantitatively, for example loss of summer birds per number of birds.

Another example is provided by the work of Wagenaar's study group at Leiden University. In his doctoral dissertation, Groeneweg sets out patterns for risk characteristics for risks of accidents in large businesses (Gro92; see figure *13*). Figure *13* also shows that for the intended goal—namely the management of industrial risks of accident—a risk characterization in terms of chances of effects is not always the most suitable one. On the basis of an analysis of the root causes of accidents, attributes were chosen which refer to stages at the beginning of the sequence leading from activity to effect (see figure *7*), such as the condition of equipment, the quality of the organization and the level of staff training.

Annex **K**

Type of problem and decision-making principles

In the Health Council's report about 'external safety' (GR84a), the same questions were discussed as in the present report, albeit with reference to possible accidents in industrial installations with serious consequences for the surroundings ('external safety'). The committee which drew up that report distinguished between operational problems (I), location problems (V) and development problems (O). These distinctions correspond to those between operational, tactical and strategic problems in the present report. According to the 1984 report, decision-making principles can be classified using the criteria 'information level' and 'basis of evaluation'. The committee stated three levels for the first criterion:

- information about the risks
- information about the risks and the benefits of the activity
- information about alternative methods of obtaining the benefit.

The criterion 'basis of evaluation' was also split up into three:

- existing behaviours (the situation which has been established should show whether a risk is tolerable)
- expert analyses
- societal preferences.

The committee then classified various decision-making principles on the basis of the two criteria and according to the type of problem. This resulted in a matrix (table VI.6

Table 5 Classification of administrative decision-making principles for external-safety problems according to primary suitability for set-up problems (I), location problems (V) or development problems (O) based on evaluation basis and information level. The table has, with some alterations, been taken from GR84a

	basis of evaluation					
	existing behaviours		expert analyses		societal preferences	
information level						
risks	natural risks	I	professionalism	I	public pressure	I
	social practice	I	standardization	I	the market	V
			ALARA	V		
risks and benefits	social patterns	V	cost-benefit analysis	V	informed public	V
			advisory committee	O	innovation practice	O
alternatives			multi-criteria analysis	V	participation in problem formulation	O
					trial and error	O

in GR84a) which is reproduced in table *5*. For a more detailed explanation, the reader is referred to the 1984 report.

Annex **L**

Risk assessment in health care

At the request of the committee, one of the members of the committee—Professor Habbema—drafted a short note about risk assessment in health care.

The assessment of risks with respect to patient treatment is simplified by two characteristics. Firstly, the potential victim is also the person who benefits from the activity. Secondly, the medical activity does not, with the exception of an improvement in the health of the patient, generate any other ‘products’ which play a direct role in weighing the risks and the benefits. (However, the inclusion of the effects on society of increased life expectancy or improved health are currently under discussion.) In addition to the advantages and drawbacks for individual patients, considerations on the population level play a role: equality versus effectiveness and present versus future generations (in the case of ‘genetic counselling’ and fertility treatment).

Risk management, in the sense of striving after a better balance of risks and benefits, plays an important role in medical activities. A distinction is made in this respect between new and existing facilities. For example, three research stages precede the introduction of new medicines: I—safety, II—effectiveness and III—comparison with existing alternatives. Currently, introduction on the market is followed by stage IV—postmarketing surveillance. In order to be registered, the medicines must meet certain requirements for effects and risks. A second example is that of ‘operations’. These can be seen as complex systems where reliability needs to be monitored and improved. There are also FONA* committees, which record accidents and near-accidents in hospitals and, where necessary, take action.

Risk assessment in health care is relative: the balance of benefits and risks has to be positive. In an assessment context like this, a concept such as ‘maximum tolerable risk’ is meaningless. An operation for a rupture of the aorta, with a risk of mortality during the operation of 40%, is acceptable because an average of 8 out of 10 patients will die without the operation. Needless to say, ‘absolute’ standards apply to the reliability of equipment.

The assessment of the risks of medical interventions are therefore inextricably bound up with the overall prognosis for individual patients or groups of patients. There are two sides to a ‘prognosis’: life years and medical condition. The evaluations of these attributes can lead to different choices. Life years and medical condition can be integrated into a combined measure, Quality-Adjusted Life Expectancy (QALE).

Once it has been established that the influence on health will be, on balance, positive, cost considerations may then play a role. If costs are high by comparison with the achieved effect, the evaluation of the treatment could still be negative. This evaluation might be based on the comparison of cost-effectiveness ratios for similar interventions. In that case, the cheapest would be chosen. This approach corresponds to the recommendations made by the Dutch Health Insurance Funds Council.

Within health care, a discussion is under way about whether the efficiency of entirely different health-care facilities can be evaluated using one and the same measure for the cost-effectiveness ratio. At present, Dutch opinion is that this is not possible or at least not desirable: decision-making procedures relating to facilities for ‘cure’ as opposed to facilities for ‘care’ (in other words, for curable as opposed to incurable diseases, severe mental and physical handicaps being an example) run largely in parallel. However, the two types of facility are not directly compared in terms of costs and effects.

* FONA—the Dutch abbreviation for errors, accidents and near-accidents. These committees are now also referred to as ‘report committees’ (‘meldingscommissies’).