ports to the Government

Sustained Risks: a Lasting Phenomenon

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Contents

Summary

In 'Sustained Risks: a Lasting Phenomenon', the Scientific Council for Government Policy (WRR) examines the various ways in which the concept of sustainable development can be manageably translated into policy terms. This approach centres on the notion that the operationalization of this concept is unable to circumvent the uncertainties associated with the interdependence of the environment and society. The resultant risks for the environment and the economy will need to be weighed against each other.

Over the next half-century, global economic activity will have increased to the point that the relationship with the natural environment has radically altered. The long-term continuity of both economic activity and the global economic system would appear threatened as a result. At the same time there is major scientific uncertainty concerning the conditions under which the continuity can be assured in both areas.

On account of these threats and despite this uncertainty, sustainable development is regarded as an important guideline for government policy. In the customary policy elaboration of sustainable development the notion of the 'environmental utilisation space' (EUS) occupies a key place. In essence, however, this by-passes the uncertainty concerning the relationship between the environment and the economy.

This report argues that it is impossible to work with an objectively fixed elaboration of sustainable development. In order to elaborate the concept of sustainability as a genuinely operative policy concept it is necessary for normative choices in relation to the identified risks and uncertainties to be made explicit.

Under the approach towards sustainable development advocated by the WRR, the operationalization of sustainable development involves a survey of the risks. Insight into the existing uncertainties renders it possible to enter into a discussion as to how these risks should be handled. Various action perspectives have been worked out in this report as an elaboration of the various directions in which a development may be regarded as sustainable. In this respect not just differing perceptions of environmental risks are a factor but also divergent perceptions of social risks, namely attitudes towards society's ability to cope with processes of change.

The action perspectives are ideal-type constructions that seek to bring out the potential differences in practical implementation. In practice, however, this policy process does not in any way come down to a once-and-for-all action perspective but on-going adjustments are made to the perspective on the basis of a continual process of reassessment, for example as new information becomes available.

The accumulation of scientific knowledge provides the basis for the identification of environmental problems. Advances in ecological understanding have drawn attention to hitherto unknown and unsuspected problems. At the same time, science relativizes its own products, in that the uncertainty concerning the relationship between the environment and science is itself fed by science.

Environmental policy aimed at resolving and preventing environmental problems therefore essentially implies making decisions on an uncertain basis. The present state of knowledge is limited and hedged about with uncertainties, but is all that policy-makers have at their disposal in making choices.

The concept of the EUS, which has become an established feature in many studies of sustainability, implicitly assumes that it is possible scientifically to determine the limits to the burden that may be imposed on the environment. This, however, fails to do justice to the value driven and hence political nature of the choices that have to be made. There is also the suggestion that the determination of the EUS is of a higher order than political considerations, so that weighing it against these 'lower' goals and interests would be inappropriate. It is conceivable that these kinds of absolute criteria arise when the survival of the human species is at issue; this is not open to bargaining. It needs however to be recognized that in respect of most environmental problems such threats do not arise. Even if one were to have complete knowledge at one's disposal concerning the extent to which the environment is capable of absorbing the consequences of human action now and in the future, the scale of 'the' EUS would still not be firmly established. Auxiliary concepts such as 'restoration of the natural situation' or 'maintenance of natural balances' are not axiomatic but derive from judgments as to the goal to be pursued. The link between the empiricism established by science and judgements on that subject is not a logical, coercive one but a normative one. The requirements imposed by the environment are not immanent features but assigned ones. In this respect the approach towards the environment does not differ from that of other policy areas. This does not render the application of norms or targets any the less legitimate, but there can be no suggestion of science supplying such legitimacy.

Policy is characterized by factual and normative uncertainty; this already applies in the current situation and even more so with respect to the future. Factual uncertainties are characteristic not just of the ecological but also of the social domain. While it is true that the lack of correspondence between the desired and the expected ecological situation provides grounds for talking of unsustainability, not just ecological but also economic and other social risks play a role in formulating possible solutions to this problem. The assessment of such information and the weighing of the risks is the essence of politics.

Even when one is working on the basis of the same information attitudes towards sustainability can therefore diverge considerably. On the basis of the differing weight attached to facts, uncertainties and risks with respect to the environment and society, each of these approaches - elaborated in this report as 'action perspectives' - may justifiably at first sight be labelled as 'sustainable'. The consequences of these differing weights, perceptions and acceptances of risks are very great. The elaboration of each of these action perspectives based on sustainability into long-term scenarios brings this out clearly and may in consequence result in the tightening or adjustment of the action perspectives.

Four action perspectives have been elaborated in this report in the various sub-areas. These have been termed *Utilizing, Saving, Managing and Preserving*. These action perspectives differ from one another in two respects, mainly the extent to which they avoid or accept environmental and social risks and the degree to which they intervene in the form of adjustments in the production and/or consumption sphere. The environmental risks to which the action perspectives relate concern the exhaustion of finite resources and the disruption of ecosystems as a result of human activities.

The Utilizing action perspective is based on confidence in the resilience of the environment. By contrast, the ability to influence social dynamics by policy measures is considered limited. Environmental problems need to become urgent before sufficient creative energy can be mobilized in society in order to solve that problem. This approach places particular reliance on technological solutions.

In the Saving action perspective confidence in the resilience of the environment does not extend across the board. On account of the enormous growth in the scale of human activities, the continuity of those activities is even regarded as under threat in the long term. A cut in living standards is therefore required, which is where policy comes to bear. The possibilities for applying technology must not be overestimated.

Under the Managing action perspective, the risks to the ecological system are avoided as far possible. This is, however, subject to the condition that the rise in living standards is largely left undisturbed. Under this perspective, the social risks of rigorous intervention are regarded as so great as to call into question the legitimacy of such intervention. Although the Managing perspective does provide for some moderation of consumption the solutions are primarily sought in the technological sphere.

The Preserving action perspective exhibits little confidence in the resilience of the environment, for which reason adjustments are required to economic and other social activities that impose a burden on on the environment. Measures can be brought to bear both in the field of consumer behaviour and with respect to the production system. Ultimately, the necessary social willingness is deemed to exist under this perspective.

These four action perspectives have been elaborated in the form of scenarios looking to the year 2040. The scenarios describe the course of a number of basic environmental issues, such as the world food supply, the global energy supply, nature conservation, the management of resources (especially copper and chlorine) and water management in the Rhine/Meuse basin. For each of these aspects a reference scenario is provided which sets out the potential developments given unchanged policies. In most cases these provide clear evidence of situations that may be regarded as unsustainable.

In the case of the world food supply the elaboration has taken the form of asking whether the rapidly growing world population could potentially be fed and whether the agricultural methods with which this would have to be done can satisfy various ecological requirements. In this respect a distinction has been drawn in the consumption sphere between a relatively 'luxurious' and a more moderate food package and in the production sphere between globally and locally-oriented agriculture. On a world scale an adequate food supply appears realizable for all four scenarios; depending on the scenario between 11 and 44 billion people can be fed. Regionally, self-sufficiency is not universally attainable; in East and Southeast Asia this is possibly only given a moderate food package and globally-oriented agriculture. In Africa enough food can be produced for self-sufficiency under all four scenarios. This contrasts with the situation described in the reference scenario. Although sustainability does not run into fundamental obstacles in any of the four scenarios, achieving it does involve far-reaching objectives for the world community.

The reference scenario anticipates an explosive growth in the consumption of energy in the next century, caused in particular by rapid population growth and a rise in living standards in the Third World. This growth in energy consumption will be coupled with a substantial burden on the environment due to energy extraction, as well as a very rapid rise in $C0_2$ emissions. Due to the differing estimates of the risks of fossil fuels and alternatives such as nuclear energy and renewable sources of energy, the scenarios aimed at sustainability exhibit major differences in energy consumption and in the mix of energy sources. The scenarios range from a development in Utilizing that broadly corresponds with present Dutch energy policy to a development in Preserving in which a further decline in the energy-intensity is combined with a marked penetration of renewable forms of energy. In all four scenarios achieving the desired situations calls for a radical effort on the part of the world community.

The Preserving and Saving scenarios essentially aim at the preservation of unspoiled nature, while the Managing and Utilizing scenarios centre on the preservation of interesting natural features. In the first two cases the emphasis is therefore on preventing the loss of biodiversity as a result of human intervention, while the other two aim at an interesting living environment. The second dimension where the scenarios differ concerns the space to be set aside for natural areas; under the Utilizing and Saving scenarios a smaller area is set aside for future generations than under the Managing and Preserving scenarios. If nature protection is to have anything other than symbolic meaning under any of these scenarios this will involve radical changes.

In the reference scenario for copper, it is clear that consumption will increase sharply in the coming decades, particularly as a result of the growing economic importance of the Third World. The sustainability scenarios differ in terms of estimates of copper reserves and the damage to the ecological system that is accepted as a result of the extraction of copper ore. The varying estimates of the stocks give rise to various levels of extraction, now and in the future, that are deemed sustainable. In the Saving and Preserving scenarios, the reserves are in principle regarded as finite whereas the Utilizing and Managing scenarios assume unlimited reserves. The latter do, however, involve the continual exhaustion of richer ore deposits. This in turn means that ever poorer ore deposits have to be used, with an increase in the extraction costs. Greatly stepped-up recycling is therefore advocated under all four scenarios.

The pollution aspects of raw materials are illustrated on the basis of chlorine and chlorine products. Attention to chlorine is in order because it is highly damaging in certain compounds. The action perspectives indicate how chlorine compounds need to be handled, either as intermediary products or as final products. In the first place consideration may be given to the replacement or non-replacement of chlorine compounds by alternatives. Secondly, the functions fulfilled by chlorine can in certain cases be scaled down.

The reference scenario for the domestic water supply in the Netherlands indicates that the consumption of both surface waters and groundwater will double over the next 50 years. In addition it is evident that the quality targets for both surface waters and groundwater will not be attained. The pollution with nitrates, heavy metals and biocides consequently threatens the safe supply of drinking water in the Netherlands. The Saving and Utilizing scenarios are based on the present quality standards. From the reference scenario it is evident that supplementary measures will in any case be required in order to achieve these standards. In the Preserving and Managing scenarios the quality standards are further tightened, thereby necessitating more radical measures. Apart from the differing water quality standards, the scenarios differ in terms of the demand for water. The Utilizing and Managing scenarios assume that the rising demand for mains water will continue, while the Saving and Preserving scenarios assume substantial savings in water consumption. Quality and/or quantity problems need to be overcome in all four scenarios and the necessary measures call for far-reaching political decisions.

Most of the elaborations described are on a global scale. This is indeed self-evident: sustainable development is a global issue. Many environmental issues of relevance for domestic policy consequently also have a global dimension.

A policy aimed at sustainable development is also by nature a policy aimed at the longer term. The elaborated scenarios may therefore be regarded as making a particular contribution towards strategic policy-formation. This places heavy demands on the political decision-making. The findings of the various analyses highlight all sorts of issues which, in the Council's opinion, require a more prominent place on the political agenda. The exhaustion of fossil fuels is, for example, a very real prospect; this raises the question of the possibilities for a radical energy-conservation policy as well as for encouraging alternatives. In the case of food supply the possibilities for globally or locally-oriented agriculture need to be drawn into the debate in the light of the rapidly growing world population. Radical choices also arise in the other areas investigated.

In the interests of the debate, the WRR has also adopted its own standpoint in the light of the analysis of the various attitudes and elaborations of sustainable development. In this respect it has been guided by three considerations: the future freedom of action must be guaranteed as far as possible, the interests of future generations must be visible in the decisions taken and the measures must be primarily directed towards adjustments in the production sphere. On the basis of these considerations and the results of the scenarios, the Council notes that it is not possible to arrive at a uniform application of one scenario of sustainable development. It has therefore decided in favour of differing scenarios for the various environmental aspects. In the case of energy the transition from finite to renewable energy needs to be promoted. Active environmental diplomacy and the deployment of adequate market-based instruments will be jointly required to get this transition under way. In the case of this elaboration the Council has opted for a scenario in between Managing and Preserving. In the case of the world food supply, globally-oriented agriculture needs to be encouraged as far as possible, while the promotion of a moderate food packet at global level is neither desirable nor necessary. In this respect the Council opts for a scenario between Utilizing and Saving. In the case of nature conservation the Council has opted in favour of safeguarding the greatest possible area in the interests of maintaining biodiversity. This implies a scenario between Preserving and Saving. This choice cannot be viewed in isolation from the position adopted by the WRR in approaching the world food supply issue. Precisely in the case of an efficient, globally-oriented agriculture the pressure to use natural areas for food production is lowest. In the case of the domestic water supply the Council opts for a scenario aimed at Saving supplemented by elements from the Managing scenario. In particular the use of mains water can be effectively tackled. The necessary measures do, however, call for purposeful decisions. In view of the anticipated sharp rise in the global demand for copper and the uncertainties about the ultimately extractable reserves, the demand needs to be cut back. Policy should be more closely concerned with the promotion of recycling, conservation and substitution; the possibilities have been barely exploited. In the case of chlorine the Council notes that a policy aimed at chlorine in a general sense will lack any real substance; the problems surrounding chlorine do not so much concern extraction and transport as the use of chlorine in certain products. This calls for a flexible strategy in which the policy is aimed at problematical applications of chlorine.

Preface

On 5 September 1990 the Dutch government asked the Netherlands Scientific Council for Government Policy to produce a report on the relationship between environment, economy and administration. The tackling of environmental problems has evolved into a first-order policy issue. In the short term, scaling down excesses, such as soil pollution, is in itself an enormous undertaking. Looking to the longer term, the government contends, more is required. By way of follow-up to the report *Our Common Future* by the Brundtland Commission, the Dutch National Environmental Policy Plan takes the line that environmental problems can most effectively be tackled in the framework of sustainable development.

The government posed the Council two questions. The first concerned the instruments of environmental policy, in that it is very much open to question whether the traditional set of instruments is adequate for bringing about the radical changes in personal habits and commercial practice that are deemed necessary. For this reason the government asked the Council first of all to examine the types of instruments that could be used in order to achieve the objectives of sustainability in the medium and long term.

The Council issued its advisory report on 29 April 1992. In its report *Environmental policy: strategy, instruments and enforcement*, the Council recommended that government environmental policy should make more use of the potential of instruments concerned with mechanisms of transaction and persuasion. The report developed a system for the most suitable types of instruments for dealing with certain environmental problems, given the characteristics of those problems [1].

The Dutch government also wanted an in-depth study of the concept of 'sustainability'. The definition of the concept in *Our Common Future* is open to interpretation. It would essentially be a matter of defining which needs of the present and future generations must be safeguarded. Such a decision cannot be based on objective, measurable ecological data only; normative choices also play an important role. The government asked that this question be examined in the second stage of the study.

The present report deals with the second question. Four different interpretations of the concept of sustainable development are distinguished, which differ in terms of the perceptions of the risks associated with the changing relationship between the environment and society. The consequences of these 'action perspectives' can vary markedly in the longer term. This is illustrated by means of scenarios drawn up for a number of leading problem areas, namely the world food supply, energy supply, raw materials, nature and water.

Even though sustainability may be interpreted in very different ways, far-reaching choices are involved if this political value is taken seriously. This is evident from the reference scenarios developed by the Council in the various problem areas, in that major problems arise in most areas given the continuation of present trends.

Recognition that sustainability can be interpreted in various ways accentuates the political nature of this concept. This report accordingly examines the

1) An English summary of this report is available.

necessary political and administrative conditions for strategic policy-making aimed at sustainability.

The Council did not wish to stop short at this analysis, in that the presented interpretations of sustainability and the possible consequences of those interpretations invite a considered judgement. In the interests of the debate, the Council has concluded the report by spelling out its own position on the subject matter in question.

The report was prepared by an internal project group of the Netherlands Scientific Council for Government Policy chaired by Professor R. Rabbinge, a Council member; the project coordinator was Professor I.J. Schoonenboom, a senior member of the Council's staff. When the report was completed the project group consisted of J.P. Donner and H. Hooykaas, both Council members, and R.M. van Bruggen, Dr. W.M. de Jong, H.C. van Latesteijn and D. Scheele (Council staff members). W.J. ter Keurs of Leiden University, O.C.H. de Kuijer and Dr. S.J. Langeweg were also members of the project group for extended periods.

The report draws on the results of studies carried out by a number of research institutes on behalf of the Council, namely the DLO Centre for Agrobiological Research in Wageningen, the Centre for Energy Conservation and Environmental Technology in Delft, the International Centre of Water Studies in Amsterdam, the Department of Environmental Biology of Leiden University and Delft Hydraulics. The studies are or will be published seperately.

Each of these studies, as well as two studies on chlorine and copper produced by staff members of the Council, have been submitted to a number of experts for comments and suggestions. The Council would like to thank all these institutions and individuals, as well as other persons who were consulted, for their assistance.

Introduction

I

1.1 The request for advice

On 5 September 1990 the Dutch government asked the Netherlands Scientific Council for Government Policy to produce a report on the relationship between environment, economy and administration (see annex). The reason for doing so was the government's intention to tackle environmental policy in the framework of the development of a sustainable society, in line with the findings of the report by the World Commission for Environment and Development (the Brundtland Commission) [1]. The Dutch National Environmental Policy Plan (NEPP) elaborated a large number of objectives on this basis and put forward a number of appropriate instruments [2]. According to the government, however, it was not certain whether the necessary changes in behaviour required for sustainability could be brought about with the traditional set of instruments, based primarily on command and control. The government accordingly asked the Council first of all to examine the types of instruments that could in principle be used.

The Council published its report on the instruments of environmental policy on 29 April 1992. In its report *Environmental Policy: strategy, instruments and enforcement*, the Council called for greater use of instruments of regulation other than the direct controls most generally applied up to that point [3]. According to the Council, environmental policy needed, in terms of the instruments used, to be 'layered'. By placing greater emphasis on social and private law regulation, a sense of responsibility could be engendered towards the environment, which could in itself reduce 'unnecessary' use considerably. Another effective instrument for achieving a further reduction was the regulatory levy. A major advantage of this instrument is that it generally involves lower enforcement charges than the 'heaviest' public law instrument, namely direct regulation. Finally, the more selective application of bans and obligations - in relation for example to serious risks - could alleviate the associated enforcement problems.

In this way environmental policy could not just become more effective and efficient but could also acquire greater legitimacy, as the policy could start to yield better results. The latter is particularly important because environmental policy is primarily long-term in nature; today's environmental gains must not be lost tomorrow. The gains will not however be sustainable if they are solely the result of an ever burgeoning system of public law behavioural precepts largely lacking enforceability. If the process is to be a cumulative one it is vital for environmental values to form an increasingly normal part of the decision-making process in society. In the Council's view, this means that structural limitations on the burden to be imposed on the environment must wherever possible be built into the structure and ordering of social processes. In this regard the Council considers that environmental policy needs to be regarded as a learning process in which the choice of instruments is not just derived from the adopted objectives but in which, conversely, the selection of goals also depends on the results achieved.

[1] World Commission on Environment and Development, *Our Common Future*; Oxford, Oxford University Press, 1987.

[2] *Nationaal Milieubeleidsplan* (National Environmental Policy Plan), Tweede Kamer, 1988/1989, 21 137, nos. 1 and 2.

[3] WRR, *Milieubeleid; strategie, instrumenten en handhaafbaarheid* (Environmental Policy: strategy, instruments and enforcement); Reports to the Government no. 41, The Hague, Sdu Uitgeverij, 1992.

The previous report was concerned with the administrative and instrumental aspects of environmental policy and not with its potential goals. In the request for advice, however, the government also asked the Council to examine the latter subject. The Brundtland Commission defined the concept of sustainable development as one 'that meets the needs of the present without compromising the ability of future generations to meet their own needs' [4]. What needs must the present generation safeguard for itself and coming generations? Such a decision cannot be based on objective, measurable ecological data alone; radical normative choices are also at issue.

The government therefore requested the Council, in a second stage of the study, to examine various interpretations of sustainable development and to show the potential consequences these would have. The Council was also asked to examine the extent to which the various objectives of sustainability were mutually compatible in terms of these differing approaches, as well as in terms of a single perspective.

The present report forms the response to the second part of the request for advice. The first chapter sets out the way in which this has been approached and the structure of the report.

1.2 Sustainable development

The concepts of sustainability and sustainable development arose in reaction to a general and diffuse sense that the environment was being increasingly harmed by human activity. The fear is that if things go on as they are an untenable situation will arise and that people will not only degrade the physical environment by their actions but, ultimately, also threaten human existence itself. That untenability manifests itself in such ways as the wasteful use of finite raw materials, the utilisation of natural resources in excess of their regenerative capacity and damage from human action to the conditions for existence of all manner of plant and animal species. The latter may be regarded as reprehensible enough in itself, but particularly so if potentially vital information for human survival is lost. This untenable relationship with the environment must therefore be moulded into a tenable, sustainable relationship.

This sense of unease is undoubtedly fed by numerous scientific publications on all sorts of environmental aspects, such as the deteriorating condition of agricultural soils and of forests, the carcinogenic properties of various chemicals, the depletion of the ozone layer, species threatened with extinction as well as highly prominent incidents such as algae plagues, oil-spills, Chernobyl and floods due to erosion.

All these factors, however, also tend to make for simplistic generalisations, such as taking a few hot summers as evidence of the anthropogenic greenhouse effect. It is easy to overlook the fact that agriculture has been capable of feeding the sharp rise in the world population, that life expectancy has increased substantially, that people's health has improved significantly and that the supply of energy has been associated with far fewer deaths than hitherto. At the same time this does not deny the fact that these achievements are also associated with the possible exhaustion of resources and with damage to the natural environment.

Although sustainability was formulated as an objective for the relationship between humankind and the environment as far back as the 1970s, it was the

4] *Our Common Future*, op. cit., p. 43.

work of the Brundtland Commission that placed the concept firmly on the political agenda of national governments and international forums. By way of follow-up numerous more or less different definitions have since been developed.

Sustainable development in the NEPP

In the Netherlands, environmental policy went into higher gear as a result of the Brundtland Report, followed by the publication a year later of the first national environmental survey by the National Institute of Public Health and Environmental Protection (RIVM) [5]. The environmental survey produced by the RIVM clearly shows that in terms of scale the current environmental problems are of a different order from those with which earlier generations were confronted. The clean-up of chemical waste, filtration of polluting emissions and reduction of large fertiliser surpluses have not brought about sufficient improvement. The policies aimed at eliminating the (unintended) negative effects of production and consumption have therefore been supplemented by policies to prevent pollution. In doing so the National Environmental Policy Plan (NEPP) and the modified version in the form of the NEPP Plus explicitly adopted the recommendation of the Brundtland Commission that sustainable development should be treated as an objective [6]. Many sectoral policy documents have also been written from the same viewpoint. The recently published NEPP-2 takes matters further again [7]. The latter is, however, primarily concerned with the instrumental aspects of previously agreed objectives.

One of the key concepts in the NEPP is the carrying capacity of the environment. The latter is damaged if it is excessively burdened. In these circumstances serious and possibly even insuperable environmental problems can arise, as a result of which people die or get ill, suffer serious inconvenience or loss of well-being and animal and plant species die out, ecosystems are ruined, water supplies, soil fertility and the agricultural heritage are damaged while physical and economic development can be held back [8]. By determining the carrying capacity of the environment, constraints can be defined for the various activities that impose a burden on the environment. These constraints can in turn be used to determine the necessary changes in behaviour for sustainable development.

According to the NEPP, the preservation of the environment's carrying capacity to make sustainable development possible is the main objective of environmental management. The functions that the environment can fulfill, both now and in the future, need accordingly to be preserved as effectively as possible. Steps need to be taken to prevent environmental problems from being displaced onto other areas or different levels of aggregation and onto future generations, and each generation should in principle hand on the environment in good condition. In order to prevent the carrying capacity of the environment from being harmed and to prevent problems from being displaced, negative feedback mechanisms need, according to the NEPP, to be introduced. Feedback link to source can be effected by closing substance-cycles wherever possible, conserving energy and enhancing the quality of products with a view to the lengthier exploitation of substances in the economic cycle. Feedback by means of risk policy is designed to limit the likelihood that activities will

5] National Institute of Public Health and Environmental Protection, *Concern for Tomorrow, a National Environmental Survey 1985-2010*; Alphen aan den Rijn, Samsom H.D. Tjeenk Willink, 1989.

6] *Nationaal Milieubeleidsplan* (National Environmental Policy Plan), op. cit.; Nationaal Milieubeleidsplan plus (National Environmental Policy Plan Plus), Tweede Kamer 1989/1990, 21 137, no. 20.

7] *Nationaal Milieubeleidsplan 2* (National Environmental Policy Plan 2), Tweede Kamer 1993/1994, 23 560, nos. 1-2.

8] *Nationaal Milieubeleidsplan* (National Environmental Policy Plan), op. cit., p. 92.

adversely affect human beings, environmental functions and ecological features [9].

The NEPP and NEPP Plus proceed to spell out these general objectives in terms of targets for (for example) emission reductions and energy consumption and in limits, norms and risk-limits. A series of measures have been taken or are in the process of preparation in order to achieve these goals. The aim of the planning is to leave behind a good quality environment within the space of a single generation (20-25 years).

Problems

Understandably enough, the NEPP and NEPP Plus tend to be rather abstract when it comes to spelling out what sustainable development means in practice. Clearly, all sorts of questions can be posed. What is good environmental quality? To what extent can substance-cycles be closed? What functions can the environment fulfill over an extended period and which can it not? What is the carrying capacity of the environment?

The for the time being abstract formulation of sustainable development need not form a problem if the concept provides an effective framework for generating social mobilisation with a view to eliminating the worst pollution and wastage. A more precise definition of sustainable development is, however, necessary once the first steps have been taken.

According to the definition of the Brundtland Commission given above, sustainable development is designed to meet needs '... without compromising the ability of future generations to meet their own needs'. Taken literally, these needs would already need to be known at this point, but to a large extent such knowledge is of course out of reach. Furthermore this definition suggests that the social structures erected by our generation should not limit the options for coming generations. Any action now, however, sets the limitations and possibilities for later: the cultural legacy of a particular generation can never be a blank cheque. Our choices now cannot be determined by what might be desired at a later stage but must be guided by what we want to leave behind for later generations by our actions now. But what does this mean in practical terms? Is this primarily a matter of establishing the right physical conditions for existence? Meadows et al., for example, define extreme limits for the margins for sustainability, such as [10]:

- the sustainable level of use of renewable resources (land, water, forests, fish) must not exceed the natural speed of regeneration;
- the level of use of non-renewable resources (fossil fuels, mineral ores and groundwater) should not exceed the rate at which renewable and sustainably exploitable substitutes become available;
- the sustainable level of discharge of polluting substances may not exceed the pace at which the damaging substance can be reclaimed, absorbed or rendered harmless by the environment.

Or do we seek this legacy not so much in physical quantities but in the generation of know-how and technology that future generations can utilise in order to meet their needs? In this respect substitution and improvements in extraction and processing techniques can involve a radical change in what is now regarded as sustainable.

[9] Ibid., p. 12.

[10] D.H. Meadows, D.L. Meadows and J. Randers, *Beyond the Limits, Confronting global collapse; envisioning a sustainable future*; London, Earthscan Publications, 1992.

It is not easy to make these kinds of choices. Only infrequently is it possible to base decisions on the environment on incontrovertible scientific facts. The burden on the environment is not generally well defined and dynamic factors are not taken into sufficient consideration in the interaction between humankind and the environment. Although much is known about the effects of human intervention on the environment in a number of areas, the effects in other areas are much less clear. This is for example evident from the differing attitudes towards the effects of the enhanced greenhouse effect, ranging from a cooling-off to a zero effect and accelerated heating of the earth. The ambiguous nature of environmental trends and the impact of human activities on the environment make it difficult to define the latter's carrying capacity. The choices that have to be made with respect to the legacy to be left to succeeding generations are therefore characterised by a high degree of uncertainty. Furthermore, it cannot be assumed that this uncertainty will ever be eliminated. Scientific advances may increase the insight into relationships - but could also add to the uncertainty.

Such uncertainty is not unique to the man/environment relationship. What, for example, do we know about the long-term employment effects of reducing the gap between gross and net pay?

This does not eliminate the fact that environmental trends and the impact of human activity on those trends are a comparatively virgin scientific field. This leaves considerable room for images of the future based on fear or unfounded optimism, in turn giving rise to a debate that tends to be seen in black and white terms. Opinions such as 'economic growth is bad for the environment' versus the converse are one example; another is the commonly held view that the greenhouse effect will bring about the destruction of agricultural production systems in large parts of the world and so endanger the world food supply or that - on the contrary - CO_2 enrichment of the atmosphere will be to the benefit of agro-ecosystems. Particularly where nature and the environment establish the framework for human existence, these divergent images are not surprising.

Similar attitudes arise when it comes to possible solutions. It is, for example, argued that the exhaustion of raw materials can be offset by substitution and technological advances and that the increase in CO_2 in the atmosphere would restore concentrations from an unduly low level. Science and technology are regarded as the prime cause of non-sustainability, but are at the same time advanced as the main agent of solution. Agriculture that makes use of large quantities of external inputs is often defined as 'bad' for the environment and agriculture that does not do so as 'good'. In so far as such attitudes derive from knowledge, the latter is often partial in nature.

But even if we were to have complete knowledge and if the carrying capacity of the environment could be defined on the basis of that knowledge, this would still not give rise to any clear-cut norm for human activity. The constraints imposed on a particular activity cannot simply be translated into the necessary conduct for sustainable development. The seriousness of the effects is by no means always such as to leave only one behavioural alternative, namely to cut the activities back strongly or discontinue them altogether. Such radical action might perhaps be expected if the most vital factor of all for humankind were at issue, namely the survival of the human race itself. As long as this is not the case, the impact on the environment will continually be weighed against other considerations and this trade-off will not be seen in the same way by all. The fact that plant and animal species are disappearing as a result of human activity is certain - but this needs qualification in the sense that the majority of these species have never been described or known but only presumably exist. The question as to whether their disappearance should be prevented on principle is therefore no longer relevant. The basic issue is *which* species would be preserved as a result of a conservation policy and how we should organise our efforts in this regard. Opinions will often differ widely on this matter, but a balanced judgement will in any case require insight into the relationship between the necessary conditions for existence of these species and the impact of human activity on those conditions.

The trade-off process does not just relate to values attached to a particular activity and their environmental effects; environmental aspects are also weighed against one another, for what may be good in terms of one environmental objective may be at variance with another environmental asset. For example, ammonia emissions can be reduced substantially by means of manure injection, but this mechanical solution also has a highly negative effect on the breeding potential of meadowland birds.

An environmental situation or development will, therefore, generally be assessed in a relative rather than absolute sense. Environmental wishes or requirements are not divorced from other wishes and requirements. The case for felling the tropical rainforest will look different from the comfortable position of the northern hemisphere than from the viewpoint of a local farmer whose livelihood is at stake. In other words, when the 'maximisation' of the environmental interest arises only in a situation in which survival itself is at stake or in which, on further analysis, less importance is attached to environmentally harmful activities, 'optimisation' will nearly always apply. Such optimisation takes place subject to the available know-how and is guided by values, attitudes, interests, 'necessities', the force of habit and characteristics of the political system. Differences in interests and power have a bearing on what one perceives to be an environmental problem and on the legitimacy of conduct. If one has an interest in a certain development that is regarded by others as the cause of an environmental problem, one will be more inclined to trivialise the problem in question. These attitudes entail a different set of priorities with respect to the values and norms governing the relationship between humankind, nature and the environment and are also relevant for the way in which uncertainties and environmental risks are responded to.

The sequence 'carrying capacity/constraints/behaviour' suggests a high level of knowledge and the potential for consensus concerning the implications. The knowledge about environmental developments and the impact of human activities on those trends is, however, inadequate for determining the carrying capacity of the environment and, from that, to deduce the necessary changes in behaviour. In addition, the notion of consensus presupposes the existence of identical wishes concerning the man/environment relationship. In doing so 'man' is treated as an indivisible unit, which does not of course apply.

Nevertheless many people, both inside and outside government circles, assume that the concept of sustainability can be operationalised in this manner [11]. These approaches are highly attractive because they all assume that the 'demands' made by the environment and nature now and in the future can in principle be determined unambiguously. Politically, such an approach is attractive as it simplifies the legitimation of measures involving radical changes in behaviour. The argument that 'there's no other way if we are not to transgress vital limits' provides a more attractive legitimation than one in terms of 'we think this is better for the environment'. It is therefore no

11] See for example Sociaal-Ecnomische Raad, *Advies Our Common Future* (Advisory Report on Our Common Future); no. 89/06, The Hague, 1989; J.B. Opschoor and S.W.F. van der Ploeg, 'Duurzaamheid en kwaliteit; hoofddoelstellingen van milieubeleid' (Sustainability and quality: basic objectives of environmental policy) in: *Het milieu; denkbeelden voor de 21ste eeuw*, by Commissie Lange Termijn Milieubeleid, Zeist, Kerkebosch bv., 1990; D.H. Meadows, D.L. Meadows and J. Randers, op. cit.

accident that environmental objectives are so frequently related to arguments of survival ('nature conservation is self-preservation', 'nature lets us live'). In an administrative sense the approach is also a practical one, because it means that hard parameters or constraints can be formulated to provide a frame of reference in the various policy sectors.

However attractive this approach might appear, it is questionable whether society can or should ever respond to it. As noted, it presupposes that knowledge about developments in the environment and nature and the share of human activities in those trends is (or will be) adequate to form a judgement as to what is and is not permissible. It also assumes that that judgement can be unanimous. In view of all the uncertainties and gaps in knowledge in the field of the environment and the relationship between the environment and human activity as outlined above, it will be clear that in many cases no more than the illusion of certainty can be offered.

1.3 Definition of the problem

Now that the efforts to eliminate the negative environmental legacy of the past and to prevent a further legacy of this kind from being passed on have been intensified with the publication of the NEPP, NEPP Plus, NEPP-2 and related policy intentions, the question increasingly arises as to how production and consumption processes need to be modified in order to safeguard the quality of the environment in the longer term. The eradication of excesses from the past, such as large manure surpluses, soil pollution, chemical dumps and dead rivers is now well under way. However, while this reverses obvious cases of non-sustainability this does not in itself guarantee the ability to sustain a sound environment on a long-term basis.

This confronts both the international community and Dutch society with the difficult issues referred to above, such as the extent to which biological diversity is deemed possible and desirable, to what extent closed substance cycles are possible and desirable, which resources are renewable and replaceable (and to what extent), the legacy our generation wishes to leave behind, the uncertainties we are or are not prepared to accept and the risks society is prepared to run. These questions cannot be answered unambiguously. Not only do they demand more knowledge of and insight into the environmental effects, the finite nature of resources and the carrying capacity of living production systems. They call in particular for trade-offs concerning the quality that is to be achieved, what damage one is prepared to accept for which functions and how the costs and benefits of changes in behaviour are to be apportioned. Attitudes towards these issues vary widely and can have highly divergent consequences both for society and for the environment.

This report will certainly be unable to answer all the questions posed above. Nor is that necessary. The world is at the beginning of a lengthy process of scientific research and opinion-formation concerning the meaning of sustainability. At the present time, the concept has been unduly elevated into a symbol with which it is not possible to take issue. The intention, however, is clear: we are concerned with a relationship between man and the environment that will safeguard the quality of the latter on a long-term basis. The analogy with 'social justice' is a self-evident one. It is no more possible to provide an operational definition of sustainable development that will have the same meaning for all and that will remain valid over time than it is for the concept of social justice. Defining the meaning of the concept is a continuous process which always takes place on the basis of incomplete knowledge and which will not be the same for all at any given point. The meaning assigned to sustainability is determined by the current circumstances, including the existing state of knowledge. As noted, these conditions, including expectations concerning the future dynamics, can be interpreted differently.

The problem tackled by this report arises from the considerations set out above. In brief, the problem may be defined as follows: what systematic diversity of opinion is to be discerned with respect to sustainability and how - taking into consideration the possible consequences - is a usable definition to be arrived at?

The Council sees the main importance of this approach as that of helping to clarify the process of social and political decision-making concerning sustainable development. This emphasis naturally follows from the nature of the subject-matter. However one wishes to define sustainable development, taking the underlying principles seriously poses difficult political choices, and spelling out these trade-offs and their possible consequences may be helpful. The Council regards it as part of its terms of reference to formulate its own judgement on the insights reached, and in so doing to present the government with a usable concept of sustainability. By nature this report is by way of a strategic survey: the emphasis is on possible goals in the longer term. How these are to be achieved is not the primary focus of this report. The Council previously reported on the instrumental aspects in *Environmental policy: strategy, instruments and enforcement* [12].

1.4 The approach

1.4.1 General

The approaches referred to earlier aim at determining the carrying capacity of the environment or 'environmental utility space' [13] which is then to be translated into constraints and behavioural adjustments. By contrast, this report takes the behaviour itself as its starting point and the assumptions concerning the consequences of that behaviour for the environment and society. The report argues that it is not possible to work with one objectively measurable practical definition of sustainability or sustainable development. To begin with the report distinguishes a number of divergent possibilities, in order to explore the limits to what may be understood by the concept of sustainability. These have then been operationalised on a stepwise basis into potential activities and forms of behaviour, after which by means of scenarios the possible longterm consequences for the environment and ecology on the one hand and the restructuring of social processes on the other are explored. This means that from the very outset, the report explores divergent choices between the environment and society, all of which at first sight can be justified in terms of sustainability. The potential longterm consequences of these choices could then facilitate a more solidly based interpretation of the goals to be pursued, given the price in terms of needs and environmental values and the qualities that we as a consequence hand over to succeeding generations. This approach also explores the carrying capacity, not by postulating it but by setting the limits differently on the basis of those interpretations, both qualitatively and quantitatively, and then exploring these in more detail. Precisely by analysing what the limits depend on, greater insight can be obtained into the weighing process that needs to be followed in order to arrive at a temporary or more permanent demarcation.

[12] WRR, op. cit., 1992.

[13] The concept of 'environmental utilisation space' is elsewhere also referred to as 'ecoscope' or 'ecospace'.

1.4.2 Action perspectives

The essence of the approach consists of a subdivision into four basic viewpoints concerning the way in which sustainable development is to be attained. These concern the relationship between man, the environment and nature. The basic point of departure is that this relationship is subject to major uncertainties. The amount of 'environmental utility space' we will have in the future is a matter of estimating inherently uncertain changes in preferences and technological possibilities and the consequences these will have for the environment. The inability to foresee the future means that any assessment based on the sustainability of future trends must derive from an estimate of the associated risks. This estimate may vary depending on whether a more environmental-risk-avoiding or environmental-risk-accepting attitude is adopted.

Sustainability does not however relate just to the environment but also to the relationship between *man* and the environment. Views differ on society's capacity for adjustment; any decision as to whether or not to intervene in the environment will also involve an assessment of what society can undertake and of the social risks likely to be incurred. Here again a risk-avoiding and a risk-accepting attitude may be distinguished.

The report proceeds to outline four perspectives for action in which varying weights are attached to environmental and social risks. These differences are often relative: whatever action perspective one supports, risks will be accepted or avoided in both domains at all times. The perspectives provide the basis for scenarios. As will be seen in Chapter 3, these action perspectives are primarily analytical, ideal-type constructs based on a priori attitudes. Although particular groups in society will find their views reflected in certain of the perspectives, the various constructs distinguished by the Council should not be identified with the opinions of any particular grouping in society. Nor are they the only possible formulations of the concept of sustainability. Equally, it would be inadvisable for any particular group henceforth to identify itself with any of these perspectives. An analytical working method is, however, needed in order to provide a sufficiently clear guideline for the many choices that need to be made in an exploration of future trends.

Needless to say, however, no analytical approach is or may be divorced from social reality at any given point. Although the four viewpoints may not be identified with particular groups in society, those stances will be clearly identifiable in the social debate concerning, and the behaviour of relevance for, the relationship between man, the environment and nature. But then particularly as the embodiment of ambivalence in determining group positions with respect to concrete problems. The significance of the various positions that have been distinguished is that this ambivalence is systematically charted and can therefore serve to illumine opinion formation. Mutatis mutandis the same may be said about the specifications of these perspectives in the scenarios that have been worked out in selected fields. These stem from the four perspectives, but not in any logically compelling way. In that sense they are always comparatively arbitrary. For some these specifications will therefore not go far enough, for example 'because this will not bring about sustainability', while for others they go too far 'because society can't cope with such change'. While the specifications should not be regarded as hard and fast, they also reflect the possibilities and frames of reference that are considered relevant for sustainability at the present juncture. The fact that the analysis is set in a particular period of time also illustrates the provisional nature of the choices made. In a different time-frame different choices will be made. The possibility cannot even be ruled out that obligations entered into at an earlier stage in the interests of sustainability will later be regarded as holding back that very aim.

The recognition of the inherently provisional nature of the action perspectives does not detract from the importance of thinking in these terms. The plausibility or desirability cannot, however, be determined in advance but can only be assessed in the light of potential consequences.

The unremitting and undeviating as-if reasoning that has been advanced above should not be misunderstood. Even if the choices initially made on the basis of ideal-type constructs may be regarded as realistic, the consequences over time may be such as to rule out realisation. This does not imply that the concept of sustainability should be jettisoned but that one is obliged to look for other, possibly more realistic specifications that are capable of functioning as objectives. The objectification of the underlying assumptions and their specification in terms of place and time help render the concept of sustainability more manageable.

This report does not set out to provide integral scenarios of the future as systems showing the future consequences of behaviour based on the perspectives in question. Not only is the relevant knowledge lacking but this would have little point, since the choices made by social and political groupings on the basis of these perspectives will probably always remain mixed in nature. It will also become evident that it is not possible to apply the same perspective to all the topics that have been distinguished.

It is not therefore possible to outline a blueprint for a sustainable society. The various factors that have to be weighed against one another are, however, made clearer and more measurable, thus providing a point of orientation in policy formulation.

1.4.3 Detailed analysis of individual areas

Any meaningful discussion of sustainability will be concerned on the one hand with the activities that satisfy human wants and, on the other, with environmental values and functions. Society must arrange its activities in such a way that the environment retains these assets and functions as far as possible. This does not eliminate the fact that the debate about sustainability centres on the undesired changes occurring in the environment as a result of human activities. The goal of sustainability is directed towards the prevention of environmental problems, that is, situations regarded as unsustainable. From this point of departure the four action perspectives based on the concept of sustainable development have been elaborated in a number of self-evident problem areas, namely areas in which the man/environment relationship entails a substantial likelihood of serious problems and risks.

This elaboration on the basis of environmental problems is not, however, all-embracing. Instead it has been decided to limit the discussion to a number of vital environmental functions: the world food supply, energy, nature, the availability of a number of important raw materials threatened with exhaustion and the water supply in the Dutch catchment area. Although the range of environmental problems has not therefore been dealt with exhaustively, the Council considers that a number of problem areas widely regarded as vital will at least be covered in this way. It will also be clear that this study is not primarily directed towards the Netherlands but is generally conducted at higher levels of scale. In fact, this could hardly be otherwise; there can be no question of sustainability if the Netherlands alone tidies up its own backyard while problems accumulate elsewhere. On account of the economic and ecological interdependencies, food and energy supply are global issues; there is no

sense in tackling them in isolation in the Netherlands. At any event enough is known about the possibilities of food self-sufficiency in times of crisis [14].
In the case of nature the picture is a diversified one. With respect to raw materials, chlorine has been dealt with as a special case-study. Given the importance of the Netherlands as a chlorine producer, a distinction has been drawn in the analysis between production effects of a local nature and those with a global impact. By contrast the issue of water supply is primarily a riparian issue, and the emphasis in the analysis is accordingly on the Netherlands, although a global water study has been conducted with respect to the world food supply.

The information generated on the higher levels is also relevant for Dutch policy, in that the Netherlands forms part of the world community, not just as an element in the aforementioned economic and ecological interdependencies but also as a participant in decision-making at various levels of scale. These interdependencies will of course need to be taken into account in the decision-making concerning the implications of sustainability in the Dutch context.

The application of sustainability as a global concept has implications for the content and further specification of the perspectives. This report assumes a certain convergence in the burden imposed on the environment per world citizen. For some this will be a matter of a normative starting point, in so far as they consider that a sustainable relationship with the environment and nature cannot be combined with large structural differences between the impact made on the environment by citizens in various parts of the world. For others, convergence will instead be the result of efforts to raise living standards throughout the world. The latter possibility is by no means unrealistic given the increasingly international nature of trade and industry and the opening up of more and more countries to the world market. Whether we regard convergence as an aim or a result, it presents the goal of sustainability with an enormous challenge. From an environmental viewpoint, the size of the world population is a crucial factor in this respect. It is not just human activities in themselves that are responsible for the present environmental problems but also their mass scale. Furthermore, the world population will continue to increase over the next 50 years from around 5.5 billion people now to over 7.5 billion given low population growth rates, or as much as 11 billion plus given high growth rates - or in other words a doubling of the present numbers.

Although many people consider that the population of developing countries will continue to grow for a considerable time, others - such as Herman Kahn as early as the 1970s - consider that the increase in population will flatten out or even go into reverse [15]. A rise in prosperity in the developing countries is regarded as a necessary precondition for this, not just to ensure higher living standards but also for a whole complex of associated factors, including the level of education and the ability to provide a wide range of facilities. Although a rise in living standards of this kind will also initially increase the impact on the environment, the situation in the next century will benefit from the application of modern, clean and energy-efficient technologies. A situation of converging prosperity cannot of course be achieved overnight; the present differences are too great. Although a certain convergence is discernible, very lengthy transitional periods will be required, varying according to the action perspective in question. The period examined in this report does not cover the entire process but a period of 50 years up to the year 2040, with - depending on the issue in question - an occasional glance further into the future.

14] T. Bakker, *Horizonten von zelfvoorziening* (Horizons of self-sufficiency), The Hague, Landbouw-Economisch Instituut, 1984.

15] Herman Kahn, William Brown and Leon Martel, *The Next 200 Years; a Scenario for America and the World*; Hudson Institute, 1976.

1.5 Arrangement of this report

Chapter 2 examines the concept of sustainability in greater detail. The necessary level of knowledge for dealing with the concept is examined, while the chapter also brings out the unavoidability of trade-offs between conflicting interests, including environmental assets themselves. This then creates a level playing field for the action perspectives, i.e. potential paths for the realisation of sustainability. The latter are then spelled out in more detail in Chapter 3 in scenarios on a number of selected topics. Important common topics for the sub-scenarios include population growth and the time-scale in question. A justification is provided for the choices made and the results are presented.

Given the terms of reference of the government's request for advice, the report might in fact have concluded at this point, since the action perspectives may be regarded as differing concepts of sustainable development. However, the Council also wished to illustrate the potential application of this survey for strategic policy development. To this end insight is required into the policy process and the existing discrepancies between the scale of the ecological problems and that of the jurisdiction. Chapter 4 examines the political and administrative aspects of the approach presented and the results of that strategy. Finally conclusions are drawn from the findings and the Council provides its own, balanced standpoint on various topics in Chapter 5.

Sustainable development, environmental utilisation space and action perspectives

2

2.1 Introduction

Sustainable development is concerned with a longlasting relationship between human beings, the environment and nature. It was noted in Chapter 1 that this concept has now largely become a symbol that nobody cares to oppose. Many people have therefore seen the importance of defining the concept more precisely and have made efforts in that direction. This has resulted in a large number of highly divergent interpretations. Generally speaking these approaches assume that the boundaries between a sustainable and a non-sustainable development can be unambiguously determined, in other words that it is possible to indicate the 'carrying capacity' of the environment.

By contrast this chapter argues that it is exceptionally difficult and often even scientifically impossible to determine the carrying capacity of the environment. Even if this were to succeed it would then be difficult to translate the carrying capacity into constraints for activities - apart from which it is not easy to translate these constraints into behavioural precepts. All this knowledge is required in order to establish a link between sustainable development and human activity. Only then does it become possible to make directional statements concerning the strategy to be pursued.

In the absence of clearcut criteria, it will be argued below that the strategy can only be determined by trade-offs based on normative interpretations. The argument leads to four action perspectives that illustrate the possible differences in normative attitudes when making a trade-off between human activities and the effects of those activities. The action perspectives have been worked out in Chapter 3 in scenarios up to the year 2040. Taken as a whole they illustrate normative choices, the uncertainty in the scientific field and the uncertainty concerning the possibilities and consequences of social change based on proactive rather than reactive policy.

2.2 Sustainable development: from abstract principle to usable preconditions

In the report *Our Common Future*, the Brundtland Commission provides a formulation of the concept of sustainable development that leaves a good deal of room for individual interpretation [1]. The message in the report that 'sustainable development' is threatened by both wealth (over-exploitation) and poverty (neglect) has, however, been broadly adopted. In the case of the Dutch government, a commitment was made in response to the Brundtland report in the Government Declaration of 1989 to achieve sustainable development within the space of a single generation [2]. The Brundtland Report states that: 'In essence, sustainable development is a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are all in harmony and

1] World Commission on Environment and Development, *Our Common Future*; Oxford, Oxford University Press, 1987.

2] 'Regeringsverklaring nieuw kabinet: Beleid gericht op rechtvaardige en evenwichtige verhoudingen' (Government declaration by new administration: Policy directed towards equitable and balanced relationships); *Staatscourant*, 27 November 1989, no. 231.

enhance both current and future potential to meet human needs and aspirations.'

This definition makes it clear that sustainable development is concerned with at least two dimensions: the continued well-being of humankind and that of the environment. In doing so harmony must be established between all the activities required in order to meet human needs. This does not, however, say anything about the extent to which human needs should be met. In addition attitudes towards what are acceptable human needs will vary. The Brundtland Report does not elaborate what is meant by the harmonious treatment of the environment or when human activities will result in unacceptable damage to the environment. The fact that divergent responses are possible to these questions is evident from the differing measures used to determine this limit. In the NEPP, for example, the yardstick for sustainability consists primarily of the feedback link to source of environmental problems aimed at the closing of substance cycles, the conservation of energy and promotion of product quality [3]. This differs markedly from the way in which the concept has been elaborated by S. Swaminathan of India, the former chairman of the World Conservation Union (IUCN) and former minister in the Indian government, who distinguishes six decisive elements for sustainable development: nature and food production, economic and social values and two equity values.

Both these elaborations take the Brundtland Report as their starting point. The report, in fact, broadly sets the stage, without any precise definition or elaboration.

2.2.1 The subjective nature of sustainable development

The room that the Brundtland Report leaves for interpretation has made it possible for deeply-rooted differences in interpretation to surface. One controversial point, for instance, is whether economic growth is required for sustainable development. The Business Council for Sustainable Development, for example, considers that it is [4]. In the Council's view a change for the better for the environment can only be brought about in a dynamic system driven by economic growth. The non-sustainable nature of present-day society is caused on the one hand by the nature of the technology applied and on the other by the forms of social organisation. It is for example inevitable that people will use more energy, but sustainability demands that non-fossil energy sources be explored. Scientists have also been prominent in this field: Van Noort and others, for example, have calculated on the basis of a number of simple assumptions that an economic growth rate of at least two per cent is required for a sustainable environmental policy [5].
Ranged against this is the view that economic growth is in fact responsible for the environmental problems. Hueting, for example, concludes that a growth in national income is the last thing we need in order to relieve the burden on the environment [6]. In an analysis of the preconditions for a 'sustainable natural environment in the Netherlands', Stortenbeker argues that sustainable development cannot come about if economic growth is a precondition [7]. At best, in his view, there would be sustainable use. As a minimum, the growth

[3] *Nationaal Milieubeleidsplan* (National Environmental Policy Plan), Tweede Kamer 1988/1989, 21 137, nos. 1 and 2.

[4] Stephan Schmidheiny with the Business Council for Sustainable Development, *Changing Course: a global business perspective on development and the environment*; Massachusetts Institute of Technology, 1992.

[5] P.C. van den Noort, 'Groei als voorwaarde voor duurzaamheid' (Growth as a precondition for sustainability); *Economisch Statistische Berichten*, 4 August 1993, vol. 78, no. 3922.

[6] R. Hueting, 'The Brundtland report: a matter of conflicting goals'; *Ecological Economics*, volume 2, 1990, pp. 109-117.

[7] C. Stortenbeker, 'Op weg naar het Paaseilandscenario' (On the way to the Easter Island scenario), in: *Het Milieu: denkbeelden voor de 21ste eeuw*; by Commissie Lange Termijn Milieubeleid, Zeist, Kerkebosch bv, 1990.

of GNP would need to be adjusted to reflect the degradation of nature and the environment in order to achieve sustainable development.

The list of examples on this subject is virtually inexhaustible. In essence, however, each of these examples turns out to involve a partial approach. The question as to whether or not economic growth is 'necessary' cannot be answered without examining other considerations. Ultimately, the answer depends heavily on the type of sustainable development that is desired. As noted previously, the interpretation can vary markedly. In Swaminathan's India the 'social issue' turns out to play an important role in sustainable development. According to the statements in the NEPP, the Dutch government has in mind a low-emission future. Evidently both parties consider that their approaches are a satisfactory response to the question of sustainable development in the environmental field.

In the Netherlands the elaboration of the concept in the NEPP is the dominant view on sustainability. This view implies that it is possible to determine the requirements laid down by a sustainable environment, thus specifying the requirements which a sustainable society must satisfy. When it comes to implementing environmental policy, however, conflicts arise at this point, in that people are far from agreed when it comes to the social sacrifices required in order to achieve environmental goals. In the ultimate choice a trade-off made has to be reached that does justice to both the environmental criteria and the social criteria. This then raises the question as to how a trade-off between these criteria can be achieved.

2.2.2 The relationship between the environment and society

The differences in definitions and elaborations make it clear that sustainable development is not an objective feature of a process. Instead it involves assigning the label of 'sustainable' or 'non-sustainable' to human activities and their consequences for the environment. Sustainable development is a two-sided relationship as both the well-being of mankind and society and that of the environment play a role in evaluating those activities. Social well-being can be measured in terms of the extent to which needs are satisfied and the well-being of the environment in terms of the extent to which environmental functions and assets are left unharmed. In defining these needs we are dealing with a broad concept; these cover the needs not just of the present generation but also of future generations. As discussed in Chapter 1, the definition of the needs of future generations must be viewed as a need felt by the present generation on behalf of the future generations. The assessment as to whether human activities deserve to be labelled 'sustainable' consequently needs to be based on these two fundamentally different approaches towards developments that are deemed desirable.

Figure 2.1 indicates how this satisfaction of social needs and the quality of the environment are interrelated. In fact there are two separate 'circles'. In the economic circle activities affect society via the satisfaction of existing needs and in the ecological circle activities affect environmental functions and values via the inevitable emissions of (for example) polluting substances. The burden imposed on the environment by a particular activity can take many different forms. Apart from emissions there may be disruption, fragmentation and exhaustion, etc. Together, these influences are known as 'impact'. So, apart from having a positive effect on the satisfaction of needs, an activity can therefore have a negative impact on the environment. There may moreover be a feedback with the economic system if the impact involves damage to an environmental function or asset that helps meet an identified need in the economic system.

The impact of human activities on the environment exhibits a relationship with the number of people involved in that activity and the way in which the activity is carried out. Take for example the environmental impact of the production and use of paper. In the first place the impact on the environment depends on the number of people using paper. Secondly, the impact depends on the amount of paper each person uses. Finally, the impact depends on the way in which the paper is manufactured, i.e. the way in which wood-fibres are processed into pulp, whether or not the paper is bleached and whether waste paper is recycled, etc.

Figure 2.1 shows that the size of the *impact* (I) is the resultant of a certain population size (*population* P), a certain degree of per capita prosperity (i.e. material welfare) (*welfare* W) and the *environmental intensity* of the human activity, which is a function of the environmental intensity of the production (E_p) and that of the consumption (E_c). At a particular level of prosperity the environmental intensity will be affected by both consumption (consumer preferences) and production (technological improvements), emission and immission reductions). The relationship between these five variables may be expressed with the aid of the following equation [8]:

$$I = P \times W \times f(E_p, E_c)$$

In many elaborations of sustainable development just one of the two circles is taken into consideration, either as a condition of the ecological system to be defined in isolation (the large circle) or the economic system (the small circle). In the former case a standard is assigned to elements of the environment that may not be exceeded. In the second case the satisfaction of defined needs is considered necessary. Both cases are dealing with sustainable development from their own particular vantage point.

Where the emphasis is placed on the ecological system this may manifest itself in a proposal to set a sustainability norm in order to adjust national income [9] or to accord greater priority to 'environmental criteria' than to human needs [10]. In this approach, 'ecological constraints' are determined in absolute values or an 'environmental utilisation space' is determined. This indicates the limits within which human activity must take place if it is to be sustainable [11]. The maximum impact (I) is determined by specifying requirements for environmental values and functions. Generally speaking this means that the impact must decline in relation to the present situation. On the basis of the definitional equation given above this can be achieved by reducing the product of the population (P), material welfare (W), the environmental intensity of production (E_p) and the environmental intensity of consumption (E_c).

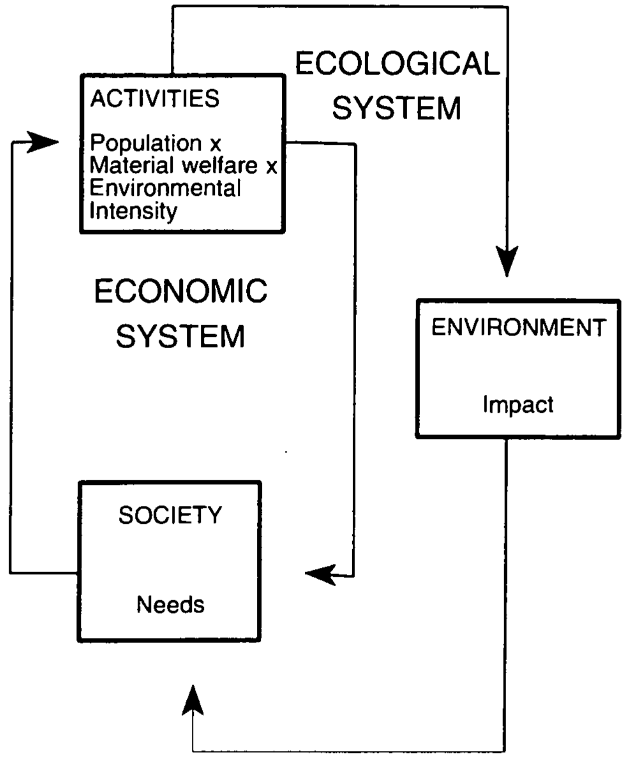
8] The dimension of I is environmental pollution, e.g. in the form of SO_2 emissions or another emission unit; P is population size; W is gross national product per person in guilders; E_p is environmental intensity for unit of production in for example SO_2 emissions and E_c ditto per unit of consumption, so that the dimension analysis balances.

9] R. Hueting, op. cit.

10] H.E. Daly, 'Towards some operational principles of sustainable development'; *Ecological Economics*, Vol. 2, 1-6-1990.

11] J.B. Opschoor, *Duurzaamheid en verandering; over de ecologische inpasbaarheid van economische activiteiten* (Sustainability and change: on the ecological compatibility of economic activities); oration, Amsterdam, VU Uitgeverij, 1987.

Figure 2.1 **Interrelationships between activities, needs and the environment in the economic and ecological system**



Source: WRR.

In principle all four variables are potential objects of government policy. This then identifies the steering variables of policy. The most far-reaching are proposals for population control (B). This is generally prompted by the anticipated growth of the population in developing countries. Combined with a rise in living standards this would impose an unacceptable burden on the ecological system. In these cases the view may be taken that environmental criteria necessitate an active population policy [12].
Instead proposals may also relate to the adaptation of material welfare (W). Under this perspective per capita income is reduced so as to relieve the burden on the environment. This should not be confused with a variant under which it has been proposed that consumption, especially in the rich West, should be 'de-materialised'. In the latter case the starting point is that the impact on the environment will be reduced if human wants on average assume a less material nature. For example, the consumption of culture (e.g. going to a concert) is less harmful to the environment than the procurement and use of a speed boat. Under this approach, however, policy does not come to bear on living standards but on the environmental intensity of consumption Ec.

12] In his farewell lecture as Professor of Atmospheric Hygiene and Pollution at Wageningen Agricultural University, Adema refers to evolutionary development which '....as long as human beings do not get in the way in my view... is the purest form of sustainable development'. On the basis of a maximum permitted burden on the environment and the desired level of prosperity, he calculates that there is room for a maximum of two billion people in the year 2040.
See: E.H. Adema, *Boeren tussen hemel en aarde, hoe lang nog?* (Farmers between heaven and earth, how much longer?), farewell lecture as Professor of Atmospheric Hygiene and Pollution at Wageningen Agricultural University on 28 April 1992.

Finally, it may be urged that the environmental intensity of production Ep be modified. This would involve investments in new, replacement technology in order to turn the negative effect on the environment around.

If the sole focus is on the assets and functions of the environment, this means that a significant element of the social satisfaction of wants is either left out of account or becomes a derivative factor. Proponents of environmental interests can, for example, adopt the uncompromising standpoint that all use of chlorinated hydrocarbons is unacceptable on account of the environmental consequences, without taking into account the consequences for human activities and other interests. This position is justified by those concerned with the notion that the environmental risks are exceptionally great and that the latter may not therefore be exposed to a 'corrupting' process of trade-offs. This ignores the fact that others may have an - in their eyes - equally as justified although totally different attitude towards the use of these substances, in which the environmental risks are kept within acceptable limits. In these circumstances 'hard' environmental requirements come in to conflict with the 'hard' requirements of society, with, in the background, a difference of interpretation concerning the risks involved. If the required standard of living, the environmental intensity of production and consumption or population size cannot be regulated, or only with difficulty, a stalemate is reached. The most common response to an absolutist but unattainable norm is to find a way of escaping the burden imposed by that norm. In these circumstances there is a risk that when concrete choices have to be made, the skin will prove closer than the shirt and that priority will be given on imperative grounds to employment, economic growth, improvement of the infrastructure and so on - in brief, to more 'worldly' needs.

Alternatively, confidence in the ecological system may be so robust that emphasis is placed one-sidedly on the economic system. In these circumstances the evaluation of activities is conducted entirely against the background of social needs. The satisfaction of those wants is given primacy and any consequences for the environment are justified in terms of the express desire of meeting those needs. Under this viewpoint, the risks of undermining these social needs are regarded as excessive.

In the definitional equation provided earlier this means that the level of material welfare (W) is left unfettered and that the impact (I) is simply accepted. This approach does not primarily examine whether needs can be satisfied in an 'environmentally-friendlier' manner. Under this approach environmental interests automatically come into focus if the perceived social needs which the environment is required to facilitate can no longer be achieved. If the I should prove too great the scope can then be examined for modifying the environmental intensity of production and consumption or the population size. This 'learning by doing' approach implies that there are sufficient feedback mechanisms in society and that there is enough reaction time. A clear exponent of this vision is Wildavsky [13]:

'Formerly people always needed a justification for doing nothing. These days we need a justification for doing something. Progress is based on trial and error, but now we suddenly want a trial without error. We want a free lunch. Unfortunately there's no such thing.'

Both the one-sided approaches discussed above fail to do justice to the complexity of society. In the one case environmental requirements are imposed

[13] S. Rozendaal, 'Milieubeleid is geldverspilling. De tegendraadse opvattingen van politicoloog Aaron Wildavsky' (Environmental policy is a waste of money. The heretical views of the political scientist Aaron Wildavsky); *Elsevier*, 12 December 1992.

and the rest of the social system has to fit in as best as possible. In the other case economic requirements prevail and the resulting quality of the environment is accepted as an inevitable factor. These partial approaches cloak a risk of an imperative denial of other potential approaches.

Schwartz and Thompson have illustrated the danger of such an a priori division into proponents and opponents on the basis of the debate about nuclear energy [14]. By reducing the analysis to one of proponents and opponents the complexity of this kind of decision-making fails to come into its own. Schwartz and Thompson argue that politics, technology and public choices are inextricably interwoven. By concentrating unduly on one of the elements the view of the whole is lost and the issue is tackled simplistically.

Similarly in the case of sustainable development, there is a danger of reducing the debate to proponents and opponents. It is, however, critically important to acknowledge that there are a number of highly divergent and in some cases conflicting perceptions of sustainability that exist side by side. Each of these perceptions provides its own interpretation of the two most important aspects of sustainable development: the ecological norms and values to be respected and the socio-economic norms and values to be respected.

Failure to take into account all the relevant aspects in elaborating the concept of sustainable development is the rule rather than the exception. For this reason the Council considers it essential for both the broadly interpreted socio-economic and ecological dimension to be incorporated in the analysis for the purposes of rendering sustainable development operational. Choices in favour of certain environmental values or certain human needs need to be determined in the light of the consequences of those choices or the other dimension. This is not in itself a new notion but this 'double goal' is not always equally as clear in the present policies aimed at bringing about sustainable development.

2.3 The 'environmental utilisation space' as basis for environmental policy

In the debate about the appropriate environmental policy, the concept of the 'environmental utilisation space' (EUS) has been introduced in recent years in an attempt to pin down the maximum permitted damage to the environment. In doing so primacy is explicitly attached to the environment: society must act in accordance with the potential room for use of the environment. There can be no question of a trade-off with social goals. On account of its popularity in the Dutch debate this approach is examined in more detail below.

Interpreting the concept of the EUS requires information on the absorption capacity of the environment; an indication is provided of the margins within which properties and functions of the environment may be used. The limits within which change must take place are thus made explicit. Once the EUS has been determined limits can be set on activities that could affect the quality of the environment in one way or another.

The concept of the EUS derives from resource economics [15]. This presupposes well defined limits to the scale of reserves, such as those of raw materials and energy, familiarity with the resilience of natural and agro-ecosystems, clarity

14] M. Schwartz and M. Thompson, *Divided we stand. Redefining politics, technology and social choice*; New York, Harvester Wheatsheaf, 1990.

15] G.A.J. Klaassen and J.B. Opschoor, 'Economic of sustainability or the sustainability of economics; different paradigms'; *Ecological Economics*, Vol. 4, 1991, pp. 93-115.

about the effects and degree of tolerance of alien substances, and so on. Although various researchers acknowledged that the information in certain areas remains inadequate, this does not eliminate the fact that the notion of an objective, generally accepted definition of the EUS has been broadly adopted at all levels of aggregation.

Administratively, the concept appears highly attractive. In principle the EUS can be determined without the intervention of politics but is based on scientific (i.e. objectified) argumentation. Ecological insights and analyses provide the basis for determining the burden that the environment can withstand. The EUS is therefore a usable intermediate stop for the development of norms. Once those norms have been established they can be used to develop policies and instruments can be selected and deployed. In doing so environmental control is reduced to the determination of the EUS, after which the selection of the appropriate instruments is a question of applying well-tried mechanisms. For this reason the concept is very much in vogue in environmental policy. In view of the one-dimensional nature of the EUS, however, its usability in working towards sustainable development is questionable. Further analysis will expose the weak spots.

2.3.1 Origins of the concept

The basic idea behind the EUS is that 'the biosphere' provides a finite base in the form of stocks of natural resources and the capacity to absorb pollution and environmental degradation [16]. 'Finiteness' should not be interpreted in a geological but in a human timeframe: the limits of the EUS can be achieved within one or two generations. In this respect sustainable development has been interpreted as a 'form of economic development which ensures that the resulting environmental burden can be "ecologically assimilated"'. By this is meant that 'the future functioning of regeneration systems, absorption capacities and other elements of the EUS are qualitatively and quantitatively guaranteed as regards the exploitation potential'. Wetering en Opschoor indicate that we are concerned here with an aspect of environmental quality. The environment must also comply with criteria with respect to diversity, integrity and amenity [17]. All this is, however, based on the underlying premise that scientific consensus can be achieved concerning the EUS in such areas as nature, energy, raw materials and land-use. This then sets the limits for politics and administration.

The EUS may be regarded as the embodiment of the carrying capacity of the environment. In order to clarify this Daly has introduced the metaphor of the 'Plimsoll mark' for the environment [18]. Plimsoll was a British Member of Parliament who proposed in 1875 that a line be painted on the hulls of ships, indicating the maximum depth to which they could be safely loaded. The mark was designed to prevent ships from being overloaded - a frequent occurrence in the cut-throat competition of those days, and the cause of shipping disasters. An example of a Plimsoll mark is shown in Figure 2.2.

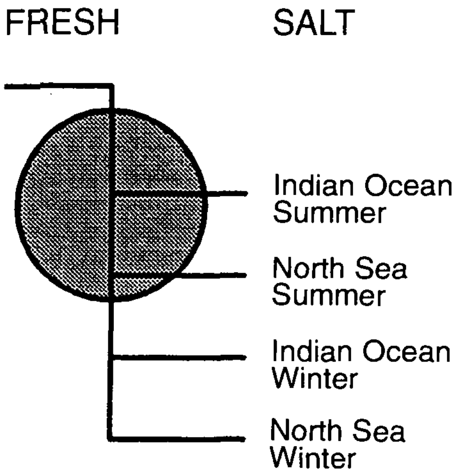
A Plimsoll mark for the environment would therefore indicate the level to which the environment can be burdened without unacceptable consequences. In an economic sense this mark may be interpreted as a limiting condition imposed on the economic system. Within that constraint, the trade-off mechanisms of the economy are allowed to operate. To continue the metaphor, the

[16] R.A.P.M. Weterings & J.B. Opschoor, *De milieugebruiksruimte als uitdaging voor technologie-ontwikkeling* (The environmental utilization space, a challenge for technological development); Raad voor het Milieu- en Natuuronderzoek, Rijswijk, April 1992.

[17] Ibid.

[18] H.E. Daly, *Steady-state economics*, San Francisco, Freeman, 1973.

Figure 2.2 **Example of a Plimsoll mark on the hull of a ship. The lines indicate the maximum depth to which the ship may be loaded in differing conditions**



Source: WRR.

economy can ensure that the load is distributed evenly throughout the vessel, but the amount of cargo is determined by the Plimsoll mark - the economic system itself is unable to influence the latter in any way.

The drawing up of Plimsoll marks is also evident in numerous other policy fields. These are not generally based on scientifically determined possibilities; instead a norm is postulated for which various arguments are advanced. In drawing up this norm a political wish is translated into operational variables. All manner of examples could be cited: the burden of tax and social security contributions should not exceed 53.6 per cent for a financially healthy government; according to the Nature Conservation Policy Plan, an area of 250,000 hectares should be designated as 'natural areas'; in order to ensure that workers have a minimum degree of financial independence, a minimum wage has been set.

2.3.2 Problems

The notion that the EUS can objectively and unequivocally indicate the margins within which human activities must take place is, to begin with, at variance with the observation made earlier that sustainable development is about the quality of both the environment and society. If the 'demands' of the environment do not cut across social desiderata there is of course no problem. In practice, we accordingly find that the greatest progress is made in 'win-win' situations of this kind. Where ecological and social desiderata come into conflict with one another, however, the EUS rapidly ceases to act as a guide: if a criterion that is laid down as 'absolute' proves to be unattainable, the policy in question will cease to provide a guiding framework.

The aim of reducing the world population to two billion people on the basis of an 'objectively' determined EUS forms an example of this [19]. Whatever the inherent merits of this calculation, the social consequences rule it out as a practical proposition. The calculated EUS does not, however, provide any guideline as to what sort of population figure should be aimed at.

Even if an abstract consensus has been reached about the need to work on the basis of an EUS, the latter can suddenly prove paper-thin once the consequences become visible and tangible. This is evident from the construction of motorways, car mobility and industrial development, etc. Instead of providing clarity the application of the concept then simply leads to escapist behaviour.

The concept of the EUS suggests that definitive knowledge is achievable in principle, i.e. knowledge that enables the limits to and criteria for behaviour to be determined. This is what makes the concept so attractive for government administration: hard, scientifically formulated constraints and parameters can render all sorts of political debates superfluous.

This is, however, to deny the dynamic nature of science. New knowledge is consistently generated that qualifies or tightens previously formulated 'demands' on society. What was previously regarded as incontrovertible knowledge then proves to have been no more than provisional knowledge. This is not just a consequence of the fact that the accumulation of knowledge in general is an on-going process while in the environmental field many of the areas of scientific investigation are still in their infancy, but also of the fact that relevant knowledge also derives from action itself, or in other words from experience.

But apart from these fundamental problems there are also difficulties with applying the concept of the EUS. By way of analogy with the Plimsoll mark, a good deal of research and effort has been put into defining the EUS with the aid of a set of sustainability indicators. It has not, however, proved possible to draw up clear-cut indicators for sustainability or sustainable development [20].

The metaphor of the Plimsoll mark is itself illustrative of the problems one encounters in seeking to identify clear-cut indicators. As may be seen in Figure 2.3, the mark does not show a single maximum level but a whole series. Different loading limits apply for freshwater and saltwater, for various seas and oceans and for various seasons. The deadweight capacity of the vessel is not fixed but depends on the salt-content of the water and the anticipated weather conditions. Even in the case of a relatively uncomplicated issue such as the permissable load of a ship, we therefore find that there are a number of mutually interacting factors which, taken as a whole, produce a highly differentiated system.

The complexity of sustainability indicators as an operationalisation of the EUS is, however, much greater again. To start with, far more factors determine the carrying capacity of the environment than just the salt-content and wind. Furthermore, the individual contribution of those factors is often unclear. But even where these are clear, it is often virtually impossible to indicate the critical values (i.e. windforce 8 or 9). The question then arises as to what an indicator in fact shows.

The main scientific problem in determining the EUS is the lack of the requisite information for a complete and coherent analysis. In many cases the knowledge concerning environmental developments and the impact of human activities on those trends is no more than fragmentary. In particular two problems arise: ignorance and uncertainty.

[20] *In search of indicators of sustainable development*; by O. Kuik and H. Verbruggen (eds.), Kluwer, Dordrecht, 1991.

Inherent ignorance

The EUS may be depicted as a system in which certain limits have to be set. As noted, it is a complex system, which is concerned with setting quality standards for the environment. The environment does not exist as a unit or entity but needs to be defined as a system of differing ecosystems (such as forests, fenlands and river deltas, etc.) supplemented by abiotic elements (e.g. a supply of raw materials). The ecology is concerned with the analysis of ecosystems and could therefore provide the most important building blocks for the quality standards for the environment. To date, however, it has proved all but impossible unambiguously to determine which elements are vital for the sustainable functioning of an ecosystem.

This may be clarified by drawing a distinction between repeatable and unique systems. Repeatable (agro) ecosystems such as a field of potatoes or wheat can be identified and the mechanisms of their functioning explained. The time-scale of the system is known and the number of elements of the system is limited. Hypotheses on the functioning are testable and can be experimentally falsified, not least because the object of the system is clear, i.e. to produce potatoes or wheat. All non-productive elements of the original natural ecosystems, such as weeds and vermin, are therefore eliminated as far as possible in the development of the ecosystem. All other external influences on the system are related to the ultimate goal. In a productive sense this knowledge is used in order to respond to changing influences. If for example the density of a plague organism exceeds an experimentally determined threshold, it may be decided to take countermeasures.

Even in the case of these comparatively simple systems there is no lack of any ambiguity concerning the relevant indicators for sustainable development. The concepts of stability, resilience, productivity and tenability are employed side-by-side, with attention to the use of both renewable and non-renewable resources.

The majority of natural ecosystems, however, form part of the unique systems in which the time-scale is in fact infinite. Unique systems are characterised by a large number of unknown positive and negative feedbacks, so that the characteristics of the system cannot be described. In contrast to repeatable agro-ecosystems, the most important goal of the system, and consequently the most important elements in it, are less clear in the case of natural ecosystems. For this reason numerous qualitative standards are imposed on ecosystems that are highly localised and time-bound and which draw for their frame of reference on the state of nature in the past. Salmon, for example, should return to the Rhine, and beavers to the Biesbosch. In consequence, various indicators of sustainable development can co-exist, without the ability to assign priority to them on scientific grounds. Various indicators are for example used side-by-side in order to establish the ecological value of the Wadden Sea: feeding places for birds of passage, the number of seals, size of the region and wealth of lower organisms. 'Roving and straying' is also used as a characteristic of this wildlife area.

If quality standards relate to the entire system, the system characteristics become important. In the case of more complex natural ecosystems, however, knowledge of the resilience, robustness and persistence of the system is highly limited. Much may, on the other hand, be known about individual elements of such systems and the consequences of disruption can therefore be estimated. The consequences of such disruption for the system as a whole, however, remain largely confined to speculation. The tropical rainforest, for example, is known especially for its abundance of species, but the precise numbers, what their frequency should be and the precise situation concerning persistence are unknown.

Whereas science is at best able to provide a partial and conditional insight into positive and negative feedbacks, policy by contrast is interested in the net result and seeks absolute statements: is the earth warming up or not? Especially in the case of unique systems, science is unable to indicate all the determining factors for the functioning of the ecosystems. In the absence of such knowledge, it is, precisely for these unique systems, impossible unambiguously to determine the quality of the environment. Similarly it is also often impossible to provide a response to questions about ecological disruption. The absence of unambiguous indicators and lack of knowlegde about the consequences of change is virtually characteristic of unique systems. Clear-cut, non-controversial definitions prove impossible, as illustrated in Chapter 3.

Uncertainty

Determining the EUS is hampered by statistical and fundamental uncertainty. The statistical uncertainty stems from the lack of precise knowledge concerning human intervention and its effects on the environment, while the fundamental uncertainty stems from partial knowledge of complex relationships that may lead to differences in insight concerning that relationship. In a number of places, it is possible within reasonable limits to predict the consequences for the quality of the environment of a certain intensity of human activity by means of dose-effect relationships. This applies for example to the relationship between urbanisation and nature conservation; clearly, nature must give way where urban development takes place. In many cases, however, this relationship is surrounded by uncertainties and ambiguities. Industrial activities, for example, result in the emission of acidifying substances such as nitrogen oxides and sulphur dioxide, but the effects on the vitality of forests can only be determined by averaging a large number of observations on lowered vitality. In this regard the system is treated as a black box and the impact is only examined on the outside of that box (i.e. the imposition of acidifying substances) and the effect (declining vitality). Sometimes, causal relationships can be established at the level of the component elements. This applies for example to the effects of acidification on the bio-chemical process that forms part of photosynthesis. Extrapolation of these relationships to crop situations is controversial and conclusions cannot be reached straightforwardly with respect to the growth and production of forests. In this case it is therefore necessary to make do with a statistical estimate of the average effect of acidifying deposition on the vitality of forests. The relationship between the dose and the effect may then be portrayed in the form of a scatter diagram indicating that a number of effects have been observed for a particular intervention. The relationship between the intervention and the effect is evidently disturbed by background interference that cannot be screened out.

In the case of many dose-effect relationships it is not even possible to provide an indication of the size of the background interference and there is total uncertainty about the precise position of the points. The reason for this is that much scientific research into these relationships does not only reveal statistical uncertainties but also that more fundamental uncertainties prove unbridgeable. A good example is provided by the theoretical foundations for measures in the field of climate control. Far-reaching statements have been made about climatic changes due to the greenhouse effect, all of varying reliability. These statements range from the belief that the next ice age will be brought forward to a zero effect and finally the accelerated warming of the earth.

A study by the IPCC, however, has examined the status of the various data by classifying these into facts, suppositions and guesses [21]. It is for example a scientifically established *fact* that the CO_2 content of the atmosphere has been increasing at an accelerating rate due to human activity (i.e. the combustion of fossil fuels and deforestation). The increase in CO_2 levels is, however, lower than would otherwise be expected on the basis of the combustion of fossil fuels and deforestation; there is a gap in the carbon balance sheet. It has been suggested that this may be because more $C0_2$ is absorbed by the oceans or because greater quantities are stored in root systems, but there is no scientific certainty. It is *suspected* that the increase in $C0_2$ levels will enhance the greenhouse effect and result in higher average temperatures on earth. This supposition is based on calculations using incomplete models of the 'unique' climate system. Tests can be conducted on the component elements of these models but not on the models as a whole. This means that, depending on the feedbacks allowed for, the results can vary considerably. For this reason it is necessary to speak of estimates and suppositions and not of probabilities and facts. Finally there are *guesses* that the greenhouse effect will result in a rise in sea levels; these are not based on hydrological models of the world but are generally no more than speculative in nature and therefore highly controversial [22].

However, even if the relationship between (for example) the use of fossil fuels and the rise in sea levels is unknown, choices have to be made for policy purposes. In these circumstances the potential risks thought to be incurred become the determining factor in the choice. In the case of a statistical risk this can be estimated and both the distinguishing capacity and the reliability of the statements can then be calculated. In the case of theoretical risks one is confined to making a normatively determined estimate of that risk. In fact we are therefore concerned here with the perception of risks, with respect to both the environment (i.e. can the environment cope with a particular impact) and the socio-economic order (can society with its needs, wishes and institutions, etc., adapt to new activities without problems).

These perceptions of risk come into play when a choice has to be made in a specific instance about adapting economic activities in order to reduce the burden imposed on the environment. Generally speaking this will then mean that environmental investments have to be made. If the relationship between environmental investments and environmental quality is a diffuse one, it will not be clear how great the investment needs to be in order to achieve a given level of environmental quality, and conversely it is unclear what level of environmental improvement will be achieved by a given investment. The recent debate concerning the costs for the agricultural industry of manure policy in the Netherlands and the supposed benefits in the form of vital forests provides one example. Many farmers are naturally well disposed towards the natural environment but they did not all prove convinced of the need to eliminate every last emission of (for example) ammonia from animal pens at high cost because the benefits were not immediately apparent to them. For nature conservationists wishing to spare the Peel region in the Dutch province of Brabant from negative external influences, the benefits in the form of an unspoiled wildlife area are clear. The estimation of risks therefore invariably comes with a price tag, either for the socio-economic order or for the environment.

21] J.T. Houghton, G.J. Jenkins and J.J. Ephraums (eds.), *Climate change: the IPCC scientific assessment*; Cambridge University Press, 1990.

22] For a commentary on the IPCC conclusions see for example: C.J.F. Böttcher, *Science and fiction of the greenhouse effect and carbon dioxide*; The Hague, The Global Institute for the Study of Natural Resources, 1992.

Apart from differences of insight concerning the relevant dimensions there is also a difference of insight concerning the extreme value that a sustainability indicator may assume while still falling within the EUS. It is, however, by no means always the case that if an assigned critical value or an indicator is exceeded, life as we know it will cease to exist. It is, accordingly, virtually impossible to base policy decisions on scientifically established facts. An attempt has, for example, been made to draw up sustainability indicators for copper and aluminium [23]. In doing so the present level of consumption has been compared with 'permitted consumption'. The latter has been derived from a calculation based on the exhaustion of reserves in 50 years' time. As will be shown in Chapter 3, however, the latter is subject to highly varying interpretations. Taking the case of aluminium, there is an enormous difference between the present commercially exploitable reserves and the geological reserves, which differ by a factor of 400 million. On the basis of what is considered technically feasible at present, the technically extractable reserves are estimated at roughly 700 times the currently commercial reserves. Differing assumptions about technological progress may lead to lower but also substantially higher estimates of these technical reserves. Reducing all these uncertainties to a 'safe' margin of 50 years is therefore, at the very least, a gross simplification of reality. The length of the critical reserve period is in fact determined by the uncertainty concerning the volume of the reserves and the development of suitable substitutes. If that uncertainty is assessed differently this then results in a different indicator.

Opschoor and Reijnders accordingly note rightly that the problems surrounding the determination of indicators for sustainable development arise at both scientific and ethical/normative level [24]. For example, the question as to whether species and quality characteristics need to be taken into account in order to determine the functioning of an ecosystem needs itself only partially to a scientific answer. Normative arguments also come into the discussion: which elements of the environment are regarded as vital for the quality of the environment? Opinions on this aspect tend to vary considerably.

The ethical question as to whether the sustainability indicator in question must relate to the conditions of existence for human beings or also to those of other organisms is an additional factor. Do plant and animal species have an independent value and should they therefore come under the goals of sustainable development, or do they have a value only in so far as human beings are able to utilize them in some way?

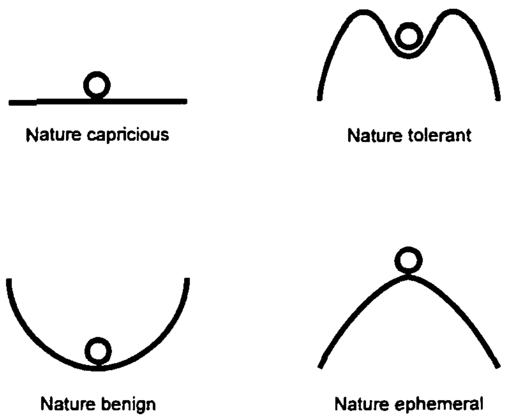
The answer to these questions proves heavily dependent on the assumptions one makes with respect to the resilience and absorption capacity of the environment. In order to illustrate these differing interpretations, Schwartz and Thompson have distinguished four 'Myths of Nature' that determine the attitude one adopts towards trade-off issues between social interests and the interests of nature and the environment [25]. The various attitudes they distinguish are shown in Figure 2.3. Nature has been conceived as a ball on a plane. Human beings are able to exert influence on the natural environment. Depending on the assumption one makes concerning the plane, the latter may cause the ball to oscillate slightly or dislodge it from its unstable position of equilibrium. Various assumptions about the robustness of nature therefore lead to totally different judgements concerning damage to the environment.

[23] P. van Egmond, F. Graafland, E. Hanekamp, A. Petit, J. Raad, Y. van Sark, N. Spanbroek and J. Vlak, 'Is een duurzaamheidsindicator (al) een betrouwbare barometer?' ('Is a sustainability indicator (already) a reliable barometer?'); *Milieu*, 1992/4, pp. 120-128.

[24] H. Opschoor, L. Reijnders, '*Towards sustainable development indicators*'; in: O. Kuik and H. Verbruggen, op. cit.

[25] M. Schwartz and M. Thompson, op. cit.

Figure 2.3 **Four different attitudes towards nature**



Source: M. Schwartz and M. Thompson, *Divided we stand. Redefining politics, technology and social choice*; Harvester Wheatsheaf, New York, 1990.

The four different attitudes that one can adopt towards nature are also reflected in the discussion concerning the importance of environmental indicators. What those who regard nature as 'benign' consider to be an impact readily absorbed by the environment because the latter is well able to absorb a shock is contested by others. Those who regard nature as 'tolerant', for example, will not be unduly concerned about the risk of exceeding threshold values. If however one considers that nature is in an unstable position of equilibrium (i.e. 'ephemeral') then each adverse impact is one too many. Even if scientific uncertainties can be reduced to a minimum, differences in normative attitudes mean that there will still be uncertainty concerning the delimitation of the EUS. This is in part a consequence of the multi-dimensional nature of the concept of environment. The identification of environmental problems depends on the state of science in combination with culturally determined attitudes concerning 'good' nature and a 'good' environmental result. This perception of environmental problems plays a major role in determining the EUS.

When it comes to operationalisation, however, it is evident that critical values are interpreted wholly differently. Scientific research may, for example, demonstrate that the extent to which surface water may be burdened with unavoidable pollution as a result of human group activity depends on the season. The possibilities for natural recovery vary throughout the year. This does not, however, say anything about the critical values. These are dependent on the weight assigned to the activity in question, the environmental damage and the possibility of compensation. Evidently the perception of the risks incurred by the environment plays a decisive role.

2.4 Risk as central concept

From the above it will be clear that both scientific and normative problems may be traced back to perceptions of the risks at issue. Specific scientific research can in certain cases help draw a distinction between facts, suppositions, probabilities and beliefs. Statistical risks can also be reduced, for example by improved observations, and some fundamental risks can be eliminated by unravelling causal links. The advancement of knowledge will, however, always be relative, in the sense that greater knowledge about the functioning of systems is also accompanied by greater knowledge about the possible threats to those systems. In addition, research does not resolve the fact that opinions may differ about the relevance of environmental assets.

In the former case account will need to be taken when a concrete decision is taken of the statistical risks inherent in the inadequate knowledge of dose-effect relationships. In the second case there are fundamental risks which people will or will not be prepared to take. Normative perceptions of this kind of risk are a major factor in the final policy action.

What this ultimately comes down to is people's perception of the risks at issue. How great is the risk put that certain relevant variables have been overlooked? How great is the chance that the uncertainty has been incorrectly estimated? Part of the effects of human activities can only be indicated in the form of a certain probability of an effect. In these circumstances one can only conduct a probability calculation. A familiar example is the discussion about the height of dykes. At a given height of the dyke there is a probability of X per cent of a collapse. This is then expressed as 'once in so many years'. The distinction between sea and river dykes and between lowland or highland rivers refines these statements but ultimately it remains a probability calculation.

The average citizen is accustomed to dealing with risks. People for example take out insurance against the risk of fire and accident. The public is also familiar with individual risks (smoking, alcohol consumption, participation in traffic) and collective risks (the collapse of a dyke, energy supply). In addition a distinction is also often drawn between micro-risks (i.e. minor or major probability with local or comparatively brief effects) and macro-risks (low probability but with very great and drawn-out consequences, such as an uncontrolled fission process in a nuclear power plant). In the debate about sustainable development, a classification of this kind into the various sorts of risks often takes a back seat, meaning that no trade-offs are made vis-à-vis other risks or social needs. Further elaboration is required to prevent the trade-off being made implicitly and by a small group of decision-makers rather than explicitly and by public participation. It may not prove possible to achieve consensus, but at least a democratic basis of support can be achieved.

2.5 Action perspectives

2.5.1 Perception of risks

Achieving the goal of sustainability necessarily involves weighing the available information on the environment and the impact of human activity. In view of the numerous gaps in the available knowledge, such a weighing also involves uncertainties and risks. The solutions that people put forward can therefore never be solely dictated by the available information. Among other things, the solutions are determined by assumptions and attitudes arrived at on the basis of historical experience, contemporary opinion-formation and the context in which one operates.

For example, the information that the reserves of a particular resource will be exhausted in 20 years' time is not as straightforward as it seems, in that the exploration for further reserves is never final. No-one therefore knows whether the known reserves are in fact the 'final' reserves or whether we are still at an earlier stage of the reserve curve. Historical experience never provides a single lesson: one person will be able to use past experience to show that further exploration will demonstrate the existence of new reserves or that replacement raw materials can be found, while another can cite analogous cases of exhaustion.

If sustainability is to be achieved on the basis of these attitudes - which differ in particular concerning the extent to which environmental risks are to be avoided - the consequences can vary widely. The notion of sustainability obliges one to ask what form the responsibility towards future generations should take. The belief that reserves 'will last for only another 20 years' will necessitate cutbacks in consumption so that something is left for future generations. On the basis of this environmental-risk-avoiding attitude, the debate will then centre particularly on the question as to how much should be left. If, on the other hand, the risks to the environment are considered less great, one will be expected to be more optimistic about the reserves; here the reasoning will be more in terms of a dynamic stock. Further exploration will be expected to result in new reserves. It will therefore more readily be assumed that there will be enough for future generations or that it will be possible to switch to substitutes. The responsibility for future generations will be sought in the generation and transfer of adequate know-how and techniques for the extraction of the raw material or alternatives.

Similarly the information about the disruption of ecosystems due to human activity does not automatically lead to conclusions. The judgement made will depend on assumptions concerning the fragility or robustness of nature. If nature is regarded as a complex system of precarious equilibria, one will be more inclined to assume that small changes in the component parts can have an enormous knock-on effect. In this case sustainability will be largely interpreted in the sense of avoiding the violation of what are regarded as fragile ecosystems and minimising activities that pose risks to the natural environment. If, by contrast, nature is regarded as a dynamic and robust system, there will be a certain amount of a priori confidence in its resilience. It will then be noted that negative feedbacks soften the effects of positive feedbacks. Furthermore, ecosystems are - quite independently of any human activity - permanently in a state of flux, and a further adaptation of the effects of human activity need not necessarily be associated with a loss of specific environmental features and functions. And where this cannot be avoided, this will be regarded under this approach as a challenge to human ingenuity: if nature becomes scarce it will have to be produced. If there are signals that the resilience is being undermined, on the other hand, caution will be called for; it may be that gene banks or genetic manipulation can provide some solace by giving nature a helping hand in the selection process.

It will be clear that these kinds of assumptions provide frameworks for the interpretation of the available partial information. In this respect they also play a role in assessing which activities should take place to assist the environment and which should be discontinued.

The risk perceptions with respect to the environment are therefore relative in so far as environmental risks can never be totally excluded, however risk-avoiding one sets out to be. Conversely it is not the case that no risks whatever are incurred, however robust nature may be perceived as being. Furthermore a certain risk perception need not be adhered to once and for all; human beings are capable of learning and altering their stance in response to fresh information. Nor will the same assumptions be applied across the board in the environment: it is perfectly conceivable that the uncertainties in the energy field will be interpreted differently from those applying to nature. If anything the distinction brings out the ambivalence that can arise using uncertain information.

It was suggested above that the label of sustainability or reduction of insustainability relates to the quality of the relationship between the ecological and social systems. In the same way that it is impossible unambiguously to interpret the environmental situation we are working towards, the same applies to the social transformation that is deemed desirable and possible from the viewpoint of sustainability. Similarly the consequences of social intervention for environmental reasons are often uncertain and imply certain risks. Undesired environmental effects are generally the consequence of behaviour patterns that are essentially regarded as normal and also desirable, and which are underpinned by numerous institutions in society. The packaging of consumer goods is based on considerations of efficiency, hygiene, competition and customer-friendliness but in fact generates an enormous amount of waste. Consumption, and hence the assault on scarce resources and the generation of waste, is, among other things, a function of the number of households. The fall in average household size means that the number of households and, therefore, consumption is growing. The curtailment and 'internalisation' of undesired environmental effects can touch, therefore, on deeply felt rights and freedoms. Interference with these - such as the freedom of production and consumption or the size of households - can produce reactions that cut across the desired objectives. The violation of interests can also have undesirable political and economic consequences. A recent example concerns the threat created by the further tightening of environmental regulations that economic activities could be transferred to other countries with less strict rules.

Opinions may also differ about the risks to society that one is prepared to accept in response to proposed changes to improve the environment. It may for example be assumed that the well-tested mechanisms behind the existing socio-economic dynamics will once again demonstrate their problem-solving capacity if they are confronted with the environmental issue. The risks of far-reaching autonomous social intervention are, moreover, deemed excessive. Improvement of the existing mechanisms is therefore the appropriate path. The social risks are minimised if the 'scarcity' of the environment is as far as possible regulated by means of the normal coordination mechanisms. The market (under this approach) is viewed as the most efficient and effective path.

The market will show just how valuable particular needs are considered to be. Prices bring together information in a highly efficient manner. If prices reflect environmental preferences this will then elicit the necessary change in behaviour. It will also give rise to a process of technological information aimed at mitigating the environmental problem in question. Assimilation into the world economy is, accordingly, regarded as the best way of countering the environmental problems in the Third World and ensuring that people there also have access to scarce resources. The West can contribute to this process by creating favourable conditions for economic take-off, i.e. liberalisation of the world market and the abolition of protective measures.

If however the 'normal' coordination mechanisms are feared to be inadequate, it will be argued that more rigorous adjustments are required in order to establish a sustainable relationship with the environment. It is also argued that the market's time-horizon is short by definition, whereas in the case of the environment we are concerned with short-term changes in the interests of preventing problems in the long term. Furthermore there are also environmental interests that cannot be expressed in price terms. Particularly where the necessary changes in behaviour take the form of a slowdown in consumption and production the curative effects of the market cannot be guaranteed. Refraining from certain forms of consumption or needs, acceptance of redistribution in favour of the Third World and future generations on account of the scarcity of resources and the stimulation of technological change even where there is no consumer demand are all new paths the social consequences of which are not readily brought into focus. The social risks need not, however, be taken too seriously. Confronted with this wholly new assignment, society must certainly be deemed capable of developing new organisational forms, given the necessary commitment.

Under this view, it is held that society is willing to accept these political and socio-economic 'innovations' on account of the ecological threat, or that it can be mobilised to do so. In other words, the risks of social adjustments weigh less heavily than they do under the previously discussed set of views. If, on account of prisoner's dilemmas, these changes are not spontaneously reflected in the economic process it is then regarded as desirable and possible for this to be superimposed, namely by legitimating governments to impose conditions on individual or state behaviour.

The respective attitudes towards environmental and social risks are both relative positions. Even if one seeks to avoid social risks, one will nevertheless be prepared to accept some such risks - for example as a result of a change in prices - in the interests of sustainability.

The judgement about social flexibility need not be the mirror-image of that concerning the environmental risks. If one considers that social activity poses major risks to the environment this does not necessarily mean that the social potential for change will be considered high. Nor need the reverse apply: faith in the changeability of society need not necessarily mean that major importance is assigned to environmental risks. Both dimensions may, therefore, be viewed to some extent in isolation from one another. On the other hand, as argued previously, the two are by no means always seen in combined terms. Calls for a radical improvement of the environment presuppose the capacity for substantial social change, but this sometimes remains implicit. Conversely, trivialisation of environmental problems is often prompted by the unexpressed assumption that social processes cannot or should not be changed.

This report is based on the assumption that sustainability implies that the present environmental risks are regarded as unacceptable and that there is a willingness to make social adjustments. Various positions may be adopted with respect to the seriousness of the perceived environmental risks and the extent to which one is prepared to accept social risks in order to mitigate the impact on the environment. These positions are discussed below in stylised form.

2.5.2 Elaboration into action perspectives

Choices must be made in both risk domains. To this end an estimate has to be made of the environmental risks that one is prepared to accept or which one considers should be avoided. The same applies to an estimate of social resilience. This finally gives rise to an estimate of the ability to prevent environmental problems by means of adjustments in human activities.

Although, as seen in section 2.2.2, the size of the population and level of prosperity also affect the impact of human activity on the environment, consumer and producer behaviour lend themselves particularly to direct intervention by (government) policy. On environmental grounds, an active population policy is highly relevant. In order to place this in perspective, account has been taken in the elaboration of the action perspectives of the various variants of population developments.

In tackling the environmental problem, the action perspectives focus especially on the consumer needs or functions that are to be fulfilled and/or the activities with which those needs are to be met.

Table 2.1 **Four action perspectives aimed at the achievement of sustainable development**

	Consumption	
Production	high	low
Adaptation of production methods	Utilizing	Saving
Change in nature of production methods	Managing	Preserving

Source: WRR.

The view may for example be taken that only minimal adjustments are required in order to cope with environmental problems. Both the present level of consumption and the production technology can be continued with some adjustment over a lengthy period without endangering sustainability. This perspective may be described as Utilizing.

It can also be argued that the solution should not be sought so much in the production sphere but that, more especially, the volume or pattern of consumption - for example of energy or animal proteins - should be adapted. This perspective may be labelled Saving.

Another alternative is to counter environmental problems by continuing to meet the present high level of consumer needs while modifying the productive activities directed towards those needs, for example by a change in technology or the use of different energy sources. This action perspective may be described as Managing.

Fourthly, environmental problems may be viewed so seriously that both the level of consumption and production processes need to be adapted. This perspective is concerned with Preserving.

The four attitudes or sets of views which have been taken as the starting point are outlined in more detail below. The description of these action perspectives is confined to the a priori attitudes. The tenability of those attitudes will be examined more closely in Chapter 3 on the basis of the scenarios worked out for the next 50 years in the various areas.

2.5.3 The Utilizing action perspective

Deliberately engineered radical social transformation for environmental purposes is regarded under the Utilizing action perspective as undesirable and impossible. At best the social dynamic can be adjusted, not directed. In addition there is the danger that simpler solutions to environmental problems will be ruled out in the laborious process of imposed behavioural change. This applies not just to consumption processes but also to excessive intervention in production processes. Problems need to achieve a certain scale in order to unleash creative energy.

This may be at the expense of particular environmental wishes; a certain level of environmental risk can never be ruled out. Some forms or levels of pollution of water, soil and air are, however, acceptable. Others can be mitigated by means of technological adaptations. The availability of energy and raw materials is not regarded as a major problem. Much can be achieved by technology. Furthermore, the growing scarcity of resources will mean a rise in prices, leading in turn to endogenous substitutions. If the conventional sources of energy are exhausted in the next century this may not be a problem if the know-how and technology for other sources have been developed in the meantime. This means that in those areas where energy is now freely available investments need to be made in good time in new know-how. Nuclear energy, including in particular nuclear fusion, are options that must not be put to one side. Terrible though catastrophes such as Chernobyl are, they have also produced some benefits, e.g. in the form of improvements in the safety of nuclear power plants in Eastern Europe. The problem of the storage of nuclear waste could also be nearing a solution. Risks cannot be totally excluded but are comparable with those associated with (for example) the extraction of coal (i.e. lung disease and accidents). The nuclear energy option is therefore placed in a new light, particularly if the environmental aspects - the physical exhaustion of fossil energy, acidification and $C0_2$ - are taken into account.

Under this action perspective there is a particular need to check the rapid growth of the world population. The growth of the population in the Third World is the source of major concern. The associated poverty results in major environmental problems (erosion, destruction of the tropical rainforests, etc). Precisely because it is difficult to alter the development of consumption and production, tackling poverty becomes an important lever. A rapid increase in prosperity is called for, both indirectly in order to mitigate the population numbers and directly to improve the environment. An increase in prosperity in Western countries is also regarded as desirable and possible. The institutions predicated on high living standards are so firmly enshrined that any reduction in prosperity may be regarded as illusory.

2.5.4 The Saving action perspective

Under the Saving action perspective, both environmental risks and the risks inherent in the process of social adaptation are, to a certain extent, accepted and taken in the interests of sustainability, in that the resilience of both systems is regarded as considerable. Methods of production, including technology, cannot however be changed rapidly. Nor is this required from the viewpoint of environmental risks. These can be reduced to acceptable levels by reducing the volume of consumption bearing on the environment. This provides the most important lever for change. Major cutbacks in consumption are not just required for the environment but are also regarded as necessary in the interests of a fairer distribution of scarce resources both worldwide and between present and future generations.

Under this view, it is desirable to work towards a package of consumer needs in which each world citizen makes limited use of natural resources. This is based on the assumption that ultimately everyone has the same right of access to sufficient resources in order to meet certain priority consumer needs (i.e. redistribution), before all kinds of luxury needs can be met. Environmental problems which, despite the lower level of consumption, could still arise, are accepted as potentially insoluble or inevitable. There is however little confidence in the effectiveness of banning certain substances or the rapid development and application of renewable resources. Nor does this particular set of beliefs share the optimistic noises about the possibilities for recycling and the replacement of existing raw materials. In many cases this just leads to the displacement of problems. Because it can never be determined in advance whether or not environmental problems are insoluble it is best to allow for a cautious margin for error by exercising restraint with respect to consumer needs. This applies all the more since a high level of population growth cannot be ruled out. Emphasis is also placed on reducing dependence on natural resources.

2.5.5 The Managing action perspective

The Managing action perspective is based on the assumption that, contrary to the way in which they are met, needs cannot be rapidly changed. The natural environment is regarded as 'robust within limits', meaning that these limits need to be monitored closely in order to prevent accidents. Risks exceeding those limits are not acceptable. The social capacity for adjustment is regarded as considerable, but the optimism of the Preserving action perspective is not shared. It is not for nothing that the present of level of consumption in the West is widely pursued throughout the world. For this reason the potential in terms of organised human inventiveness - R & D - needs to be exploited in order to come up with new production methods that spare the environment as far as possible. The focus is placed on regulating adjustments in production.

It is important to accumulate as much information as possible in order to provide the foundation for a deliberate, future-oriented policy. This information is used in order to accelerate the dematerialisation of production, possibly followed by the dematerialisation of consumption. This applies especially to the West, for at global level the consumption of materials is increasing. By 'investing in the future' - for example by the development of 'clean' technologies and new materials - it becomes possible on a worldwide scale to revive renewable resources and reduce leakages.

2.5.6 The Preserving action perspective

Under the Preserving action perspective there is a willingness to change both consumer and producer behaviour. Environmental risks are regarded as high and avoiding them requires adjustments to the level or pattern of consumption and changes in the relevant production activities. It is held that the necessary social willingness will ultimately be available. Undoubtedly this will arouse resistance, since the necessary intervention will cut across numerous interests and acquired rights.

This perspective seeks to minimise the uptake of non-renewable resources and to control the utilisation of renewable resources in such a way that their regenerative capacity is not overburdened. Under this vision, sustainable development means that people must submit to tight ecological constraints and reconcile themselves to a sober lifestyle. There is also considerable confidence in the potential that technological contributions can make towards solving environmental problems, but this is technology concerned with the recycling of scarce raw materials and renewable sources of energy. By cutting back heavily on the initial consumption of raw materials, the large-scale closure of cycles and the increasing use of renewable resources, environmental risks can be minimised. Even more than in the Saving perspective, the emphasis is on meeting certain priority consumer needs for each world citizen now and in the future. This course of action is advocated since a substantial increase in population must be allowed for. The uptake of scarce resources by the rich countries must be reduced so as to leave something for the developing countries and for future generations.

Where there is certainty about the consequences of human intervention (e.g. the hole in the ozone layer), immediate adjustments in both production and consumption are automatically required. New products may only be marketed if their harmlessness to the environment has been demonstrated. As long as there is uncertainty concerning the environmental consequences of behaviour that behaviour needs to be modified in line with the risk. The scientific uncertainty concerning the consequences of the combustion of fossil fuels or the temperature of the earth, for example, entails such major risks that energy use must be radically reduced as long as non-harmful energy extraction (i.e. renewable sources) is not available. At the same time the process of innovation must concentrate more on renewables. To an even greater extent than under the Saving perspective the radical government intervention is legitimated. This in turn calls for strong governments that are capable of making use of all the available means, both directly and indirectly, for example via the market.

2.5.7 Scenarios

The description of the four sets of views above is based on the attitudes that stem logically from the various risk perceptions in the ecological (environmental) and societal/socio-economic domain. On the basis of those perceptions choices are made. Confrontation with the consequences of those choices can lead to a review of the a priori attitudes. For this reason, a number of scenarios have been worked out in particular areas in Chapter 3. On the one hand these illustrate the incompleteness of the information and the scientific uncertainty, while on the other they demonstrate how different attitudes need to be adopted in various areas if sustainability is to be a 'realistic' concept.

Scenarios in selected areas 3

3.1 Introduction

Sustainable development has been discussed in a general sense above. It was made clear that science cannot be expected to reveal the path to sustainability in any clear-cut manner; the available knowledge is too fragmentary. But even full-scale (although inherently unattainable) knowledge would still not dictate the goals, in that information, including the inherent uncertainty and risks, can be weighed differently. It was contended that this trade-off relates to both the ecological and the social domain. The analysis gave rise to four generally formulated action perspectives, in which the risks are weighed differently.

The action perspectives will be worked out in more detail in time and space in a number of areas that may be regarded as particularly problematical from an environmental viewpoint. By working the action perspectives up into concrete objectives and examining the adjustments this would require, greater clarity may be obtained about the ways in which it is considered that sustainability should be approached.

The action perspectives and their specifications may be regarded as input parameters for scenarios covering the period 1990-2040. For some this time-span will be too long for achieving the proposed sustainability, while for others it will be too short. The nature of the consequences to which the selected goals in the various areas give rise may mean that the original judgements have to be qualified.

The topics examined below are, in order, the world food supply, energy, nature, various resources and water. Although this selection does not cover the full range of environmental problems, it does cover those areas where the demand for sustainability is particularly acute. Not only do all these areas involve radical environmental consequences but major social interests are also at issue. The trade-off between the environment and social goals is particularly stark in these areas, and the breaks in the trend that are deemed necessary will therefore have substantial consequences.

Most of the topics selected have been worked out at global level. That this should be so is largely self-evident: energy and food supply, for example, are global issues. Analysis at more local levels is not meaningless but can easily remain a matter of good intentions if higher levels are not examined as well. On account of the limited tradeability of water, the water supply is largely a regional or local matter, and this aspect has therefore been worked out in respect of the catchment area for the Netherlands.

The primarily global scale of sustainability does not mean that the analyses have to be conducted solely at that level. Insight into the global energy problem means that account has to be taken of highly divergent regional developments. The nature of the regional particularisation required for the analysis differs from topic to topic. Insight into the food supply, for example, can be obtained at more local level than in the case of the energy supply.

Separate studies have been conducted on each of these topics, which form an important source of inspiration for the analysis below [1]. In addition the suggestions made by a number of experts to whom the studies had been submitted for comment were used.

As far as possible each of the topics has been dealt with along the same lines below. Following the identification of present developments, a 'reference' scenario is extrapolated to the year 2040. To avoid any misunderstanding, this is not the most likely development but is simply designed to show where the present developments would lead in the absence of an exogenously or endogenously induced change of course. The four action perspectives aimed at sustainability are then each elaborated for the problem area in question. In this way it becomes clear what weighting has been assigned to the uncertainties and risks in the individual areas and the choices to which that weighting has led. By examining these action perspectives in the form of scenarios against the developments in the next 50 years, insight is obtained into the potential consequences of the choices made. This is then examined in more detail in the evaluation.

The growth in population to the year 2040 is of major importance for both the reference scenarios and the scenarios based on the action perspectives. Although the growth in the world population depends in part on the action perspective in question, it has been treated here as an exogenous variable. In order to identify the potential impact of the action perspectives, a number of variants of population growth have been used.

Demographic trends vary widely throughout the world. In some parts of the world there is concern about ageing [2], while in other, much more sizeable parts of the world with a comparatively youthful population structure, we are witnessing population explosions.

In order to incorporate demographic developments into the scenarios, the United Nations long-term scenarios have been used. These forecasts elaborate demographic developments at subcontinent level. The UN estimates that depending on the growth scenario in question, there will be between 5 and 28 billion people in the world in the 2150 [3].

Because the scenarios presented in this report look to the year 2040 and sometimes also relate to a lower level of scale, use has also been made of another UN publication containing population projections for individual countries up

1] The studies in question are as follows:

a) J. Dogterom and P.H.L. Buijs, *Duurzaam watergebruik in Nederland* (Sustainable water-use in the Netherlands), The Hague, W80, 1994;

b) B. van den Haspel, J.P. van Soest, G. de Wit et al., *Energie tot oneindig: concepties van duurzaamheid in vijf wereldenergiescenario's* (Infinite energy: conceptions of sustainability in five world energy scenarios), Delft, Centre for Energy Conservation and Environmental Technology, 1994;

c) W.M. de Jong, *Chloor in duurzaam perspectief* (Chlorine in a sustainable perspective), The Hague, W79, 1994;

d) T. van der Meij, J.H.W. Hendriks, C.J.M. Musters, et al., *Ontwikkelingen in de natuur; visies op de levende natuur in de wereld en scenario's voor het behoud daarvan* (Developments in nature; visions on the living nature in the world and scenarios for its preservation), Preliminary and background studies V87, The Hague, Sdu Uitgeverij, 1995;

e) D. Scheele, *Duurzaamheid materiaalgebruik en de exploitatie van mineralen* (The sustainable use of materials and exploitation of minerals), The Hague, W78, 1994;

f) P.S. Bindraban, H. van Keulen, F.W.T. Penning de Vries et al., *Sustainable world food production and environment: options for alternative developments*, Wageningen, Delft, AB-DLO/WL, 1993; forthcoming.

2] See for example WRR, *Ouderen voor Ouderen, demografische ontwikkelingen en beleid* (Demographic Developments and Policy), Reports to the Government no. 43, The Hague, Sdu Uitgeverij, 1993.

3] United Nations, *Long-range world population projections (1950-2150)*; New York, 1992.

to the year 2025 [4]. The population size in the year 2040 has been arrived at by linear extrapolation between 2025 and 2150 and has then been translated into the regions distinguished below. In those cases where the analysis carried out for the present study relates to regions smaller than those in the UN projections the latter figures have been adjusted. The results are shown in Table 3.1.

Table 3.1 Population size of 19 world regions according to low, mean and high population growth in the period up to 2040

	Population size (in millions)		
Region	low growth	middle growth	high growth
South America	481	558	683
Central America	202	241	282
Caribbean	48	55	65
North America	274	328	398
North Africa	277	343	419
West Africa	466	635	798
Central Africa	190	240	286
East Africa	537	679	842
South Africa	89	100	123
Oceania	32	37	44
Southeast Asia	658	820	1005
East Asia	1503	1770	2098
South Asia	1503	1770	2098
West Asia	249	324	399
USSR	323	369	419
Eastern Europe	104	119	135
Southern Europe	126	143	161
Western Europe	131	151	172
Northen Europe	75	850	95
World total	7729	9405	11292

Source: WRR on basis of United Nations, *Long-range World Population Projections (1950-2150)*; New York, 1992; United Nations Population Reference Bureau, *World Population data sheet*; Washington D.C., 1992.

3.2 World food supply

3.2.1 Introduction

The most elementary prior condition for sustainable development is an undisturbed food supply, as the persistence of the human race obviously depends critically on a guaranteed food supply. At the same time agriculture constitutes a threat to the continuation of nature and environment in many places. In the case of the world food supply, the essence of the trade-off problem outlined in Chapter 2 therefore soon becomes clear.

The explosive growth of the world population has been accompanied by an enormous expansion in food production. Whether the fivefold increase in the world population in the 20th century has been made possible by the farmer or the doctor is hard to say. What can be stated with certainty is that structural food shortages have been eliminated in this century. The world food produc-

[4] United Nations Population Reference Bureau, *World Population data sheet*, Washington D.C., 1992.

tion is now more than sufficient to feed everyone, but wars and other disasters are responsible for acute local shortages. At the same time it has become clear that agricultural production is not equally as easy everywhere. Nor is it always risk-free. In some places too much is demanded of the productive capacity of the land. Where there is over-exploitation this becomes visible in various forms of environmental degradation, such as exhaustion, erosion, soil pollution and salination.

In order to obtain a clearer view of the problems relating to the food supply, a reference scenario is first worked out below. In this scenario a number of current problems are discussed as well as problems that could develop up to the reference year 2040 (partly in the light of the population growth). Four scenarios are then examined each providing a different interpretation of a sustainable agricultural system that would also be able to meet a reasonable demand for food for well into the future without occasioning insuperable socio-economic and/or environmental problems. The differences between the scenarios are based on a distinction in the method of agricultural production and differences in the consumer's level of needs. The elaboration of the scenarios concludes with an evaluation, which includes a discussion of what is needed in order to realise the various scenarios. It is then examined whether those requirements could in fact be met. In doing so a distinction is drawn between the required social adjustments, the uncertainties with respect to the consequences for the environment and the potential conflicts between the desire to meet the demand for food and other objectives relating to land and water use.

3.2.2 Reference scenario [5]

Trends in agricultural production

Part of the increase in world food production has been due to the expansion of the area under cultivation, but the bulk of the increase has been due to the increase in agricultural productivity.

Agricultural techniques remained more or less unchanged for many centuries. Only marginal improvements were made to cultivation techniques, resulting in the case of grain production in average annual improvements of around 4 kg per hectare. Since the start of the century yields have been increasing much more rapidly, especially in the industrialised West. Average increases in yields are now being achieved of around 80 kilograms per hectare per year. The growth in productivity has therefore been characterised by breaks in the trend, also known as 'green revolutions'.

These breaks in the trend occurred in the industrialised world (Europe and North America) between 1945 and 1955 and in a number of developing countries (India, China and Indonesia) between 1965 and 1975. The revolution has still to take place in other developing countries (namely almost the whole of Africa and parts of West Asia).

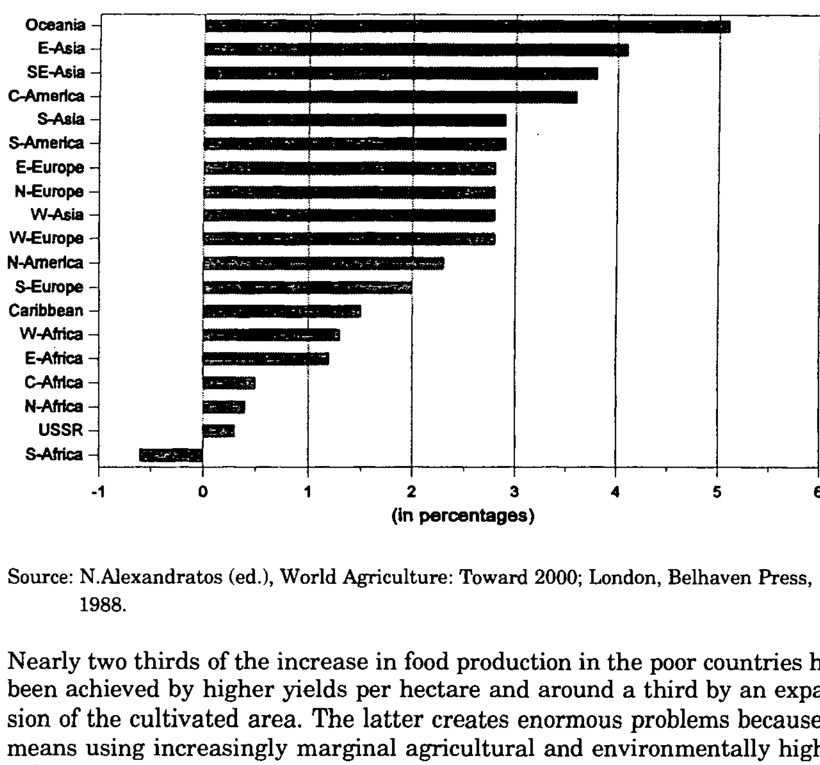
The sharp increases in agricultural productivity have been due to a combination of improved operational technological know-how and the ability to apply this knowledge. The resultant synergy has led to accelerating productivity gains. In particular, the hefty increases in output per hectare have been due to the ability to overcome poor soil fertility and water shortages by means of fertilisers and irrigation.

5] The reference scenario presented here is largely based on two FAO studies: N. Alexandratos (ed.), *World Agriculture: Toward 2000*; London, Belhaven Press, 1988. Food and Agriculture Organization of the United Nations, *Agriculture: Towards 2010*, Rome, 1993.

Even more impressive has been the increase in labour productivity. During the course of this century labour productivity in agriculture has risen in the industrialised world from 4 kg of wheat per man-hour to 600 kg per man-hour. This is reflected in the loss of employment in agriculture. In 1860, 44 per cent of the labour force in the Netherlands was still engaged in agriculture; the figure is now around 5 per cent. Similar developments are currently taking place much more rapidly in parts of China, India, Indonesia and South America.

For the world as a whole the production of food has risen slightly more rapidly than the growth in population (2.3% compared with 1.9% a year in 1970-1989). The growth in food production varies considerably in the various regions of the world (see Figure 3.1). The FAO expects that food production will continue to increase in many poor countries until the year 2010, at a rate of just under 3 per cent a year. Compared with the period 1970-1989 this represents a fall in growth. According to the FAO the growth in food production in the rich countries is falling sharply to less than 1 per cent a year due to the large production surpluses, virtual stagnation of exports and limited rise in the demand for food.

Figure 3.1 **Average yearly growth in food production in various regions of the world, 1970-1985 (in %)**



Source: N.Alexandratos (ed.), World Agriculture: Toward 2000; London, Belhaven Press, 1988.

Nearly two thirds of the increase in food production in the poor countries has been achieved by higher yields per hectare and around a third by an expansion of the cultivated area. The latter creates enormous problems because it means using increasingly marginal agricultural and environmentally highly vulnerable land.

Ranged against this growth in agricultural output has been a growth in the population to be fed. The most recent FAO projections suggest that the growth in food production will outstrip population growth in virtually every region in the world. An exception is Southern Africa; although the situation is improving in relative terms, the amount of food per head of population will continue to fall by an average 0.2 per cent a year until the year 2010. During the period 1970-1989 per capita food production fell by an average 1.1 per cent a year.

The overall conclusion reached by the FAO is that the availability of food in developing countries can rise from 2500 kilocalories to 2700 kilocalories in the year 2010. This does not eliminate the fact of continuing malnutrition in numerous developing countries, especially in Southern Africa and Southern Asia. Of the 800 million people who still face hunger and malnutrition, 650 million will remain in the same circumstances in 2010.

Other institutes put forward somewhat different figures and more particularly reach different conclusions. According to the Worldwatch Institute, for example, per capita food production has ceased to increase throughout the world since 1984 [6]. According to their figures, the average growth in production from that point on has been less than 1 per cent a year, while the population has continued to increase at over 2 per cent a year.

From this the conclusion is drawn that major problems are looming. The 6 per cent fall in per capita food production between 1984 and 1992 cannot be viewed in isolation. The degradation of the environment and the threat of a growing greenhouse effect combined with a loss of momentum in food production and the inability to check the growth of the world population will ultimately result in growing hunger in the world.

Social problems in the food supply

Despite differences in interpretation, it is clear that the average availability of food per head of population has increased in recent decades. This is clearly evident from the rise in per capita grain production as shown in Figure 3.2. The distribution of the food, however, is a source of major concern. According to the FAO food has not become more readily available in poor countries or for poor people in wealthier countries in recent decades. This is therefore not so much a problem of food production and availability but of access to food. The main causes of the distribution problems are war, natural disasters and poverty. The disastrous food situation in a number of African countries is largely attributable to the consequences of war, poor government and the self-perpetuating effect of the poverty spiral. Healthy agriculture requires investment in the means of production. The lack due to poor harvests of the necessary financial resources to undertake such investment results in a further decline in agricultural yields. This in turn reduces the chance of the necessary investments being made in the following season.

Environmental problems associated with the supply of food

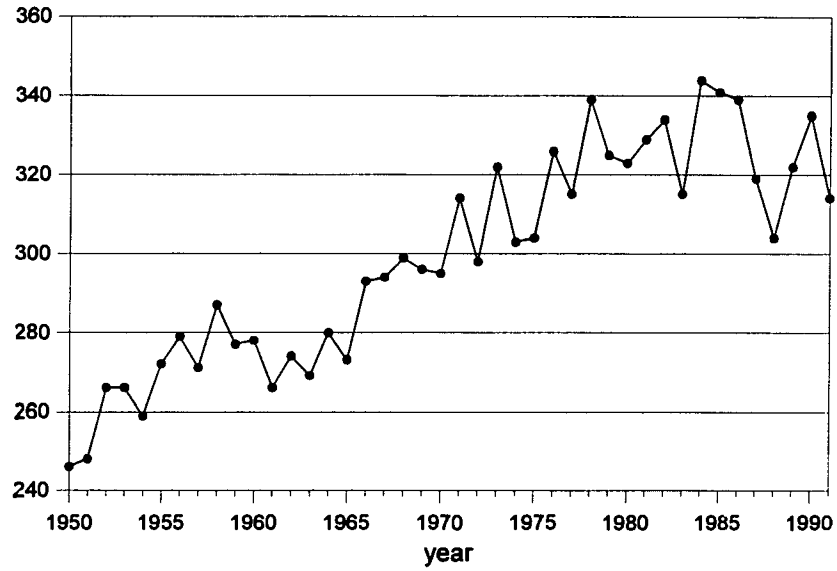
For all the benefits that agricultural production has brought, humankind has been aware for many centuries that certain forms of agriculture also come at a cost. The exhaustion of soils and over-utilisation of irrigation systems have resulted in erosion and the irreversible loss of good soils. The bare hills in the Mediterranean, especially Greece, provide evidence of this tragedy. The same applies to the over-exploitation of irrigation in what used to be Mesopotamia, where salination has rendered large areas unsuitable for agriculture. Another example is the overcropping in the Mid-West of the United States in the 1930s, which gave rise to extensive dust storms.

Not that erosion is generally an undesirable phenomenon. On the contrary: the inhabitants of lowlands, coastal areas and estuaries have erosion to thank for the fertile soil on which they conduct their agriculture. The same applies to the fertile loess regions that have been created in Asia by wind erosion. Soil degradation due to erosion occurs primarily on less fertile soils. Agriculture on

6] L.R. Brown, A. Durning, C. Flavin et al., *State of the World 1993*; New York, W.W. Norton Company, 1993.

excessively steep slopes or shallow soils or in semi-arid areas is inviting difficulties. In many cases, however, the local population is forced to turn these fertile soils to productive account due to population pressures and poverty. Farmers lack the capital to maintain the soil fertility, so that the soils become overfarmed and the soil degradation continues.

Figure 3.2 **Average cereal production per head of the world population, 1950-1991**



Source: L.R. Brown, C. Flavin, H. Kane, *Vital Signs, the trends that shape our future 1992-1993*; London, Earthscan, 1992.

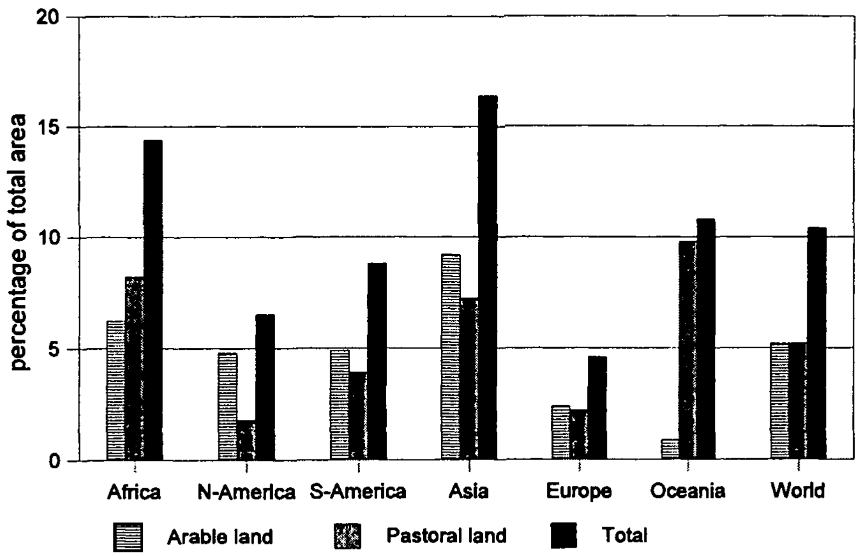
In sharp contrast to the environmental problems in agriculture caused by poverty are those arising from prosperity. In parts of the industrialised world and, increasingly, also in the NICs (Newly Industrialised Countries), fertilisers and pesticides have been over-utilised in both environmental and agricultural terms. This has caused major environmental problems. The same applies to the consequences of large-scale irrigation projects that use water in an uncontrolled manner.

Environmental problems arising from poverty and wealth imperil the continuity of food production. Food security is not, therefore, wholly guaranteed.

On the basis of various figures an impression may be obtained of the extent to which agricultural lands are at present suffering from soil degradation. Figure 3.3 shows the estimated percentage of arable and pastoral land in the various regions of the world that have been lost due to incorrect use.

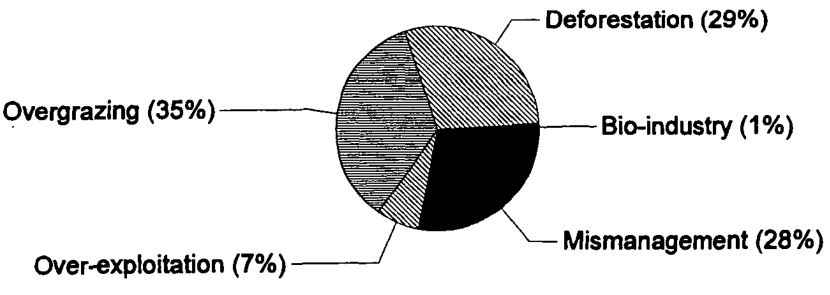
The human activities responsible for erosion may vary markedly from place to place. Figure 3.4 provides a survey of the estimated shares of the various activities in the total process.

Figure 3.3 **Percentages of arable and pastoral land in the various regions of the world where the consequences of erosion are discernible**



Source: WRR, on basis of L.R. Oldeman, R.T.A. Hakkeling, W.G. Sombroek, *World map of the status of human-induced soil degradation. An explanatory-note*; Wageningen, International Soil Reference Information Centre, 1991 and World Resources Institute, *World Resources 1992-93*; New York, Oxford University Press, 1992.

Figure 3.4 **Estimated shares of various activities in the erosion of agricultural lands: situation in 1990**



Source: L.R. Oldeman, R.T.A. Hakkeling, W.G. Sombroek, *World map of the status of human-induced soil degradation. An explanatory note*; Wageningen, International Soil Reference Information Centre, 1991.

3.2.3 Lack of knowledge and structural uncertainties

In the previous section it was seen that the present trends in the food supply can not beforehand be characterised as sustainable. The issue of the world food supply is, however, subject to numerous uncertainties when it comes to the possibilities. There is also a major lack of knowledge about the relevant relationships: is the environment suffering especially from overinput or underinput; can erosion be countered by changes in agriculture or do all activities result in a loss of soil quality? These uncertainties and questions have not only resulted in differences of insight into the present situation but, as seen before, also in major differences in the way in which it is considered that agriculture could develop. The FAO, for example, has conducted various forward-looking studies based largely on the extrapolation of current trends. The available production *potential* is of little if any account in such analyses. The present scale of production is the decisive factor in estimates of future production. This results in the expectation that the food supply will not be able to grow sufficiently in order to meet the rising demand caused by the growing world population. Shortages could therefore arise in due course in many places.

If greater confidence is invested in the human capacity to exploit the production potential a totally different picture emerges. Calculations of the world food production potential were made in a number of studies in the 1970s [7]. These calculations are based on all the lands that satisfy a number of minimum agricultural requirements. The production potential can be calculated on the basis of the quality of the various soils and the characteristics of the local climate. These computations have not taken account of possible limitations due to water shortages or of the possible impact of climate change. The studies also indicate that a great deal more is possible than assumed on the basis of the present scale of production.

Any analysis of the possibilities for sustainable food production is obliged to take account of the potential. For the purposes of this report the DLO Institute for Agrobiological and Soil Fertility Research (AB-DLO) and the Delft Hydraulics (WL) were asked to conduct a joint study into the ultimate potentials for world food production.

For the purposes of the study a number of assumptions have been made with respect to sustainability. In the first place the latter presupposes the aim of closing all cycles as effectively as possible. Agriculture makes use of nature's productive capacity, tapping outputs from the system in the form of products. If agriculture is to be maintained over a lengthier period, inputs need to be added to the system in order to compensate for the tapped off outputs. Now by definition inputs can never be 100 per cent converted into outputs; this implies that part of the inputs will be lost to the environment as leakages. These leakages can never be completely sealed off, so that the substance cycles in agriculture can never be fully closed.

Various strategies may be pursued in order to obtain an optimal result. Efforts may be made to close cycles as far as possible at regional level in order to bring the losses to the environment under local control. Another strategy is based on closing the cycles at global level with a view to maximising the efficiency of the system and hence minimising the overall losses. Within each of

7] P. Buringh, H.D.J. van Heemst and G.J. Staring, *Computation of the absolute maximum food production of the world*; Dept. of Tropical Soil Science, Wageningen, Wageningen Agricultural University, 1975.
H. Linneman, J. de Hoogh, M.A. Keyzer and H.D.J. van Heemst, *MOIRA: Model of International Relations in Agriculture*. Contributions to Economic Analysis 124, Amsterdam, North Holland Publ. Comp., 1975.

these two approaches the agricultural system can be organised in many different ways.

The study carried out by the AB-DLO and WL works out two different systems of agriculture that are considered to set out the extreme estimates for the production potential without violating the principles of sustainable production. These are Globally-Oriented Agriculture (GOA) and Locally-Oriented Agriculture (LOA).

GOA seeks to achieve sustainability by aiming at the maximum efficiency of agriculture at global scale. This is based on the notion that the environment is best served by the *lowest possible loss of inputs per unit of output*. This then makes it possible for comparatively high local leakages to the environment to be accepted with a view to reducing the overall burden on the environment. By making use of efficiently produced fertiliser and transporting it to places where these nutrients can be converted as efficiently as possible into agricultural products, an attempt is made to limit the total losses as far as possible.

With a view to guaranteeing sustainability, LOA aims as far as possible at closing regional or local cycles. This is based on the underlying premise that the quality of the environment is best served by the *lowest possible loss of inputs per hectare*. This principle results in the deployment of techniques that avoid the use of external, alien substances such as fertilisers and pesticides wherever possible. Efficiency is therefore defined at a totally different level of scale.

Both globally and locally-oriented agriculture aim at maximum efficiency within their own limiting conditions, with a view to the sustainable functioning of the entire system. Under the GOA system the output is ultimately limited by the available agricultural land and the local availability of water. Under the LOA system the output is limited not just by the local availability of land and water but also by the amount of nitrogen that can be fixed from the atmosphere by natural means. In addition other physical conditions play a role in determining the production potential, such as the quality of the soil. The computations have been made on the assumption that other aspects, such as energy, minerals, investments and labour, do not impose constraints. Any demand for energy or investment can therefore be met in both the GOA and the LOA system. In relation to the present situation this represents a substantial expansion of production.

In many parts of the world, however, there are distinct limitations, attributable to the lack of resources and manpower. The necessary quantities of fertiliser or energy are, for example, by no means procurable universally. Furthermore, the necessary infrastructure is lacking in many places. Even if money were for example available under development projects to buy fertiliser, it remains questionable whether the fertiliser could be applied in the right place in the right way. The assumptions on which this model study is based therefore clearly indicate that the calculations can provide insight into the maximum potentialities of both agricultural systems, but these potentialities tell us little if anything about probable developments in the various regions. For this, far more information is required on the range of obstacles impeding agricultural development in various places.

The availability of water does, however, constitute a possible obstruction in calculating the production potentials of both systems. The maximum possibilities have therefore been made dependent on physical factors. This has been calculated by examining how much water is available for irrigation purposes in each catchment area in the 19 regions distinguished in section 3.1. For each region the demand that can be derived from possible population developments on the basis of UN scenarios has been combined with the production possibilities. The basic calculations of these potentials have been made on a 1° x 1° grid basis. The comparison between demand and supply indicates whether the demand for food can be satisfied in each of the 19 regions, while at a world scale it is possible to establish whether agricultural production is able to feed the growing population. The differences between the regions are indicative for the need for the transport of food from surplus to shortage areas.

Opinions on sustainable food production differ not only in relation to the potential agricultural techniques but also as to the package of food which the average world citizen could consume in the future.

The choice in favour of a *Western* or a *Moderate* diet is prompted by differing estimates of the environmental consequences. The choice in favour of a Moderate diet may be based on the view that in the long term the world population cannot be fed at the present level of Western consumption as this would impose an undue strain on the environment. In the case of a Western diet, by contrast, the environmental risks are deemed acceptable. It may be noted that neither of these two diets is extreme; the Moderate diet is substantially higher than the present world average, while the Western diet is lower than the present level of consumption in, for example, the United States. The Western diet contains a comparatively high proportion of meat and is equal to the present level of average European consumption. This requires a primary production of around 4.2 kilograms of grain-equivalents per person per day [8]. The Moderate diet requires around 2.4 kilograms of grain-equivalent per person per day. The difference is due to the conversion of cereals into meat. In some countries, including the Netherlands, a high degree of efficiency has been achieved in converting animal fodder into meat. This applies especially to intensive livestock farming. The global average is around 8 kilograms of grain per kilo of meat. A diet containing more meat therefore leads to a substantial increase in the necessary volume of grain-equivalents.

The calculations have drawn on two estimates for the growth of the world population based on United Nations figures [9]. The low estimate produces a figure of 7.7 billion people in 2040 and the high estimate a figure of 11.2 billion. A decision in favour of either one of these variants will obviously have a major impact on the results of the calculations.

3.2.4 Action perspectives

The four action perspectives referred to in Chapter 2 differ in terms of food supply with respect to the combinations of production techniques and diets. Table 3.2 indicates how the Utilizing, Saving, Managing and Preserving action perspectives relate to the normative differences in insight.

Utilizing

The Utilizing perspective aims at the provision of a Western diet on a worldwide basis as quickly as possible. It is assumed that this level of consumption is consistent with the ambitions in large parts of the world. Potential environmental problems are regarded as not insuperable. In addition, there is marked confidence in technological solutions to environmental problems. In particular, increasing agricultural output on good soils can result in the highly efficient utilisation of physical inputs such as fertilisers and pesticides, to the benefit of the environment. Per unit of product this agricultural tech-

8] The use of grain-equivalents enables various agricultural products (e.g. wheat, rice, millet and maize) to be brought under a common denominator.

9] United Nations, *Long-range world population projections (1950-2150)*, Dept. of International Economic and Social Affairs, 1992.

nique requires a minimum level of physical inputs. Furthermore, comparatively little land is taken up at maximum levels of production. The social risks

Table 3.2 **Action perspectives for sustainable development of the world food supply**

	Luxury package	Moderate Package
Globally oriented agriculture	Utilizing	Saving
Locally oriented agriculture	Managing	Preserving

Source: WRR, on basis of *Sustainable World Food Production and Environment: Options for Alternative Developments*; by P.S. Bindraban. H. van Keulen, F.W.T. Penning de Vries et al., forthcoming.

associated with the introduction of a production-oriented agricultural system that is required to meet a sharply increasing demand for food are regarded as acceptable under this vision. Relevant know-how is also increasingly exploited by food producers throughout the world.

Saving

The Saving perspective considers that major environmental risks are attached to feeding a rapidly rising world population. Locally-oriented agriculture would, however, involve an excessive change in relation to the present forms of agriculture, for which reason it is sought to minimise the risks for the environment by limiting the demand for food. This will involve a substantial reduction in the pressure exerted by the agricultural system on the environment. The aim is for a moderate diet - without much meat - for each world citizen now and in the future. This situation must be realised by the redistribution of the food produced. Residual environmental problems that could arise under the globally-oriented system are regarded as soluble. The system can be finely tuned to the point that alien substances such as fertilisers and pesticides need not be released in large quantities into the environment.

Managing

The Managing perspective departs from the aim of a moderate diet on account of the associated social risks. This must not, however, be at the expense of subsequent generations. The risks to the environment of a globally-oriented agricultural system are therefore regarded as excessive. The environment faces threats not so much from the losses per unit product as from the local losses to the various environmental compartments. Water, soil and air must be or remain of high quality and energy and resources must be used sparingly. The comparatively high uptake of land that may be expected under a locally-oriented agricultural system is regarded as less of a problem, as are the necessary adjustments in the structure of production.

Preserving

Under the Preserving perspective the risks to the environment are regarded as so grave that the demand for food needs to be limited and local substance cycles optimised by the development of modified agricultural systems. The introduction of alien substances and the long-range transportation of potentially harmful substances (e.g. fertilisers) are considered to pose an undue risk to the environment. The social risks of 'adjusting' the demand to a Moderate diet are regarded as acceptable. It must be possible at global level to hold down the trend towards rising levels of consumption of animal protein. In the rich countries, the consumption of meat will therefore need to fall sharply to around 40 grams a week. The reduction in demand combined with careful chain-management at local scale would guarantee a sustainable world food supply. Here too the emphasis is on an equitable distribution of the by no means overabundant supply of food.

3.2.5 Translation of the action perspectives into scenarios

The potential grain yields per hectare, corrected for storage and transport losses, are between four tonnes under Locally-Oriented Agriculture (LOA) and 10 tonnes per hectare under Globally-Oriented Agriculture (GOA). In the tropics two to three crops can be cultivated per year given sufficient irrigation water. An estimate of the suitable area is required in order to determine the potential yield. The land must be capable of supporting sustained farming over a number of years, so that vulnerable lands have been left out of account. By way of illustration, 128 million hectares of land are currently used for agriculture in the EC, while on the basis of the soil properties, the AB-DLO/WL study reaches the conclusion that 80 million hectares may be deemed suitable for agriculture in the longer term.

The available land in each of the regions may or may not be irrigated. Clearly, this depends on the amount of water available for irrigation purposes in the region in question. It will also be clear that the various production levels of LOA and GOA result in different water requirements. Taking everything into consideration, the distribution is as shown in Figure 3.5. In all cases over 8 billion hectares (approximately 70% of the total area) is unsuitable for agriculture. In the scenarios based on locally-oriented agriculture, some 20 per cent of the area is irrigated. Globally-oriented agriculture results in the irrigation of some 14 per cent of the total area. This distribution turns out to be comparatively insensitive to the various world population growth variants. Although the demand for water for household and industrial purposes rises in line with the population, this increase has little if any impact on the total amount of water available for agriculture.

Figure 3.5a **Breakdown into suitable and unsuitable agricultural land under Locally-Oriented Agriculture and Globally-Oriented Agriculture**

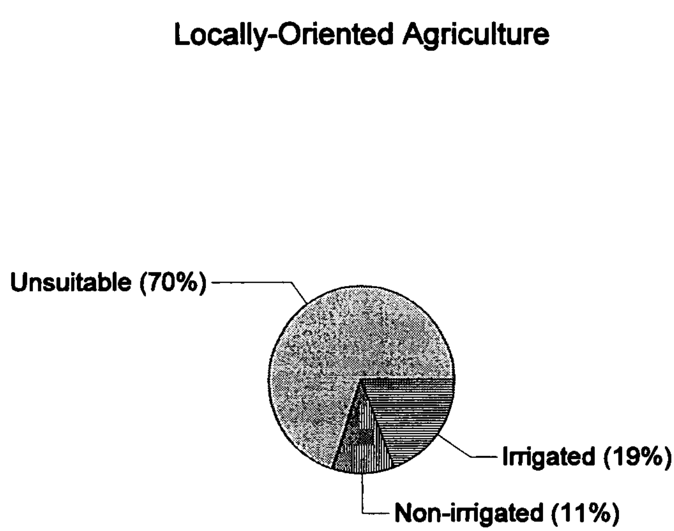
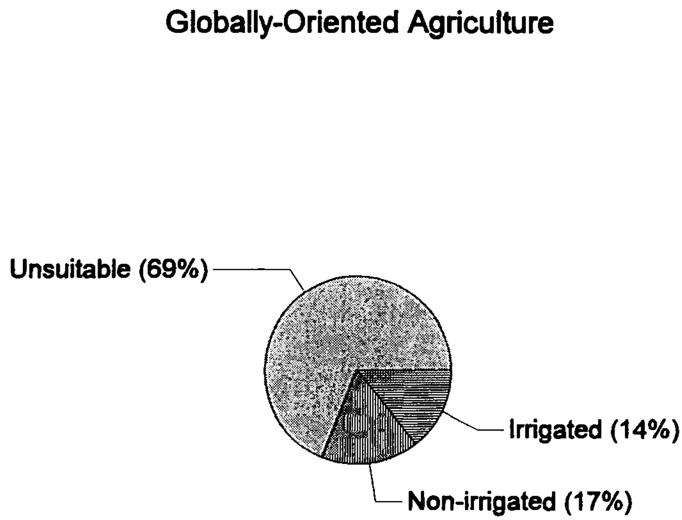


Figure 3.5b



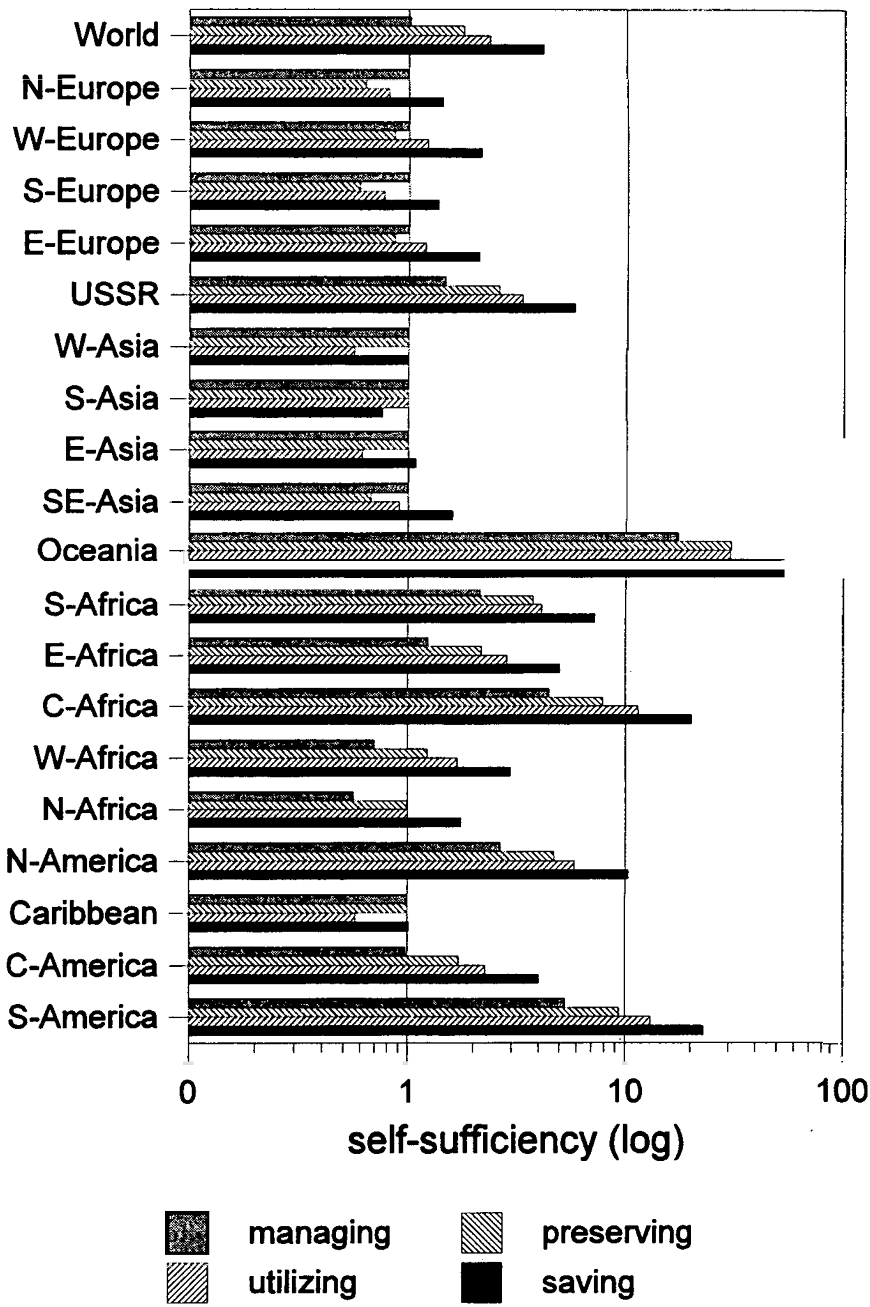
Source: WRR, on basis of *Sustainable World Food Production and Environment; Options for Alternative Developments*; by P.S. Bindraban, H. van Keulen, F.W.T. Penning de Vries et al., forthcoming.

The results of the calculations based on the number of people in the region, the preferred level of consumption and the agricultural system in question are shown in Figure 3.6 for the high population growth variant and in Figure 3.7 for the low population growth variant.

From Figures 3.6 and 3.7 it may be seen that self-sufficiency is realisable at global level in all the four scenarios. Even in the low population growth variant, however, there are shortages in a number of regions in three of the four scenarios. Only in the Saving scenario under low population growth can self-sufficiency be achieved in each region. This implies that in all other scenarios, certain regions suffer from shortages and that inter-regional trade is required in order to meet food needs.

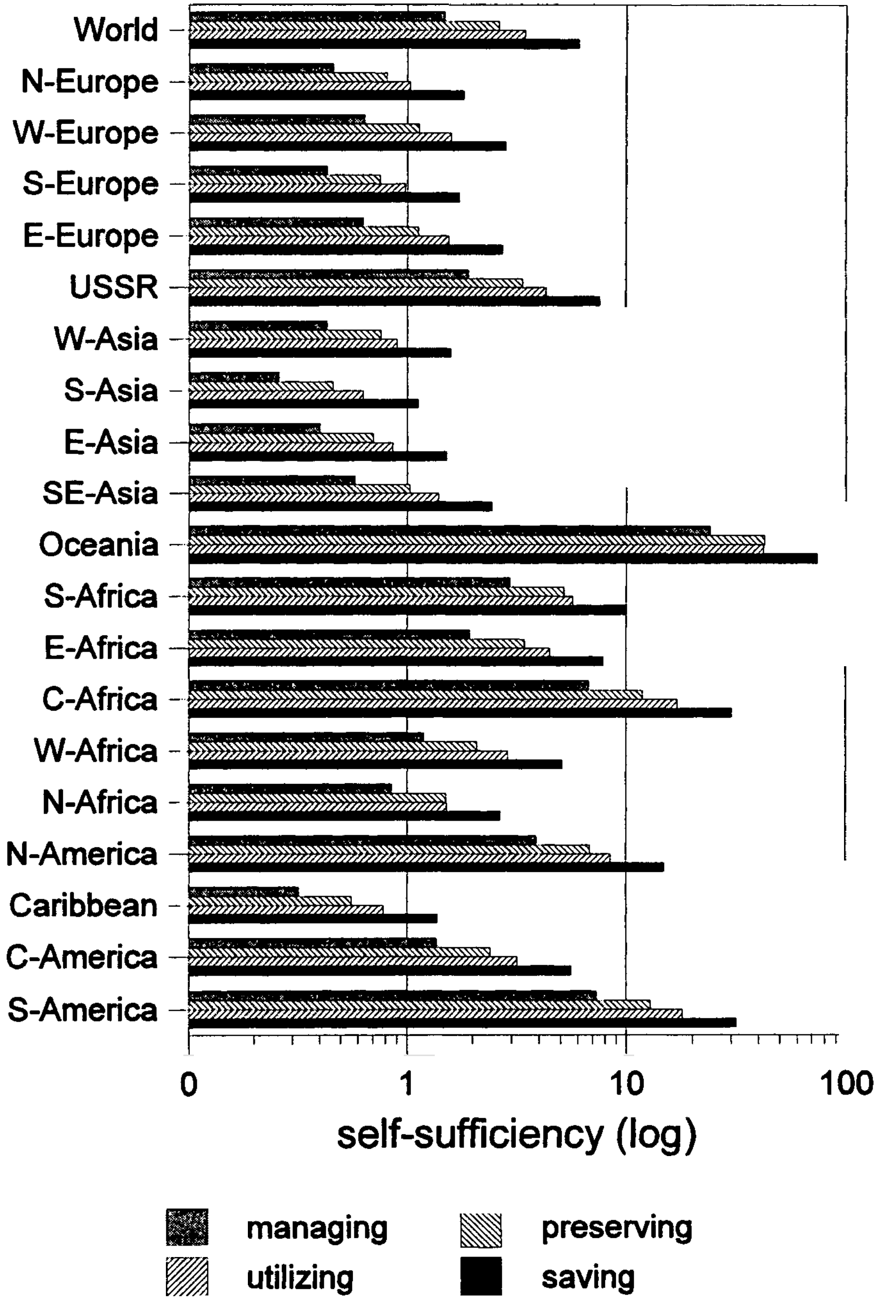
A self-sufficiency index does not of course tell us much about the absolute quantities, for which reason the results of the scenarios are shown in somewhat different form in Tables 3.3 and 3.4. In these tables the maximum production per region is compared with the regional demand, which is equal to a self-sufficiently index of 1.1. A safety margin of 10 per cent has therefore been built in in all regions. Table 3.3 indicates the consequences of this under high population growth. In this case the Managing scenario turns out to be unattainable. The combination of locally-oriented agriculture and the wish to provide a Western diet therefore proves out of reach given a high rate of population increase. At world level there remains a shortfall of around 1.5 billion tonnes of grain equivalent.

Figure 3.6 **Self-sufficiency index in the four scenarios for the 19 world regions given high population growth, 2040**



Source: WRR, on basis of *Sustainable World Food Production and Environment; Options for Alternative Developments*; by P.S. Bindraban, H. van Keulen, F.W.T. Penning de Vries et al., forthcoming.

Figure 3.7 **Self-sufficiency index in the four scenarios for the 19 world regions given low population growth, 2040**



Source: WRR, on basis of *Sustainable World Food Production and Environment; Options for Alternative Developments*; by P.S. Bindraban, H. van Keulen, F.W.T. Penning de Vries et al., forthcoming.

The other scenarios show a surplus. The imposed 110 per cent self-sufficiency can therefore be achieved. In all three of these scenarios, however, there remain regions with a shortfall, especially Asia (E, SE, S and to a lesser extent W). These will need to be supplemented from other regions with a food surplus. It is not however possible to specify a criterion to indicate which other regions will become exporters with a view to redressing the global balance. What the scenarios can do is to indicate the total shortage in the regions with a deficit. This total shortage provides an initial indication of the trade flows that would be required in order to meet the demand in all regions.

The biggest trade flow is required under the Utilizing scenario and amounts to around 5.5 billion tonnes. This is followed by the Preserving scenario, with around 4 billion tonnes, and finally the Saving scenario with around 1 billion tonnes. The figures also reveal that the impact of a change in the diet is greater than that of the production technique applied. Different population growth figures also have a major impact on the necessary trade flows. Given low population growth (Table 3.4) all four of the scenarios prove attainable. The necessary transport flows amount in this case to 5.5 billion tonnes (Managing), 2 billion tonnes (Utilizing and Preserving) and zero (Saving).

3.2.6 Evaluation

Prior conditions for safeguarding world food production

Enough food can be produced to feed the entire world in almost any of the scenarios. Depending on the level of consumption selected, the agricultural system in question and the availability of water, between 11 billion (Managing scenario) and 44 billion (Saving scenario) people can be fed worldwide. A sustainable food supply does not therefore run up against the limits of a physical environmental utilisation space for the world as a whole. The extent to which the world population can be fed depends rather on political and socio-economic factors.

An important demand made in many countries and regions is the ability to feed one's own population. Various economic blocs (EU, NAFTA and the former COMECON) attach major importance to food security, thereby underlining the strategic importance of food. The analysis in this report does not permit statements to be made at individual country level, although the possibilities for self-sufficiency at the level of large regions can be established.

The results indicate that sufficient food can always be produced in South America, North America, Central Africa and Oceania to meet the demand, irrespective of the preferred diet. In East and South Asia, however, this is only the case given a moderate diet and a globally-oriented agricultural system. Problems can arise in various regions. In a limited number of regions (North and South America and Europe) one can in fact afford the luxury of a Western diet combined with locally-oriented agriculture, but this is an exception. For the rest of the world the distribution of food is a possibility. This presupposes an economic climate conducive to international trade, adequate purchasing power in the deficit regions and a high degree of international solidarity. In terms of the present world community, these are extremely exacting conditions.

In the regions where more food is produced than required for self-sufficiency, it is in principle possible to increase production in order to offset the shortages in other regions. The regions in which such extra production would need to take place would depend on the optimal level of production in each region. The desire to minimise the transportation of agricultural commodities throughout the world might for example lead to a choice to locate the additional produc-

Table 3.3 Regional production balance in the four scenarios given a self-sufficiency index of 1.1 and high population growth (in 10^6 tonnes)

	PRESERVING (LOA/moderate)			SAVING (GOA/moderate)			MANAGING (LOA Western)			UTILIZING (GOA/western)		
	production	demand	balance	production	demand	balance	production	demand	balance	production	demand	balance
S-America	5353	630	4724	13173	630	12543	5353	1109	4244	13173	1109	12063
C-America	420	268	152	976	268	709	420	471	-52	976	471	505
Caribbean	23	62	-30	57	62	-5	23	109	-86	57	109	-52
N-America	1612	378	1235	3539	378	3161	1612	665	947	3539	665	2874
N-Africa	359	398	-39	637	398	239	359	700	-342	637	700	-64
W-Africa	847	758	90	2049	758	1291	847	1335	-487	2049	1335	714
C-Africa	1944	271	1672	4966	271	4695	1944	478	1466	4966	478	4488
E-Africa	1585	799	786	3645	799	2845	1585	1408	177	3645	1408	2236
S-Africa	399	116	282	768	116	652	399	205	194	768	205	563
Oceania	1184	42	1142	2069	42	2026	1184	74	1110	2069	74	1994
SE-Asia	583	955	-372	1386	955	431	583	1682	-1099	1386	1682	-296
E-Asia	912	1993	-1082	1958	1993	-36	912	3511	-2600	1958	3511	-1554
S-Asia	775	2744	-1969	1897	2744	-847	775	4834	-4059	1897	4834	-2937
W-Asia	163	379	-216	340	379	-39	163	667	-505	340	667	-328
USSR	939	398	541	2110	398	1712	939	701	238	2110	701	1409
E-Europe	100	128	-28	245	128	117	100	226	-126	245	226	19
S-Europe	82	153	-71	188	153	36	82	269	-188	188	269	-81
W-Europe	128	163	-35	319	163	155	128	288	-159	319	288	31
N-Europe	52	91	-38	118	91	27	52	160	-107	118	160	-42
World	17461	10725	6735	40438	10725	29713	17461	18894	-1433	40438	18894	21544

Source: WRR, on basis of *Sustainable World Food Production and Environment; Option for Alternative Developments*; by P.S. Bindraban, H. van Keulen, F.W.T. Penning de Vries et al., forthcoming.

Table 3.4 Regional production balance in the four scenarios given a self-sufficiency index of 1.1 and low population growth (in 10^6 tonnes)

	PRESERVING (LOA/moderate)			SAVING (GOA/moderate)			MANAGING (LOA Western)			UTILIZING (GOA/western)		
	production	demand	balance	production	demand	balance	production	demand	balance	production	demand	balance
S-America	5353	457	4896	13173	457	12716	5353	805	4548	13173	805	12367
C-America	420	192	228	976	192	784	420	338	81	976	338	638
Caribbean	23	45	-22	57	45	11	23	80	-57	57	80	-23
N-America	1612	260	1352	3539	260	3279	1612	459	1154	3539	459	3080
N-Africa	359	263	96	637	263	374	359	463	-104	637	463	174
W-Africa	847	443	404	2049	443	1606	847	780	67	2049	780	1268
C-Africa	1944	181	1763	4966	181	4785	1944	318	1626	4966	318	4648
E-Africa	1585	510	1075	3645	510	3135	1585	899	687	3645	899	2746
S-Africa	399	84	314	768	84	684	399	148	250	768	148	620
Oceania	1184	31	1154	2069	31	2038	1184	54	1131	2969	54	2015
SE-Asia	583	625	-42	1386	625	761	583	1101	-518	1386	1101	285
E-Asia	912	1428	-516	1958	1428	530	912	2515	-1603	1958	2515	-557
S-Asia	775	1866	-1091	1897	1866	31	775	3287	-2512	1897	3287	-1390
W-Asia	163	236	-74	340	236	103	163	417	-254	340	417	-77
USSR	939	307	632	2110	307	1803	939	541	398	2110	541	1569
E-Europe	100	99	2	245	99	146	100	174	-74	245	174	71
S-Europe	82	120	-38	188	120	68	82	211	-130	188	211	-23
W-Europe	128	125	4	319	125	194	128	220	-92	319	220	99
N-Europe	52	71	-19	118	71	47	52	125	-73	118	125	-7
World	17461	7343	10118	40438	7343	33095	17461	12935	4526	40438	12935	27503

Source: WRR, on basis of *Sustainable World Food Production and Environment; Option for Alternative Developments*; by P.S. Bindraban, H. van Keulen, F.W.T. Penning de Vries et al., forthcoming.

tion as close as possible to the areas of shortage. On the other hand the optimisation requirement might mean that the additional production was located in those areas where the highest yields could be obtained with the least amount of irrigation.

In all cases the scenarios outlined above will involve enormous changes in the agricultural system in comparison with the present structure. These adjustments will require across the board cooperation by all concerned. In both a system aimed more at self-sufficiency and one based on international trade, considerable demands will be made on international cooperation and solidarity. Just how likely this is to succeed can be assessed very differently.

Both the agricultural systems that have been elaborated are based on optimal management methods. This will require a great deal of know-how, insight and 'green' fingers - which will also need to be combined with 'green' brains. The entire know-how innovation system will need to be geared to this end. In practice, this is asking a great deal. It implies for example that farmers be well educated and that modern technologies be available worldwide. This will require an enormous transfer of know-how and technology. A huge effort will be required to achieve this situation within a time-frame of 50 years. As noted earlier, the results mainly indicate the potential, not the most probable development. If it proves impossible in large parts of the world to meet the prior conditions for optimal agriculture this will create additional problems. The aim of a Western diet in a situation where regional food needs can scarcely be met will then be an illusion. There will probably be numerous physical and organizational obstacles towards bringing about the optimal developments.

On the other hand it should be noted that policies aimed at bringing about a moderate diet will be very difficult to operationalise. Despite the enormous growth in population, animal production in the developing countries is rising substantially. The FAO anticipates that the per capita consumption of cereals in developing countries will rise disproportionately as a result of the rapid growth in livestock farming. The developing countries will therefore need to increase their grain imports. It is therefore expected that local displacement can take place of the cereal production potential for human consumption [10]. The demand for meat is evidently very strong. In reality the choice between the Western or Moderate diet is substantially more complicated. For those who can afford it the Western diet acts as a natural norm. For the remainder, who have to survive on what's left, the Moderate diet becomes an unaffordable luxury.

Environmental consequences of the scenarios

The globally oriented agricultural system assumes the availability of the necessary external inputs. The requirement of best technical means assumes that the production techniques applied will have only limited negative effects on the environment. The quality of the soil will for example need to be maintained. In the present situation this is not the case. It will also be difficult to limit nitrogen losses under Locally-Oriented Agriculture, meaning there will be an impact on the environment. Locally, the leakages per hectare will be greater under Globally-Oriented Agriculture than under Locally-Oriented Agriculture. However, since the production under LOA is lower than under GOA, the leakages per unit product will be higher. Both LOA and the desire to provide a Western diet will necessitate a higher volume of interregional food trade. In the case of LOA this will in fact be at variance with the underlying premises, such as that of closing substance cycles.

10) UN Food and Agriculture Organization, op. cit.

The differences between non-irrigated and irrigated production are dramatic. In river basins there will often be no lack of water to realise maximum production. In Europe, for example, a good deal of water is available in a comparatively small area. Similarly there is sufficient water for food production in Iran, even though the availability of water in the catchment area is lower, since the agricultural area is extremely limited. In South America, which has a large catchment area, water is by contrast a limiting factor for food production because the area available for agriculture is so enormous.

The application of irrigation is based on the most efficient techniques. Even more would be possible if household and industrial waste water were to be used for irrigation. All this makes heavy demands on the available technical know-how but also on the institutional and social structure, as well as political stability in the region in question, in that there is the potential for conflict between the various categories of water users, not just between households, industry, agriculture, fishery and the like but also between individual countries and regions. Access to water is already giving rise to conflicts, which can only be exacerbated as population pressures mount.

Apart from increasing yields irrigation can also have negative effects on the environment, such as a growing nutrient load, salination, diseases, drying up of soils elsewhere and soil erosion. The quality of the water available for irrigation is also important. High salt concentrations and other forms of pollution are harmful to agricultural crops and will lower the potential yield.

Relationship with other goals

The availability and suitability of land constitute a vital factor for food production. Together with the availability of water these determine the potential yield of a region. The availability of land depends in part on the agricultural system chosen. A production-oriented agricultural system will require less land than biological agriculture.

Few standard figures are available on the suitability of land on a worldwide basis. Suitability is at present determined on the basis of relatively simple criteria. Soils that cannot be farmed with modern, mechanised agricultural techniques are designated as unsuitable. Processes such as acidification, nutrient exhaustion or deforestation and over-exploitation are left out of account in determining suitability. These processes can however substantially damage the quality of the soil and hence the latter's suitability for agriculture [11].

A large area of land is required for food production. A good deal of land remains available for agriculture, for example in South and North America and Central and North Africa. The area considered suitable for agriculture, however, includes the present tropical rainforests, including those in Central and Southern Africa. Realisation of the agricultural potential in these regions will often involve large-scale deforestation, with an increased risk of soil erosion.

Clearly, other claims on land can come into sharp conflict with the demands made by food supply. The overall picture is, however, that 70 per cent or more of the total area is not deployed for agricultural purposes in all the scenarios. This area is therefore available for other claims, e.g. nature conservation. These macro figures do, however, disguise the locally strong

11] L.R. Oldeman, R.T.A. Hakkeling and W.G. Sombroek, op. cit.

competition between the various forms of land-use. In general it is fair to say that the less land demanded for agriculture the more opportunities there are for the realisation of other goals. This means that both the aim of a moderate diet and the development of a globally oriented agricultural system can contribute towards the solution of land-use conflicts.

If nature conservation policy is interpreted as the preservation of 'cultivated nature' such as the Dutch meadow birds, a combination with locally-oriented agriculture may stand a greater chance under certain supplementary limiting conditions. A concentration of the results of the various elaborations with respect to nature with the scenarios for world food supply can throw further light on this subject. In any case it is clear that not every combination of wishes with respect to nature and food supply is possible in all regions.

3.3 Energy

3.3.1 Introduction

The global energy supply occupies a central place in the discussions about sustainable development. The supply of energy is vitally important for the functioning of the economy. There is a widespread impression that the sustainability of the world energy system is under threat in various respects. Both exhaustion and pollution are regarded as key factors.

The growth in the demand of energy means that the exhaustion of energy reserves is now a genuine prospect. The process of industrialisation and associated rise in living standards has contributed in large measure to the demand for energy. The question of possible exhaustion was already raised in Britain in the 19th century. The economist William Stanley Jenkins, for example, asked what would happen if coal reserves were to be exhausted [12]. Although he saw that technical improvements and substitution could bring alleviation, he concluded in relation to the limited reserves in Britain that 'we have to make a choice between brief greatness and longer continued mediocrity'. Energy reserves have risen substantially since Jevons's time and, due in part to the exploitation of oil and gas reserves, the growth in energy consumption has been able to continue undiminished.

At the same time, we have obtained a much clearer idea of the remaining reserves of fossil energy as a result of intensified and technologically more advanced exploration. If the consumption of energy rises several fold in the next few decades, primarily as a result of the rising prosperity and unbridled population growth in the Third World, fossil energy reserves, the extraction of which is comparatively straightforward and subject to only limited environmental damage, could be exhausted. This applies especially to oil and gas reserves. In an environmental sense the extraction of oil and gas not only compares favourably with the remaining fossil reserves, such as coal, but also leads to fewer emissions upon combustion than for example does coal.
The next century may therefore see not so much an absolute as a relative exhaustion of energy reserves, in that fossil alternatives will always be available upon the exhaustion of oil and gas, even if the scale is unclear, although it may be assumed that the costs of extraction of those alternatives will rise. It would also be possible to turn more to nuclear energy, but this would involve serious safety risks. Geopolitical risks are rising since the energy cartels can operate more effectively in conditions of growing scarcity. Finally,

12] W.S. Jevons, *The cool question*; London, MacMillan, 1866, p. 376.

the environmental costs of a number of conceivable alternatives to oil and gas are greater than those at present.

Sustainable development implies that the consumption of energy by the present generation should not be at the expense of the ability of future generations to meet their needs. It is however open to question whether the pace of consumption of the world energy reserves and the consequences of that consumption for the environment are in accordance with the objective of sustainable development.

3.3.2 Reference scenario

In order to provide insight into global energy consumption trends, the Council has drawn up a reference scenario. Particularly important trends in this regard are population growth, industrialisation and the rise in living standards in the Third World. The reference scenario indicates the scale that the global consumption of energy could achieve and in what period this could occur if no limits were to be imposed by scarcity or environmental factors. To this end the reference scenario has been projected forward to the year 2040 and also throws light on a limited period beyond that date.

The demand for energy

The development in the demand for energy in the action perspectives takes place as a reaction to the rising price of energy, which in turn is a translation of the acceptance of environmental and scarcity risks elaborated in the perspectives. The reference scenario by contrast abstracts from the cost factors that are characteristic of the various action perspectives. In this way. the reference scenario reflects a widely supported demand-led development and therefore provides an indication of the need for energy in a world unhampered by physical and geopolitical scarcities, environmental risks and the like. Such 'maximisation' enables a clear light to be cast on the problems that could arise as a result of present-day ambitions and developments. The action perspectives represent sustainable development trends as a response to this.

This means that the reference scenario is atypical. It differs from the business-as-usual reference scenarios, which are based on plausible developments given unchanged policies. The compilation of a plausible long-term trend requires that account be taken of all kinds of positive and negative feedbacks. A reference scenario drawn up along these lines would cease to be a true reflection since the fact that the feedbacks can be highly divergent in nature would remain underexposed.

The reference scenario as developed here is therefore based on an energy-supply situation such as applied for a large part of this century. Over the course of time increasingly inaccessible reserves of fossil energy have been tapped. Advances in extraction technology have prevented the cost of energy from rising. In the reference scenario it has been assumed that the progress in extraction technology can provide long-term compensation for the deterioration in extraction conditions.

The high energy prices in the period 1973-1986 associated with the oil crisis depart from this long-term path. The reference scenario abstracts from this. It is notable that, calculated in 1990 dollars, the oil price in 1986 of $15 per barrel is back to near the 1973 level. After the Gulf crisis had caused a temporary price increase, the price of oil fell back once more in 1994 to close to 1973 levels. In comparison with the period before 1986 the pace at which energy conservation is taking place has clearly eased.

The construction of the reference scenario draws on the development of per capita energy consumption. From 1950 onwards the latter grew markedly in all the countries of the OECD as well as in the former Eastern bloc countries. For these countries as a whole a certain stabilisation in per capita consumption occurred in the 1970s. This stabilisation was the most pronounced in the United States, where the consumption at nearly 300 GigaJoule (GJ) per head is significantly higher than in the remainder of the industrialised world. In Western Europe the figure is 175 GJ and in the Netherlands, on account of the energy-intensive industry, 220 GJ. The reference scenario has assumed that per capita energy consumption will eventually rise to saturation point. This appears virtually to have been achieved in the United States, a particularly mature economy. In most other developed market economies, however, per capita energy consumption continues to rise.

At a constant price level it is reasonable to assume that per capita energy consumption will reach saturation point. Many energy applications themselves have a saturation point, while limits probably also apply to the demand by individuals for heating, ownership of household appliances and mobility. Similarly the demand for materials, the production of which generally takes a great deal of energy, has proved subject to saturation in more mature economies. In so far as the consumption of energy continues to increase in growth sectors, that consumption is offset by an autonomous flow of improvements in energy efficiency across the sectoral board.

In terms of per capita energy consumption, the reference scenario is assumed to describe a logistic curve. This indicates how initially exponential or proportionate growth gradually tapers off as saturation point is reached.

The long-term development in the consumption of energy in the industrialised economies (the 'North') has been separately described in the reference scenario from the energy consumption in the Third World, or 'South'. Due among other things to climatic factors, the saturation level in the North as a whole has been put at a lower figure than per capita consumption in the United States, namely 265 GJ per head [13].

With regard to the global demand for energy, developments in the demand for energy in the Third World are much more important than those in the North. The consumption of energy is likely to rise substantially in the South for three reasons. First, the population is bound to continue rising sharply in the decades ahead in the South as a result of the youthful age structure of the population; over a third of the population in the Third World is aged under 15. The consumption of energy will increase if only because each individual necessarily consumes energy. Secondly, large parts of the Third World are going through a stage of economic development that is associated with high energy-intensity. Thirdly, economic development means rising living standards, which in turn is associated with a more energy-intensive life-style. These three factors, combined with the fact that the energy efficiency in the South often lags behind that in the North, mean that the consumption of energy in the South will exceed that in the North within the foreseeable future [14].

For the time being the consumption of energy in the South is still in the initial stage of the logistic curve, namely that of virtually unbridled proportionate growth. The level to which per capita energy consumption will rise in

13] The saturation level has been estimated on the basis of figures for the period 1950-1990.

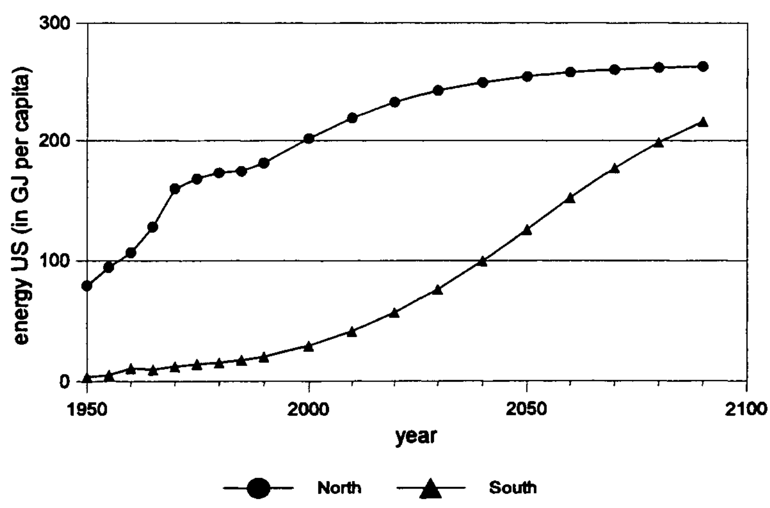
14] The World Bank, *Energy efficiency and conservation in the developing world*; International Bank for Reconstruction and Development, Washington D.C., 1993.

the South in the next century is debatable. Apart from the lower requirement for space heating, the ambitions that have been expressed provide few if any arguments as to why the per capita energy consumption in the South in the reference scenario should not in due course rise to the levels in the North. The developments in Asia and, to a lesser extent, in Latin America indicate that significant economic growth is to be anticipated in the South in the coming decades.

Along the same lines as the projection for the development of consumption in the North, per capita consumption in the South has been drawn up in the reference scenario on the basis of a logistic growth curve. A comparable saturation point for per capita energy consumption has been assumed to that in the North, which will be achieved around the end of the next century.

The development in per capita energy consumption in the North and South according to the reference scenario is shown in Figure 3.8. During the first stage of the logistic curve there is unbridled or proportionate growth; a figure of 5 per cent a year has been assumed [15]. The United Nations middle population projection combined with the per capita energy consumption provides a reference scenario for the total energy consumption, broken down into the North and South shares.

Figure 3.8 **Per capita energy consumption in the reference scenario**



Source: WRR.

Table 3.5 **Energy consumption in the reference scenario; middle**

Unit: EJ	1990	2020	Growth in % 1990-2020	2040	Growth in % 2020-2040
World	302	798	3.3	1411	2.9
North	220	322	1.3	347	0.4
South	82	476	6.0	1064	4.1

Source: WRR.

15] Per capita energy consumption in the South rose by an average annual 4.6 per cent during the period 1950-1990.

What is the relationship between the cumulative consumption of energy and energy reserves in the reference scenario? Estimates of the ultimately exploitable reserves of fossil energy are shown in Table 3.6. The cumulative consumption of energy between 1990 and 2040 according to various variants ranges from 30,000 EJ to 40,000 EJ [16]. Assuming that three quarters of this energy consumption relates to fossil fuels - in 1990 some 85 per cent of the world consumption of processed energy was generated from fossil sources - and that less than half of this fossil energy consumption relates to coal and the remainder to oil and gas - in 1990 coal accounted for two thirds of fossil energy consumption - it will clearly be impossible for the supply of energy to remain based on oil and gas in the second half of the next century since oil and gas reserves will have been largely exhausted.

According to the same reference scenario variants the cumulative energy consumption in 2090 will range between 90,000 EJ and 190,000 EJ. This broadly corresponds with the ultimately extractable reserves of the most common fossil fuel, namely coal.

The conclusion to be drawn from the reference scenario on scarcity grounds is that a transition from an energy supply predominately based on fossil fuels to one predominately based on alternatives will need to take place in the course of the next century. This will be required in order to safeguard the continuity of the energy supply beyond the period covered by the reference scenario. Part of the solution could also come from more vigorous energy conservation measures than provided for in the reference scenario. Low variant population growth would not eliminate the shortage but would slow it down substantially. The two variants of the reference scenario just discussed, which are linked to the high and low population variants, differ at the end of the next century by a factor of two with respect to energy consumption.

Table 3.6 **Ultimately exploitable reserves of fossil fuels**

Unit: 1000 EJ

	WEC	Holdren	Skinner
Crude oil	8.4	18.9	15.0
Natural gas (conventional)	9.2	12.6	11.0
Coal	142.8	157.7	210.0
Heavy oils, tar sands and unconventional gas	6.1[1]	31.5[2]	5.0 to 25.0[1]
Shale oil	18.9	946.1	10.0

1] excluding unconventional gas
2] speculative.

Source: World Energy Council, *Energy for tomorrow's world*; London, Kogan Page, 1993.
Holdron, J.P. '*Prologue. The transition to costlier energy*'; in: *Energy efficiency and human activity: Past, trends, future prospects;* by L. Schipper and S. Meyers, Cambridge, Cambridge University Press, 1992.
Skinner, B.J., *Earth resources*; Englewood Cliffs, Prentice Hall, 1986.

16] These variants are generated by the combination of the low UN population projection and a moderate growth in per capita energy consumption on the one hand and the high population projection with a more rapid growth in per capita energy consumption on the other; the coefficients of proportionate growth have been set at 4 and 5 per cent respectively.

The energy supply

The estimates of the ultimately extractable reserves of crude oil, natural gas and hard coal, lignite and other solid fuels indicate a margin of uncertainty that pales into insignificance compared with the uncertainty concerning the ultimately exploitable reserves of less conventional fuels such as heavy oil, tar sands and shale oil. Part of the uncertainty about the ultimately exploitable reserves, especially these less conventional energy sources, is attributable to the marked dependence on largely unforeseeable technological developments. An evident disadvantage of many unconventional reserves is the low energy density. Compared for example with the extraction of crude oil, a greater mass of earth has to be mined in order to extract the same quantity of energy. For this reason the mining itself requires a higher input of energy and the environment is placed under greater pressure. Skinner, for example, notes that the large-scale mining of shale oil would lay waste to many millions of hectares of the earth's surface [17]. Given also the pollution associated with the extraction, the signs are that only a very limited part of these enormous reserves will be exploitable.

Under the reference scenario fossil reserves look like being exhausted at the end of the next century, but even during the course of the century fossil fuels will become steadily more expensive. Exhaustion will mean that increasingly polluting varieties of fossil fuels will have to be used. The sharp increase in energy consumption and the finite nature of easily extractable fossil fuels mean that the necessary transition time to other fossil energy resources will become steadily shorter. We are concerned here not with centuries but with decades.

The 'cleanest' fuels will be exhausted first. The remaining reserves will contain ever increasing levels of harmful substances, such as sulphur or heavy metals, that are released in combustion. Environmental interests will also be increasingly at issue in mining. The increasing importance of hard coal, especially in a number of large developing countries [18], will also result in a more rapid increase in the atmospheric concentration of the greenhouse gas CO_2. Emissions of carbon dioxide in the reference scenario could be five to 14 times higher in the year 2090.
With a view to sustainable development, a switch will need to be made to alternative energy resources well before fossil fuels near exhaustion point. The advantages and disadvantages of the various types of energy are assessed differently in the four action perspectives, in that the alternatives to fossil energy are also subject to limitations.

Alternatives

Biomass in the form of wood, agricultural waste and manure has traditionally formed an important source of energy. Biomass continues to make an important contribution to the energy supply, especially in rural areas and developing countries. The annual production of biomass is however limited and is increasingly unable to meet the demand for energy. Increasingly, biomass is being replaced by fossil fuels.

In traditional societies the efficiency with which sunlight is converted into biomass is low. In a modern biomass production system, the efficiency can be increased from 1 per cent to 2 to 3 per cent [19].

17) B.J. Skinner, *Earth resources*; Prentice Hall, Englewood Cliffs, 1986, p. 47.

18) World Energy Council, *Energy for tomorrow's world*; London, Kogan Page, 1993, p. 89.

19) D.O. Hall, et al., 'Biomass for energy: Supply prospects'; in: *Renewable energy: sources for fuels and electricity*; T.B. Johansson et al. (eds.), Washington D.C., Island Press, 1993.

The large uptake of suitable agricultural land and freshwater supplies by biomass production generates conflicts of interest with agriculture. Although an increase in the cultivation of crops for energy purposes is possible it will necessarily remain limited. Johansson et al. outlined a situation in the year 2050 in which 429 million hectares are cultivated worldwide for energy purposes, generating 128 EJ per year [20]. This would enable 30 per cent of the present demand for energy to be covered using a land area three times as great as the present European cultivated area. Not only is the future demand much greater but highly optimistic estimates of the energy production are made. In the case of food production large parts of the world are achieving no more than 30 per cent of the potential, while with new energy crops even that figure will not be reached for the time being.

Another form of renewable energy is *hydroelectric power*. In contrast to traditional biomass production, this form of energy generation is entirely integrated into the world energy system. Energy from hydropower has long been the most important alternative to the use of fossil fuels for electricity generation. The potential for hydropower is not unlimited. The construction of dams involves substantial social costs, apart from which the most suitable locations have already been utilised. On a worldwide basis a trebling to quadrupling of the present hydropower production of 7.3 EJ is considered realisable [21]. Hydropower will therefore be able to make only a very limited contribution to the global energy supply.

The third alternative to the use of fossil energy is *nuclear energy*. The application of nuclear energy took giant strides in the second half of this century. Generation from nuclear sources currently amounts to some 15 EJ. Although nuclear power is continuing to expand appreciably (it is growing nearly twice as fast as global energy generation) the initial optimism has evaporated and powerful social opposition has arisen in various parts of the world. Where this has happened the future of nuclear energy is dependent on the social and political support that this form of energy is able to muster and expansion plans are stalling. In other parts of the world - especially the former Eastern bloc countries and the Third World - a substantial increase in nuclear power is likely in the next few decades.

The social and political problems associated with nuclear energy focus on three main aspects: reactor safety, the waste problem and the proliferation problem. An additional problem consists of the limited reserves of uranium.

A high proportion of the nuclear-power producing countries operate an open cycle, under which less energy is withdrawn from the nuclear fuel than is technically possible. Only a limited number of countries, including France, the United Kingdom and Japan, reprocess and re-use the nuclear fuel, thus extending the useful life of the uranium. In reprocessing the proliferation-sensitive plutonium released in a nuclear reaction is separated from the uranium. The ultimately extractable reserves of high-grade uranium, which are estimated at 10 to 25 million tonnes U [22], have an energetic value in the open cycle of 3,360 to 8,400 EJ_{th}. The continuing expansion of nuclear fission

20) T.B. Johansson, et al., 'Renewable fuels and electricity for a growing world economy; defining and achieving the potential'; *Renewable energy sources for fuel and electricity*; T.B. Johansson et al., op. cit.

21) J.B. Moreira and A.D. Poole, 'Hydropower and its constraints'; in: Johansson et al., op. cit.

22) A.G. Darnley, 'Resources for nuclear energy'; in: *Resources and world development*; D.J. Mclaren and D.J. Skinner (eds.), Chichester, John Wiley & Sons, 1987, pp. 187-210.

in an open cycle will therefore also lead to the exhaustion of uranium reserves in the next century.

If nuclear energy is to play a significant role as an alternative to fossil fuels in the long term it will be essential for the energetic yield of the nuclear cycle to be appreciably increased. Reprocessing could be of marginal benefit but a substantial step in the direction of sustainable energy supply based on nuclear fission would involve the use of breeder reactors. The latter enable several tens as much energy to be extracted from the available fuel as conventional reactors. In order to do so, either the proliferation-sensitive plutonium or the equally proliferation-sensitive uranium 233 has to be recycled. The social and political risks of nuclear energy would be substantially enlarged by the global application of breeder reactors. Both the risk of incidents and the scale of the consequences would rise substantially in comparison with the present situation.

Biomass, hydropower and nuclear fission are not the only alternatives to fossil energy. Some set considerable store by the coming on stream of nuclear fusion technology, but this is totally speculative. It is unclear whether this technology will ever be available and equally it is unclear whether nuclear fusion will in fact offer advantages in relation to the alternatives whose future availability is now reasonably assured.

Wind energy, solar energy and geothermal energy are already being used successfully on a comparatively small scale. Numerous other forms of renewable energy, however, are conceivable, some of which hold out a bright future.

One of these is *solar energy* in its various guises (i.e. thermal and electrical). If renewable sources such as wind and solar energy, the availability of which is subject to continuous variation, are to account for a significant proportion of the energy supply, they will need to be supported by storage systems. The costs of the large-scale application of renewable sources will therefore rise in comparison with the costs of the present energy supply. The full realisation of the potential in terms of renewable energy sources will therefore demand enormous investments in a comparatively capital-intensive energy supply. This forms a further reason why the notion that a full-scale substitution of renewable energy for fossil energy towards the end of the next century is hotly debated [23].

3.3.3 Consequences of the emission of carbon dioxide

It was noted previously that according to the reference scenario, the emission of $C0_2$ could increase between five and 14 times by the end of the next century, thus increasing the concentration of the greenhouse gases in the atmosphere. On account of negative feedbacks in the carbon balance sheet, the scale of this increase is still subject to uncertainty. In theory the increased concentration of a greenhouse gas such as $C0_2$ results in the warming of the global temperature. The radiation balance between the earth and space remains in equilibrium given a doubling in the concentration of carbon dioxide in the atmosphere if the temperature rises by 1°C. Opinions differ about the consequences of this initial warming. A rise in the temperature will mean that the atmosphere is able to absorb more water vapour - another important greenhouse gas, thus leading to a positive feedback.

[23] World Energy Council, op. cit., p. 95.

On these grounds the Intergovernmental Panel on Climate Change (IPCC) concludes that the temperature on earth will rise in a response to a doubling of the carbon dioxide concentration not by 1°C but by 1.5°C to 4.5°C [24].

If more than three quarters of the energy supply remains based in the reference scenario on fossil fuels, the carbon dioxide concentration in the atmosphere could even more than double in the next century. According to the IPCC, a climate change is therefore likely in the reference scenario.

Various other experts, however, emphasise the existence of *negative* feedbacks on the radiation balance [25]. As a result of these negative feedbacks the temperature could on balance also rise by less than 1°C. Increasing concentrations of greenhouse gases could moreover disrupt identified and unidentified unstable equilibria with even less predictable consequences for climate change, in which a fall in temperature is not ruled out. The uncertainty about long-term temperature changes as a result of the cyclical pattern of ice ages complicates the consequences still further.

There is therefore major uncertainty about the size of the temperature change that could occur as a result of an increase in the carbon dioxide concentration in the atmosphere. It is even uncertain whether any increase in temperature due to the enhanced greenhouse effect could ever be distinguished from variations in the mean global temperature taking place independently of the anthropogenic enhanced greenhouse effect.

Statements on the social and political consequences of any increase in temperature due to the enhanced greenhouse effect are subject to even greater uncertainties. When it comes to the likelihood of further consequences such as an increase in mean sea levels, uncertainties are piled on uncertainties.

Higher carbon dioxide concentrations need not, however, always have a disruptive effect. In agro-ecosystems, higher concentrations promote photosynthesis and enlarge the water utilisation efficiency. In the case of natural ecosystems, however, which are limited by the availability of phosphates and nitrates, the growth-inducing effect is much less pronounced. An elevated carbon dioxide concentration could disrupt the highly fragile balance of competition, leading to species impoverishment. The evolution in these natural ecosystems can perhaps not keep pace with the increase in carbon dioxide concentrations, but this is all purely speculative.

There is therefore no clarity about the dividing line between non-sustainability and sustainability. Designating the reference scenario as unsustainable therefore depends heavily on the weighing of the risks at issue.

Two extreme positions are however clearly at variance with sustainable development. First of all, major risks will be incurred if developments in the energy field are allowed to run their course. Secondly, there are the risks of external effects such as climate change, as well as the exhaustion of fossil fuels if a switch is not made in good time to other energy resources. Equally, however, risks will be taken if the use of fossil fuels is rapidly - e.g. in the space of a few decades - reduced to zero in the interests of the environment. In both cases this involves an absolutist approach towards the objectives.

24) Intergovernmental Panel on Climate Change, Working Group I, *Climate Change 1992, The supplementary report to the IPCC assessment*; J.P. Houghton, B.A. Callander and S.K. Varney (eds.), Cambridge, Cambridge University Press, 1992.

25) J.F. Böttcher, *Science and Fiction of the Greenhouse Effect and Carbon Dioxide*; The Global Institute for the Study of Natural Resources, The Hague, 1992.

Sustainable development demands that the interests of both the present and future generations be weighed against one another.

3.3.4 Action perspectives

Four action perspectives are set out below that are all concerned with sustainable energy supply. They have in common the fact that the reference scenario is regarded as unsustainable. The grounds on and extent to which this occurs, however, differ; both the scarcity problem and the environmental problems are weighed differently.

In this regard the action perspectives differ with respect to the choice of energy resources, technological developments and changes in life-style and energy consumption. The four action perspectives distinguished in Chapter 2 - Utilizing, Saving, Managing and Preserving - are spelt out in greater detail below. The four perspectives have also been elaborated into the same number of scenarios.

Table 3.7 Action perspectives

fall in energy intensity	slow	rapid
supply side structure energy management		
limited change	Utilizing	Saving
radical change	Managing	Preserving

Source: WRR.

Utilizing

Under the Utilizing perspective, a certain degree of ecological risk, as associated with the consumption of fossil energy, is regarded as acceptable. An increase in the concentration of greenhouse gases in the atmosphere is, for example, regarded as an acceptable risk given the present state of knowledge about the greenhouse effect. The measures that need to be taken in order to hold down a rise in the concentration represent a social and political risk that does not weigh against the risk of an enhanced greenhouse effect. Although measures are taken to limit the emission of greenhouse gases these are also taken on the basis of other objectives, such as conserving the reserves of fossil fuels. In social and political terms energy conservation is often preferable to expanding the supply of energy, apart from which it reduces carbon dioxide emissions. Waste must be avoided but any further-going reductions call for radical change in deeply rooted institutions and perceived freedoms.

The ecological risks associated with nuclear energy may also be acceptable under the Utilizing perspective, particularly since nuclear energy helps reduce the risks to the climate from CO_2 emissions. In the longer term the possibility of fast breeder reactors is not to be ruled out. In addition the social and political risks of not applying nuclear energy are downplayed under this perspective since there are deemed to be sufficient reserves of fossil fuel. As far as nuclear energy is concerned, the desire to avoid social and political risks therefore carries little weight in the trade-off between the social and political risks of non-application and the ecological risks of going down the nuclear path.

The available reserves of fossil energy are there to be exploited. Fossil energy will remain the most important source of energy in the next century. A continuing emphasis on fossil energy is acceptable in view of the anticipated increase in ultimately extractable fossil reserves. In addition there remains a large potential for energy conservation, in which investment is imperative. In so far as fossil reserves become scarce in the next century the solutions lie in the technological sphere. Utilizing is largely synonymous with the avoidance of the social and political risks of changes in life-style.

Saving

The risk of scarcities for future generations weighs heavily under the Saving perspective and the social and political consequences of the necessary adjustments are accepted. This perspective is accordingly based around an austerity strategy. Saving implies caution with respect to possible reserves of fossil energy and the potential of renewables, which should not be overestimated. There is also a possibility that nuclear energy will not live up to expectations. The most pronounced growth in the demand for energy will occur in the Third World. The complicated technology of nuclear power plants will mean the latter find only limited application in the Third World in the decades ahead. This leaves no alternative to facing the social and political challenge and, especially in the developed economies, achieving a sharp reduction in per capita energy consumption. In the Third World adjustments need to be made to the future perspective of a potentially high level of prosperity. The level of energy consumption currently prevailing in the West is one-off; for the Third World and for future generations, consumption on this scale would not be sustainable.

The intended reduction in energy consumption cannot be achieved simply by increasing the energy efficiency. For this reason this perspective calls for a more sober Western life-style.

The ecological risks of energy consumption are largely accepted under the Saving perspective. In principle nuclear energy would provide a welcome supplement to a meagre energy diet. The social and political risks of a failure to stimulate nuclear energy are significantly higher under this perspective than in the Utilizing perspective. The trade-off between ecological and social risks in the Third World is, for the time being, of a different order from that in the developed economies; this also applies to fast breeder technology. Once this technology becomes available there will be a market for it in the Third World. Technological support could make this development acceptable.

Primacy is not attached to the ecological risks of the greenhouse effect. Social and political risks are accepted when it comes to avoiding the scarcity risk. Additional social risks to prevent a greenhouse effect are avoided. The austerity strategy, however, has the effect of reducing the risks of an enhanced greenhouse effect. By reducing the use of fossil energy the risks of a greenhouse effect and of energy scarcity can be avoided.

Managing

Under the Managing perspective, certain ecological risks attached to the use of energy are not acceptable. This applies among other things to the risks of a heightened atmospheric concentration of greenhouse gases. Managing means a clear reduction in the potential growth of fossil energy consumption. In so far as use is made of fossil energy the emphasis should as far as possible be placed on natural gas, which produces comparatively low carbon dioxide emissions. The use of fossil energy should be combined on a large scale with the catchment and storage of carbon dioxide. The social costs of such development are accepted.

By contrast the social risk of a sharp reduction in energy consumption per head in order to reduce fossil energy consumption is not acceptable. Renewable sources of energy are a significant factor in maintaining per capita energy consumption. It is, however, virtually inevitable that this involves accepting a certain scarcity risk.

Among other things, the scarcity risk arises because the risk of nuclear energy is not accepted under the Managing perspective. The future supply of energy is therefore rendered dependent on the development of renewable sources. Despite the favourable prospects for certain renewables, such as biomass and wind energy, a high degree of penetration in the energy supply in the near future is far from assured. Of all the renewable sources, biomass combines a not unfavourable profitability with, in global terms, the highest potential. For this reason an intensification of energy conservation fits into this action perspective. It is not ultimately a matter of maintaining a certain level of per capita energy consumption but of maintaining certain social functions for which that energy is required.

Preserving

Under the Preserving perspective, both ecological and scarcity risks are avoided. This means that substantial social risks are accepted. Energy resources must be switched as quickly as possible to a system based on renewables. At the same time an austerity strategy needs to be adopted. This means that apart from a marked increase in energy efficiency, Western life-styles need to become simpler and plainer.

The social and political risks associated with this perspective are related to the incomplete state of development of numerous renewable sources, which will need to account for a high proportion of the energy infrastructure in the next century. Combined with the austerity strategy, this can have a radical effect on economic growth. It is assumed that society is sufficiently impressed by the ecological and scarcity risks to accept a radical change in life-styles.

Table 3.8 Specification of the action perspectives

Fall in energy intensity / supply side structure / energy management	slow	rapid
Limited change	**Utilizing:** ● continuation of fossil use ● some CO_2 fixing ● development of fast breeder ● moderate development of renewable sources ● moderate energy ● conservation	**Saving:** ● reduction in fossil use ● some $C0_2$ fixing ● development of fast breeder ● moderate development of renewable sources ● emphasis on energy conservation ● life-style change
Radical change	**Managing:** ● reduction in fossil use emphasis on gas ● fixing and storage of $C0_2$ ● emphasis on development of renewables ● moderate energy conservation	**Preserving:** ● fixing and storage of $C0_2$ ● switch to renewables ● emphasis on energy conservation ● life-style change

Source: WRR.

3.3.5 Elaboration of action perspectives in scenarios

Population trends have been based on the United Nations' population projection [26]. The scenarios presented here are based primarily on the middle projection. Scenario variants corresponding with the low and high projections are also discussed in passing.

The likely economic rate of growth in the South is based on the growth assumed by the Central Planning Office in its Balanced Growth scenario as well as on the growth in the basic path of the Asia survey in the Central Economic Plan of 1994 [27] [28]. A sensitivity analysis conducted by the Council has indicated that the scenario results are closely correlated with population growth and, to a lesser extent, with the pace of economic growth in the Third World.

Needless to say the margin is important in this regard. A growth of 6 per cent results in much higher energy consumption than 2 per cent growth, but the difference between 4 and 5 per cent is limited. In view of the enormous pressure for growth in the South it would appear unrealistic to work on the basis of low percentages. The selected growth figures are shown in Table 3.9. It has been assumed that per capita growth varies slightly with population growth. Although it is known that there is no direct link between population growth and economic growth, it is, however, broadly clear that a rapid increase in population impedes the growth in per capita income and conversely that a period of actual or anticipated income growth results in lower birth figures.

26) United Nations, *Long range world population projections; Two centuries of population growth 1950-2150*; New York, United Nations, 1992.

27) Central Planning Bureau, *Scanning the future: A long-term scenario study of the world economy 1990-2015*; Sdu Publishers, The Hague 1992.

28) Centraal Planbureau, *Centraal Economisch Plan 1994* (Central Economic Plan 1994); The Hague, Sdu uitgeverij, 1994.

In the case of the North it has been assumed that per capita income will rise by 2.5 per cent a year. This rate of growth is consistent with the figures achieved in the past. The growth is lower than in the Third World because the economies of the North are more technologically advanced and growth is not spurred on by the impetus to catch up as it is in the Third World. Since the consumption of energy in the Third World will be higher than that in the North within the space of a few decades, the sensitivity of global energy consumption to the rate of economic growth in the North is declining.

Table 3.9 **Growth in per capita income (%)**

Population scenario:	low	middle	high
North	2.5	2.5	2.5
South	5.0	4.75	4.5

Source: WRR.

Energy intensities

The scenarios express various perceptions of the costs of energy supply. This is not just a matter of the extraction costs but also of the costs associated with a guaranteed energy supply, with the risks of nuclear energy and with various environmental risks, including those of climate change. The energy intensity is falling in response to the rising costs of energy: the higher the perceived costs, the more rapid the fall in energy intensity.

The energy intensity in the North (11.5 MJ/$'90) in 1990 was significantly lower than that in the South (25.6 MJ/$'90). In part this reflects the different stage of economic development in the South, which is associated with less efficient energy use. The energy intensity has been declining in the North since as far back as the 1960s. With the exception of China, there has been a rising trend in energy intensity in the countries of the Third World during the period 1950-1990 [29]. The assumptions concerning the development of energy intensity in the first half of the next century are shown in Table 3.10.

Table 3.10 **Development of energy intensities (in %)**

	1990-2020		2020-2040	
	North	South	North	South
Reference	-1.5	-0.4	-2.1	-1.5
Utilizing	-1.8	-0.7	-2.4	-2.1
Saving	-3.0	-1.9	-3.7	-3.3
Managing	-2.0	-0.9	-2.7	-2.3
Preserving	-3.5	-2.4	-4.2	-3.8

Source: WRR.

In order to enable the initially slow decline in energy intensity in the South to manifest itself in the Utilizing and Managing scenarios, the period 1990-2040 has been divided into two. Among other things, the slow decline in energy intensity up to 2020 is the result of rapidly rising mobility and the increasing ownership of household appliances. In addition, growth in the South remains

29] A. van Hamel, M.J. Stoffers and W.J.M.L. Wong, *Wereldenergiescenario's* (World Energy Scenarios); Centraal Planbureau, Research memorandum 101, The Hague, 1993, p. 7.

concentrated in the energy-intensive industrial sector on account of the high demand for investment to build up the infrastructure.

The spread in the fall of energy intensities in the South and the various scenarios during the period 1990-2020 corresponds with the results of other scenario studies. In the variant with a delayed decline in energy intensity in the South the World Energy Council assumes a rate of decline of minus 0.8 per cent [30]. In the most far-reaching variant the energy intensity in the South falls by 2.4 per cent. In another analysis conducted for Greenpeace International a fall in the energy intensity in the South of 2.8 per cent is regarded as feasible, combined with economic growth (GNP) of 3.7 per cent [31]. The Central Planning Office sees the fall in energy intensity in China and the rest of the Third World as varying from 3.6 per cent and 2.4 per cent respectively in Balanced Growth and 0.5 per cent and 0.3 per cent in Global Crisis [32]. The Balanced Growth scenario allows for the introduction of a global $C0_2$ levy gradually rising to the equivalent of $33 per barrel of oil.

Especially in the Saving and Preserving scenarios, the fall in energy intensity in the North exceeds that provided for in the three aforementioned scenario studies. In all the latter scenarios the greatest fall in energy intensity in the North is between 2.5 and 3.0 per cent. Another study specifically concerned with the prospects for a further fall in energy intensity in the OECD countries comes to more far-reaching conclusions [33]. A fall in energy intensity of 3.6 per cent in the OECD countries is attainable during the period 1985-2010. To achieve this a sharp internalisation of external effects is required, so that the price of energy at the end of this period would be two to two and a half times as high as that at present. An increase in price on this scale must support a powerful energy conservation programme, comparable in intensity with the energy conservation activities conducted in 1979-1983.

The Saving and Preserving scenarios also imply adjustments in Western lifestyles in order to correct the most extravagant forms of energy use. Suggestions in this connection relate to a reduction in mobility and living comfort, for which reason a fall in the energy intensity in the North of over 3.0 per cent on an annual basis has been assumed.
The fall in energy intensity in the North in Utilizing and Managing is not a matter of 'business as usual'. In the eyes of Schipper and Meyers a substantial effort will be required in order to achieve a development path of this kind [34].

The fall in energy intensity in the post-2020 period is greater in both North and South than in the preceding period. This is a logical outcome of the assumption that per capita consumption is approaching saturation level. The higher the level of prosperity, the less energy used per unit of prosperity, since the growth in energy use falls as saturation is reached but economic growth continues undiminished. In both North and South there is therefore an accelerating fall in energy intensity in the reference scenario as time goes by. The energy intensities in the scenarios based on the action perspectives fall less rapidly (one more than the other) than in the reference scenario.

30] World Energy Council, op. cit., p. 82.

31] M. Lazarus, et al., *Towards a fossil free energy future*; Boston, Stockholm Environment Institute - Boston Center, 1993.

32] Central Planning Bureau, op. cit.

33] L. Schipper and S. Meyers, *Energy efficiency and human activity: Past, trends, future prospects*; Cambridge, Cambridge University Press, 1992.

34] L. Schipper and S. Meyers, op. cit.

Energy use

The extent of energy use in North and South may be deduced in the various scenarios from the assumptions made concerning the fall in energy intensity and the rate of economic growth. The forward calculations must be placed against the background of the current use in North of 220 EJ and in South of 81 EJ. The energy use in South exceeds that in North in all scenarios after the year 2020.

Table 3.11 **Development of energy use (Exajoules)**

		North	South
Reference	1990	220	82
	2020	322	476
	2040	347	1064
Utilizing	2020	298	441
	2040	302	881
Saving	2020	203	302
	2040	159	466
Managing	2020	276	409
	2040	266	776
Preserving	2020	174	259
	2040	123	361

Source: WRR.

Alternatives to fossil energy

Each of the scenarios provides for a growth in alternatives to fossil energy. A distinction has been drawn here between nuclear energy and renewables. The extent to which nuclear energy and renewables contribute towards the energy supply differs from scenario to scenario, in that the pros and cons of nuclear energy are differently weighted. In Preserving rapidly growing social resistance towards any kind of nuclear energy is allowed for. In the short term this resistance translates itself into a gradual reduction in nuclear capacity.

In Managing nuclear energy fulfils a temporary role in the world energy supply. The open cycle becomes standard and a large-scale application of breeder technology fails to get off the ground as the associated risk of proliferation is regarded as excessive. After 2020 the growth in nuclear energy gradually switches to contraction. The ability to control the risks means that nuclear energy ends up on the list of superseded energy options and the application of the open cycle brings forward the exhaustion of uranium reserves. By contrast in Saving and Utilizing the potential of nuclear energy is developed further. Compared with Utilizing, Saving provides for a rapid growth in nuclear capacity.

Table 3.12 **Growth and contraction rates of nuclear energy (in %)**

	1990-2020	2020-2040
Utilizing	2.5	2.0
Saving	4.0	3.0
Managing	2.0	-2.0
Preserving	-2.5	-5.0

Source: WRR.

All four scenarios provide for a growth in renewables, but in Preserving and Managing the penetration of renewables is vigorously encouraged. The input of renewable energy is particularly important in Managing, in which the risk of an enhanced greenhouse effect is taken very seriously, while at the same time energy use takes off. In absolute terms the input of renewable energy is higher than in any of the other scenarios. On account of the favourable profitability and available know-how, biomass is the most important source of energy. In 2040 the share of biomass could amount to 15 per cent of energy use. Since the technology for a number of promising renewable sources of energy is still in the process of development, the utilisation of renewable energy rises more rapidly in the period after 2020 than before. This will require large-scale investment, not just for generation but also for storage and transport.

Table 3.13 **Growth and contraction rates of renewable energy (in %)**

	1990-2020	2020-2040
Utilizing	2.0	2.5
Saving	2.0	3.0
Managing	4.0	4.0
Preserving	3.0	4.0

Source: WRR.

The shares of fossil, nuclear and renewable energy in the global energy supply follow logically from the assumptions about the growth in nuclear energy and renewable energy. In 1990 86 per cent of the global energy demand was met by fossil energy, 9 per cent by renewables and 5 per cent by nuclear energy. In the Utilizing and Managing perspectives, the share of fossil energy remains at a high figure.

Table 3.14 **Share of various energy sources (in %)**

		1990	2020	2040
Reference	fossil	86		
	nuclear	5		
	renewables	9		
Utilizing	fossil		87	87
	nuclear		5	5
	renewables		8	8
Saving	fossil		78	66
	nuclear		11	17
	renewables		11	17
Managing	fossil		81	76
	nuclear		5	2
	renewables		15	22
Preserving	fossil		81	63
	nuclear		2	0
	renewables		18	36

Source: WRR.

Fixing and storage of carbon dioxide

Two of the four scenarios, namely Managing and Preserving, attach particular importance to the risk of an enhanced greenhouse effect. Despite the efforts to bring about a rapid penetration of renewable energy, the share of fossil energy remains high, particularly under the Managing perspective. In order to prevent the emission of carbon dioxide, a large-scale switch is made to fixing and storage. On account of the need to achieve international consensus on these aspects, realisation cannot get properly under way until after 2020. In Managing and Preserving, 45 per cent of the emissions of carbon dioxide into the atmosphere are ultimately prevented. In Saving and Utilizing the catchment of carbon dioxide is much more limited.

Table 3.15 **Fixing of carbon dioxide (in %)**

	2020	2040	2090
Utilizing, Saving	0	10	25
Managing, Preserving	10	20	45

Source: WRR.

Cumulative use of fossil fuels

The use of fossil fuels - oil, gas and coal - has been brought into harmony with the way in which the risk of a disrupted supply due to geopolitical factors or exhaustion has been weighed in the various scenarios against the certainty of a more modest but guaranteed supply. Utilizing and Managing perspectives allow for ultimately extractable reserves of oil and gas of 15,000 EJ each, while in Saving and Preserving the figure is put at 10,000 EJ. On account of the enormous reserves, coal forms a balancing item in all the four perspectives and continues to play a role in the energy supply.

The weight assigned in Managing and Preserving to the risk of ecological effects provides grounds for the accelerated exploitation of reserves of gas and oil.

Oil and gas provide a significant component of the energy supply in the first half of the next century in all four scenarios. Production is expected to peak in the period 2020-2040. In the second half production eases and the share in the energy supply falls markedly. Towards the end of the century the ultimately extractable reserves of oil and gas are down to a quarter of less. This applies to all the scenarios.

In Utilizing and Managing, the consumption of coal at the end of the next century has assumed an inconceivable scale by present-day standards, namely a 14 to 20-fold increase in relation to the present consumption of 88 EJ. If the local environmental consequences of consumption on this scale are to be kept in bounds, large-scale investments will be needed in the environment in the next century. Although none of the four scenarios provides for the exhaustion of global coal reserves within the next century, it is clear that coal too can play only a finite role in the global energy supply. Especially in the high population scenario, the prospects in the Utilizing scenario at the end of the next century are far from rosy.

Table 3.16 **Development of coal consumption**

Unit: EJ

	1990	2040	2090
Reference	88		
Utilizing		728	164
Saving		266	112
Managing		329	976
Preserving		134	122

Source: WRR.

The cumulative consumption of coal in the next century, as shown in Table 3.17, needs to be juxtaposed against ultimately extractable reserves of 150,000 to 200,000 EJ.

Table 3.17 **Cumulative consumption of coal over the period 1990-2090**

Unit EJ

	middle	high
Utilizing	77844	114853
Saving	19216	33065
Managing	48620	77831
Preserving	10522	18249

Source: WRR.

In Utilizing and Saving, nuclear energy continues to play a significant role. Especially in the Savings scenario, in which the growth in nuclear energy is greatest, uranium reserves would reach exhaustion point in the second half of the next century if the open cycle were generally applied. A permanent role for nuclear energy therefore implies that reprocessing and breeder technology make greater inroads in the course of the next century. The same outlook applies in the case of Utilizing, except that the reserve situation affords more room for manoeuvre.

Enhanced greenhouse effect

In the base year 1990 the emission of the greenhouse gas carbon dioxide due to the use of fossil fuels amounted to 5.4 Gigatonnes C. All four scenarios provide for the fixing and storage of carbon dioxide. Nevertheless, in the middle population scenario, the emission of carbon dioxide in the year 2090 has more than quintupled in Utilizing and more than doubled in Managing due to the use of fossil fuels. Saving and Preserving emissions of carbon dioxide fall by half in the next century. Apart from the fall in energy intensity, the penetration of nuclear energy is important in Saving for reducing the carbon dioxide emissions, while in Preserving the latter also comes down due to advances in fixing and storage.

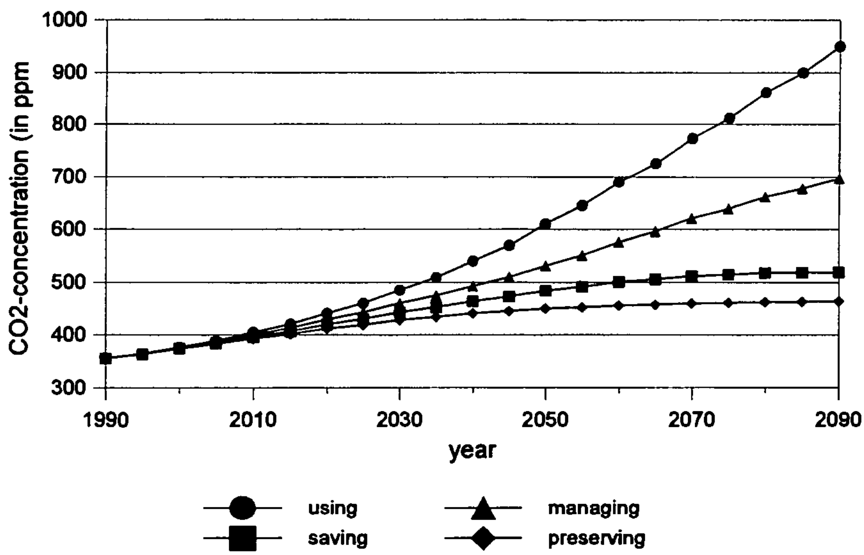
Table 3.18 **Emission of carbon dioxide [Gigatonnes C]; middle**

	1990	2020	2040
Reference	5.4		
Utilizing		13.2	22.1
Saving		8.2	9.1
Managing		10.0	13.9
Preserving		6.2	5.6

Source: WRR.

The emission of carbon dioxide by the combustion of fossil fuels affects the atmospheric concentration of carbon dioxide. The growth in atmospheric carbon dioxide concentrations has been calculated in the various scenarios with the aid of a simple model, in which account has been taken of the exchange of carbon dioxide between the atmosphere, biosphere and oceans [35]. In the absence of knowledge about possible feedbacks the results need to be treated with caution. In terms of the assumptions in question, however, the trends are unmistakable. The results are shown in Figure 3.9.

Figure 3.9 **Growth of atmospheric carbon dioxide concentrations**



Source: WRR.

It has been possible to establish that the atmospheric concentration of carbon dioxide in the pre-industrial period from 1000-1800 fluctuated between 270-290 ppmv. In 1990 the concentration at 353 ppmv was approximately 25 per cent higher. Ice core research has revealed that the present concentration is higher than at any time in the last 160,000 years [36]. The carbon dioxide concentration is currently rising by around one and a half per cent a year due to anthropogenic emissions. The increase in carbon dioxide concentrations, especially in Utilizing and Managing, therefore means a radical break with historical concentrations.

35] See: E.C. van Ierland and L. Derksen, *Economic Impact Analysis for Global Warming: Sensitivity Analysis for Cost and Benefit Estimates*; Paper presented at OCFEB Workshop Quantitative economics for environmental policy, Rotterdam, 22 March 1994.

36] J.T. Houghton, G.J. Jenkins and J.J. Ephraums, *Climate change: The IPCC scientific assessment*; Cambridge, Cambridge University Press, 1990.

Land uptake

The scenarios imply major differences in the land area required for energy supply. Biomass generation is highly land-intensive. Under the Managing scenario, biomass would provide some 15 per cent of energy needs in 2040. Even allowing for the advances in cultivation techniques by that time, the required area would be more than three times the present cultivated area in Europe. In this regard it needs to be borne in mind that the cultivation of biomass is most effective on superior soils. If less good land is used the land uptake becomes much larger again. Solar energy by contrast requires a much smaller area, namely by an estimated factor of five to ten less. Furthermore the cells can be stationed on otherwise unusable land, such as deserts.

3.3.6 Evaluation

The future energy supply appears as though it will entail a number of substantial risks. The most prominent of these are the risk of climate change and the risks associated with nuclear energy. If the present trends in the consumption of fossil fuels are continued, the atmospheric concentration of greenhouse gases, the emission of which is closely correlated with energy use, will rise sharply. The Climate Convention that arose out of the Rio conference aims at a stabilisation of these gases at the 1990 level. Given the trends discussed in this report, especially in the Third World, the prospects of achieving this must be regarded as highly limited. The Convention is accordingly a first but insufficient step to bring to a halt the increase in atmospheric greenhouse gas concentrations.

If the present growth in the use of nuclear energy continues at global scale, this will bring forward the exhaustion of uranium reserves and breeder technology and the associated proliferation risks will become unavoidable. A third environmental risk is incurred if coal reserves and possibly also shale oil reserves are exploited on a hitherto unknown scale, as this would inevitably involve widespread local environmental pollution.

There is however no compelling need to go down the technological trails with which these risks are associated. There are alternatives involving less risk. The demand for energy can for example be controlled by improvements in energy efficiency and by switching to life-styles with a much lower consumption of energy. The potential energy from renewable sources has also been barely exploited. These alternatives will. however. increase the cost of the energy supply and it is debatable whether societies throughout the world will be prepared to bear those costs.

For the time being fossil energy sources can meet the demand. This kind of energy is moreover comparatively safe and clean. The risk of scarcity, however, will become a major factor in the next few decades. Time-preferences are therefore at issue, fed by the uncertainty about technological developments. The more that the decision to go down alternative technological trails is deferred to a later stage, the higher the costs of a transition to a less risky form of energy supply.
The costs that need to be incurred in order to avoid the long-term risks associated with the energy supply are substantial. The Utilizing scenario corresponds the most closely with present Dutch government policy. The proposed fall in energy intensity roughly corresponds with the targets that have been set by the Dutch government. Nevertheless, this scenario still allows for an enormous increase in global $C0_2$ emissions. The emphasis in the Managing scenario is on avoiding both the climate risks and the nuclear risks. This is a major challenge. While the nuclear risk remains controllable up to a certain point, this scenario also exhibits a major increase in atmospheric car-

Table 3.19 **Summary table**

	Reference	Utilizing	Saving	Managing	Preserving
Growth rates [%]					
Energy intensity					
1990-2020					
North	-1.5	-1.8	-3.0	-2.0	-3.5
South	-0.4	-0.7	-1.9	-0.9	-2.4
2020-2040					
North	-2.1	-2.4	-3.7	-2.7	-4.2
South	-1.5	-2.1	-3.3	-2.3	-3.8
Nuclear					
1990-2020		2.5	4.0	2.0	-2.5
2020-2040		2.0	3.0	-2.0	-5.0
Renewables					
1990-2020		2.0	2.0	4.0	3.0
2020-2040		2.5	3.0	4.0	4.0
Shares in %	1990	2040			
Fossil	86	87	66	76	63
Nucleair	5	5	17	2	0
Renewables	9	8	17	22	36
CO_2 fixing in 2040		10	10	20	20
Energy (EJ)					
Use in 2040					
North	347	302	159	266	174
South	1064	881	466	766	259
of which coal		728	266	329	134
CO_2 emissions in 2040 [Gigatonnes C]		22.1	9.1	13.9	5.6

Source: WRR.

bon dioxide concentrations, rather than the intended stabilisation. Coal reserves are also used on a much greater scale, even though the Managing scenario provides for a rapid expansion of renewable energy and a sharp fall in energy intensity by present standards. The Savings scenario is primarily characterised by far-reaching energy conservation and a rising input of nuclear energy. This would require significant technological and social breakthroughs. This is not just a matter of reactor safety and the waste problem but also of the issue of proliferation. Current solutions to this problem under the Non-Proliferation Treaty are based in part on mutual confidence. The conditions for such confidence have, however, deteriorated sharply in a world in which the sources of conflict have become steadily less predictable.

Only the Preserving scenario - provided it is sustained - is strong enough for the aforementioned long-term risks to be largely avoided. The required transition is, however, enormous: the objective of a worldwide reduction in energy intensity implies a radical break in the trend in both North and South. In order to indicate the order of magnitude, it would in the case of the Netherlands involve a doubling of the rate on which the - increased - present objective of an annual 1.7 per cent reduction is based, and this would need to be sustained over an extremely long period. The assumed rate at which the share of renewables will need to increase throughout the world and the necessary infrastructure would also require a huge effort. If society is unable to bear the social and political costs of these transitions one or more of these risks will gradually need to be accepted.

In thinking through the scenarios, the various risks will need to be weighed up against one another. This includes an open trade-off between the risks of the large-scale application of nuclear energy (including the application of breeder technology) and the risks of an enhanced greenhouse effect. It is notable that in the IPCC scenarios this trade-off has resulted in a large share for nuclear energy.

Without exception the scenarios point to the exhaustion of oil and gas in the next century. Only in Saving is this exhaustion controlled. All scenarios therefore stress the necessity of developing alternatives in the first half of the next century. This is the most urgently required with respect to the demand for mobility, which will rise particularly sharply in the Third World. During the next decades mobility will remain largely dependent on oil.

The scenarios are based on a rate of economic growth which, especially for South, implies a break in the trend. In the light of developments in South and East Asia, where even higher growth figures are now being achieved, the plausibility of such growth is however acceptable.

The assumed growth is a significant cause of the fact that the growth in energy consumption in the South turns out comparatively high and that, in comparison with other scenarios, a scarcity situation is brought significantly forward [37]. The likelihood of a rapid rise in energy use in the South provides an important argument for the transition towards considerably more expensive energy in the next century.
In the absence of supplementary criteria none of the four scenarios may be designated as less sustainable than the others. Each of the scenarios is based on a different trade-off between social and environmental risks. Each of these trade-offs may be translated into a differing perception of the margins for energy use. The required efforts, however, differ sharply, which is where the trade-off comes in.

Among other things sustainable development involves ensuring that the coming generations are not prevented from satisfying their wants by the fact that fossil reserves have been exhausted. The uneven global distribution of energy use makes this a highly discernible problem. The next generation in the Third World will be unable to achieve the level of prosperity envisaged for it by the present generation in that part of the world, and which is inspired in part by the level of Western Prosperity, if the present level of energy use in the developed economies rapidly leads to scarcities. It is therefore important for the increasing scarcity of energy to be countered by improvements in the efficiency of energy use and the development of alternatives. The transfer of technology is therefore required in all four scenarios. To this end countries in the Third World must bring the operation of their energy markets more closely into line with the conditions in the world market.

Finally the findings point to the importance of low population growth. The lowest possible growth in population will be unable to prevent fossil scarcity but can substantially extend the necessary transitional period.

37] See for example: J. Sathaye and A. Ketoff, 'CO_2 emissions from major developing countries: Better understanding the role of energy in the long term'; *The Energy Journal*, 1991, volume 12 no. I, pp. 161-196.

3.4 Nature

3.4.1 Introduction

Humankind has never dealt particularly carefully with the natural environment, but in recent decades there has been a sharper increase in awareness that current practices are very much to the detriment of nature. Direct exploitation for the purposes of food production, timber and other raw materials is resulting in the withdrawal of large areas from the natural environment. In addition considerable damage is being caused indirectly by the pollution of soil, water and air. The result is a substantial change in natural conditions, in turn reflected in flora and fauna [38]. Traces of human activity are to be found in even the most unspoiled areas.

The scale and severity of the damage has led to the realisation that a halt must be called to these developments, both nationally and internationally.

The increasing public involvement in nature is evident in the Netherlands from the very rapid growth in the number of members of or donors to bodies such as the Nature Conservation Society and Greenpeace. Campaigns organised by the mass media on behalf of threatened animal species often receive massive support. It is not only acute problems, however, that arouse a response. More and more, attention is devoted to the prevention of problems: it is no longer a matter of waiting until a particular species is threatened with extinction but of preventing threatening situations from arising. At policy level this aim has translated itself into a network of protection areas, for which a considerable expansion is envisaged [39].

Internationally too the attention has been growing: since 1970 there has been a sharp increase in nature conservation areas from 5 to 7.5 million km^2, or over a sixth of the total wildlife and countryside area in the world. The protected area does not just concern wildlife areas but also landscapes that are deemed characteristic on account of a 'harmonious interaction between inhabitants and land' (IUCN criteria).

The assignment of protected status to an area does not however guarantee that it will in fact be or remain protected. The protection measures can vary widely and there are major doubts concerning their effectiveness. Furthermore certain treaties and conventions permit the protected status of certain areas to be lifted if this is in the urgent national interest.

In the present situation a limited part of the global wildlife area is afforded protection against direct harm but not against indirect disturbance. Once again the question arises as to what sustainability in the man/nature relationship could imply. In deciding which natural areas need to be protected from the viewpoint of sustainability, it needs first of all to be determined what 'nature' means. This is a matter of considerable ambiguity; attitudes vary widely. What is regarded as 'natural' may on further reflection in fact relate to features that have arisen as a result of human activity, such as excavated peatlands or manmade lakes. Furthermore the frame of reference may vary from person to person: for an urban dweller a trip through farmland may mean a venture into 'nature', whereas for a biologist the same farmland will be regarded as short on natural features. For both, however, nature is defined here as the occurrence of interesting natural assets in an area, and this can

38] R.J. Bink, D. Bal, V.M. van der Berk et al., *De toestand van de natuur 2* (The condition of nature 2); Wageningen, Informatie- en kenniscentrum Natuur, Bos, Landschap en Fauna, 1994.

39] *Natuurbeleidsplan* (Nature Policy Plan), Tweede Kamer, 1989/1990, 21 149, nos. 2 and 3.

also relate to an area or landscape affected by human activity. The extent to which one considers that an area represents natural assets is determined on historical, aesthetic, educational and recreational grounds. As the example of the urban dweller and the biologist indicated, these are all subjective variables. An objective, universally valid content cannot therefore be assigned to this category of 'nature'.

In the case of natural assets we are concerned in particular with the safeguarding of 'strokeable' animal species (seals, beavers, black-tailed godwits) or 'strokeable' natural features (peatlands, sand drifts, reedlands) within a cultivated area influenced by man. This is also designated as secondary nature.

Nature conservation may, however, also relate to safeguarding wildlife areas, i.e. areas largely untouched by human activities (in the Netherlands: the Wadden Sea, parts of the dunelands and the Voordelta). This is sometimes designated as primary nature.

In both cases the satisfaction of human needs arises. For the protection of both natural assets and unspoilt nature, anthropocentric motives apply since we are concerned in both cases with the assignment of a value. When it comes to the protection of unspoilt nature it is also sometimes argued that this is in the interests of nature itself, in the sense that nature has intrinsic assets and deserves to be protected on those grounds. In the latter case it is of course once again human beings who form a judgement concerning the intrinsic value of nature. This distinction is therefore also arbitrary and the reason for on-going debate [40].

The distinction drawn is also open to debate for other reasons. Ultimately, the natural assets also form part of the goal of nature conservation in wildlife areas. In practice, therefore, the protection of natural assets comes down to leaving the social use of the area in which those assets occur undisturbed. If human activity constitutes a threat to the maintenance of the natural assets, a system of limiting conditions will be imposed on the activity in question. This is clearly visible in the Dutch Policy Document on Agriculture and Nature Conservation and the EC's hillfarmers' regulation. In both cases a number of conditions are imposed on agricultural activity in order to give natural assets, such as the continued existence of meadow birds, a chance in that area.

When it comes to the protection of wildlife areas, the entire area is to begin with withdrawn from human activity. Only once it becomes clear that the available or desired natural assets are dependent on human management can agricultural activities be carried out, such as grazing in dune valleys and moorlands. It will be clear that in the latter case it is not in fact a matter of maintaining unspoilt nature. These grey transitional zones between primary and secondary nature can never be fully closed.

The implications of these two definitions of nature for the appropriate policies can, however, differ widely. Although many will wish to see both kinds of nature fulfilling requirements, the solution in the case of conflict with other needs will vary widely. If the emphasis is placed on natural assets, the pressure to exploit as yet unspoiled natural areas will easily be given into and the emphasis will be placed on the realisation of natural assets in cultivated areas. In terms of the other approach the latter will not be unimportant but has little to do with genuine nature.

40) A.R. van Amstel, G.F.W.Herngreen, C.S. Meijer et al., *Vijf visies op natuurbehoud en natuurontwikkeling* (Five visions on nature conservation and nature development); Publications series RMNO no. 30, Rijswijk, Raad voor het Milieu- en Natuuronderzoek, 1988.

To begin with the changes that take place in nature according to the two approaches are examined below. Despite patchy information, the resulting picture is one of decline according to both definitions of nature. This provides grounds for examining how developments could be moulded in a more sustainable direction. It will be seen that the various definitions of nature result in highly different elaborations.

3.4.2 Reference scenario

If one wishes to form a picture of developments in the natural environment, one runs into major gaps in knowledge. Global evaluations, of which use has been made here, do not for example pay any systematic attention to the occurrence of natural assets in urbanised areas. This may reflect the attitude of researchers towards nature, in the sense that species associated with civilisation are not regarded as forming part of 'genuine' nature and consequently receive less attention. This can result in a distorted picture of the state of nature, at least in the eyes of someone who views nature differently.

Similarly knowledge concerning the species in large natural areas and developments in the past is no more than fragmentary. The total number of plant and animal species on earth is not even remotely established; estimates range from five to 80 million. Only some 1.7 million species have been described. Over half the species live in tropical jungles, ecosystems in which the wealth of species has barely been identified. The majority of the as yet undescribed species relate to insects and mites.

Significant differences in definition also interfere with the comparison and interpretation of research findings. How unspoiled must a wildlife area be to qualify as such? When does a group of trees form a forest? What is meant by tropical rainforest? What precisely is a species and which organisms belong to it? For how long must there have been no sightings of a particular species for it to be regarded as extinct and how intensively should it have been looked for?

It is comparatively common for species to die out in a certain locality. After a certain interval it may happen that the species in question reappears in that place because individual animals or seeds are reintroduced from elsewhere. If the distribution of species is confined to a small area, this recovery chance is fairly limited. In such cases the population in the locality in question may account for virtually the entire species. This applies particularly to natural ecosystems such as the tropical rainforest. The geographical area employed in order to determine the extinction of species is therefore decisive for the results. The timescale employed is also, as noted, a relevant factor.

The research findings can therefore sometimes differ widely, as may be seen from Table 3.20. This makes it difficult to make precise statements about the current state of affairs.

Table 3.20 **Globally extinct and threatened species (after 1600)**

	McNeely et al. 1990			WCMC 1992		WRI 1992
	Extinct	Threatened	Known	Extinct	Threatened	Known
Plants	384	19,078	294,650	595	23,078	400,000
Mammals	83	497	4,170	60	507	4,170
Birds	113	1,037	9,198	116	1,029	8,715
Fish	23	343	19,056	29	713	21,000
Reptiles	21	170	6,300	23	169	5,115
Amphibians	2	50	4,184	2	57	3,125
Invert.	98	1,355	1,046,361	252	1,977	1,300,000

Source: T. van der Meij, J.H.W. Hendriks, C.J.M. Musters et al., *Ontwikkelingen in de natuur; visies op de levende natuur in de wereld en scenario's voor het behoud daarvan* (Developments in nature; visions on the living nature in the world and scenarios for its preservation), Preliminary and background studies, V87, The Hague, Sdu uitgeverij, 1995.

Nevertheless, the picture to emerge from the survey conducted for the purposes of this report is one of steady decline virtually across the board, measured in terms of both natural assets and unspoiled nature [41]. The variety of plant and animal species is declining and many species are threatened with extinction. The main cause is regarded as the disappearance of biotopes and biotopic deterioration through the over-exploitation of plants, animals and soil minerals and the pollution of soil, water and air.

Given the continuation of present trends, the global forest cover would decline between 1990 and 2040 from 4,100 10^6ha to 3,700 10^6ha. The area of tropical jungle - of which 4 per cent is protected - is shrinking much more rapidly; between 1981 and 1990 the area contracted by around 0.9 per cent a year. If the main causes - the requirement for agricultural land by poor farmers, the need for firewood on the part of the indigenous population and agricultural land for exports - continues, the area of tropical forest will be substantially reduced in the next half century. Current policy developments in the countries in question are inadequate to prevent far-reaching deforestation. Figures on the annual decline of the tropical rainforest - which accounts for 50-90 per cent of all plant, animal and microbe species - vary widely from 0.6 to 2 per cent a year. Present trends provide little ground for optimism about the prospects for tropical jungle, including the rainforest [42]. Nevertheless, a few positive developments are discernible. In a few countries, for example, more forest is being planted than felled. Chile is one example, while the reafforestation programmes in Brazil, Zambia and Zimbabwe are reasonably successful.

In temperate areas, the forest cover declined heavily in the 19th and early 20th century. Recently, an increase has even been discernible; planted forests are, however, much less rich in species than primeval forests. A significant proportion of the present forest cover no longer consists of primeval forest. The Netherlands - the majority of which was originally covered by primeval forest - has not contained any such forest since the end of the last century. The

41] T. van der Meij, J.H.W. Hendriks, C.J.M. Musters et al., *Ontwikkelingen in de natuur; visies op de levende natuur in de wereld en scenario's voor het behoud daarvan* (Developments in nature; visions on the living nature in the world and scenarios for its preservation); Preliminary and background studies, V87, The Hague, Sdu uitgeverij, 1995.

42] World Resources Institute, *World Resources 1992-93*; World Resources Institute in collaboration with The United Nations Environment Programme and The United Nations Development Programme, New York/ Oxford, Oxford University Press, 1992.

remaining primeval forests, such as those in Canada, are threatened by conversion to forestry and commercial exploitation.

The continued existence of the savannahs, prairies, open forest areas and tundras are also threatened. An estimated one third of these natural grasslands are affected to a greater or lesser extent by cultivation, erosion, degradation and desertification as a result of overintensive use. In the Netherlands the natural grasslands have largely disappeared as they have been converted into meadowlands.

Of the original area of wetlands (e.g. swamps and mangrove forests) an estimated 25-50 per cent has been lost on a worldwide basis, primarily in recent decades. These wet and swampy areas are seriously threatened, chiefly by activities connected with agriculture: drainage, reclamation or the construction of dykes, dams and barriers in or near water-bearing rivers. Only a very small proportion - 5 per cent - enjoys protected status under the Ramsar convention. If the present rate is sustained, only a quarter of the original area of wetlands will be left in 50 years time. In densely populated areas only minimal remnants would be left. In the Netherlands over 60 per cent of the wetlands disappeared between 1950 and 1989 [43]. Furthermore, the complexion of wetlands such as Lake IJssel and the Zeeland waters has changed due to the construction of the Barrier Dam (Afsluitdijk) and the Delta project, for example on account of the loss of tidal action. In some cases this has led to the generation of new wetlands, such as the Oostvaarder Lakes in the Netherlands, and existing wetlands are restored, but this is by no means sufficient to compensate for the loss.

The dunes are also declining in terms of both quality and quantity. As a result of urbanisation, tourism and recreation the area of dunes in Europe has shrunk by 40 per cent since 1900. In the Netherlands the figure is 5 per cent. Even so, only 34 per cent of the Dutch dune area is regarded as unspoiled. Water extraction, reforestation, recreation and urbanisation are the main causes for this impact.

The speed at which species die out as a result of human activity is generally regarded as higher than that in prehistoric times, leaving aside natural disasters. The number of plant and animal species is currently declining in developing countries due to biotopic loss and in industrial countries due to biotopic deterioration. It is frequently assumed that a reduction in the area of an ecosystem by 90 per cent results in a 50 per cent fall in the number of species. The estimates of the number of species faced with extinction range from a few to 140 a day. It is however difficult to provide a complete picture of the extinction or threatened extinction of species in various parts of the world. The total number of plants, animal and micro-organism species on earth is unknown. Knowledge about the condition of these species is even more limited. If the speed at which species are dying out is estimated at 10 to 100 species per day, this will result over the next 50 years in a loss of some 200,000 to 2,000,000 species. In the latter case this would even exceed the number of known species today. In this respect it needs to be borne in mind that 'attractive' species obtain a kind of protection in botanical gardens, zoos and gene banks. The majority of the species, however, are unidentified. These species could only be aided by means of general conservation measures - especially the designation of protected areas - but generally speaking these are not well developed.

According to the OECD, the percentage of threatened bird, mammal, reptile,

43) Organisation for Economic Co-operation and Development, *OECD Environmental Data; Compendium 1991*; Paris, 1991.

amphibian and fish species is the highest in Western Europe [44]. The possibility can also not be excluded that this percentage is related to the intensity of research conducted in this part of the world. The extent to which birds and mammals are threatened has been the most intensively investigated; the continued existence of over 10 per cent of the species is threatened. In the Netherlands the situation of reptile, amphibian, butterfly, mushroom and toadstool and higher plant species has deteriorated markedly [45].
Nevertheless there are also a number of positive developments, such as various summer birds that have re-established themselves in the Netherlands. Even so it may be anticipated that the biodiversity will decline further in the coming decades as a result of the pressure on nature from the growing nutrient load, acidification, parching and fragmentation [46].

Against the background of the deterioration of the natural environment there is every justification for asking what a sustainable relationship with nature would involve. The notion of sustainability means that account needs to be taken not just of the nature or specific natural features that currently need to be safeguarded or realised but also of what nature or specific natural features need to be passed onto future generations. It may be objected that natural conditions are always dynamic and have always been changed by human activity. The present generation does not miss the dinosaur or those species associated with the cultivated landscape as it existed in the Netherlands in the last century. This argument amounts to the fact that adjustment will always take place to changes in specific natural features and the amount of unspoiled nature; why therefore could future generations not in turn adjust to an environment with less nature or fewer specific natural features? The question is, however, whether the present generation in fact wants this. The perspective also takes on a different complexion if it is borne in mind that the processes of decline have increased sharply throughout the world in recent decades as a result of population growth and economic activity.

3.4.3 Action perspectives

The scenarios presented here are based on action perspectives which differ primarily in their definition of what should be aimed for in terms of nature. The aim of the Preserving and Saving action perspectives is the preservation of an unspoiled natural environment, while the Managing and Utilizing action perspectives seek to realise and sustain specific natural features. Clearly, the responsibility of future generations is given widely differing interpretations in these two pairs of action perspectives. The emphasis in the first two is placed strongly on combating the loss of species caused by human activities; interaction between man and the environment must be minimised since, it is argued, it has led to a strong increase in the risk of species loss. In the Managing and Utilizing action perspectives there is a commitment to transferring an interesting living environment to future generations. Extrapolated to its furthest extremes, the consequence of this approach, namely the 'world as one great park', is ultimately not seen as unsustainable; in fact, optimum interaction between man and the environment is seen as desirable. This attitude may also be inspired by a 'second best' interpretation of sustainability, in which the processes of environmental impoverishment due to population pressure and economic activity are seen as so strong that the only possible strategy remaining is to safeguard the continued existence

44] Ibid.

45] National Institute of Public Health and Environmental Protection (RIVM), op. cit.; J.A. Weinreich and C.J.M. Musters, *Toestand van de natuur. Veranderingen in de Nederlandse natuur* (The condition of nature. Changes in the Dutch countryside); ministerie van Landbouw, Natuurbeheer en Visserij, Sdu uitgeverij, The Hague, 1989.

46] R.J.Bink, D. Bal, V.M. van der Berk et al., op. cit.

of those specific natural features which are regarded by man as being of great importance.

Both pairs of action perspectives are therefore aimed at combating irreversible trends, though in one pair this attempt is non-selective and in the other pair selective. An attempt can be made to translate these basic principles into claims on an area of countryside to be protected. This gives rise to a difference within each of the pairs of action perspectives because, although the aim is to preserve as large an area as possible of unspoiled nature, the actual extent of that area depends greatly on whether this basic principle means 'the total area which is still unspoiled' (Preserving) or 'all current options for the natural environment must be kept open' (Saving).

On the basis of the principle that important natural features must be sustained, a distinction can also be made between an action perspective which seeks to realise these features primarily in cultivated areas (Utilizing) or mainly in natural areas (Managing).

Table 3.21 **Action perspectives for sustainable development of nature**

	Natural features	Unspoiled nature
Minimum space	Utilizing: Interesting nature in cultivated areas and towns	Saving: Preservation of representative ecosystems
Maximum space	Managing: Interesting nature in natural areas	Preserving: Preservation of all unspoiled nature

Source: WRR.

Utilizing

The Utilizing action perspective is based on the principle that humans not only have a need for natural products but also for green spaces and contact with interesting, attractive, fascinating and appealing plants and animals which deserve our care. In order to satisfy the need for these natural resources, however, it is not considered necessary to set aside separate areas on a large scale. It is perfectly possible to enjoy and study nature within built-up and non-built-up cultivated areas, zoos, botanical gardens, parks, etc. Nature and the landscape in economically exploited situations can also be highly attractive from a recreational and educational point of view. It is perfectly possible to maintain species in cultivated settings, if necessary through breeding and cultivation programmes. Ecosystems can even be imitated on a small scale. The creation of separate spaces in the form of nature reserves is therefore only necessary if certain valuable species or ecosystems cannot be sustained in a cultivated setting. The population size of those species and the extent of those ecosystems must be large enough to enable samples to be taken from them at intervals in order to enable the populations of botanical gardens and zoos, etc., to be supplemented.

Saving

The Saving action perspective is based on the principle that natural areas must be safeguarded. Moreover, the opportunities for using those areas must also be retained for the future. At least one representative section of each type of ecosystem must be protected in as complete a form as possible. The size of the systems must be such that they are self-sustaining, possibly supported by a certain amount of management aimed at maintaining important parameters for the system. This supportive management must then be focused on important environmental factors such as the supply of clean water and maintenance of the soil structure and/or key species, such as the most important producers, consumers, predators and reducers. The knowledge required for this is already available or will be available in the short term. Nature management using 'large grazers' is an example of this approach.

Managing

In this action perspective the need for contact with nature can only be satisfied by observing plants and animals under natural conditions. Space has to be created for this, and nature conservation therefore has to concentrate on preserving and developing plants and animals and their respective biotopes. Opportunities must also be created for recreational and educational use of these natural areas, though this must take place in such a way that the species concerned and their biotopes are disrupted or eroded as little as possible. National parks can be seen as an example of this perspective.

Preserving

The Preserving action perspective is based on the view that all the earth's existing unspoiled nature must as far as possible be allowed to develop unhindered. In places where that nature has been eroded or become extinct, the natural conditions should be restored as far as possible. This is the only way to keep open all options for future generations. It is acceptable for the preservation and restoration of wildlife to take up a lot of space, though not at the expense of other functions. This view is based on the idea that each component in an ecosystem has a function which cannot be substituted. Systems cannot be sustained by simply protecting a typical part of them, because this brings the risk of the system becoming isolated and thus impoverished. In this perspective, humans must form part of and add themselves to the ecosystem. A nature policy which allows nature a completely free head to develop in a given area is typical of this view. This does not mean, however, that areas which are currently not used by humans are by definition areas of unspoiled nature; the natural environment in these areas may have been indirectly disrupted or may not yet have recovered from severe disruptions in the past.

3.4.4 Elaboration of the action perspectives in scenarios

Habitat destruction, i.e. reduction of the amount of space available for nature, is the most important threat to many specific natural features and valuable natural areas. The various solution paths have therefore been worked out in terms of the claims on that space. Although this is a rough criterion, it does give an indication of what the concept of sustainability could entail. The question is whether science can help in the specification of the subjective action perspectives. For example, what area would be needed in order to sustain the present wealth of species?

Clearly, the amount of space needed in the Utilizing scenario is limited. In this scenario, it is perfectly possible to study and enjoy nature within agricultural areas, productive forests, the urban environment and in museums, though protected nature reserves will be needed in order to sustain species which cannot as yet be bred or cultivated. In this scenario, the aim is to preserve the existing acreage of protected areas, amounting to 5 per cent of the total land area. This would appear to be a realistic option for the preservation of some species. In Africa, for example, it has been estimated that the present acreage of protected areas is the minimum necessary to preserve large mam-

[47] M.I. Soulé, B.A. Wilcox, C. Holtby, 'Benign neglect; a model of formal collapse in the game reserves of East Africa'; *Biological Conservation*; vol. 15, 1979, pp. 259-271.

mals [47]. What will be necessary is a relocation of the protected areas in order to ensure that sufficient space is created for nature conservation. This will involve expansion of the protected areas in Asia and Africa and, to a lesser extent, in Europe and the former USSR; the existing acreage in North and South America is more than adequate.

There is a greater need for space in the Managing scenario. The assumption is that 10 per cent of the total land area will be required, twice the size of the present protected areas. This choice is relatively arbitrary, since the knowledge required for a precise determination is not available. What is clear, however, is that the present protected area is too small, so much so that many attractive species are already facing extinction.

The Saving scenario also opts for a total protected area covering 10 per cent of the overall land area, though here again a great deal of research is needed in order to establish this figure more precisely. This estimate is based on calculations by Wolf, which produce a figure of 1.3 billion hectares [48]. The location of this 10 per cent is not identical to that in the previous scenario, since the Saving scenario covers all possible ecosystems.

The Preserving scenario designates all presently uncultivated areas - 60 per cent of the total land mass - as worthy of protection.

Obviously, debate is possible on the size of the areas chosen; there are no hard scientific indications for either the minimum or the maximum area required. Nonetheless, given the principles upon which they are based, the choices appear defensible. It is plausible, for example, that preservation of the existing wealth of species and ecosystems will not permit further domestication and resultant reduction in the present area of unspoiled nature. The 'hardest' consequences of the scenarios relate to the use of space. The amount of space available on earth is a fixed given, and if part of it is reserved for nature, the question arises of how much space is left for other purposes, in particular for the other activity which demands large amounts of space, namely agriculture.

Table 3.22 **Present use of space (in 10^6 ha) and population (in 10^6)**

Region	Area	Pop.	Agric.	Woodland	Other	Nature	Protected	Agric./ cap.
World	13,129	5,292	4,801	4,095	4,233	3,486.1	651.3	0.91
Africa	2,964	642	1,077	686	1,201	823.2	117.1	1.68
N.+ C. America	2,138	427	642	715	780	907.7	160.5	1.50
S. America	1,753	297	619	896	238	374.6	101.4	2.09
Asia	2,731	3,112	1,149	539	1,044	377.6	90.6	0.37
Europe + USSR	2,700	787	827	1,102	771	765.9	121.8	1.05
Oceania	843	26	486	157	200	237.1	48.6	18.69

excl. Greenland area: 217.3
excl. Antartica area: 1,321

Source: T. van der Meij, J.H.W. Hendriks, C.J.M. Musters et al., *Ontwikkelingen in de natuur; visies op de levende natuur in de wereld en scenarios voor het behoud daarvan* (Developments in nature; views on living nature in the world and scenarios for its preservation). Preliminary and background studies, V87, The Hague, Sdu uitgeverij, 1995.

48] E.C. Wolf, *On the brink of extinction; conserving the diversity of life*. Worldwatch Paper 78, Washington D.C., Worldwatch Institute, 1987.

The tables 3.23, 3.24 en 3.25 indicate the amount of space which remains for agriculture for varying assumptions of population growth. For each scenario, the amount of space to be set aside for nature is distributed roughly 'pound for pound' over the different continents.

Table 3.23 **Use of space in 2040 for nature scenarios (in 10^6 ha) with low population growth (in 10^6)**

Region	Utilizing		Saving		Managing		Preserving	
	Remaining	Remaining per capita	Remaining	Remaining per capita	Remaining	Remaining per capita	Remaining	Remaining per capita
World	12,473	1.61	11,816	1.53	11,816	1.53	5,252	0.68
Africa	2,816	1.81	2,668	1.71	2,668	1.71	1,186	0.76
N. + C. America	2,031	3.88	1,924	3.67	1,924	3.67	855	1.63
South America	1,665	3.46	1,578	3.28	1,578	3.28	701	1.46
Asia	2,594	0.59	2,458	0.56	2,458	0.56	1,092	0.25
Europe + USSR	2,565	3.38	2,430	3.20	2,430	3.20	1,080	1.42
Oceania	801	25.00	759	23.72	759	23.72	337	10.53

Source: WRR, based on T. van der Meij, J.H.W. Hendriks, C.J.M. Musters et al., *Ontwikkelingen in de natuur; visies op de levende natuur in de wereld en scenarios voor het behoud daarvan* (Developments in nature; views on living nature in the world and scenarios for its preservation); Preliminary and background studies, V87, The Hague, Sdu uitgeverij, 1995.

Table 3.24 **Use of space in 2040 for nature scenarios (in 10^6 ha) with medium population growth (in 10^6)**

Region	Utilizing		Saving		Managing		Preserving	
	Remaining	Remaining per capita	Remaining	Remaining per capita	Remaining	Remaining per capita	Remaining	Remaining per capita
World	12,473	1.33	11,816	1.26	11,816	1.26	5,252	0.56
Africa	2,816	1.41	2,668	1.34	2,668	1.34	1,186	0.59
N. + C. America	2,031	3.26	1,924	3.09	1,924	3.09	855	1.37
South America	1,665	2.98	1,578	2.83	1,578	2.83	701	1.26
Asia	2,594	0.49	2,458	0.46	2,458	0.46	1,092	0.21
Europe + USSR	2,565	2.96	2,430	2.80	2,430	2.80	1,080	1.25
Oceania	801	21.60	759	20.51	759	20.51	337	9.11

Source: WRR, based on T. van der Meij, J.H.W. Hendriks, C.J.M. Musters et al., *Ontwikkelingen in de natuur; visies op de levende natuur in de wereld en scenarios voor het behoud daarvan* (Developments in nature; views on living nature in the world and scenarios for its preservation); Preliminary and background studies, V87, The Hague, Sdu uitgeverij, 1995.

The four scenarios sharply illustrate the consequences of the various sizes of the areas to be set aside for nature. The category 'Remaining per capita' in the tables indicates the area left over for food production and other human activities, such as living and working.

Table 3.25 **Use of space in 2040 for nature scenarios (in 10^6 ha) with high population growth (in 10^6)**

Region	Utilizing		Saving		Managing		Preserving	
	Remaining	Remaining per capita	Remaining	Remaining per capita	Remaining	Remaining per capita	Remaining	Remaining per capita
World	12,473	1.10	11,816	1.05	11,816	1.05	5,252	0.47
Africa	2,816	1.14	2,668	1.08	2,668	1.08	1,186	0.48
N+C America	2,031	2.73	1,924	2.59	1,924	3.59	855	1.15
South America	1,665	2.51	1,578	2.38	1,578	2.38	701	1.06
Asia	2,594	0.41	2,458	0.38	2,458	0.38	1,092	0.17
Europe + USSR	2,565	2.61	2,430	2.87	2,430	2.87	1,080	1.10
Oceania	801	17.80	759	16.87	759	16.87	337	7.49

Source: WRR, based on T. van der Meij, J.H.W. Hendriks, C.J.M. Musters et al., *Ontwikkelingen in de natuur; visies op de levende natuur in de wereld en scenarios voor het behoud daarvan* (Developments in nature; views on living nature in the world and scenarios for its preservation); Preliminary and background studies, V87, The Hague, Sdu uitgeverij, 1995.

Comparison with the space currently available for food production (Table 3.22) shows that in the Utilizing scenario, with its small acreage of protected natural areas, more space than is currently available for, say, food production will only be available if there is low population growth on all continents. The gain in space for agriculture in Asia and Africa is very limited even in this scenario, however, because of the high population growth; the present diet in these regions is already very modest, but a better diet would still have to come mainly from an increase in productivity. Medium or high population growth will lead to an increase in the food production problems in both these continents. No problems will arise in the other continents, even if population growth is high.
The Saving and Managing scenarios portray a doubling of the protected area, though with major differences in accessibility. The problems in Asia and Africa prove to be even greater in these scenarios; with a high population growth, the per capita area available for agriculture on both continents even falls below its present level - in Africa by a large margin. Competition between nature conservation, agriculture, forestry and other functions which demand space is high in these scenarios. It also has to be realised that large tracts of currently unspoiled natural areas will have to be used for food production in both these scenarios. Here again, the picture on the other continents is much more positive.

The conflicts are most pronounced in the Preserving scenario. In terms of area used this scenario could be realised in Europe and the former USSR, even with varying assumptions for population growth; in almost every other continent, however, problems would arise, once again being most pronounced in Africa and Asia, where much less land would be available for food production than at present. This conclusion can also be formulated differently: if agricultural productivity remains unchanged and the population continues to increase, it will be absolutely impossible in large parts of the world to sustain the present acreage of unspoiled natural areas. The only way of making this possible is through far-reaching increases in productivity. This is of itself not an impossible task; in Asia, for example, a tripling of the yield per hectare is by no means impossible, while the possibilities in Africa, given the present low level of production, are often much greater - though the relatively poor soil does present a problem.

While the amount of physical space is the 'hardest' limiting condition for these scenarios there are also other, 'softer', factors at work, including the cost of establishing protective measures or refraining from the exploitation of nature for other purposes. Whether there is a willingness to pay the price this will demand depends on the priorities set, the physical scarcity of raw materials, etc.

Each scenario has its own specific measures and costs. In the Utilizing scenario, for example, it will be necessary to relocate a number of protected areas in order to ensure that sufficient space for nature conservation can be realised in areas where many attractive species originate; these are mainly the relatively warm and wet regions on land and the coastal areas in warm regions. The area to be protected in Africa and Asia, and to a lesser extent in Europe and the former USSR, will have to increase, while a slight reduction is feasible in North and South America.

The Utilizing scenario demands changes particularly in the way in which agriculture, forestry and urban development interact with nature. Urban areas will have to contain extensive green spaces, while rural areas will have to sustain a varied landscape and use of land. The present decline in interesting natural features due to intensification of agriculture and over-exploitation of the soil must be stopped. The space needed for forestry and agriculture will thus have to increase still further in this scenario. Many plants and animals will benefit from smaller-scale agriculture and forestry, although these will mainly be 'culture followers'. This extensification is particularly relevant for regions already practising high-production agriculture, such as Europe and the former USSR, North America and Asia.

The remodelling of urban areas will also demand more space for parks, zoos, botanical gardens, museums, etc., and substantial financial investments will be needed to achieve this. Moreover, this scenario relies strongly on the knowledge which is necessary in order to be able to determine which species can be cultivated and which species can be preserved in which areas. This knowledge will have to be accumulated in the short term.

In the Managing scenario, plants and animals will be preserved under natural conditions. Recreationally attractive species thrive best in a natural environment, and the way of life and living environment of species is part of their educational and recreational value. Moreover, the risk of extinction is regarded as lower where natural populations are preserved. Natural features in cultivated areas are accorded low value, since the occurrence of plant and animal species in these areas is not the result of natural processes. Accordingly, no requirements are set in terms of natural features in these areas.

It is not necessary to protect the entire population of the species selected in designated natural areas, but only sufficient sub-populations to guarantee the continued existence of the species under conditions which are accessible to humans. It obviously makes sense to site these areas in locations where the species thrive best. Natural areas can also be used for other purposes in this scenario, such as timber harvesting and fishing, as long as the continued existence of the population is not placed in danger.

The doubling in the size of the protected areas provided for in the Managing scenario will demand a considerable international effort in order to reach sound agreements regarding location, degree of protection, funding of purchases and management. Recreational facilities will have to be introduced in the protected natural areas and supervision will be necessary to limit the pressure on the natural environment and the populations occurring within it. A great deal of knowledge will have to be acquired for this: how large must a population be in order to be able to survive; how much space is needed for this; and what quality standards will that space have to meet? The expansion of the protected natural areas which is necessary in this scenario will to some extent take place in areas which are currently unused/unspoiled. Land will also be taken from areas which are currently in agricultural use.

Many other, less interesting species will be able to benefit from the protection of interesting plants and animals in nature reserves in the Managing scenario. Species which are susceptible to disruption by recreation and other shared use will fare less well, however. There is no reason in this scenario not to reclaim unspoiled areas which are currently inaccessible but which could be exploited. As long as the interesting nature and nature tourism are not disturbed, the 'pollution' caused by this type of activity will not be stopped. There will be few opportunities for wild plants and animals outside the designated natural areas, except in those areas which cannot be exploited.

The establishment of designated natural areas, the organisation, protection and patrolling of them, as well as increasing the knowledge on the conservation of species in those areas, are all things which will have to be financed in the Managing scenario. On the other hand, money will also flow in from nature tourism, which experiences a boom in this scenario. It is even feasible that this economic interest will offer a certain guarantee for the preservation of natural areas.

The Saving scenario seeks to preserve at least one characteristic part or example of each ecosystem. This does not mean, however, that all species of plants and animals will automatically be protected. In order to achieve this, several examples of each ecosystem would have to be protected, or supportive conservation techniques such as zoos and gene banks would be needed. A large body of knowledge would also be necessary regarding ecosystems and their limitations. All of this carries a large price tag. The costs for agriculture could also be high; a certain amount of agricultural land would have to give way to nature, forcing farming production to be concentrated on a smaller area.

Due to the minimal area which is set aside for nature in this scenario, natural areas could be quickly disrupted, including by external influences such as emissions from the intensively utilised urban and agricultural areas. Harvesting of products such as timber, minerals and energy, as well as recreational activity, will accordingly have to take place almost exclusively outside the natural areas, unless it can be demonstrated that no damage is caused to the ecosystem. The prevention of recreational shared use and exploitation of raw materials, etc., together with guarantees of sufficient water in protected areas, will demand strict limitations of behaviour. From a preventive perspective, this will also demand the large-scale development of environmentally and nature-friendly harvesting techniques and renewable sources in order to reduce total demand for raw materials and energy. Recreational facilities will have to be created in urban and agricultural areas.

Conflicts appear almost unavoidable given the need for space and other demands made by nature. These conflicts can only be avoided through plantation forestry and intensification of agriculture.

The knowledge base for realising this scenario is currently much too narrow. In order to preserve a typical example of all ecosystems, there must be a knowledge of what types of ecosystems exist and what their features are. This demands much greater knowledge than that required for the previous scenario. Given the very patchy current knowledge, a strategy which takes the objectives of this scenario seriously could mean that protected areas will initially demand even more space. The conflicts with other land uses already signalled will then increase proportionately.

In the Preserving scenario a great deal will be invested in protecting natural areas in order to preserve as much of the natural environment as possible. A very large area will have to be given protected status, and this will be very expensive. Not only will the initial costs be high, but monitoring and maintenance of the protected status - already a very weak point at the moment - will also cost a great deal of money. Moreover, it will only be possible to meet the demand for timber and timber products through a large-scale shift to plantation forestry, reducing even further the area available for agriculture. This scenario thus relies heavily on a world-wide spread of the techniques needed for high-production agriculture. The cultural, political and economic obstacles could be considerable.

Clearly, this scenario also places heavy demands in terms of advances in knowledge. Not only will the productivity of agriculture and forestry have to be radically increased, but solutions will also have to be found for the harvesting of raw materials and energy from the protected areas. While exploitation of natural areas is not ruled out, it will not be possible on a large scale and no significant disruption of the natural ecosystems will be permitted. This can only be achieved through the use of highly advanced environmentally and nature-friendly techniques. The availability of water in the natural areas must be left essentially intact; this means it will not be possible to draw water on a large scale from nature reserves, for example for irrigation. This limitation alone will lead to major conflicts with agriculture and other human activities.

3.4.5 Evaluation

The concept of sustainability in the relationship between man and nature can be interpreted in a variety of ways, each of which is normatively determined. This implies that adopting a given position means other positions are perceived as unsustainable. For example, if sustainability is interpreted as the preservation of the existing unspoiled nature and diversity of species, scenarios such as those worked out under the titles Utilizing and Managing will be seen as 'blasphemous' in view of their acceptance of the loss of certain species. Conversely, supporters of the latter positions will see the Preserving perspective as unsustainable because of the high price which has to be paid to preserve natural areas and because of the limited area allowed for world food provision.

In the Councils opinion, however, these scenarios highlight important directions for choices. The continuing impoverishment of nature and interesting natural features force a stand to be taken on whether this process should be allowed to continue unchecked. If not, the question unavoidably arises as to what sort of protection is needed: selective or non-selective. If it is felt that non-selective protection is not desirable or is no longer possible, the question of the selection criteria to be used arises. What sort of plants and animals should be protected, why and at what cost? Sustainability is not a philosopher's stone which, once found through scientific effort, automatically produces answers. Mankind will have to make the choices itself; scientists can elucidate the choices which have to be made, but cannot make them.

The choices which have to be made are also not self-evident. Even if agreement is possible on the choice dimensions, at what levels must efforts be made in order to be able to talk of sustainability? The measures currently being taken - including through international agreements - are necessarily first steps. But how far must the following steps go? If the discussion on sustainability is to become more substantive, greater clarity on this question is essential. It became clear in the foregoing section that the specifications chosen here are based on anything but firm foundations. Nonetheless, such provisional choices can clear the ground for continued discussion.

The interpretation which must or can be given to sustainability can obviously not be seen in isolation from place and time. The various positions described above were set out as if they applied to the whole world. This enabled an indication to be given of major problem areas over the next fifty years given a range of assumptions. In reality, the starting position for ideas on sustainability is obviously completely different in the Netherlands than in, say, New Zealand. In the Netherlands virtually all 'nature' is localised in cultivated areas, and areas which are regarded as unspoiled nature come close to what has been described in this paragraph as falling under the Managing perspective. And yet the distinctions made between the perspectives are also clearly recognisable within the Dutch context. This applies both to the discussion on specific natural features versus extent of the natural areas and to the question of whether natural areas should be managed or left to their own devices, as well as to the issue of what 'natural' nature is and whether natural areas should be accessible to humans. In other words, the global discussion also takes place in the Netherlands, albeit on a small scale. Maintaining the existing status of the natural environment or promoting 'new' nature is seen by many (Saving and Preserving scenarios) as offering the best guarantee for a good nature policy. Others see farmers as the main monitors and guardians of natural features and see this as the most appropriate approach for the ultimate preservation of nature in the Netherlands. Setting aside separate natural areas is only necessary for a limited number of ecosystems.

The discussion surrounding sustainability also depends on the temporal context. At the moment it is still possible in many areas to consider the various sustainability options alongside each other. As domestication and the concomitant impoverishment of nature progresses, however, in tandem with ever-increasing competition between claims made on the available space, the need to make a choice becomes more and more urgent. This need is already present for a number of highly threatened animal species, and there are even some species which now only exist in museums.

The scenarios give a first impression of the consequences of the choices assumed here. However elementary, it would appear impossible to rule out completely realisation of any of the scenarios. The problems, particularly in Asia and Africa, will be enormous, especially in the case of the Preserving scenario, but also in the Utilizing scenario. The assumed amount of space set aside for nature is greatest in the Preserving scenario and, given the population growth on these continents, there will be a need for an enormous increase in agricultural productivity. If self-sufficiency and food production is the aim here, productivity will need to increase by a factor of between four and six. Moreover, this agricultural activity must not significantly erode the natural areas. This is an enormous task, though not an impossible one on the basis of the theoretically achievable productivity increase which was discussed in the section on world food provision. Achieving such an increase in agricultural productivity will, however, demand major economic and social changes.

This alone will not be enough, however. A worldwide commitment to conserving the existing unspoiled natural environment demands a consensus on the need to protect this environment against the exploitation of production assets occurring in it. The international political structures needed to achieve this do not exist at the moment, and such structures would represent a far-reaching infringement of the sovereignty of the states concerned. This is a problematic issue for all states, but particularly for those states which have only recently gained independence. The standpoints voiced at the 1992 UNCED conference by developing countries regarding the protection of their natural environments illustrates this point.

Moreover, a high proportion of as yet relatively unspoiled nature occurs in countries with limited prosperity and high population growth. The inclination to exploit the production assets located within these natural areas will accordingly be great. The Managing scenario, in which interesting natural features within natural areas are protected, will therefore have a better chance of being realised in these locations. Mass international tourism represents a strongly increasing source of income for these countries.

The margins on other continents are wider. In Europe, for example, the spread of agricultural knowledge is such that it would be possible in the short term to reduce the acreage of agricultural land with a concomitant increase in the area of protected natural areas. There is a high awareness of the value of nature in these countries, which may well be connected to the level of prosperity achieved, and possibly also with the far-reaching degradation of the natural environment which has already taken place there. Nature and interesting natural features have become scarce. The prosperity of these countries also means that the resources are available to give these issues a higher priority. Here, too, however, changes in land use would mean a radical erosion of interests and lead to great resistance. Agriculture in the European Union, for example, is subsidised to the tune of 100 billion guilders annually. If this amount were capitalised (over a term of 25 years at 7%), this would result in a sum of 1,165 billion guilders, an amount which does not include the implicit subsidy of agriculture by high consumer prices. Applying this to natural areas (say NLG 5,000 per hectare) would make it possible to purchase 230 million hectares of land, ten times the area suggested in the WRR report *Ground for choices* as being eligible for a European ecological main structure [49]. A large sum would thus remain for purchasing natural areas elsewhere. Of course these figures need to be put into perspective somewhat - for example, the present subsidy also helps to maintain employment and natural areas also have to be managed. Nonetheless, the calculation indicates that a shifting of priorities towards a much larger acreage of natural areas need not be hampered by a lack of resources.

3.5 Raw materials

Society makes large-scale use of mineral resources as a means of generating prosperity. This raises the question of whether the earth possesses sufficient natural resources to continue supporting a prosperous society as we know it *ad infinitum*. This question becomes even more pertinent when placed against the background of the progressive increase in prosperity and a fair intergenerational distribution. The desire to improve prosperity is not restricted to the West, but is also particularly strong in regions where economic development has not yet reached Western levels. These are also precisely the regions where population growth is high and where a large claim on the earth's natural resources can therefore be expected - a claim which is likely to far exceed that in the West.

The threatened exhaustion of mineral resources was signalled in the early 1970s by the Club of Rome [50]. The sombre findings of the first report to the Club have been modified somewhat over the years; substitution by less scarce

49] WRR, *Ground for Choices; four perspectives for the rural areas in the European Community*; Reports to the Government No. 42, The Hague, Sdu uitgeverij, 1992.

50] D.H. Meadows et al., *The Limits to Growth*, New York, University Books, 1972.

raw materials and more effective use and recycling can considerably push back the scarcity horizon. Nevertheless, the exhaustion of natural resources has remained an important topic on the agenda of the environmental debate. Damage to the environment due to the extraction of raw materials and pollution from production and consumption are also becoming increasing focuses of attention.

All these aspects - exhaustion, environmental damage and pollution - deserve attention in the bid to achieve sustainable development. They will be discussed here on the basis of case studies on copper (exhaustion and environmental damage) and chlorine (pollution).

3.5.1 Copper

Copper is a scarce metal and has been chosen as a representative example of the problem of exhaustion and the environmental damage caused by its extraction. Copper is a good conductor of electricity and heat and is easy to work. Because of these almost unique properties - only matched by the much scarcer silver - copper is widely used in electrical applications. Aluminium is sometimes used as a substitute, but is less suitable for many electrical applications. Given the increasing share of electricity in the final energy supply, use of copper for electrical conduction is likely to remain significant, in spite of the existence of substitutes for a range of applications. This means that exhaustion of copper is a real possibility.

3.5.1.1 *Reference scenario*

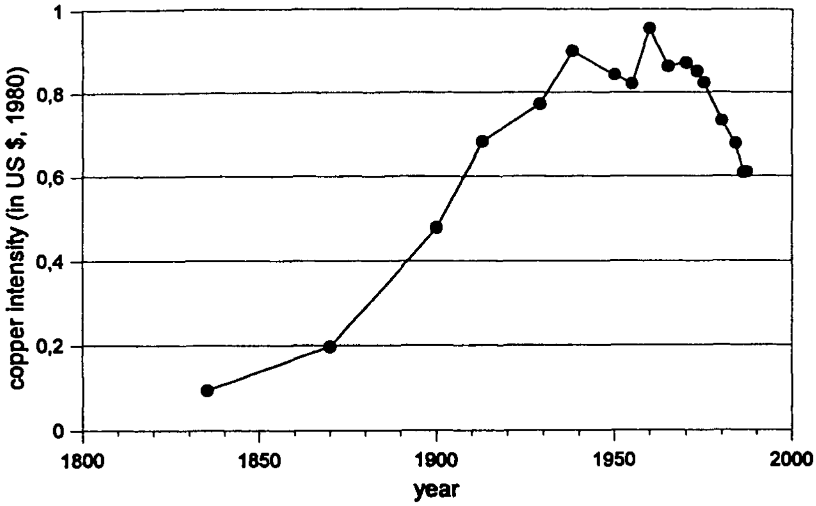
World copper consumption amounted to 10.9 million tonnes in 1989. 8.9 million tonnes of this was primary copper while the remaining 2 million tonnes was derived from secondary or recycled copper. A recycling reservoir is currently available containing more than 173 million tonnes of copper in the form of discarded products or products still in use [51].

The world copper intensity (i.e. the use of copper per unit of economic production) has risen considerably since the start of the last century in step with rising prosperity. There was a reversal in this trend around 1960, when the world copper intensity began to fall (see Figure 3.10). This 'dematerialisation' is a phenomenon which can be observed for many raw materials; it is due in part to a changing sectoral structure in the West, where the services sector, which consumes lower quantities of raw materials than some other sectors, has grown at the expense of manufacturing industry. Substitution by other materials and increased effectiveness of material use have also helped to push down the material intensity.

In contrast to the industrialised West, the copper intensity in the Third World is rising and, since the 1980s, has in fact exceeded that of the developed economies. If we assume that per capita income will increase in line with the trend - by 2 per cent in the developed economies and by 3.25 per cent in the Third World - the copper intensity (Fig. 3.12) can be extrapolated in a consistent line with the reference trend in per capita copper consumption (Fig. 3.11). A peak in copper intensity will occur in the Third World in the middle of the next century which is comparable with the peak in the West in the 1950s. Rising prosperity in the southern hemisphere will lead to an increase in demand for raw materials; since these are precisely the regions in which the population is set to undergo explosive growth, a substantial claim on the earth's natural resources can be expected.

51] Bureau of Mines, Minerals Yearbook, Volume I, *Metals and minerals*; Pittsburgh, US Department of the Interior, 1989.

Figure 3.10 **Copper intensity**



Source: WRR, based on A. Madison, *The world economy in the twentieth century*, Paris, OECD, 1989, and 'Metals output and prices - A historical perspective', *Mining Annual Review*, London, 1985.

Per capita consumption of copper is reaching saturation level in the Western economies, and it is likely that it will also approach this level in the Third World in the longer term. Consequently the same saturation level has been used for the reference trend in the Third World as for the developed economies.
The question of how long the copper intensity in the Third World will continue to increase, and to what level, is of particular relevance for the exhaustion of copper. Taken together with economic growth, the trend in copper intensity indicates the development in copper consumption. Clearly, the cumulative consumption cannot be greater than the total copper resources. As Table 3.27 shows, the economic stocks are currently estimated at less than 500 million tonnes, though the ultimately extractable stocks could well be several times larger.

If the above reference trend in per capita consumption is related to the three variants of the United Nations' population forecast, the following picture of cumulative consumption in the reference scenario emerges.

Figure 3.11 Reference trend in per capita copper consumption in North and South

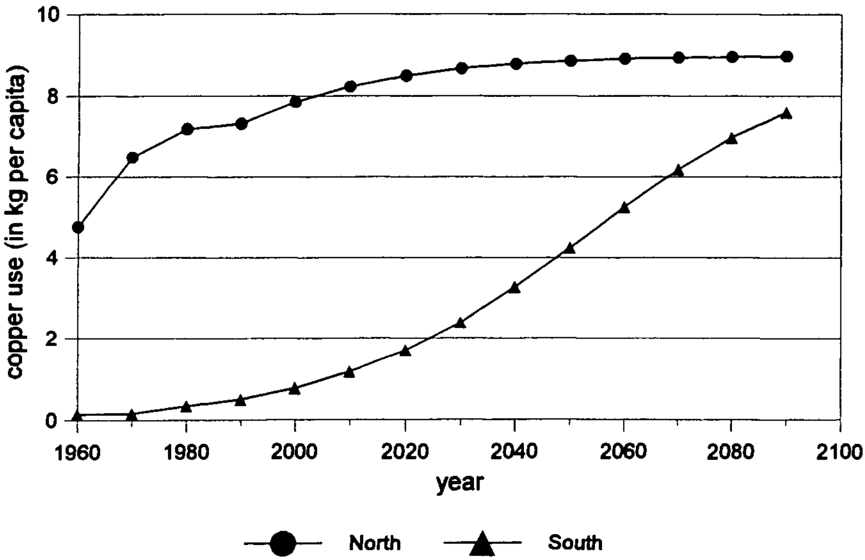
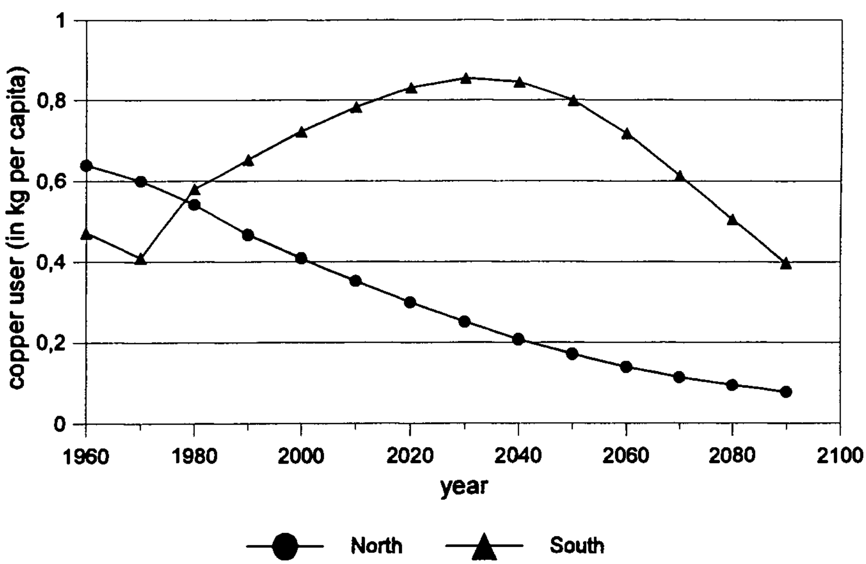


Figure 3.12 Reference trend in copper intensity in North and South



Source: WRR.

Table 3.26 Cumulative copper consumption in the reference scenario for the three population trend variants (in million of tonnes)

		2040	2090
Population:			
	low	1200	3500
	medium	1325	4750
	high	1475	6400

Source: WRR.

According to the reference scenario, cumulative copper consumption in the year 2040 will far exceed what are currently considered to be the economic reserves, whichever population trend variant is used. Consumption in 2090 also far exceeds the technical reserves shown in Table 3.27, i.e. the maximum reserves which can ever be extracted according to current technical insights. In the high population variant, consumption is three times that level.

A trend in copper consumption in line with the reference trend is not only problematic in the sense that it could lead to exhaustion of world copper reserves. The extraction of copper is usually also accompanied by severe pollution of the environment: heavy metals are released into the environment and surface water is polluted. The more extraction concentrates on ores with lower metal content - as the richer ores become exhausted - the more the scale of this pollution will increase.

The exhaustion of raw materials is one of the cornerstones of the concept 'environmental utilization space'. For its determination it is necessary to know what reserves of raw materials are available. On the basis of this 'raw materials utilization space', limits are then set for social activities which make use of the raw material concerned. The extent of the raw material reserves is anything but clear, however, and copper forms no exception. Although the extent of the 'known' reserves has been determined with some degree of certainty, the extent of any additional, as yet undiscovered reserves is unclear. While there is some evidence on which to base statements, it is insufficient to remove the uncertainty. Table 3.27 gives an impression of the occurrence and reserves of a number of metals.

Table 3.27 **Estimated occurrence, reserves and extraction of metals**

	Mass share in earth's crust [%]	Geological reserve [10^{12} tonnes]	Technical reserve [10^6 tonnes]	Economic reserve [10^6 tonnes]	Annual extraction [10^6 ton]	Typical ore content [%]
iron	5.4	1,392,000	2,035,000	93,100	510	55
aluminium	8.1	1,990,000	3,519,000	5,200	18	30
manganese	0.1	31,200	42,000	2,200	8.5	30
copper	0.005	1,510	2,120	456	8.2	2.0
zinc	0.007	2,250	3,400	157	6.6	4
chromium	0.01	2,600	3,260	780	4.4	30
lead	0.001	290	550	123	3.4	5
nickel	0.008	2,130	2,590	45	0.8	1
tin	0.0003	40	68	10	0.18	0.3

Source: The Council on Environmental Quality and the Department of State, *The Global 2000 Report to the President*, Washington D.C., 1980.
Bureau of Mines, *Minerals Yearbook*, Volume I, Metals and Minerals, Pittsburgh, US Department of the Interior, 1989.
A. Brobst and W.P. Pratt (eds.), *United States Mineral Resources*, Geological Survey, Professional Paper 820, Washington D.C., 1973.

The *geological reserve* - the total occurrence of an element in the earth's crust - of copper is estimated at 1.5 x 10^{15} tonnes. Virtually all of this occurs in the form of solid solution, in which the copper content is extremely low. Given current technology and prices, therefore, only reserves of a certain size and with ore contents above a certain level are extractable. These 'economic reserves' of copper are estimated at 456 million tonnes. Technological breakthroughs could have a major impact on what are considered economically extractable reserves, for example making it possible to extract copper from ores with a lower content and thus leading to an increase in the reserves. A striking example of such a technological breakthrough is the extraction of copper from porphyritic sedimentations, which became possible at the start of this century. Whereas before this time these sedimentations were seen as a geological curiosity, they now provide more than half the world's supply of copper. The possibility of similar developments in the future can certainly not be ruled out. This becomes even more important if the size of the technical reserve is compared with the economic reserve - a difference of a factor five.

This uncertainty regarding the copper reserves makes spreading the exhaustion over time, in a way which takes account of the interests of future generations, a problematic issue. Even if exhaustion of all stocks in the short term is avoided, it remains unclear at what rate the reserves can be used responsibly in an inter-generational context. The speed with which the copper reserves are used up therefore implies a risk for the options open to future generations.

It is not only the available quantity of copper which is relevant for future generations, however. The consumer demand which can be covered by that copper in the future is also important. Technological developments mean that the entire field of applications and substitution possibilities is constantly in a state of flux. For example, technological advances could enable the same functions to be performed in future using less copper. Not only could copper be used generally more effectively, it could also be replaced in some applications by a different, less scarce metal such as aluminium in high-voltage cables. Copper contained in discarded products or products which are currently still in use could also be recycled. Just as with the extent of the copper reserves, however, the degree to which more effective use, substitution or recycling could lead to real savings is anything but clear.

There is also a good deal of uncertainty regarding the long-term consequences of disruptions to the ecological system as a result of economic activities. This is because there are different ways of interpreting the resilience of the ecological system. What is clear is that the extraction and processing of raw materials have a negative ecological impact. For example, many metals occur in sulphur-containing mineral ores. If these are processed without precautionary measures, there is an enormous release of acidifying substances into the environment.

Similarly, mining activity has led to the pollution of entire river systems and large tracts of farming land have become so severely polluted that they are sometimes totally unusable. This has led to all manner of health problems in highly polluted mining areas and to a life expectancy which is lower than in other areas with a comparable socio-economic profile. Mining activities have also had a dramatic effect on the living conditions of many people, particularly in vulnerable regions such as the zinc mining areas of Colombia and the copper mines in Chile. This aspect of raw materials extraction has been attracting increasing attention in recent years.

Environmental pollution as a result of mining is not a new phenomenon: throughout the centuries the extraction of metals has had a severe impact on the environment. The scale of modern mining is so much greater than in the past, however, that the pollution has increased to regional or fluvial levels. The scale of mineral extraction will not only continue to increase in the future, but will also become steadily more difficult. When attempts begin to extract copper from lower-content ores, for example, larger quantities of mining waste will be created. The ore seams will become less accessible, necessitating the removal of larger quantities of earth. It remains to be seen whether technical solutions exist or will be found which are capable of adequately mitigating this problem.

On the basis of current knowledge it is practically impossible to make well-founded statements regarding the quantity of copper available to the present and future generations. There are too many uncertain factors to enable an objective indication to be given of the 'permitted use'. As argued in Chapter 2, much depends on the perception of the risks involved.

3.5.1.2 *Action perspectives*

The first difference between the action perspectives is the importance they attach to the risk of a copper shortage resulting from a combination of the available reserves, savings and recycling. Where the risk of shortage is perceived as serious (Preserving and Saving), the advocated trend in consumption is dictated, partly from an intergenerational point of view, by the idea of finite reserves whose limits are in sight. Technological advances are not considered adequate to reduce consumption to such an extent that the threat of scarcity is removed; in order to achieve savings, behavioural change is considered necessary.

Where the risk of shortage is seen as less serious (Managing and Utilizing), the desired consumption trend is governed by rising exploitation costs due to the exhaustion of the richer ore reserves. There is less concern regarding the possibility of finite reserves. Great faith is placed in the ability of technology to reduce raw materials consumption, primarily through an increase in raw materials productivity - i.e. the production of goods and services for which a raw material is used as input, calculated per unit of that raw material.

Just as important as the reserves of raw materials are the specific natural features which could be damaged by the extraction and circulation of those raw materials. Given the uncertainty regarding the resilience of these natural features, they are treated differently in the various action perspectives. The Utilizing and Saving perspectives recognise the erosion and pollution associated with mining, but rely on the ability of technology to provide solutions. The Managing and Preserving perspectives perceive these ecological risks as being even more important. The Managing scenario seeks a solution in far-reaching environmental measures governing extraction, while Preserving refrains from extraction in vulnerable locations. The differences between the action perspectives are summarised in Table 3.28.

Table 3.28 Action perspectives for sustainable raw materials development

	Slow fall in raw materials intensity	Rapid fall in raw materials intensity
Careful extraction	Utilizing	Saving
Restricted extraction	Managing	Preserving

Source: WRR.

3.5.1.3 *Translation of action perspectives into scenarios*

Utilizing

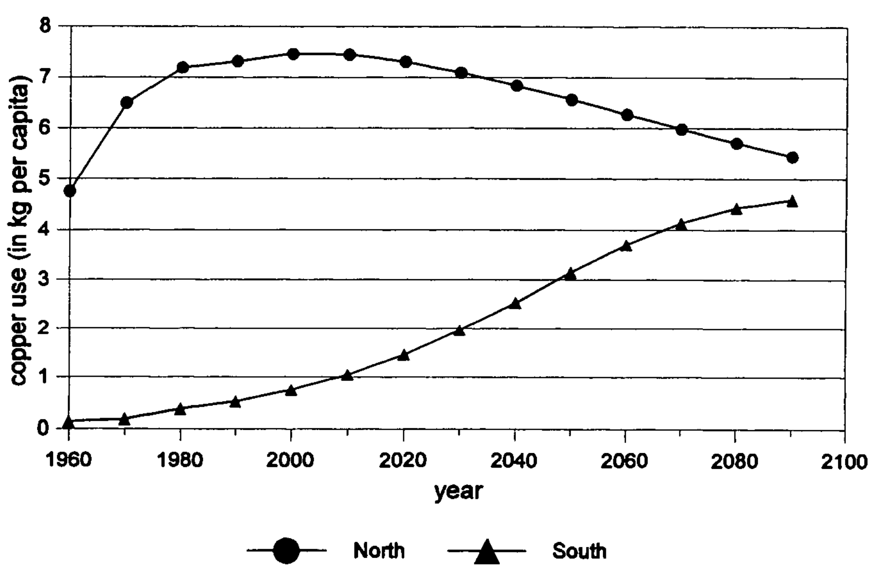
The Utilizing scenario does not assume that raw material reserves are infinite, but is based on the idea of decreasing ore contents which make the reserves more difficult to extract. Although this has always been the case, major technological advances have to date meant that no significant cost increases have occurred in spite of the falling contents of copper ores. If technological developments were unable to prevent an increase in the costs of extraction from less rich ores, however, then sustainable development is still possible if the productivity of copper increases at the same rate as the extraction costs. Extra efforts in the Utilizing scenario make an increase in copper productivity of 0.5 per cent relative to the reference scenario a feasible proposition.

Although subsequent generations will have less high-grade copper ores at their disposal, they need not necessarily be at a disadvantage, provided sufficient investments are made in order to reduce future consumption [52]. It is already possible to substitute copper with less scarce raw materials. In addition, technology can contribute to an increase in the productivity of copper consumption. Depending on the rise in extraction costs, the level of recycling will also increase substantially - from its present level of 18 per cent to more than 50 per cent by the year 2090 in this scenario. While the costs of extraction could increase fourfold by the end of the next century, recycling could limit this to a threefold increase in the present costs per tonne of copper.

Finally, increasing scarcity of copper will be translated into rising copper prices. This will lead to copper being used only for the most essential functions, in turn leading to a reduction in demand for copper. Exhaustion need not then occur.

A complicating dimension however is the present and future economic development of the southern hemisphere. Rising affluence is accompanied by increased use of raw materials. The potential claim on world copper reserves by southern nations, with their high population growth, is accordingly large. It will also be necessary to pass a raw materials-intensive 'hump' before an equally satisfactory raw materials-extensive consumer pattern is achieved in the South as in the North. In order to prevent this leading to scarcity, progressive technological development in the extraction, productivity and recycling of copper is desirable now (Fig. 3.13).

Figure 3.13 **Per capita consumption of copper in Utilizing scenario**



Source: WRR.

In 1990 the cumulative total of copper extracted from the earth's crust to date was around 350 million tonnes. In the Utilizing scenario this cumulative

[52] J.M. Hartwick, 'Intergenerational equity and the investing of rents from exhaustible resources'; *American Economic Review* (66), 1977, pp. 972-942.

extraction rises to 1,175 million tonnes in the year 2040 and to 2,550 million tonnes in 2090. 8.9 million tonnes of primary copper were extracted in 1990. In the Utilizing scenario this rises to 22.6 million tonnes in 2040, peaks shortly afterwards and then enters a downward trend, reaching 26.1 million tonnes in 2090.

Saving

The view of copper scarcity in the Saving scenario is dominated by the idea of finite raw materials reserves; the ecological risks associated with raw materials extraction are not given great importance. The ultimately extractable reserves of copper are estimated at 1,500 million tonnes. Although the exhaustion period for copper, related to the economic reserves, has remained constant over the years, this is no guarantee that the trend will continue in the future. There are even a number of factors pointing to the reverse trend. For example, the majority of the copper reserves are concentrated in a limited number of locations, which are gradually becoming exhausted. While it is true that new reserves are continually being found, the period between the start of explorations and the start of production is steadily increasing [53]. These exploration efforts will have to be continually stepped up. In addition, there is little reason to assume that there are still large undiscovered reserves of poorer ores in the earth's crust. The assumption that these reserves are many times greater than the richer ores has never been objectively confirmed. Although technological advances have removed many obstacles to copper extraction in the past, if the practically extractable reserves become exhausted, there is no technology which can maintain production levels. The measured economic scarcity is therefore a delayed indicator of an impending physical scarcity.

As copper will always be an essential input in the economy, the extraction of this metal must therefore decrease, and this decrease must proceed at the same rate as the decline in the copper reserves. The exhaustion period - the number of years within which the reserves become exhausted at a given constant level of extraction - will remain the same throughout the years. The Saving scenario opts fairly arbitrarily for an exhaustion period of 50 years.

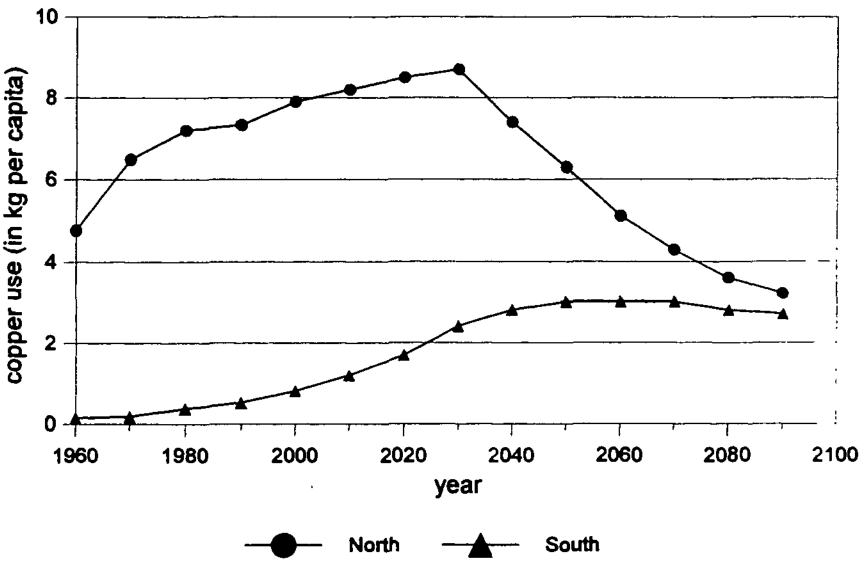
The question is how to achieve the envisaged decrease. The main impact of technological developments will be in facilitating more effective use of copper, for example through a further reduction in the copper intensity. Overall, however, it cannot be said that technological developments are moving in the direction of lower use of copper. In the industrialised nations, for example, the copper intensity has been falling for some time, but the steady rise in prosperity means that per capita consumption has not fallen. At best it can be said that technological development will enable the various potential uses of copper to be better identified so that there will be a certain optimisation of the use of copper. Provided a sufficient level of technology transfer can be achieved, this will also enable a similar level of prosperity to be achieved in the Third World as in the developed economies today, though with a markedly lower per capita copper consumption.
In addition to achieving a copper productivity which exceeds the trend, a high degree of recycling will also have to be encouraged. The maximum achievable level of recycling is set at 75 per cent by 2090 in the Saving scenario, a figure based on an assumption of leakages of the order of only 10-15 per cent during both collection and recovery. Even if recycling takes off in this way, however, the level of primary copper extraction will remain high because of the strong growth in demand for copper in the Third World. It is thus far from certain that technological changes will be capable of reducing the level of extraction,

53] D.P. Harris, 'Mineral exploration and production costs and technologies - Past, present and future'; in: *Resources and world development*, D.J. McLaren and B.J. Skinner (eds.), Chichester, John Wiley & Sons, 1987, pp. 423-442.

and this scenario therefore treats a concomitant reduction in per capita copper consumption as essential.

If an ultimately extractable reserve of 1,500 million tonnes of copper is assumed and an exhaustion period of at least 50 years, the permissible per capita consumption if sustainable development is to be maintained is shown in Figure 3.14.

Figure 3.14 **Maximum permissible per capita consumption in Saving scenario**



Source: WRR.

Of the initial copper reserves of 1,500 million tonnes as estimated in 1990, 625 million tonnes remain in 2040 and 200 million tonnes in 2090. The level of extraction in 1990 amounted to 8.9 million tonnes. The maximum permissible extraction according to the Saving scenario is 15.3 million tonnes in 2040, falling to 5.0 million tonnes in 2090.

Managing

Like the Utilizing scenario, the Managing scenario does not accord great importance to the risks of copper scarcity; improved extraction technology will enable the exhaustion horizon to be extended in time. The scenarios differ in their view of the relationship between man and the environment, however. Protection of the environment and nature is of prime importance in the Managing scenario and must be accorded great importance when making economic judgements.

The costs of primary copper are made up not only of extraction costs but also of the costs of environmental protection measures. As the copper content of ores reduces, environmental costs per tonne of copper increase disproportionately. Greater amounts of earth have to be moved, so that the disruption of the natural environment and the level of pollution become ever more serious. A very cautious attitude to the extraction of new finds will therefore be adopted in the Managing scenario.

The costs of extraction, including the environmental costs, could be ten times the extraction costs in 1990 by the year 2090 under the Managing scenario.

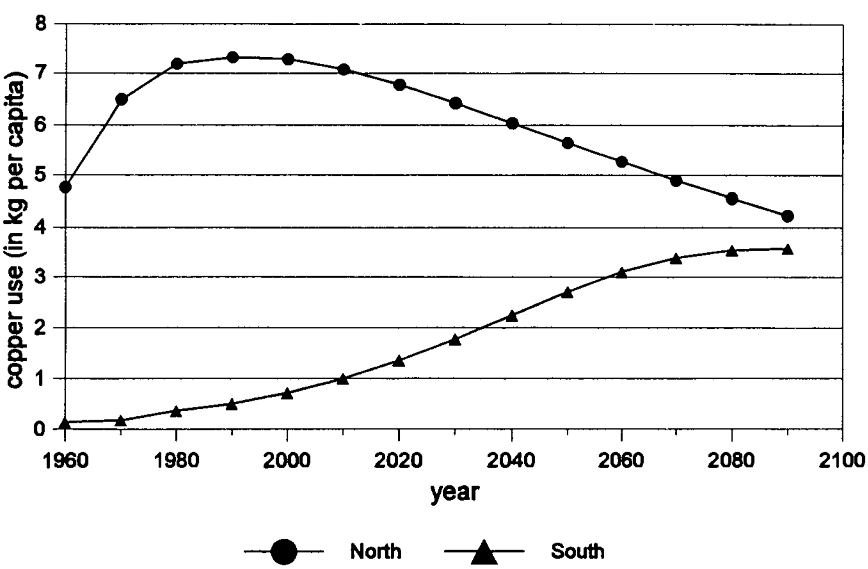
However, the high level of recycling - 79 per cent in 2090 - keeps the costs of the copper supply down to four or five times their present level.

Future generations must not be saddled with the costs of present-day extraction practices, in the sense that they are restricted by high costs from benefiting from the available natural resources to the same extent as today's generation. The productivity of copper usage will therefore have to increase sufficiently to compensate for both extraction costs and environmental costs. It is assumed in this scenario that such a balance has been achieved when an additional increase in copper productivity of 0.75 per cent annually relative to the reference scenario is realised.

Once the southern hemisphere is over its raw materials-intensive 'hump', this condition could be ameliorated and compensation could be found in less raw materials-intensive but equally satisfactory consumption patterns. The results of these assumptions for copper consumption are shown in Figure 3.15.

The cumulative extraction, which amounted to 350 million tonnes of copper in 1990, reaches a level of 1,025 million tonnes in 2040 under the Managing scenario and a peak of 1,750 million tonnes in 2090. The 1990 level of extraction of 8.9 million tonnes increases to a peak of 15.9 million tonnes in 2040 before falling to 10.1 million tonnes by 2090.

Figure 3.15 **Per capita copper consumption in Managing scenario**



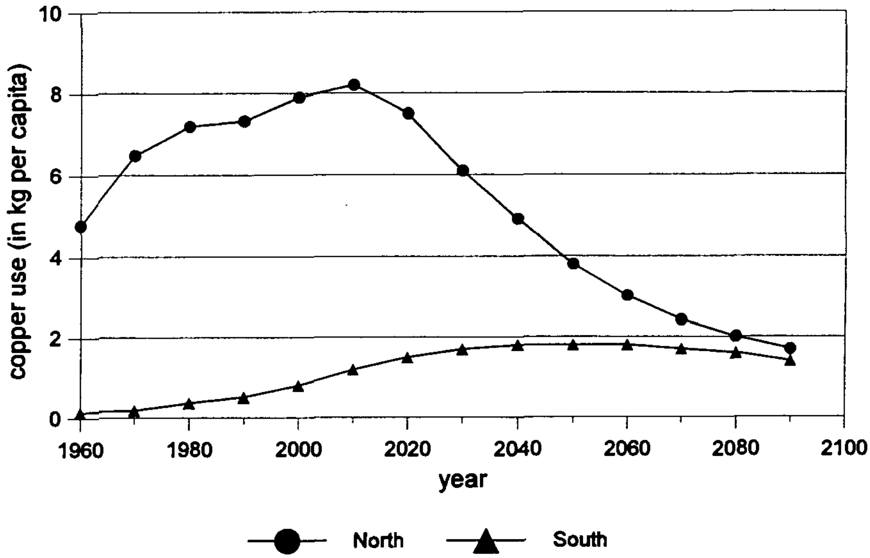
Source: WRR.

Preserving

The Preserving scenario also treats the risk of scarcity as the major world problem. The ecological risk associated with the extraction of metal ores, though also treated as serious, has only a regional scope. In a worldwide culture in which local environmental risks are avoided, however, a world shortage is inevitable, since the reserves will then not be exploited, or not fully, because of environmental considerations. The costs of extraction could also rise because of the need to take all manner of environmental measures.

Under the Preserving scenario, the reserve potential must not exceed the carrying capacity of the environment. The extractable reserves of copper are therefore limited in this scenario to 750 million tonnes. As in the Saving scenario, the ratio between extraction and remaining reserves is set at a minimum of 50 years and the maximum achievable level of recycling at 75 per cent. The permissible sustainable per capita consumption resulting from this is shown in Figure 3.16.

Figure 3.16 **Maximum permissible per capita consumption in Preserving scenario**



Source: WRR.

Of the initial primary copper reserves of 750 million tonnes available for extraction in 1990 under the Preserving scenario, 250 million tonnes remain in 2040 and 80 million tonnes in 2090. The level of extraction in 1990 was 8.9 million tonnes. In this scenario the maximum permissible extraction in 2040 is 6.3. million tonnes and in 2090 2.1 million tonnes.

Summary of key figures

The main features of the scenarios are ranged against each other in Table 3.29. To aid a correct interpretation, it should be borne in mind that the maximum permissible consumption is given for the Saving and Preserving scenarios; this could imply a very abrupt modification of the level of recycling.

Table 3.29 Summary of scenario results

Unit: kg Cu per capita		Per capita consumption		Per capita recycling	
		North	South	North	South
Year:	2040				
	Reference	8.78	3.26		
	Utilizing	6.83	2.54	2.6	0.53
	Saving	7.40	2.80	6.27	1.05
	Managing	6.03	2.24	3.85	0.76
	Preserving	4.90	1.80	5.56	0.93
Year:	2090				
	Reference	8.97	7.59		
	Utilizing	5.43	4.60	2.94	2.03
	Saving	3.20	2.70	3.27	2.15
	Managing	4.22	3.57	3.87	2.68
	Preserving	1.70	1.40	1.81	1.19

Extraction
Unit: mln. tonnes Cu

Year:	1990	2040	2090
Utilizing	8.9	22.6	26.1
Saving	8.9	15.3	5.0
Managing	8.9	15.9	10.1
Preserving	8.9	6.3	2.1

Cumulative consumption for central population projection variant after 1990
Unit: mln. tonnes Cu

Year:	2040	2090
Utilizing	825	2200
Saving	875	1300
Managing	675	1400
Preserving	500	670

Source: WRR.

3.5.1.4 *Evaluation*

The cumulative consumption of primary copper exceeds the levels of what are currently regarded as economically extractable reserves in all scenarios, though to a considerably lesser extent than in the reference scenario. All scenarios therefore speculate on developments which lead to an increase in the economic reserves, mainly through improved extraction technology. This speculative nature of the scenarios is brought into sharper relief when it is borne in mind that all scenarios assume a rise - sometimes a very sharp rise - in the recycling of copper.

Each of the definitions of sustainability set out in the action perspectives therefore entails considerable adaptations on the supply side. In addition, changes in the demand for copper are also desirable. While the policy in this area is still in its infancy, it could enable a number of relatively painless successes to be achieved in the coming decades. Extending the environmental technology policy could have a positive effect, for example through the promotion of recycling.

The scenarios reveal that a high level of recycling help to moderate sharply rising extraction costs. The promotion of recycling can therefore be seen as an insurance against severe shortages. This promotion need not only take place through technology policy; the introduction of a policy-based residual value could also have a major positive impact on recycling, and is also desirable from the point of view of waste policy.

Substitution technology also deserves attention. There are real opportunities for substitution. For example, the use of copper is being concentrated more and more on the conduction of electricity, whereas the geologically much less scarce aluminium could also be used for this. Substitution of copper by aluminium is currently hampered on many fronts by a series of technical drawbacks. In many respects, therefore, this is an example of an insufficiently developed technology. Research aimed at increasing the usability of aluminium for electrical applications is potentially one of the greatest contributions to avoiding a severe shortage of copper. All scenarios of a sustainable society are based on the need for a declining per capita consumption of copper. This decrease will have to take place first in the developed economies and later also in the southern hemisphere. Only after the raw materials-intensive 'hump' in those countries has been passed, will there be scope for the per capita copper consumption to fall. There are different ways of reducing this consumption, for example through technology or via changes in consumer preferences.

The finite life of products creates a continuing substitution demand for raw materials. One way of stemming this demand is to increase the life of consumer durables. This could be achieved, for example, by protecting products more effectively against external influences which shorten the life or by intensifying maintenance and repair activities during the period of use. Low-maintenance product designs go some way to meeting this need. Institutional barriers which frequently stand in the way of the labour-intensive maintenance process could also be demolished. It is notable, for example, that the tax system leaves the discarding of raw materials relatively untaxed whilst taxing extensions to the period of use.

There are various other approaches aimed at increasing raw materials productivity. For example, the usage intensity of copper has a direct impact on its productivity. By raising the usage intensity of products containing copper, the usefulness of these products can be increased. Ways of increasing this intensity include measures designed to favour the use of consumer durables rather than the possession of them, for example through user pools or hire schemes.

Copper productivity can also be increased through material savings. Technological development makes it possible to perform the same function with less and less material. The trend towards miniaturisation is also of importance in this respect. Economic stimuli can also play a role in the implementation of material savings.

Finally, copper productivity can be increased by substituting copper with other materials. Known examples include the replacement of copper with aluminium in high-voltage cables and car radiators. Technological development in the substitution options is steadily reducing the use of copper to applications in which no alternatives are available or in which the alternatives lead to a higher cost price. A rise in the price of copper increases its marginal productivity.

Per capita use of raw materials can also be reduced through a policy aimed at changing consumer preferences. Such a change is generally the result of a response to changed scarcity ratios. It is also possible that changes in lifestyle, other than those arising from the demographic structure or income distribution, have an influence on the per capita consumption of copper. If this is the case, the possibility of trying to influence the choice of a particular lifestyle could be considered.

In contrast to energy, for example, a raw material such as copper is not consumed directly. The demand for copper is derived from the demand for goods and services for which the metal forms an input. A copper-saving policy driven by the price mechanism therefore has only an indirect influence on consumer preferences.

A policy focused on limiting leakages from the raw materials chain, in other words achieving the highest possible level of recycling, acts on two fronts. First, the returns on collection must be increased with a view to preventing the loss of copper-containing products for collections. In principle there are various ways of achieving this. A price stimulus in the form of a returns system is highly effective for some product groups. Secondly, the returns on recovery itself must also be increased; this is largely a technical issue; the product design must make recovery possible. Moreover, the processes used to recover raw materials can also be improved.

Such measures cannot be carried through in an isolated, national context. Technological developments are increasingly taking place on a global scale, and international coordination and collaboration are indispensable in this field. On the other hand, the removal of institutional barriers to facilitate recycling or extend or intensify the use of raw materials, for example, is more a matter for national policy initiatives.

3.5.2 Chlorine

3.5.2.1 *Introduction*

The pollution aspect of raw materials use is illustrated by chlorine and chlorine products. There are various reasons for devoting explicit attention to this raw material. The present-day affluence of modern economies is based to a large extent on chlorine, with roughly 60 per cent of consumer goods containing chlorine or made using a chlorine-dependent process. Examples include plastics (PVC), washing powder additives, non-stick coatings to frying pans, insulation materials, rainproof clothing, glues, medicines, herbicides and pesticides and compact discs.

Much attention has been devoted to chlorine in the environmental debate in recent decades. Chlorine compounds such as chlorofluorocarbons (CFCs) and substitutes such as HCFCs, chlorinated pesticides such as PCBs (polychlorobiphenyls), dioxins and furans, are important factors in the environmental issue. Household waste incineration plants located in Leeuwarden, Leiden and Zaanstad recently had to be closed because of unacceptable emissions of chlorinated dioxins.

There are many innocent chlorine compounds, the most important being common salt. In this section, however, the compounds that are harmful to the environment are the main topic of discussion.

3.5.2.2 *Environmental impact*

The production and consumption of goods involving the use of chlorine can have consequences for the environment. The production of chlorine is based mainly on the electrolysis - decomposition using electrical current - of salt.

Some electrolytic processes use environmentally harmful auxiliary substances such as mercury and asbestos. The production methods used in the Netherlands are relatively modern and clean, however: almost half the chlorine production takes place using membrane electrolysis. In addition many chlorine compounds have their own environmental impacts. Most of these problems have been known for some time.

Influence on biological and physical processes

Chlorine (in gaseous form) is of itself aggressive: low doses lead to irritation of mucous membranes and skin, while high doses are quickly lethal. Gaseous chlorine can form highly explosive mixtures with certain substances, such as hydrogen, acetylene, ammonia, phosphorous and powdered metals. Intensive sunlight is sometimes sufficient to ignite these mixtures. Its high reactivity means that chlorine rarely occurs in nature except in compounds, though heating chlorine-containing products can release gaseous chlorine and other chlorine compounds.

A number of organochlorine compounds are carcinogenic to humans and/or animals in the event of chronic exposure above a certain level; they may also encourage mutations or damage organs or systems in other ways. Some physical processes, such as the formation of the stratospheric ozone layer, also appear to be strongly influenced by the presence of chlorine. It is thought that only a few p.p.b.v. (parts per billion volume) of chlorine are sufficient to cause severe damage to the stratospheric ozone layer.

Persistence

Chlorine is a reactive element which bonds rapidly with almost all other elements and with itself. The strong intramolecular bonding means that many chlorine-containing compounds have a long life under practical conditions. This stability can be regarded as positive during the period of useful application, but can sometimes have an adverse effect during the remainder of the life of the compounds.

Cumulative behaviour

Several chlorine compounds are lipophilic, i.e. easily absorbed by animal and/or vegetable fats. This property, combined with the high persistence, can lead to accumulation in food chains. A well-known example of this is the insecticide DDT (dichlorodiphenyltrichloroethane). This substance has now been banned in many countries, though is still used in a number of places in the world. Even in countries where its use has been banned since the end of the 1970s, DDT is still present in the food chain. The concentrations fall only slowly: in animal fat tissue by roughly 6 per cent per year (half-life approximately 10 years) [54].

The use of persistent and cumulative chlorine compounds has been greatly reduced in recent years. This does not mean, however, that problems involving persistence and accumulation are completely a thing of the past. The chlorine compounds used today still give rise to some problems in this respect.

Transformation into harmful decay products

In addition to the stability, decomposition also creates problems in some cases. There are various examples of rapidly decaying and relatively harmless

54] For example, the content of DDT measured in eels (river Rhine) in 1991 averaged 20 g/kg product, and in cod liver (southern North Sea) 300 g/kg product. DDT is also found in mothers' milk (970 g/kg fat, 1986, West Germany); (Algemene Milieustatistiek ['General Environmental Statistics'], 1992, pp. 185-187; *Chlorine Dialogue Paper*, VCI, 1991, 15).

chlorine compounds which are converted into highly persistent and harmful decay products. Undesirable transformation plays an important part in several environmental problems involving chlorine. Examples include the photolithic decay of halogenated carbohydrates to form ozone-depleting halogen radicals. Another example is the conversion on combustion of virtually harmless chlorine compounds into dangerous chlorinated dibenzodioxins and dibenzofurans. Transformation into harmful substances is difficult to predict fully and usually occurs in environments over which there is virtually no control.

Increased susceptibility to disturbance

The susceptibility of biological and physical systems to external disturbances can be significantly increased by the presence of certain substances, and the same appears to apply for certain chlorine compounds. Examples include the increase in carcinogenity of benzopyrene in the presence of small and in themselves probably relatively harmless quantities of tetrachlorodioxin; the increased sensitivity of the ozone layer to aerosols in the presence of chlorine radicals; the greatly increased lethality of viral infections in seals in the presence of PCBs; and the immunotoxocological effects of dioxins in humans which can lead to higher susceptibility to disease. Combination effects such as those referred to above have a non-linear action, so that the total impact is greater than the sum of the individual effects. There is a great deal of uncertainty regarding all these combination effects.

Environmental effects such as those described above are not exclusively the result of industrial activities. Several halogen compounds synthesised by man also occur freely in nature, and the presence of natural organohalogens is in fact greater than originally thought. Moreover, harmful halogen compounds can also arise in non-industrial activities such as household waste incineration, the burning of fuel oil at sea, the burning of open fires and barbecues.

The use of chlorine compounds and production process involving the use of chlorine can thus cause environmental problems. On the other hand, they can also help to reduce environmental problems. For example, the high chemical reactivity and selectivity of chlorine have made it possible in a number of cases to save significant amounts of energy. Another example is the production of the paint pigment titanium dioxide, in which the transition from the sulphate process to the chlorine process has produced substantial environmental benefits such as a drastic reduction in the discharge of heavy metals and plaster and a fall in the amount of solid waste of more than 90 per cent.

In a number of cases the environmental effects of using chlorine has also been significantly mitigated. Over the last two decades, for example, substantial improvements have been made in the production of chlorine and chlorine compounds. This has led to a drastic reduction in the emission of harmful substances, with some companies cutting the discharge of chlorohydrocarbons into water by a factor of more than 100. A range of measures have also been introduced to further reduce the risk of accidents; in the production of PVC, for example, there was only one industrial accident in the whole world in the period 1970-1979, resulting in four victims; in the period 1980-1989 there was also one accident, this time with 17 deaths. The same applies to the transport of elementary chlorine. Chlorine is a highly reactive substance, but the efforts of various groups - chlorine safety groups and sector organisations, chlorine help agencies, railway organisations and public authorities - have reduced the transport risk to a very low level. Not a single accident has occurred in Western Europe during the large-scale transport of chlorine since the Second World War. Only 20 per cent of the total chlorine production in the highly industrialised North-western Europe and North America is transported between companies above ground - mainly using special block trains - and this fraction is falling further.

3.5.2.3 *Uncertainties*

There is almost universal agreement on the economic importance of chlorine. It would be difficult to do without chlorine as a raw material in the very short term. In time, however, substitution should not be impossible for the majority of applications. According to some observers there are already existing alternatives for many chlorine products, which would be perfectly capable of meeting the economic and technical requirements either now or after a certain amount of further development in the near future.

On the other hand, various groups also argue for a complete ban on chlorine. An integral chlorine policy would then have to be focused on finding substitutes for chlorine as quickly as possible or banning the use of chlorine as a raw material. This argument is justified on the basis of the major risks associated with the use of this raw material.

And yet there are still considerable uncertainties regarding the precise environmental effects of chlorine compounds. Little is known, for example, about the actual harmful effects of the present generation of organochlorine pesticides on flora and fauna and about their possible ecological consequences.

The use of chlorofluorocarbons (CFCs) will cease in a few years' time under international agreements on their rapid elimination. Nevertheless, the role played by CFCs in the creation of the Antarctic hole in the ozone layer and the depletion of stratospheric ozone elsewhere in the world has still not been fully proven. There are probably also other causes, and there is still uncertainty regarding the reinforcing effect of aerosols, for example those originating from volcano eruptions.

Several chlorinated dioxins and furans are known with great certainty to be extremely harmful in high doses. There is once again great uncertainty regarding the effects of chronic exposure of humans to low doses, however. It is particularly difficult to provide evidence based on epidemiological grounds. The great variation between animal species means that results obtained with test animals cannot simply be assumed to apply to humans as well. Statements regarding risks and uncertainties also demand far-reaching differentiation in forms of production and application. This is a totally different situation than for a raw material such as copper, where the problems can be indicated with relative ease, such as scarcity - although the future scale of this scarcity is also surrounded by uncertainty - and the environmental consequences of extraction.

Given the many applications of chlorine and the great differences in environmental consequences, there is little point in drawing up a reference scenario for chlorine. Instead, a description has simply been given of possible action perspectives which estimate the risks of production and consumption for the environment and society. There has also been no translation of these action perspectives into scenarios, since this is only useful when carried out for each specific application.

Notwithstanding these limitations, there are extremely good reasons for including chlorine in this report. Presentation of the action perspectives is important since it enables an indication to be given of how great the uncertainty is and illustrates the complexity of the considerations which play a role in sustainability. The public debate is marked by a polarisation for and against chlorine. The existence of a more differentiated picture can perhaps break through this simplification.

3.5.2.4 *Action perspectives*

The description takes account of the above differences between chlorine products. Since a complete description of all important activities or products involving chlorine is impossible, the discussion of the various perspectives focuses on the following issues: production and transport, PVC, pesticides, CFC substitutes and PCBs.

Table 3.30 Four action perspectives for sustainable use of chlorine

	High consumption	Low consumption
Careful management	Utilizing: 'More with chlorine'	Saving: 'Frugal with chlorine'
Transition to alternatives	Managing: 'Alternatives for chlorine'	Preserving: 'Avoiding chlorine'

Source: WRR.

Utilizing

The Utilizing action perspective assumes a high capacity of the environment to recover, a high optimising capacity on the part of the market, a high problem-solving capacity for technology and a high capacity to adapt on the part of humans. On the basis of these assumptions, there is no need for excessive anxiety in the interaction with nature. It is unnecessary constantly to aim for zero emission levels. When formulating norms, account should be taken of the natural background levels of harmful substances, while the relative importance of the risk must be kept in view. A 'trial-and-error' approach, with rapid corrective action where necessary, can keep the problems within bounds.

The Utilizing perspective puts great faith in technical production and transport solutions for achieving acceptable environmental risk levels. The improvements achieved in this respect in the recent past illustrate the feasibility of this view. The restructuring and industrialisation of Eastern Europe and Asia will lead to an expansion of the chlorine industry in those countries. In order to keep the accompanying risks within reasonable limits, it is very important that the environmental protection measures taken by the chlorine industry in the West should also be applied there. Investments by Western industry and targeted exchange of knowledge can make important contributions to this aim.

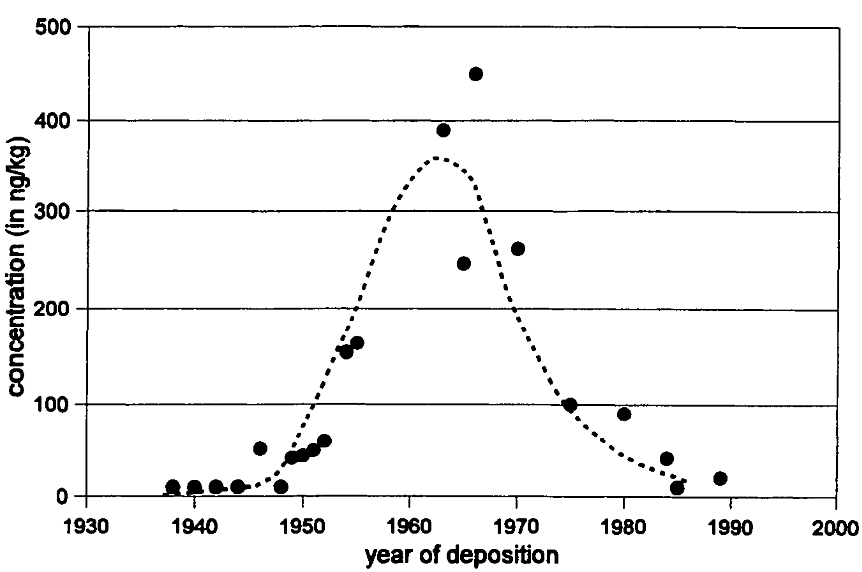
PVC is regarded in the Utilizing perspective as a particularly durable plastic which, if used carefully, is also highly environmentally friendly. When mixed with certain additives, PVC is resistant to many forms of attack and can be used for a broad spectrum of applications. It also has a good price/performance ratio. The production processes are advanced and meet stringent emission standards. Production in large plants facilitates optimum energy efficiency.

Careful management of PVC demands the use of modern production techniques, the careful collection of PVC waste, polymer recycling of the high-grade waste fractions and monomer recycling or advanced combustion with recovery of energy and hydrochloric acid in the case of the low-grade fractions. Better additives need to be developed for certain applications. The introduction of new PVC formulations must allow for recycling. The recycling of PVC requires not only technical solutions; further measures also need to be taken on the logistical front and a sufficiently large and reliable market needs to be created.

Although broadly speaking chlorine-containing pesticides have greatly improved in recent decades, the Utilizing perspective recognises that the control of disease and plagues, with whatever agent, can give rise to problems. For the time being, however, pesticides and herbicides are a necessary evil in a world where many people have to be fed and a healthy life must be assured. Expansion of the use of chlorine-containing pesticides and herbicides therefore appears likely. Large-scale exports of chlorine-containing agents which are banned in the Netherlands still take place to developing countries. The inherent open use of pesticides and herbicides, i.e. a form of use in which the substances are freely released into the environment, threatens to increase particularly in the southern hemisphere, where highly stable, broad-spectrum and highly toxic agents are still used.

Chlorofluorocarbon compounds (CFCs) have made a major contribution to prosperity and welfare. For example, chlorine-containing refrigerants have made a great contribution to improving the health status of humans. They have reduced the deterioration of foods and led to a more sustainable use of agricultural products. Although the causal link has still not been proven, the risk of depletion of the ozone layer is not imaginary and, given the nature and scale of the potential consequences, the necessary decrees to substitute CFCs were drafted rapidly, a reflection of the flexibility with which such developments can occur. HCFCs and HFCs are good substitutes for the majority of applications. They facilitate a rapid reduction in the use of CFCs and make it easier to achieve an orderly transition to other substitution techniques. Hindering the use of H(C)FCs leads to delays in the reduction of CFC use, with all the concomitant adverse environmental consequences. The majority of H(C)FCs have been subjected to extensive toxicological tests and do not appear to carry the risks of some other substitutes. They also often score from an energy point of view. Several H(C)FCs are of the 'drop-in' type, while a number of other substitutes require completely different capital goods and products. This could lead to an unsustainable waste of capital and materials.

Figure 3.17 **The result of a careful approach: strongly reducing concentrations of dioxin (Rhine mud deposited in the Ketelmeer lake)**



Source: J.E.M. Beurskens et al., 'Geochronology of priority pollutants in a sedimental area of the Rhine river', *Environmental Toxicology and Chemistry*, Vol. 12, December 1993, 1549-1566.

The Utilizing action perspective is based on the observation that more and more indications are emerging that the problems of chlorinated dioxins and the related furans have been exaggerated in the past. While it is true that they are harmful substances, they are less harmful to humans than was at first feared. Among inhabitants of Seveso, who have been exposed to high doses of 2,3,7,8-TCDD (up to 27 ppb in serum) since 1976, the only health effect which has been unambiguously demonstrated is chlorine acne.

The indications referred to above allow a certain amount of scope in the exposure to dioxins. There is therefore no need to aim for a zero standard in this action perspective. Improvement of process conditions during waste incineration, in the paper and metal industries, during the production of chlorinated aromatic compounds and in transport methods can enable the emission of dioxins to be reduced to a sufficiently low level. An emission of 0.1 mg I-TEQ/m^3 during incineration is quite acceptable from the point of view of sustainability. This very low emission level is also an illustration of what careful management of chlorine-containing processes can achieve in a short span of time.

Saving

The Saving action perspective supports careful management and frugal consumption on the basis of the environmental risks. Little faith is placed in alternatives: these have their own disadvantages and tend to do no more than displace the problems. Moreover, many of the drawbacks of alternatives will only become apparent at a later stage. Incidental successes with chlorine-free alternatives must not be generalised too quickly.

The proper deployment of management technology, combined with a commitment to completeness of licences, heavy sanctions for the exceeding of norms, stringent standards and the perfecting of inspection systems can considerably improve chlorine-containing processes. Process integration can minimise the transport of chlorine or harmful derivatives. The fact that the Netherlands is an international leader as regards such measures is not seen as problematic. The economic risks of taking strong action in the form of additional costs for greater care or compulsory cessation of activities due to a deteriorated competitive position simply have to be accepted.

However important careful management is, however, it is not sufficient to reduce the environmental risks sufficiently, and demand for various chlorine compounds therefore has to be reduced strongly.

There is no commitment to substitution of PVC. Many PVC alternatives have an inferior technical quality and often tend simply to push the problems to a different environmental compartment. Optimum use of the possibilities for careful management is safer, produces more rapid results and is a greater acknowledgement of the sustainable nature of some PVC applications. Careful management of PVC in terms of production, recycling and incineration also has its limits, however. Moreover, there is a risk that increasing care will reduce the environmental impact of PVC, but will increase the damage caused by the management techniques. The resulting environmental impact will therefore be equally high even with optimum care. A more frugal and selective consumption of PVC is therefore essential. In particular, the use of short-cycle PVC can be substantially reduced.

Careful management of existing control systems, such as elimination of undesirable by-products, removal of harmful optic isomers, elimination of overdoses, better formulations, delivery systems and cultivation measures are necessary in the context of sustainability, as is a responsible introduction of alternative methods, including integrated forms of control. Frugal consumption of pesticide-intensive goods - frugal in relation to the average consumption in the Western World - is an absolute necessity. Crops, and in particular crop systems, which require relatively large amounts of pesticide or which score badly in some other way on an ecological front, must be avoided.

The rapid reduction in the emission of volatile chlorofluorocarbon compounds and other compounds which attack the ozone layer is a good thing, although it could have taken place earlier. Accordingly, the supplies of CFCs which are still on the market are recovered in this action perspective. Where there is a small risk of leakage, these products are recycled or else processed or incinerated in an environmentally-friendly way. Alternatives must first be thoroughly studied for potential ecological damage before they are introduced. This applies not only to H(C)FCs, but also to other substitutes which have been around for longer. Where no harmless alternatives are yet available, or where closed use of chlorine-containing substances such as (H)CFCs is impossible, attempts will initially have to be geared to frugal consumption levels.

Dioxins are an unavoidable result of the use of chlorine in society, although there are also natural sources. Human activity has led to a more than tenfold increase in the presence of chlorinated dioxins since the Second World War, though the use of management technology has led to a sharp fall in this 'anthropogenic' emission in recent years. This management strategy must be pursued further. There are a great many sources of dioxins which are probably not yet fully known, however. Total care therefore appears a needlessly complex and expensive matter. It is more sensible to avoid as far as possible activities which can produce relatively large quantities of dioxins or their precursors. The loss in affluence which will accompany this will not be great and, where it occurs, must be accepted.

Managing

The Managing action perspective supports the use of a strategy of care. In the case of chlorine, such a strategy is regarded as suboptimal. A better allocation of resources can be achieved through the use of chlorine-free alternatives.

Pressure from environmental groups, consumers and governments has led to substantial improvements in the production of chlorine and chlorine products, although these improvements are regarded as still inadequate. More than once, emission reductions have in reality entailed no more than a shift between different environmental compartments, for example from water to soil. In contrast to Utilizing, the Managing perspective is not based on 'ideal' situations, because emissions vary widely from company to company and from country to country. Even modern economies are still frequently plagued by exceeding of norms, incompleteness of licences, inadequate sanctions in the case of infringements and subjective measurement and inspection methods. In many cases the licences for the emission of harmful substances are too flexible and are based more on economic than ecological interests. There is still a risk of serious calamities in the production and transport of chlorine. The risks must not be measured exclusively in terms of the number of deaths over the course of time. A transport fraction of 20 per cent of the total quantity of chlorine produced means that 2 megatons (2,000,000,000 kg) of highly reactive chlorine is still transported each year by road and rail. According to this action perspective, therefore, further measures are necessary.

The production of the basic materials EDC and VCM and of various additives are still beset by problems. Emissions of hydrocarbons are still fairly high and in a number of cases are not well documented. The production waste which has to be dumped also contains harmful substances. The production and use of PVC formulations leads to the dispersion of additives in the environment, while several of these substances have not yet been convincingly proven to be ecologically harmless. High-grade recycling of PVC is possible only to a limited extent. In thermal recycling, i.e. incineration with recovery of energy, PVC has an energy disadvantage compared to most other bulk plastics. Moreover, PVC produces large quantities of acid, and this produces problems during incineration. The polluted fly ash and sludge create an environmental problem. Reasonably good substitutes are available for the majority of PVC applications, however, thus raising the question of why risks are still run.

Sustainable management of chlorine-containing pesticides is not always easy to achieve in practice. Their use is too open, too dispersed and too difficult to monitor. Model situations are also not an adequate reflection of the practical situation. The concentrations of pesticides in surface water very frequently exceed the established norms many times over. Extremely harmful chlorine-containing agents are banned in some areas, but are still used. Even the agents which are now permitted often show too little selectivity, inadequate biodegradability, excessive mobility between environmental compartments and/or excessive capacity to build resistance. Predominantly chemical pest control is not only hedged around with ecological problems, but gradually also encounters economic problems. Other forms of control, such as cultivation measures and mechanical, thermal and biological/biotechnological control methods, are necessary. The open use of chlorine-containing and other chemical pesticides must be restricted.

Table 3.31 **Substitutes for PVC**

Construction	
frames	softwood, polypropylene (pp), nylon, polyester
blinds	wood
light fittings	pmma (polymethyl methacrylate)*, epoxy*polyester, polycarbonate*, glass
roof covering	bitumen, tar, ecb (a copolymer of ethylene and bitumen), polyisobutene, ethyl vinyl alcohol, butyl rubber, pdm (ethylene propylene diene rubber), wall cladding panels based on melamine resin, polyester, pmma*
glasshouses	glass, polyethylene (pe), pet, ethylene vinyl acetate
gutters, rain pipes, drainpipes	polyethylene, polypropylene, certain metals, polyester, cellulose acetate, polybutene
drinking water pipes	polyethylene, polybutene, steel, copper, reinforced concrete, cast iron
drainage and sewage pipes	polythene, nylon, polypropene, polyester, polybutene, concrete
gas pipes	steel, polyethene
Interior layout	
floor covering	wood, linoleum, stone, rubber, nylon, cork, jute
wall covering/wallpaper	paper, wood with melamine resin
doors	wood, steel
sections	rubber sections
curtain rails	metal, wood
bathroom interior	pet, pmma*, pp, pe, cotton
furniture	leather, wood, linen, cotton, certain metals, nylon, pmma*, pet, copolymer butadiene/nylon
Electricity/cables	
cable protection	pe, steel
cable sheaths, cable insulation	rubber, pe, ethylene vinyl acetate, nylon
electrical conduits	pe, pp, nylon
sockets, etc.	polybutene, pp
appliances	polycarbonate*, polyester, pp
Other	
packaging	paper, cardboard, glass, pet, pe, pp
garden hoses	rubber, pe, pp
tarpaulin sheets	polyester, nylon, cotton
infusion/transfusion material	ethylene vinyl acetate, copolymer, pp, glass, pe, pet, nylon
films for swimming pools, dumps, banks, etc.	pe-film, copolymer of bitumen and ethylene, polyisobutyl, bitumen

* if manufactured chlorine-free

Source: W. Berends and D. Stoppelenburg, *Van keukenzout tot gifcocktail* (From common salt to poisoned cocktail), Vereniging Milieudefensie, 1990.

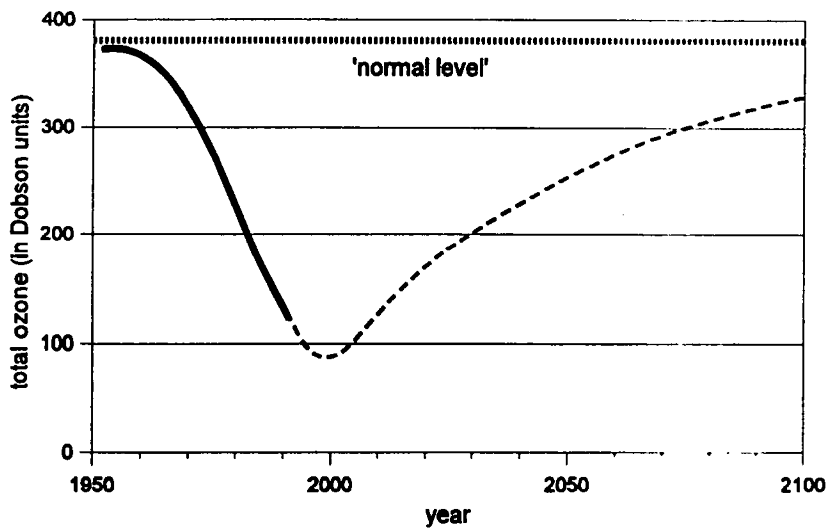
The causal link between the presence of chlorine in the atmosphere and the breakdown of the stratospheric ozone layer is regarded as virtually proven. The Antarctic hole in the ozone layer is becoming rapidly deeper, and the ozone layer is becoming visibly thinner in other regions too. The vulnerability of the ozone layer to aerosols or other pollutants has greatly increased due to the presence of chlorine. The internationally agreed rapid reduction in the manufacture of CFCs is absolutely essential, even though it could and should have been set in motion much earlier. It is therefore of prime importance to include the nations in the southern hemisphere in these global agreements. The slow reactions mean that it will be necessary to live with considerable depletion of the ozone layer in the next century. The emission of other ozone-displacing substances must also be reduced as quickly as possible. Obvious substitutes such as H(C)FCs should be used with caution and should be limited to applications which are of vital importance to society and for which there are no alternatives. The use of H(C)FCs has the disadvantage that transition costs have to be paid twice: once on their introduction and again during the envisaged replacement early in the next century. In many cases it is possible to avoid the use of H(C)FCs. Experience in recent years has shown that in many areas alternatives offer more possibilities than was first thought. The recent indications that dioxins are less harmful in low doses than was originally thought must be treated with caution; there are also indications that dioxins are more harmful than first thought. On the basis of the currently available factual data, a few practical conclusions can be drawn, particularly as regards the scope for exposure. The current level of exposure of humans is close to the limit which can just be regarded as safe according to the new insights. Given the serious problems caused by higher doses, which have been established with great certainty, no risks can be taken. Careful process management under normal conditions cannot always prevent major emissions of dioxins in the event of disasters. Production processes which on investigation are found to pose a significant risk of the formation of dioxins must be avoided as far as possible.

Preserving

In a sustainable society according to the Preserving action perspective there is no room for open use of synthetic chlorine compounds. The risk is too great and the manageability of chlorine-containing product chains too small. Chlorine compounds always have a tendency to accumulate and to break down into harmful decay products. The opportunities to respond afterwards are too small, not least because of major technical, economic and social delays. Reference can be made to the deepening and continued existence until well into the next century of the hole in the ozone layer, the now irreversible long-term leaching of pesticides into the groundwater and the presence, about which virtually nothing can now be done in the short term, of highly stable organochlorine compounds in chemical waste dumps and other, less sharply localised, deposits. Organochlorine compounds are found in polar bears at the North Pole and in penguins at the South Pole. Apart from the fact that many chlorine compounds are of themselves directly harmful, they also increase the susceptibility of physical and biological systems to other disrupting factors. The increased susceptibility of the stratosphere to volcanic eruptions and the cancer-promoting effects in animals are examples of this. It is high time that open use of synthetic chlorine compounds - in particular the organic compounds - was rapidly reduced. According to the Preserving action perspective there is only one way of achieving this, namely a restructuring of the chlorine industry. The improvements which have been made to the chlorine-containing production systems are more an indication of what was wrong in the past than what is right now. The environmental problems resulting from production and transport have been played down too much. The risk of disasters is greater than suggested in the Utilizing perspective, for example. In addition to directly demonstrable effects, there is a much larger group of people after a disaster who have a fear of later effects. This 'welfare loss' should be taken into account according to this action perspective. Even normal discharges such as those of inorganic chlorides have adverse effects, in that they lead to substantial water pollution in a number of locations. In several cases a much greater reduction in the discharge of harmful substances and an increase in safety is necessary in order to achieve a sustainable situation. The efforts needed for this are likely to be great, whereas the effectiveness of the measures is not guaranteed. It would in many cases be more sensible, safer and more economical to switch to chlorine-free processes and products.

Environmentally-friendly production, incineration and recycling of PVC has not yet been achieved, in spite of all the efforts and progress made. The production of carcinogenic vinyl chloride and other substances which are needed for PVC formulations are not yet entirely problem-free. Recycling companies generally face difficulties. The presence of chlorine in PVC creates problems both during recycling and incineration, and these push up prices markedly. Despite all the attempts, integral chain management has still not been achieved. Reasonably good substitutes are available for many PVC applications; in some cases these substitutes have a technical disadvantage, but this must be accepted for the time being. The ecological - and in due course the macro-economic - advantages of avoiding PVC are considered greater than this drawback.

Figure 3.18 **CFC use: a hole in the ozone layer until well into the next century**



Source: WRR, based on data from M.J. Prather and R.T. Watson, 'Stratospheric ozone depletion and future levels of atmospheric chlorine and bromine', *Nature*, Vol. 344, 19 April 1990, and S. Solomon, 'Progress towards a quantitative understanding of Antarctic ozone depletion'; *Nature*, Vol. 347, 27 September 1990

Pesticides are causing more and more damage to humans and animals. Accumulation and leakage to other environmental compartments is building up a substantial inheritance for future generations. Soil-bound residues - sometimes amounting to as much as 60 per cent of the consumption - are often highly persistent (100 years) and have the character of a time-bomb. The number of annual victims of inadequate safety measures and 'occupational accidents' is high. The concentration of pesticides in surface water exceeds the permitted norms by a large margin; in the case of dichlorvos, for example, these norms are very frequently exceeded by a factor of almost 100,000.

Drinking water also contains excessive amounts of pesticides. It is of great importance to switch to more environmentally-friendly alternatives quickly. The 'welfare loss' which this could initially cause in the Third World must be compensated by the wealthy nations.

Global estimates suggest that a reduction in the stratospheric ozone layer of 8 per cent would lead to around 2 million additional cases of cancer annually throughout the world. There are also many other serious effects. Less mobile organisms, in particular, such as plants and algae, will be greatly affected by increasing UV radiation. Rapid reduction on a world scale of all halogen compounds which contribute to the depletion of the ozone layer - in addition to CFCs, for example also tetrachlorocarbons, methyl chloroform (solvent) and methyl bromide (pesticide) - is therefore considered an absolute necessity in this action perspective. Rich countries must support the less wealthy nations in eliminating chlorine compounds. Available alternatives must be quickly deployed throughout the world.

Exposure to high doses of chlorinated dioxins affects the skin (chlorine acne, keratosis, abnormal hair growth), the organs (damage to the liver, pancreas, kidneys, heart), the immune system (damage to T-lymphocytes), the hormone metabolism, the reproductive functions, the nervous system and the cell division process (cancer-promoting and cancer-initiating). Little is known with any certainty regarding the harmfulness at low doses, but no risks can be taken. Question marks can be placed alongside the present norm. Exposure to low doses probably increases the susceptibility to other harmful substances and to many diseases. The total emission of dioxins is only a general indicator of the seriousness of the dioxin problem. A differentiated spread of dioxins poses the danger that deviating consumption behaviour will be punished by a much too high exposure level. From the point of view of sustainability, the exposure of the most sensitive useful organism should be examined. Animals of prey at the end of the food chain are at particular risk. The presence of harmful substances such as dioxins and furans must be reduced further, and the same applies for their precursors. This action perspective therefore demands great caution regarding the open use of chlorine-containing products.

3.5.2.5 *Evaluation*

All perspectives for chlorine involve acting in a state of uncertainty and thus involve risks both for the environment and society. The estimation of these risks is beset by major uncertainties, however, and is greatly affected by differences in perception. The necessity this sometimes involves of evaluating an extremely complex set of factors is also indicated by Udo de Haes, for example [55]. According to him, the commitment to a chlorine-free economy means new methods of extracting sodium hydroxide have to be found, because this substance is recovered from common salt together with chlorine. There are a number of alternatives to sodium hydroxide, but according to Udo de Haes these would involve serious erosion of the natural environment and landscape. From an environmental point of view, therefore, the extraction of sodium hydroxide in combination with chlorine applied in long-cycle PVC appears to be a preferable alternative.

Simple preference charts evidently run into problems fairly quickly with a substance as complex as chlorine. Each of the action perspectives places a different emphasis on the various aspects of the problem and thus arrives at different estimations of the possibilities. In the Utilizing perspective, for

55) H.A. Udo de Haes, *Zijn alle ketens te sluiten?* (Can all chains be closed?), inaugural lecture, State University of Leiden, 1994.

example, great faith is placed in the capacity of management technology to protect the environment and on the operation of market forces. The perspectives which are based on targeted frugality of use place heavy demands on the social and political willingness to do this. It is not certain that only social risks are at stake here; a reduction in prosperity could lead to a situation in which the environment also suffers serious damage.

Working from a given perspective and the associated estimation of the uncertainties, a global opinion can be given of the other perspectives. Seen from the Utilizing perspective, other perspectives are accused of taking insufficient account of the social and ecological advantages of chlorine compounds, of underestimating the economic damage which would result from a rapid abolition of chlorine compounds and of underestimating the economic, technical and ecological disadvantages of alternatives. In the Managing perspective, by contrast, the view holds that other perspectives overestimate the opportunities for modification in the present chlorine chemical industry and underestimate the economic costs, while the economic and ecological contribution of alternatives is placed too far in the future.

There is also a good deal of uncertainty regarding the costs associated with the perspectives outlined. The Utilizing perspective appears most in line with present trends and could therefore score well in terms of modification costs. There are other costs as well, however, for example for monitoring and control. Although chlorine has some very innocent applications, there is no escaping the fact that chlorine compounds break down into harmful decay products. CFCs are substances which are chemically virtually inert under normal conditions and which have a very low toxicity. Photolithic decay of these compounds in the stratosphere, however, presents society with a bill which is not inconsiderable.

It is unclear how high the total costs of controlling the many chlorine compounds and applications will be. 800 million dollars have already been spent in the United States on research into the harmfulness of polychlorodioxins, and yet their harmfulness at low doses is still unknown. On the basis of the present level of knowledge it is difficult to present an objective breakdown of the costs of the different perspectives.

Chlorine compounds exhibit great differences, and any policy will have to take these differences into account. An environment policy which concentrates exclusively and without any distinction on the use of the element chlorine is of little use. A policy which is geared to chlorine as an important area for attention and which recognises differences and correspondences between chlorine compounds and applications, and which if necessary seeks to achieve a reduction in the use of individual compounds or (large) groups of compounds, is more useful.

3.6 Water

3.6.1 Introduction

The availability of sufficient water of good quality is an essential condition for a sustainable society. Water is not only an elementary raw material for life itself, but also plays an important role in all manner of specific activities, such as hygiene, cooling, heating and recreation. At least as important is the significance of adequate clean water for the continued existence of the natural environment and landscape.

It is far from self-evident, however, that there is sufficient water in a quantitative and qualitative sense. The water supply is supplemented and refreshed naturally on a regional level. If this replenishment is not sufficient or if the water is of a poor quality for any number of reasons, shortages can arise. In contrast to energy, raw materials or products in which water is itself a raw material, water cannot be easily traded across the world. The problem of the quantitative and qualitative water supply for man and nature is thus a fluvial and regional matter.

Regional and fluvial problems can occur all over the world. Section 3.2 looked at the need for water for irrigation to safeguard the world, continental and regional food supply. The fluvial aspect can be dealt with more specifically; by way of example, the analysis in this section is restricted to the water supply in the Netherlands, one of the most water-rich countries in the world.

Many will find it strange that reports regularly appear in the Netherlands warning of threats to nature as a result of drought. This is reinforced by alarm calls signalling a deterioration of the water quality so severe that the drinking water supply is in danger and that it may be necessary to restrict the consumption of water. Both the quantity and the quality of water in the Netherlands can thus apparently be an obstacle to sustainable development. In order to investigate this a number of relevant facts and possible future trends in relation to the Dutch water supply is first presented below. Attention is then turned to a number of potentially more sustainable ways of meeting the demand for drinking water in the future [56].

3.6.2 A few facts

The Dutch water supply is based on groundwater and surface water taken from the fluvial basins of the Rhine and Maas rivers. The total quantity of water coming from rivers and precipitation is so great that, quantitatively speaking, the Netherlands by definition has a water surplus and should be capable of meeting its water needs *ad infinitum*, assuming no drastic climatological changes occur. Given the required quality, mains water is generally produced from groundwater. The Maas and Rhine rivers, as untreated water sources, each provide one-sixth of the mains water supply.

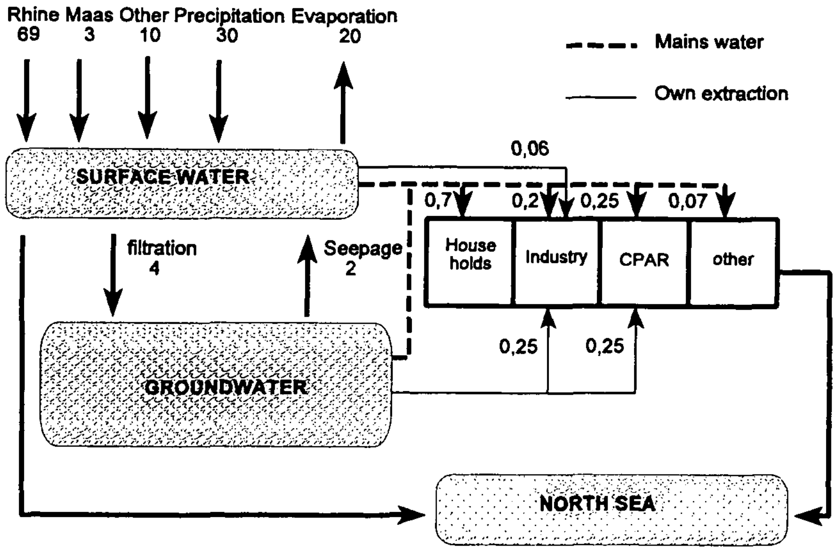
Water consumption in the Netherlands has risen in all sectors in recent years. Although the quantity of water used by industry per unit product has been declining for some years, industrial water consumption is increasing on balance because of the growth in total industrial production. In the agricultural sector some 200 million m^3 of groundwater are now consumed annually for irrigation. Domestic water consumption has also increased considerably due to an increase in the number of households and rising prosperity.

In order to be able to form an opinion of the water quality, standards are needed. In this section, the standards drawn up by the International Rhine Commission (IRC-91) have been taken as a criterion for testing the quality of the surface water. These standards are based on three principles:

- it must be possible to provide a drinking water supply using simple treatment technology;
- aquatic life must be protected. Salmon must return to the Rhine. The standards apply as NOEC values (no observed effect concentration);
- the sediment must be protected (e.g. no harmful consequences for other organisms living in the underwater bed).

[56] The data for this section are taken from J. Dogterom and P.H.L. Buijs, *Duurzaam watergebruik in Nederland* (Sustainable wateruse in the Netherlands), The Hague, W80, 1994.

Figure 3.19 **Water balance in the Netherlands in 1986 (km³)**



Source: WRR, based on J. Dogterom and P.H.L. Buijs, *Duurzaam watergebruik in Nederland* (Sustainable water-use in the Netherlands), The Hague, W80, 1994

The location of the Netherlands at the mouth of the Rhine and Maas determines not only the quantity but, in particular, the quality of the surface water. Much of the pollution of the Dutch surface water is imported. The quality of the water in the IJsselmeer lake, for example, is virtually the same as the quality of the Rhine water at Lobith in Germany. Although the industrial activity in the Rijnmond region around the mouth of the Rhine adds to the pollution of the river, the consequences of this pollution, given the location of this industry at the mouth of the river, are not directly reflected in the surface water quality figures - though the potentially harmful consequences for the North Sea are no less for this. There are internationally recognised standards for water quality. In 1990, all IRC standards for nutrients, metals and organic micro-compounds were exceeded in the Rhine [57].

The pollution of the Maas increases on its course through the Netherlands due to the addition of substances such as nitrate- nitrite-N, N-total, nickel, lead and pesticides. The quality of the Maas water has shown both improvements and deteriorations over the last five years. On balance, the Maas meets only the standard for chloride; for all other parameters the standard is exceeded. The lack of a treaty on the Maas is a serious obstacle to the cleaning up of this river.

The only data on other surface waters relate to the total phosphate and total chloride contents. For chloride, 30 per cent of the measurement points exceed the standard; around 80 per cent of the measurement points fail to meet the standard for total phosphate. Standards for a large number of pesticides are also exceeded.

The pollution of the surface water with nutrients, metals, organic micro-pollutants and pesticides has a considerable adverse impact on important natural features. The polluted water beds already pose a major problem, as does the eutrophication of the North Sea and the Wadden Sea.

57) J. Dogterom and P.H.L. Buijs, op. cit.

The *groundwater quality* was assessed on the basis of the guide values for surface water as contained in the 1984 Water Supply Act. For aluminium and potassium the limit values from the Act have been adopted, since this is regarded as desirable for the safe production of mains water. The National Institute for Public Health and Environmental Protection (RIVM) measures the quality of the groundwater at three levels: the highest level (0-1 m) is important for specific natural features and public health risks; the lower levels (5-15 m and 15-35 m) are important for mains water production and/or the seepage of this water into natural areas.

Pollution of groundwater takes place because polluted surface water and soil pollution are able to penetrate to the groundwater. In the uppermost level of groundwater the Water Supply Act guide value for nitrate is exceeded many times over, particularly beneath grassland and arable farmland in sandy areas but also in clay and loamy regions. Potassium concentrations beneath sandy soils also exceed the Water Supply Act limit values several times over. Total P-levels have so far remained below the guide value, though the buffer capacity for phosphate has virtually reached 0 in a number of regions. The guide values for the metals zinc, cadmium and copper are also frequently exceeded, while between 21 and 35 pesticides are found in groundwater in concentrations which are too high according to the applicable norms.

At a depth of 10 metres the present guide values for nitrate and the limit value for potassium are exceeded beneath arable land on sandy soil. No exceeding of the norm has been found for total phosphorous. The guide values for cadmium, zinc, copper and aluminium are exceeded many times over beneath arable land and natural/wooded areas on sandy soils. A large number of pesticides are also found in excessive concentrations.

All this pollution means that the groundwater in mains water extraction sites does not always meet the currently applicable standards; around 5 per cent of the annual supply has too high a nitrate concentration, for example. Moreover, pesticides are being found more and more frequently at deeper extraction sites.

3.6.3 Reference scenario

In order to gain an impression of the future water supply situation in the Netherlands, a scenario was drawn up of the likely development in the demand for water and water quality if existing trends continue. It was assumed that measures already taken and announced on the basis of current policy objectives are effective. On the basis of present and forecast demand, an organic growth in water consumption is assumed of 1.7 per cent per annum up to the year 2020 [58]. For the period 2020 to 2040 it is assumed that domestic water consumption will remain constant. Although this is an arbitrary choice, it can be defended on the basis of the stabilisation and potential fall in the population. For industry and the CPAR sector (commercial, public, agricultural and recreational water supply), an annual growth of 1 per cent is assumed, a levelling off possibly due to more efficient water use. A fixed figure of 200 million m^3 is assumed for agricultural irrigation. The standard for the quantity of water to be extracted fits in with present policy, and it is assumed that no further damage to important natural features can be accepted as a result of a fall in the groundwater level. No quantitative norm has been

58] RIVM, *Toekomstige woterbehoefte in Nederland: trendscenario 1986-2020* (Future water demand in the Netherlands: trend scenario 1986-2020), RIVM report no. 738906001, Bilthoven, 1989.
Waterloopkundig Laboratorium, *Water als vernieuwbare bron: thema verspilling* (Water as a renewable source: wastage), WL-report T913, Delft, 1992.

defined for consumption of surface water, since there is sufficient surface water available to meet the needs without endangering other water functions.

On the basis of these assumptions, total consumption of both freshwater and groundwater can be expected to double over the next 50 years compared to 1986. If water consumption in the Netherlands continues in line with the present trend, a substantial demand will be placed on the groundwater stocks. If present policy remains unchanged, the need for groundwater for mains water production will exceed the total estimated annual replenishment of the groundwater stocks - 2,000 million m^3/year - even before 2020.

Notwithstanding the measures announced - which in the scenario are presumed to be successful - the development in the quality of groundwater and surface water over the next 50 years offers no grounds for optimism. Although the IRC norms have been accepted as targets by the countries through which the Rhine and Maas flow, it is unlikely that the water quality in these rivers will improve sufficiently to meet these standards. The RIVM, for example, concludes that large parts of the surface water in the Netherlands will still not meet the IRC norms for nitrogen and phosphate after the year 2010. Much of the pollution of the rivers comes from abroad, though the agricultural sector also contributes. The concentrations of adsorbed metals and of at least five pesticides are also expected to remain high.

The same picture is expected with regard to groundwater quality. The RIVM estimates in a worst-case scenario that the Water Supply Act guide value for nitrate will be exceeded at 33 extraction sites in the year 2000 and at 46 sites by the year 2050.

All in all, the conclusion is that the effect of measures taken and announced is insufficient to enable the government's present objectives to be achieved. According to the present objectives, the surface water contains excessive concentrations of nitrate, metals, pesticides and organic micro-pollutants. As a result, important natural features will be insufficiently able to recover and/or will deteriorate further, the water beds will remain polluted and the eutrophication of the North Sea and the Wadden Sea will not decrease. There is also a danger that the groundwater in many places will continue to contain excessive concentrations of nitrate, pesticides and metals and will thus fail to meet the quality targets for mains water production. This means that a large number of the groundwater wells will be threatened with closure. Water companies therefore need to monitor water quality on a permanent basis and to apply ever more advanced and expensive chemical and physical treatment techniques. The combination of the prevailing quality requirements and the quantitative demand for water thus places very great pressure on the Dutch water system.

3.6.4 Uncertainties

Water quality is determined largely on the basis of standards which indicate the maximum permitted concentrations of a large number of physical and chemical parameters in groundwater or surface water. This approach enables present or future deviations from the norms to be observed, though the price of this for the quality of the environment is unclear. This means that there is presently insufficient knowledge to define sustainable water quality adequately. The standards used are based largely on assumptions and the results of negotiations. This means that a concept such as 'environmental utilization space' cannot be defined scientifically in this field.

Here again value judgements are rife. What organisms should be present in an aquatic system and in what numbers? Should the standard for the Wadden

Sea be 500 or 5000 seals? What is the reference situation for this: the Netherlands in 1900, 1950 or 1990? What state of 'naturalness' is to be preferred and why?

In some cases there is a correlation between selected standards and environmental quality requirements. For example, one standard for still freshwater is the desired level of transparency in relation to the phosphate concentration; this says something about the level of algal growth. A complicating factor, however, is that pesticides have no effect on transparency. The quality of a lake is determined by the presence or absence of a large number of substances, each of which can interfere with the system in a different way. For many substances too little is known about this interference, and this is certainly the case for the effect of a combination of dozens of substances. Ecotoxicological standardisation is still in its infancy and can barely be described as operational.

It is therefore no surprise that quality standards for groundwater and surface water are based mainly on anthropocentric considerations: what is the risk to public health; what are the costs of water treatment for the production of drinking water of the desired quality?

The determination of quantitative objectives aimed at sustainability is also less simple than it appears, and requires an evaluation of both human and 'natural' needs have to be evaluated. The state of the groundwater is important for the nature of the vegetation. Quite apart from the knowledge regarding this relationship, the normative question of which flora and fauna are regarded as desirable is once again raised.

In the case of water too, therefore, the question of what sustainability should and can be is by no means self-evident. Answering this question demands a host of difficult choices and every option comes up against a lack of necessary knowledge.

3.6.5 Action perspectives

The problems surrounding the present and future water supply can be tackled in a number of ways. A view that nature is robust can lead to the conclusion that certain concentrations of pesticides in the water are acceptable provided public health is not endangered and certain interesting natural areas are not affected. On the basis of the 'fragile nature' view, by contrast, it may be felt that continued deterioration of the water must be avoided at any cost - including the cost of restricted consumption - because the consequences for many organisms could be unpredictably great.
Depending on how the risks are perceived and how and to what extent it is felt the qualitative and quantitative requirements set for the consumption of water should be met, four action perspectives
can be identified. Each sets different requirements for water quality and water quantity.

Table 3.32 **Action perspectives for a sustainable water supply**

	Consumption	
Water quality assurance	**high water consumption**	**low water consumption**
Must meet basic standards	Utilizing	Saving
Must meet standards for drinking water preparation	Managing	Preserving

Source: WRR.

Utilizing

The Utilizing action perspective assumes that not all functions of groundwater and surface water necessarily need to be safeguarded. The fact that a number of important natural features will be threatened and that extensive and expensive treatment could be needed for the preparation of drinking water is accepted. If the quality of groundwater and/or surface water adversely affects the natural features in the water or on the land, this is not generally rejected, on the proviso that protective measures will have to be taken for regions with particularly valuable natural features. The main priority is to safeguard the supply of water for households, industry and CPAR, without it being necessary to place restrictions on consumption. In this perspective the demand for water can in principle always be covered, possibly with the help of desalination, transport, the building of reservoirs and infiltration. Combining these qualitative and quantitative principles produces a scenario in which few general precautions and limits to consumption apply.

Saving

In the Saving action perspective there is a desire to avoid major expense in order to obtain the highest water quality everywhere. A certain amount of risk is thus accepted. Since the highest quality requirements cannot be set for water everywhere, the costs of drinking water extraction are high. On the other hand, the lower general requirements for surface water and groundwater mean lower costs here. Water consumption is restricted, however: no more water may be used than permitted by the renewable stocks. On balance it is thought that people will be better off: economical consumers will have access to water at the lowest possible costs.

Managing

The aim in the Managing action perspective is in principle to preserve as many important natural features as possible. Accordingly no risks are taken with the water quality. There is also a desire in this scenario to be able to continue meeting a high demand for water, however, including in the long term. Adequate measures will have to be taken for this, the costs of which can be defended as long as the natural features can be safeguarded and the demand for water can be met.

Preserving

The principle of the Preserving action perspective is that all natural assets in the Netherlands should be preserved. This places high demands on water quality, which should be such that all water functions, including the most vulnerable, can in principle be fulfilled everywhere. Simple treatment is then sufficient for the production of mains water. Pollution must be avoided as far as possible, because the damage it causes can be extensive or may not be discovered in time. The risk of high consumption is seen as great in this action perspective. The consumption of water must therefore be restricted to such an extent that only the renewable supplies are addressed. This has consequences for the management of groundwater supplies. Since no damage to the natural environment through drought can be accepted in principle, restoration of the groundwater to what is considered to be the natural level is the aim. The renewable supplies of surface water are so great that restricting consumption has a negligible effect on the supplies, though it does mean that the quality of the surface water will have to be improved substantially.

3.6.6 Translation of action perspectives into scenarios

Water consumption

The Utilizing and Managing scenarios differ from the Saving and Preserving scenarios in the demands placed on water consumption. The first two scenarios place no restrictions on that consumption; if a shortage of groundwater should arise, this will be replenished using surface water or be accommodated via other technical solutions. These two scenarios assume a growth in consumption of 1.7 per cent per year up to 2020 and a further increase after 2020 averaging 2.2 per cent per annum (0.29% for domestic use, 3.1% for industrial consumption and 3.23% for CPAR consumption).

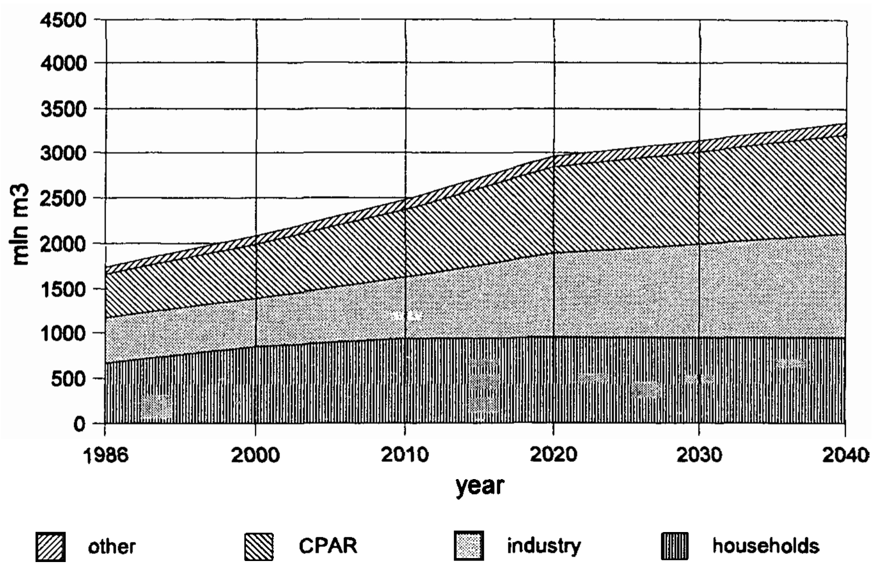
The two scenarios based on low consumption - Saving and Preserving - seek to maintain the water stocks. Consumption of groundwater must not exceed the rate of natural replenishment. Local falls in groundwater level and the associated damage to specific natural features must be reversed. They have already led to great impoverishment of the natural environment, and there is therefore a commitment in these scenarios to restore the level of use of groundwater to that of the 1950s. A per capita saving of groundwater consumption of 10 per cent in 2000 has been assumed compared with 1986 (VEWIN target for 2000), 30 per cent in 2020 and 40 per cent in 2040. The consumption of surface water is maintained at its 1986 level of around 445 million m^3 per year.

All scenarios assume a constant quantity of 200 million m^3 of groundwater per year for irrigation. The population growth estimate is based on the middle variant from the CBS forecast. On the basis of these starting points it is predicted that total consumption will increase in the Utilizing and Managing scenarios by a factor of 2.5 up to the year 2040 compared to 1986. This increase is greater than that in the reference scenario (a factor of 2). As in the reference scenario, the point at which consumption of groundwater exceeds the rate of natural replenishment will have been reached by 2020.

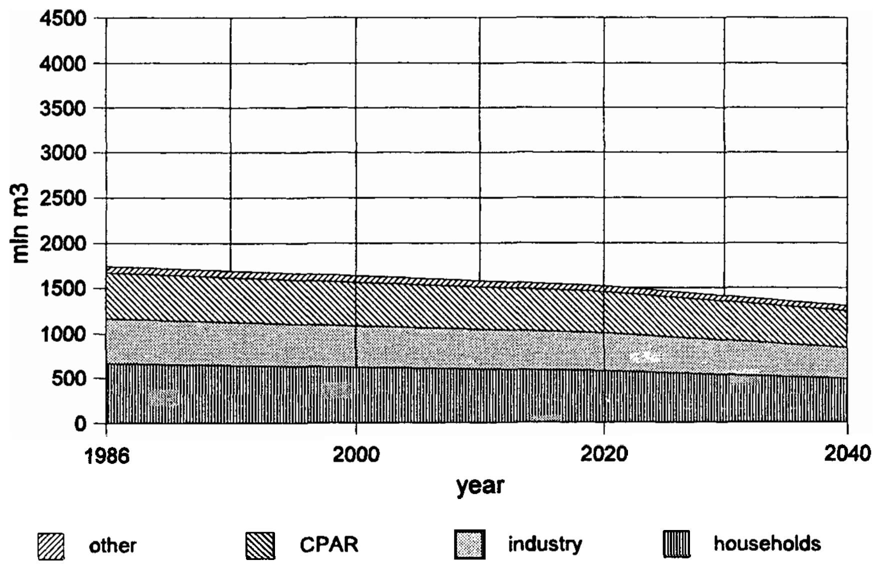
The two other scenarios show a slight fall in consumption. This is logical given their commitment to a restoration of the groundwater usage levels of the 1950s. In 1957 (the oldest available figure) this level was 704 million m^3. If the 200 million m^3 needed for irrigation are added to this, the result is a demand of 904 million m^3 of groundwater in 2040. The use of surface water is stabilised in these scenarios.

Figure 3.20 shows the fresh water consumption for the reference scenario and for the high and low consumption scenarios. Figure 3.21 does the same for groundwater consumption.

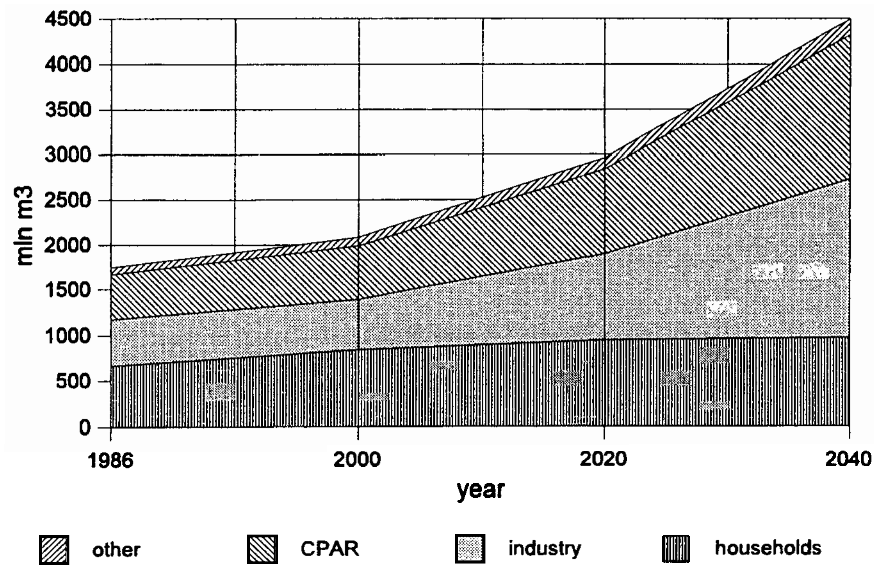
Figure 3.20 a. Freshwater consumption (1986-2040) according to Reference scenario (in 10^6 m^3)



b. Freshwater consumption (1986-2040) according to Saving and Preserving scenarios (in 10^6 m^3)

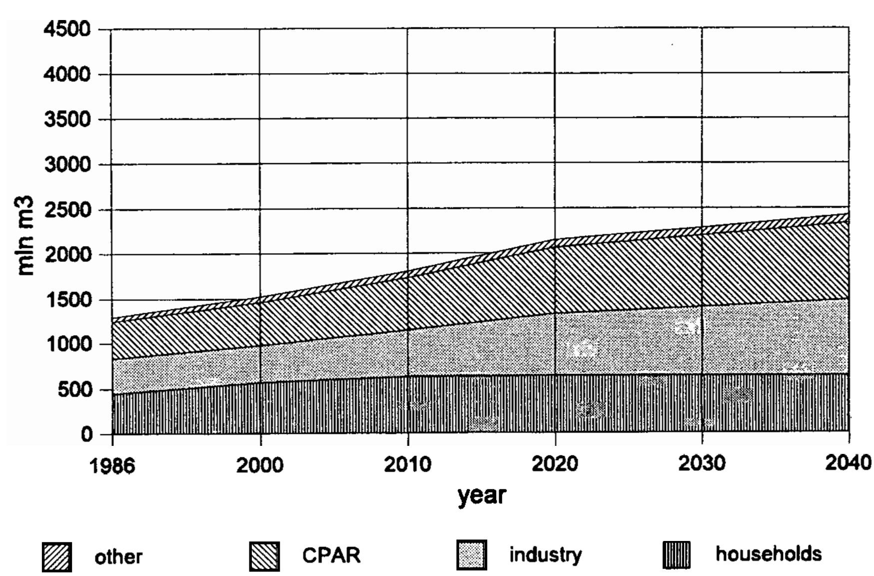


c. **Freshwater consumption (1986-2040) according to Utilizing and Managing scenarios (in 10^6 m^3)**

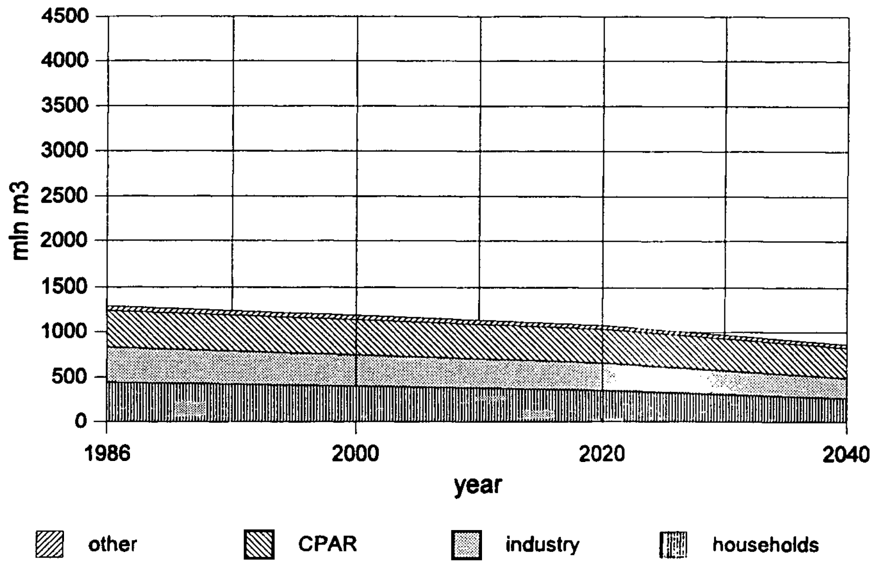


Source: WRR, based on J. Dogterom and P.H.L. Buijs, *Duurzaam waterverbruik in Nederland* (Sustainable water-use in the Netherlands), The Hague, W80, 1994.

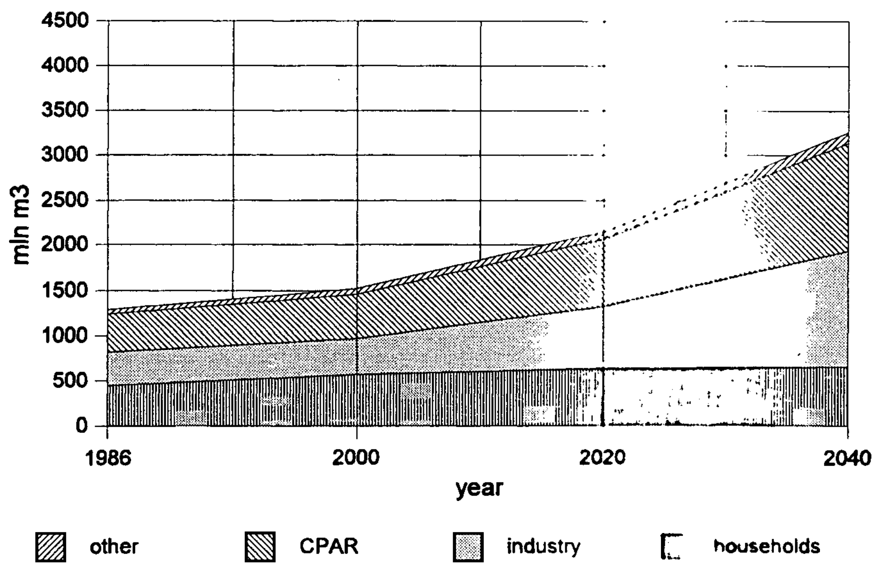
Figure 3.21 **a. Groundwater consumption (1986-2040) according to Reference scenario (in 10^6 m^3)**



b. Groundwater consumption (1986-2040) according to Saving and Preserving scenarios (in 10^6 m^3)



c. Groundwater consumption (1986-2040) according to Utilizing and Managing scenarios (in 10^6 m^3)



Source: WRR, based on J. Dogterom and P.H.L. Buijs, *Duurzaam waterverbruik in Nederland* (Sustainable water-use in the Netherlands), The Hague: WSO, 1994

Water quality

The Saving and Utilizing scenarios adopt a different stance on water quality from the Preserving and Managing scenarios. In the first two scenarios nature is seen as being robust and flexible enough to meet the challenge of changing circumstances and to adapt accordingly. It is regarded as sufficient in these scenarios to set a basic quality standard for water. The Managing and Preserving scenarios adopt a more cautious approach to the robustness of nature and the water quality standards are accordingly much more stringent. This difference is reflected in the norm systems which are used for testing water quality. The two more challenging scenarios opt for the so-called RIWA-B standard for testing surface water quality. These standards were jointly drawn up by the Rhine and Maas water companies. If the surface water meets this standard, the use of tried and tested physical and chemical preparation methods can still enable a satisfactory drinking water quality to be achieved. This standard is less stringent than the IRC norm adopted in the reference scenario. For groundwater the Water Supply Act limit value has been chosen as the norm, supplemented by general standards according to the Policy Document on Environmental Quality Objectives for Soil and Water (MIL-BOWA). This is the minimum necessary quality to be able to produce mains water without endangering health.

The other two - more cautious - scenarios adopt the Milbowa target values for both groundwater and surface water. This means that the water is unconditionally suitable for all functions and can be made suitable for drinking using simple treatment techniques. The standards are based on ecotoxicological research.

Consequences

In the Utilizing scenario more than 3,200 million m^3 of groundwater will be drawn from the stocks in the year 2040 for the production of mains water. This means that in as little as 30 years from now the consumption of groundwater will exceed the currently estimated natural replenishment rate for groundwater. This will leave little scope for other users, in particular industry and agriculture. The existing competition for use will therefore increase. This problem is reinforced by the fact that the quality of the groundwater will in many places not meet the minimum standards for producing mains water. This production will come to a standstill, leading to forced large-scale use of surface water. Several options are available for this, either direct using physical/chemical treatment techniques or indirect using (deep) infiltration. For a number of parameters, however, the surface water will not meet the minimum requirement for producing guaranteed healthy drinking water; in particular, pesticides form a problem.

The increase in groundwater consumption also means that damage to important natural features through drought could occur. The quality of the groundwater and surface water in this scenario is not good enough to protect natural features in a general sense. Where it is wished to protect special natural features, local measures will have to be taken.

The quality targets in the Saving scenario are identical to those in the Utilizing scenario, and the same applies for the measures to be taken. In contrast to the Utilizing scenario, however, it is necessary in the Saving scenario to achieve a low consumption of groundwater. This will necessitate a saving in absolute terms in groundwater consumption, unless there is a switch to use of surface water. Since the quality goals are less critical than in the Preserving scenario, they can also be achieved by importation and infiltration of water from elsewhere - though this could remove the incentive to save water. The way in which surface water is used will be weighed up by each water company and will be determined primarily by technical and financial considerations. The consequences for the natural environment will then ultimately be the same as in the Utilizing scenario.

The underlying principle of the Managing scenario is that it is not necessary to restrict the consumption of mains water, but important natural features have to be safeguarded. This necessitates a large-scale switch to the use of surface water for the production of mains water. Only the option of direct use of surface water is feasible, because infiltration is not compatible with the quality targets of this scenario. Technically this is no problem. The use of hyperfiltration offers sufficient possibilities without leading to additional environmental problems. The costs of mains water for companies which now use groundwater will increase, however, serving only to strengthen the incentive to reduce mains water consumption.

Under the Preserving scenario the functions of groundwater and surface water must be safeguarded, as must all natural assets. It must be possible to produce healthy drinking water using relatively simple treatment techniques. The consequence of this is that far-reaching measures will have to be taken to reduce the emission of nutrients, acidifying substances, metals, organic micropollutants and pesticides. The most important target groups here are agriculture, industry, the transport sector and foreign sources. For example, stringent standards will have to be set for agricultural practice, both in terms of fertiliser surpluses and ammonia emissions, and as regards the use of pesticides. Industry will have to take additional environmental protection measures after the year 2000 and the transport sector will have to tackle the emission of acidifying substances.

In order to combat the threat of continuing drought, this scenario aims to restore the groundwater level to that of the 1950s within the space of 50 years. This objective can be brought within reach by reducing groundwater consumption and/or conserving more surplus precipitation. Considerable savings are possible in all sectors. For example, agriculture could stop using groundwater for irrigation. Households could save on groundwater consumption by switching to surface water for mains water production or by reducing absolute use. For industry a saving of 13 per cent by the year 2000 compared with 1986 is regarded as both possible and probable [59]. A further saving can be achieved by ending the use of groundwater for through-flow cooling.

Savings of around 40 per cent on groundwater consumption compared with 1986, together with a ban on irrigation, could lead to a level of consumption which is below that of 1957. If measures are taken to improve the conservation of the annual precipitation surplus, the need for savings will be less urgent. A new system of water level control will be needed for this, particularly in the winter and early spring.

3.6.7 Evaluation

This section operationalises the concept of sustainability for the quality and quantity of water. The choices underlying the scenarios are arbitrary; this applies both to the consumption levels and for the water supply with more or less complicated treatment techniques and the quality standards employed. On the basis of a varying evaluation of ecological and social risks, however, these choices are feasible.

59] Krachtwerktuigen, *Onderzoek industrieel waterverbruik; eindrapportage* (Industrial water consumption study; final report), Amersfoort, 1992.

It has become apparent that the qualitative and quantitative targets selected in the scenarios demand considerable efforts. A sustainable water supply will not arise of itself. Whether the environmental risks are given greater or lesser weight, quality and/or quantity problems have to be overcome in all cases.

Improving the surface water depends to a large extent on measures taken in other countries. By contrast, qualitative and quantitative groundwater management are almost entirely a Dutch affair. Important target groups for the policy are mainly agriculture, though industry, the transport sector and households are also important. Measures to be considered are strongly linked to these target groups. Households and industry, for example, play a completely different role in quantitative groundwater management than agriculture, while the transport sector plays no role at all here, though is in turn relevant for the development of water quality.

The decline in the quality of water - particularly groundwater - observed here has clear consequences for the quantity of water, since it leads to a shortage of 'good' water for the preparation of drinking water. This problem is exacerbated by the fact that groundwater is used in agriculture for irrigation because of the poor quality of the surface water.

Many of the problems can be attributed to the quantity management policy pursued in the Netherlands. In practice, water level management is tailored to the needs of the farming industry, though infrastructural works also contribute to accelerated drainage of precipitation surpluses. All the efforts in the past have been geared to avoiding water nuisance and flooding. To this end streams have been canalised, the water level in many polders has been lowered and drainage works have been carried out. This has led to an enormous reduction in the storage capacity of the Netherlands. In the higher regions of the country every rain shower is carried away efficiently to the North Sea within 48 hours through a system of control mechanisms. The advantage of these activities is that high-quality use can be made of the soil in many areas of the Netherlands, while housebuilding and farming are possible all over the country.

The price which has to be paid for this, however, is now becoming visible. The low storage capacity means that in dry months in the higher areas of the Netherlands water shortages occur. In the agricultural sector, in particular, this shortage is covered by pumping up groundwater. This in turn leads to the drainage of water away from regions which are dependent on it, thus causing considerable damage to the natural environment. This situation has also led in some places to quantitative competition between drinking water extraction and agriculture.

A provisional finding of a model study by the RIVM indicates that a complete cessation of groundwater extraction would enable 15 per cent of the natural features in dried-out areas to recover. Far-reaching conservation of the precipitation surplus through a different water level management system, particularly in the spring, would have more effect, however, including for drinking water extraction. This would have the disadvantage that farmers would not be able to start working their land until later in the year, leading to a potential production loss. This model study, together with the above scenarios and the reference scenario, illustrates the incompleteness of the knowledge in an area which could perfectly well be charted. The absence of detailed knowledge on the consequences of accepted risks is also striking and is an indication that sustainable water management is more politically than scientifically determined.

Policy process 4

4.1 Introduction

Dutch environmental policy is coming under increasing pressure. This is due in part to changing circumstances, but also to features of the policy itself. Other problems are forcing their way to the top of the political agenda, such as the sluggish economic growth and rising unemployment. This can of itself lead to a weakening of the attention for environmental issues, and when environmental measures are also perceived as an erosion of positions which are already under threat, the legitimacy of these measures can be seriously challenged. An anticipatory environmental policy which takes insufficient account of these aspects and which derives its legitimacy exclusively from the seriousness of future environmental problems is then in danger of failing.

It is very important to recognise that environmental policy must seek to derive its legitimacy from an explicit weighing up of what is environmentally and socially desirable. As argued in the foregoing chapters, the outcome will not meet with general consensus: there is no single view of the 'general interest'. As with any other topic, therefore, this weighing-up exercise forms the core of the political process.

The previous chapter gave an indication - albeit a very general one - in the form of the action perspectives, of the topics which can form part of this weighing-up process. The scenarios show that the diverging choices have equally diverging consequences which can often lead to a need for far-reaching action. These insights can be utilised in developing a policy geared to sustainability.

This chapter will elaborate this theme further. Section 4.2 looks at a number of features of the present policy. It is argued that the current approach offers insufficient scope for the envisaged explicit weighing-up process. If it is accepted - as in this report - that sustainable development is open to a very wide interpretation, it is important to create general conditions for a social learning process. These conditions are discussed in section 4.3. The analyses in Chapter 3 can also contribute to this learning process. The results indicate that the spectrum of choices aimed at sustainability is restricted. Section 4.4 demonstrates the impossibility of adopting a single action perspective on all fronts. Section 4.5 concludes with a number of issues which should be on the political agenda on the basis of the analyses conducted here.

4.2 Current policy

The policy as set out by the Dutch government in successive National Environmental Policy Plans (NEPP) is aimed at initiating the transformation towards a more sustainable society. The concept presented in these Plans received broad public support. Principles such as 'closing the substance cycle' and 'reducing energy consumption' encouraged a recognition of the great wastage.

The closing of substance cycles should be understood as indicating the direction of proposed change. Taken literally, this principle would demand a radical reduction in the world population. Human activities always imply loss of materials and natural resources. Chapter 2 made reference to an approach in which the consequences of closed cycles were calculated as far as possible. The environment would then be able to support a maximum of 2 billion people. There is no humane population policy which is capable of achieving such a reduction in the world population, however, and this illustrates the symbolic nature of this principle; what is at stake is an ideal which everyone realises is unattainable because of its unacceptable consequences.

In this sense, this principle is no different from others such as justice or liberty. These are both unattainable in an absolute sense, but are optimised in a weighing-up process against other principles. The realisation that attainment of the ideal of sustainability is impossible is therefore no reason to remove it from the political agenda.

This also implies that the 'real' issue facing environmental policy is what leakage losses must be accepted in substance flows caused by human activity. By analogy, discussions on social justice refer to the level of income support, minimum income, minimum wage and income inequality.
Responding to these issues means weighing the interests of the activities which are at stake against the ecological damage resulting from them. This weighing-up process has to take place both within and between sectors.

The National Environmental Policy Plans played for high stakes: sustainable development had to be achieved within a single generation, and this was translated into objectives for time paths for a reduction in emissions of the order of 70-90 per cent. Figures such as these were based on purely ecological considerations. The environmental damage following these reductions could be regarded as acceptable (no effect levels). With the exception of CO_2, in particular, there was little scope when setting these targets for an assessment of the desirability of the activities causing the emissions or of weighing them against the environmental gains to be made.

Environmental policy is therefore mainly designed on the basis of what is defined as a desirable status for the ecological system at the level of intermediate variables, following which this status is translated into parameters for societal activities. The fact that the actual implementation of this policy - in consultation with target groups - led to a weighing up of interests, leading in turn to concessions, agreements on time paths, etc. does not detract from this main characteristic.

This policy structure can be used to stimulate activities aimed at eliminating unnecessary waste or leakage losses. The various sections of society have also 'discovered' over the years that limited behavioural change can lead to a substantial environmental gain and even to economic gains. These opportunities have by no means been fully exploited. A policy geared to this can therefore be successful. Subsequent steps, however, may refer to a policy for situations where there is no 'win-win' scenario at micro-level where economic actors can make environmental gain for the same or even lower costs. These steps will generally be more radical and cut deeper into interests and behavioural patterns relating to production and consumption. Reference to a consensus on the objectives and goal paths agreed earlier, in which mainly the ecological desirability was taken into account, is then insufficient grounds for legitimacy. This applies even more in the present situation, where these interests and behavioural patterns are also placed under pressure by other developments. The willingness of society to go further in translating the objectives agreed earlier into action can therefore only be secured via further elaboration and visualisation of the various alternatives and by illustrating the consequences of weighing up the various interests.

Given the policy schedule adopted in the National Environmental Policy Plan (Plus), it is no surprise that hundreds of actions have been initiated and supplemented with yet other actions in the NEPP-2. The relationship of each of these with the ultimate objectives is both clear (every reduction in emissions is welcome) and unclear (the contribution of each individual action). The main effect, however, is a highly fragmented effort in which small steps forward are taken across the board, but where the overall picture is one of shortfalls with respect to the preset goals. Evaluations of current policy which were carried out by the RIVM and others in preparation for the NEPP-2 leave no room for misunderstanding on this point. The actual improvements achieved in recent years - measured against the targets and target paths as set out in the NEPP and NEPP+ - are limited. The expectation of further improvements over the next ten to twenty years depends on often rather optimistic assessments regarding measures still to be taken and regarding the effectiveness of policies [1].

As stated, the contribution of each of the many actions is often unclear because the objectives, for example with respect to energy, are far removed from the present situation. This, too, means that every action and measure constantly has to be legitimised. The uncertainty against which the importance has to be measured easily leads to reactions such as 'why us and not them?'

Environmental policy is in a difficult situation, both politically and administratively. The envisaged goals demand cooperation from a host of different ministries; unity of government policy requires each to make a contribution to sustainability. However, the lack of a common thread which enables priorities to be set presents problems here, too. In many ministries activities have been started aimed at translating the concept of sustainability into daily practice at that ministry, but it is often unclear what route needs to be taken. This means that there is a constant need to discover what 'true' sustainability is. The only certainty is the thematic objective translated into a given ministry's own policy area, though this is generally not created as a result of the weighing up of the various interests involved.

In addition, the Dutch administrative system has difficulty dealing with issues which cut across the normal administrative competences. Intersectoral policy has a traditionally weak position compared to sectoral policy, in that the responsibility for deciding on the goals to be aimed for and the responsibility for its realisation lie in different hands. While it is true that intersectoral objectives are often pressed for with persistence, where these have to be realised by others in administrative practice the result is often disappointing from the intersectoral point of view. Even an intersectoral policy where a 'big stick' can be wielded, such as the Ministry of Finance wields over the specific departments, is not always sufficiently powerful, and the same is even more true of an intersectoral policy - such as environmental policy - which relies totally on commitment to the objectives.

The present environmental policy is by definition an intersectoral policy. The objectives formulated by the Ministry of Housing, Planning and Environment have to be implemented primarily in areas such as agriculture, transport and water management, technology and energy, all of which fall within their own sectoral responsibility regime. From the standpoint of the sector, there are many relevant goals which are often in conflict with environmental interests. Frequently, however the sectors see their first priority as defending the interests of the sector itself. Policy documents written from the point of view of environmental policy then often have the administrative status of petition documents, the proportion of which can be realised by the various sectors remains to be seen. The formulas arrived at accordingly often rest not on an

1] Rijksinstituut voor Volksgezondheid en Milieuhygiëne, *Nationale milieuverkenning 2 1990-2010* (National Environmental Survey 2 1990-2010), Alphen aan de Rijn, Tjeenk Willink, 1991, and *Nationale milieuverkenning 3, 1993-2015* (National Environmental Survey 3, 1993-2015), Alphen aan de Rijn, Tjeenk Willink, 1993.

explicit weighing up of the interests involved, including the environmental interests, but represent an adjustment of predetermined sectoral interests from an environmental standpoint. In the eyes of the public, however, this easily leads to an impression of a government which has many faces or which is to some extent indecisive. Clarity, however controversial, is better for external legitimacy, too, than creating an impression of saying one thing and doing another.

It is therefore no surprise that the agreed objectives time and time again prove to be inadequately attained. These objectives are established mainly on the basis of ecological desirability, but have to be realised by sectors of social activity whose importance played no part in setting the goals. Where, in addition, responsibility for setting the goals and implementing them is separate, it is likely that subsequent steps towards the realisation of those goals will meet with increasing difficulties. There is then a risk that the policy schedule will grind to a halt.

4.3 Sustainability as a learning process

Political decision-making on sustainability has to take account of a range of opinions on what should be seen as sustainable, and therefore involves governing in uncertainty. The environment is no different from other policy areas here. There are many fronts on which the status of the information regarding present and future problems is controversial. To what extent does the official unemployment figure represent the true figure, or the registered level of illness the true level? How will prosperity develop? How relevant is economic policy in that process, etc.? The uncertainties in these and many other areas do not rule out policy, however. The available information has to be assessed, risks have to be weighed up in advance and taken into account in the resultant action.

In its policy document 'Living with risks', the Ministry of Housing, Planning and Environment defines risks as measurable values: functions of undesired effects and the chance that these will occur [2]. This technical/scientific approach to risk is not without problems. Science is constantly developing new insights, new opportunities and new speculations which in turn create new social and political uncertainty. It will thus be impossible ever fully to know and eliminate risk or uncertainty. At best a partial objectification is obtained. The way in which society deals with risks furthermore depends not only on the available scientific information; socio-psychological research, for example, shows that the assumed manageability of the risk plays a more important part in the perception than the likelihood of that risk [3]. The usefulness of the risk-bearing activity, the distribution of risks across groups within society and the amount of influence on risk-bearing activities can all play a part in the assessment of the acceptability of risks. According to Wynne, risk is not an objective given but a social construct [4]. As argued in Chapter 2, the perception of risks thus occupies a key position in decision-making processes where several risks are involved.

2] Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer, *Omgaan met risico's* (Living with risks), The Hague, Sdu uitgeverij, 1989.

3] C.A.J. Vlek, *Beslissen over risico-acceptatie; een psychologisch-besliskundige beschouwing over risicodefinities, risicovergelijking en beslissingsregels voor het beoordelen van de aanvaardbaarheid van riskante activiteiten* (Decisions on risk acceptance; a psychological approach to risk definitions, risk comparison and decision-making rules for assessing the acceptability of risk-bearing activities), Gezondheidsraad, The Hague, 1990.

4] B. Wynne, 'Risico en reflexiviteit; van objectief naar onderhandelbaar risico' (Risk and reflectivity; from objective to negotiable risk) in: *Sturing in de risicomaatschappij* (Control in the risk society), by N.J.H. Huls and Th.H.M. de Beer (eds.), 1992.

Recognition of this fact underscores the interest of 'countervailing powers' in risk analysis, enabling the divergent assessments of risks by the various social actors to play their full weight [5]. A more continuous and interactive interchange of information on risk-bearing technology, more openness about uncertainties surrounding technological risks and the intensive involvement of public interest groups in the decision-making process are important here. Viewed in this way, comparative risk analysis can be useful as a way of objectifying opinions and avoiding ad hoc policy reactions.

Risk analysis can thus lead only to a certain structuring of the problem of choosing, by clarifying the knowledge base in statistical risks and existing uncertainties. An inherent aspect of environmental effects, however, is their multi-dimensional nature, as a result of which the ultimate weighing-up process is extremely complex and can never take place within the context of the risk analysis itself. Weighing risk prevention against risk management, immediate effects against long-term effects, weighing varying types of effect (fatal accidents versus illnesses), etc., are not issues where objective comparison can be decisive; they are issues which ultimately have to be decided politically. While risk analysis can assist the political decision-making process by providing objective information, it can never take the place of that process [6].

A decision-making process geared to sustainability is thus always a provisional process, though attempts can be made to broaden the required information base. The recommendation in the report 'Environmental policy: strategy, instruments and enforcement' that environmental policy must be expressly designed as a learning process [7], is then not only relevant for the question of the effectiveness of instruments used, but also for the objectives.

The information offered in Chapter 3 was expressly aimed at contributing to this learning process and thus improving the target-seeking process. This information is still very general, however; in many respects there is still a need for a deeper understanding. The information base on the present status quo and developments in it is still very limited in many areas, both as regards the environment and on a societal level. Further elaboration of the method of approach presented here could improve the goal-setting process. As this information becomes available, it may become clearer which choices are better from the point of view of leaving open possible options for later course changes.

It must not be expected, however, that it will ever be possible to obtain sufficient knowledge in advance. In this respect the two learning strategies identified by Wildavsky are interesting: one is based on the principle of anticipation and the other on resilience [8]. When applied to living with risks, the anticipation strategy 'trial without error' and the resilience strategy 'trial and error' are referred to. The first means that no changes are permitted unless there is sufficient evidence that the proposed substance or activity involves a zero or negligible risk. In this option, learning takes place through looking ahead; sustainability is chosen *a priori*. Learning through trial and error, by contrast, relates to the capacity to deal with unexpected risks once these have become manifest. Learning is a process of gaining practical experience based on an experimentation process aimed at sustainability. Sustainability is learned *as one goes along*.

5] P. Kalma, De 'risicomaatschappij': schrikbeeld of ideaal?' (The 'risk society': spectre or ideal?) in: *Sturing in de risicomaatschappij*, ibid., pp. 209-216.

6] Andrew Stirling, 'Environmental Valuation. How much is the Emperor Wearing?', *The Ecologist*, vol. 23, no. 3, 1993.

7] WRR, *Milieubeleid; strategie, instrumenten en handhaafbaarheid* (Environmental policy: strategy, instruments and enforcement), Reports to the Government no. 41, The Hague, Sdu uitgeverij, 1992, pp. 177-178.

8] A. Wildavsky, *Searching for Safety*, New Brunswick, 1988.

In practice, however, the choice will never be between one strategy or the other across the board. The question is whether risks can be made explicit to such an extent that a decision based on the weighing up of alternatives is possible. Such a decision may relate to behavioural alternatives for a particular goal (e.g. risks linked to nuclear energy versus those associated with coal) or a weighing up between different objectives (should priority be given to the greatest risks or to those which are easiest to tackle?).

Particularly in the case of larger-scale risks, which may have long-term effects which are difficult to repair, a risk-avoidance strategy appears more desirable. This applies not only to the dying out of species as a result of the disappearance of entire ecosystems, for example - something which cannot be reversed - but also to the depletion of the ozone layer, which demands a very long recovery period. On the other hand, the effects in terms of soil pollution are in principle reversible; here, acceptance of a certain ecological risk is more acceptable, the more so where the effects are relatively limited.

Social decision-making in terms of sustainability can be made easier by seeing it as a continuous and cumulative learning process. This process is based on a combination of trial-without-error and trial-and-error which avoids delay in behavioural change which can only be forced at a later date at very high social cost, or not forced at all. Practical experience gained is also important here.

The possibilities for designing environmental policy as a learning process are partly determined by a number of conditions. For example, society and government must be continually able to monitor progress, both in an environmental and a societal sense. Continuous alertness to the options for technological and behavioural alternatives is also essential. Responding to existing willingness to change is important as a way of mitigating social risks. These conditions will be dealt with in more detail below.

Monitoring

All the literature on decisions taken in uncertainty points to adequate monitoring as an important condition for assessing crucial variables [9]. While there has undoubtedly been a strong increase in environmental monitoring at world level recently, the results are difficult to interpret as yet; the period observed is generally too short to be able to draw conclusions. For example, monitoring of the thickness of the ozone layer in different areas has only just begun. While monitoring systems for CO_2 have been around for much longer, they are only present in a limited number of locations. In spite of all the political attention, climatic monitoring still takes place on only a modest scale, while monitoring of biodiversity is still in its infancy.

Although the supply of information is high in the Netherlands compared with other countries, there are still a number of important gaps. Much of the available information relates to deviation from preset interim variables, such as SO_2, NO_x, chlorinated hydrocarbons and ozone, while much less information is gathered on the environmental objectives which are ultimately the key issues. This report, too, was confronted with this problem. As regards water, for example, information on which substances are present in surface water and to what degree is reasonably well documented, while indicators such as BOD (Biological Oxygen Demand) are also usable measures of the quality of the water. However, there are no uniform correlations between indicators of this type and the ultimate quality of the environment. The implications for

9) See for example Donald Ludwig et al., 'Uncertainty, Resource Exploitation and Conservation: Lessons from History', *Science*, Vol. 260, 2 April 1993.

certain natural features are thus much less clear. This leaves many questions unanswered, such as to what extent natural features are eroded if the surface water is confronted with a certain load of pesticides. It is very important to have an insight into this in order to improve the setting of standards. This usually requires extremely complex and lengthy research. It is logical in such cases to adopt cautious standards before these insights have been obtained; this avoids being faced at a later date with damage which is difficult to deal with.

More generally it can be said that where there is a tendency to a greater acceptance of environmental risks, there is more confidence in the problem-solving capacity of society than when the view is taken that environmental risks should be avoided. This confidence implies above all an interest in monitoring the effects of technical solutions and less need for 'early warning'. Those in favour of avoiding environmental risks will be more inclined to opt for a more preventive approach and will be more source-oriented. Attention here is focused more on accurate establishment of intervention/effect relationships and alternative/effect relationships. This requires monitoring with a greater problem-solving capacity, enabling measurement networks to be better used as 'early warning' systems and 'early-control' systems, so as to see whether alternatives really do have less environmental impact [10].
As stated, it is a wise policy to keep open as many options as possible in order to be able to arrive at an optimum cost/effectiveness choice. While this may seem an easy statement which could imply that no choices have to be made, nothing could be further from the truth. In all cases there is an express need to set priorities. Not choosing and continuing in the old way could be disastrous. The analyses in Chapter 3 have in the WRR's view made that convincingly clear. In the field of energy, for example, changes in the use of fossil fuels are required in any of the scenarios studied, while there is a need for an improvement in efficiency in the use of raw materials. There are differences of degree, but this does not alter the fact that a policy of no change is unsustainable.

Technological alternatives

An important second condition relates to information on alternatives. It has to be recognised that distortions have occurred in the gathering of information. The funding flows often mean that those options are supported which have the broadest administrative and public support. The opportunities for technological alternatives to develop is then limited and information often comes 'too late' to be included in the decision-making process.

The inclination to allow the market to determine the development of new technologies is a misunderstanding of the need to include long-term effects in the discussion and takes no account of the slowness which is inherent in large social systems. Governments have the responsibility for the early fostering of the parameters necessary for desirable new technologies. Many mechanisms are available for this, such as the transaction mechanism, influencing the energy price and convincing through the provision of information.

It is precisely here that the government can influence the conditions for embarking on technological paths. Such paths, for example towards a reduction in the energy intensity, raw materials effectiveness and effective land use, are not imposed or forced but are initiated and stimulated through targeted policy. This means, for example, not holding down the gas price through

10) W.J. ter Keurs and E. Meelis, 'Monitoring the biotic aspects of our environment as a policy instrument', *Environmental Monitoring and Assessment* 7, 1986, pp. 161-168.

subsidies, but stimulating investments in efficient gas utilisation; not prescribing the number of cattle per acre, but taxing mineral surpluses, etc. Setting parameters in an imperfect market - and the market is indeed imperfect in many respects - is by definition a task of government.

This condition is not only of great importance for a balanced judgement between alternative options, but is also vital from the point of view of flexibility if a chosen policy line should produce disappointing results or if external circumstances make that policy line more difficult; alternative development routes are then available.

Social behaviour alternatives

Where the previous point related to facilitating greater diversity in the technological innovation process, it is equally important to obtain an insight into social behavioural alternatives. While the adage 'Allow one hundred flowers to bloom' is difficult to realise in a society which is geared to equal rights, the other extreme is not always necessary. A certain amount of diversity of solutions is possible within a decentralised unitary state. This diversity can moreover be consciously stimulated in order to foster an atmosphere of learning through experimentation as far as possible. Local and regional initiatives in which widely varying solutions are tried out, for example in the area of energy conservation, natural production or sustainable agriculture, have the best chance of flourishing if environmental policy changes from a restrictive to a development policy [11]. Like earlier recommendations by the WRR in the report 'Environmental policy: strategy, instruments and enforcement', this requires less emphasis on direct regulation in which the desired behaviour is prescribed at central level [12]. It can thus turn out that group interests which show little willingness for sustainable compromise at central level, are sometimes capable of producing creative solutions at decentralised or local level. For example, farmers show a much stronger willingness to change their behaviour in respect of natural production or canal bank management if they are offered the prospect of a reward for the realisation of certain natural features [13], than through the management agreement scheme from the Policy Document on Agriculture and Nature Conservation which prescribes what activities farmers must carry out or omit on behalf of nature [14]. This implies that the government does not prescribe detailed objectives, nor the way of achieving them through prescribed production methods, but should adopt global targets and leave room for experiments and individual creativity and initiative on the part of those concerned. This is an important condition for a cumulative process of behavioural change.

Exploiting willingness to change

While it has to be recognised that many decisions relating to sustainability are collective in nature, the thinking on this subject is not the exclusive

11) W. Salet, 'Institutionele voorwaarden voor de ecologische stad' (Institutional conditions for the ecological city), in: *De ecologische stad* (The ecological city), report of a seminar organised by the Dutch Parliamentary Labour Party in collaboration with the Labour Party working group on sustainable development on 5 June 1993 in the building of the Lower House of the Dutch Parliament, The Hague, April 1994.

12) WRR, op. cit.

13) See for example *Natuurproduktie-Experiment; opzet voor een experimenteel onderzoek naar de mogelijkheden van natuurproduktiebetaling voor weidevogels en slootkantvegetaties* (Natural Production Experiment; design for an experimental study of the possibilities of natural production payment for meadow birds and canal bank vegetation), by W. Twisk, M. Kruk, P. Vos et al., Environmental Biology Department, University of Leiden, in collaboration with the Dutch Agricultural Organizations and the Environmental Federation of South Holland, Leiden, 1992.

14) Nota betreffende de relatie landbouw en natuur- en landschapsbehoud (Memorandum on the relationship between agriculture and nature and landscape conservation), Staatsuitgeverij, The Hague, 1975.

reserve of politics and the administration; society also plays an intensive role in this thinking process. This presents many opportunities for policy, which must be exploited as far as possible. The innumerable local and regional initiatives aimed at environmentally-friendly consumption and production illustrate this point. The readiness to cooperate on such schemes, however unfocused its elaboration may sometimes be, is very high.

From the point of view of sustainability as a process it is perhaps more sensible to seek alignment with changes which are already taking place rather than to impose entirely new regimes on society. The former will in any event guarantee public support, while the second creates resistance.

It is striking in this context how little use the Dutch government makes of the broad public support for an active nature policy, for example. The prevailing policy until recently, which was strongly geared to the formation of nature reserves and the preservation of the last remains of nature in the form of natural monuments, is slowly making way for a policy which is actively geared to natural development [15]. The fact that one in seven Dutch families is a member of the Nature Conservancy Association, while around one and a half million people are members of the joint nature protection organisations, could be used by the government to pursue a more energetic nature policy and to accelerate the necessary developmental and clean-up policy in land-based agriculture. This would serve the aims of both nature and agriculture. The means and instruments for this are available, but need to be used [16].

4.4 Action perspectives as an aid to integration

Encouraging the conditions for a broad information supply is of great importance for fostering a continuous social and political learning process aimed at sustainability. This - in principle open - process naturally does not discharge society from the duty to take decisions on the basis of a given status of information and its interpretation.

The action perspectives constructed in Chapter 3 for a number of areas, together with the information derived from the scenarios portraying the consequences of those perspectives over time, can provide an aid to the formation of opinions on desired aims and tasks.

The options for choice in terms of the scenarios presented here are limited by interdependencies between the areas studied, however. This implies that it is not possible to act on the basis of a single perspective across the board. If the interdependencies between the different topics are examined, the options for the selected specifications prove to be mutually exclusive; choices in one area limit the scope for choices elsewhere. For example, it emerged in Chapter 3 that the Managing scenario for energy takes up a great amount of space through the use of biomass as a renewable energy source. This cannot be combined with an attitude whereby large amounts of land are required for agriculture or nature, as proposed by the Managing action perspective in this area; the need for space for food production in the scenario derived from this perspective is very great. In fact, therefore, a compromise is necessary, with biomass for energy production and nature and the environment both making sacrifices in terms of the amount of space claimed on the basis of the action perspective in question.

15] *Natuurbeleidsplan* (Nature Policy Plan), Tweede Kamer, 1989-1990, 21 149, nos. 2 and 3.

16] WRR, *Ground for choices: four perspectives for the rural areas in the European Community*, Reports to the Government no. 42, The Hague, Sdu uitgeverij, 1992.

The Managing energy scenario coincides in the long run only with the Utilizing scenario in the area of food supply. The Preserving scenario in terms of food supply is only compatible with Utilizing in terms of the natural environment. The Preserving raw materials scenario cannot be united with a similar attitude in the area of energy, because the energy intensity per unit of raw materials does not permit this; similarly, the view taken in the Utilizing scenario in the area of nature cannot be united with a similar attitude in the area of energy, because the use of space and raw materials intensity do not permit this.

This unavoidable lack of uniformity between the action perspectives when their consequences are viewed over time is another illustration of the need to make choices in various areas. Building on the elaboration of risks, it is possible to weigh up the various aspects. For example, the choice options regarding the use of biomass as an energy source are limited, and those relating to nature are greatly reduced if the highly biotechnological agriculture - which will largely though not exclusively have to take place on good land, and which is geared to ecotechnology and biological self-help - is unable or not allowed to develop. If the Preserving perspective is applied to the food supply, it attempts to greatly reduce the external inputs per unit area, or to eliminate certain inputs such as nitrogen fertiliser and biocides. Such an approach, however understandable it may be on the basis of the preferences derived from the idea of local cycles, leads to a very great amount of space being needed for food production and to major shortages in the areas where population densities are very high, such as East and Southeast Asia.

A general principle such as the 'precautionary principle' - at least if this is given a substance which matches the action perspective designated here as 'preserving' - thus proves inadequate for the achievement of sustainability. This does not apply for the initial steps, in which the most manifest examples of unsustainability are eliminated, but does hold for the ultimate situation, if account is taken of world population and economic development.

The absence of uniformity, i.e. the inability to adopt a single approach across the board, together with the high degree of uncertainty on a range of fronts, provides yet another illustration of the fact that 'sustainability' is by no means self-evident. The analogy with 'justice' cited earlier comes to the fore again: that is another area hedged in by a range of views. Taking the analogy further, justice which is carried to the extremes in one area can increase the injustices in another area.

These complications do not however mean that the commitment to achieving justice can be dismissed as an illusion, and the same applies to sustainability. The analyses in Chapter 3 show that radical and complex choices are necessary in most areas, however much they may differ between the individual action perspectives. As the reference scenarios revealed, developments are under way which, if they continue unchanged, will lead to extremely undesirable situations. 'Business as usual' thus offers no solution. The choices must be made in a process of weighing the various alternatives and in the light of possible future consequences.

The observation that sustainability lends itself to multiple interpretations does not weaken its desirability. The recognition that there is no single road to Rome, that there is not even a single Rome, increases the scope for weighing up the alternatives and for give and take between the various targets being aimed for.

4.5 Sustainability as a political issue

All the perspectives described in Chapter 3 are geared to solutions. These solutions are not simple, and the situation becomes more complex when the consequences over time and the mutual interdependencies are taken into account. At the same time, however, they do make opportunities for action visible, and in this sense they differ from 'deus ex machina' solutions: our mentality must change radically, governments must bring a decisive halt to our productive and consumptive behaviour, and there is a need for a world authority. Such calls are more a token of powerlessness in the face of the problems signalled than real opportunities for solutions. Cultural change cannot be created on demand, and nor can a world government. A radical limitation of production and consumption is in diametric opposition to essential and deeply-felt feelings of the freedom of individuals, institutions and states. Proposals for solutions such as these are accordingly hedged in by the risk of immobilisation: if there is a fear that the large gains cannot be attained, there is a danger that the smaller gains will be ignored.

This is not to disqualify the function of such contributions; on the contrary, they can contribute to an awareness of the problem. At the same time, however, it is clear that there is an urgent need to devote more energy to concrete options for solutions. If an awareness of the problems cannot be translated into behaviour which is geared to solving those problems, such information can even have a boomerang effect.

All of this constitutes a plea for a political process in which the debate is focused on the aspects highlighted in the action perspectives and scenarios. In the reference scenario, for example, in spite of the assumed saturation of the energy demand, exhaustion of fossil fuel energy, including coal, is seen as a very real prospect; and in all scenarios apart from Preserving, a growing shortage of oil and gas is projected for the coming decades. The Netherlands has a relatively energy-intensive industry. In this light, how should the Netherlands tackle the need for further energy-saving and the switch to other fuels? The latter include renewable sources which have still to be developed to a large extent but for which there is an established need. The argument of physical shortage is thrown into greater relief if geopolitical factors are taken into consideration.

One thing that should be remembered in all this is that the present energy policy of the Dutch government is geared less to issues of scarcity than to the reduction of CO_2 emissions.

Very radical political issues are at stake here, such as the restriction of behaviour, whereas political preference is understandably for 'hand-outs'. In addition, different spatial and temporal scales are involved than those to which politics is normally oriented.

First there is the timescale of the effects, i.e. the importance of future generations and of nature in the longer term. This is the chief element which has been added to the political consciousness by the concept of sustainability. It is a realisation of the finiteness of resources, of irreversible processes, of long-lasting after-effects and of possibly irreversible consequences, as a result of which present-day actions have been placed in a different light. The uncertainties in these areas were highlighted in Chapter 3, thus making them easier to assess. This makes general considerations more tangible and turns the debate on sustainability into one of concrete assessment of shortages and negative environmental effects, and also leads to actions with a very different level of effort.

To what extent can consolation be drawn from the emergence of mechanisms which eliminated similar concerns in the past? For example, can comfort be taken from the fact that coal became available when peat supplies began to run out? Why, if in a few decades' time there is a really pressing need, should energy sources which are now uneconomical not be able to be made economical? After all, in theory there is no energy problem: the quantity of irradiated sunlight is 11,000 times the annual consumption! Moreover, should not every generation have to deal with its own portion of problems? In other words, can the present generation be expected to solve the foreseeable problems for future generations? Are there not grounds for assuming a reasonable level of inventiveness on the part of coming generations, inspired by the problems which then exist?
While it is true that history reveals a high degree of human inventiveness, it remains arguable whether this will be adequate given the scale and tempo of the present changes in the energy supply, land use, raw materials use, etc.

In this context the WRR has commented that the responsibility of today's generations for future generations justifies an active stance on the part of the government [17]. These are after all interests which cannot be reflected in the economic process. According to this view, the government must not only act as the guardian of the present general interest, but also that of our descendants. As they cannot speak for themselves, it is the responsibility of the present generation to define their interest. Chapter 3 also showed that this definition can vary widely: the desired inheritance can be sought in physical terms (stocks), economic terms (quantity of capital goods) and cultural terms (know-how). This is a relatively new role for governments, who bear chief responsibility here. They are more used to reacting to problems than to anticipating them, let alone to anticipating problems on the timescales involved here.

This notion is not new, and in fact is the most important argument for placing the problem of sustainable development on the world political agenda.

The analyses presented here focus on goals derived from longer-term trends and options. The practice of politics, on the other hand, is concerned with interests which are located in the here and now. These interests are great and diverse. The desire to preserve tropical rainforests on the basis of diversity of species is in conflict with the economic capital which these forests represent and the currency which the export of timber earns for the countries concerned. Similarly, the sale of oil meets a capital need on the part of the exporting countries. As long as CO_2 emissions do not lead to noticeable consequences, there will be no great sense of responsibility among motorists to do anything about it. Tightening up of environmental rules often leads to mobilisation of the target group concerned.

Policy which seeks to anticipate longer-term events thus has most chance of success if it can be convincingly demonstrated that the costs of that policy - in terms of the erosion of interests or of compensating for environmental damage - are lower than the costs of forced changes in response to crises. In other words, long-term goals will be taken more seriously where they can be translated into cost benefits - 'enlightened self-interest' thus. Seen in this light, an impending physical energy shortage - accelerated by shortage caused by geopolitical factors - has more chance of leading to an anticipatory policy than an abstract climate risk with an unknown price. Energy shortages affect interests which are recognised by every government as vital. The same applies to a water policy based on a threatened problem concerning the drinking water supply, the price of which can be felt directly, or to a drought problem which

17] WRR, *Milieubeleid* (Environmental policy), op. cit.

threatens local natural features. Agricultural interest groups are easier to convince of the need to change their practices if it can be demonstrated that the quality of the land they use will otherwise deteriorate, than by the argument that their practices harm the quality of the surface water. The responsibility of politicians and governments to defend interests which do not occupy a central or powerful place in the social arena thus has the best chance of succeeding if it can be expressed in terms of the 'enlightened self-interest' referred to above.

Then there is the spatial scale. Local activities have consequences which can manifest themselves elsewhere, sometimes even worldwide; on the other hand, local problems can be caused by activities carried out elsewhere. In most cases there is a mismatch between the ecological and administrative levels of aggregation. This is particularly true in the case of pollution and erosion which transcends the limits, such as the emission of acidifying substances. The administrative scale needed to arrive at sustainable solutions has by no means been realised in all environmental areas. On the other hand, it is difficult to define how the 'ideal' administrative organisation should be structured: the rigidity which a given administrative organisation entails is often inadequate in the face of the diversity of scales on which the various environmental problems manifest themselves.

In a limited number of cases the required administrative scale lies below national level, on the provincial or municipal scale. This is the case, for example, with (parts of) the waste problem, local water supplies and the mobility associated with commuter traffic. In such cases, it is obviously most appropriate that local authorities should be given responsibility for policy to combat disruption, fragmentation, drought and acidification. The standards to be applied then depend on the local or regional circumstances. The target group policy as proposed in the NEPP (National Environmental Policy Plan) is mainly an issue for the lower-level authorities in these cases.

The topics discussed in Chapter 3 are generally not of a local, regional or national nature; they usually go far beyond the national scale, including that of the Netherlands. This scale discrepancy can be politically discouraging, and the argument is often put forward that 'the Dutch contribution to world emissions is very limited, so why should the Netherlands go to great pains to reduce that contribution still further?' Or, 'the Netherlands is too small a country to be able to change the world!' Such arguments for a passive approach, both internally and externally, imply an acceptance of the growing 'prisoner's dilemmas'. However, this also implies a meek acceptance of the lack of willingness to change elsewhere on the basis of environmental arguments. The debate must not be limited to the question of whether there is any point in the Dutch 'going it alone', but needs to focus on the strategic possibility of reinforcing an international political thrust which makes the first question irrelevant. An important question in this light is also whether the Netherlands would not do better in some areas to target its investments to improving the situation elsewhere than at home.

In an earlier report, the WRR proposed attempts to synchronise the ecological and economic scale with the scale of jurisdiction [18]. Active environmental diplomacy involving not only instruments designed to convince but also transaction instruments can contribute to an administrative scaling-up which matches the scale of the environmental problem concerned. Environmental diplomacy of this nature is not only essential for the ecological interdependencies, but can also be successful in view of the growing economic inter-

18] WRR, *Milieubeleid* (Environmental policy), op. cit.

dependence. The latter make is possible to couple positive and negative economic sanctions to environmental standards. Examples include the linking of aid - in terms of funding or transfer of knowledge and technology - to the countries of Eastern Europe or the South to environmental demands. This enables the energy-efficient production of steel, for example, which has been developed in advanced companies such as the Dutch Hoogovens to be utilised by manufacturers in Eastern and Southern Europe. The next chapter will look in more detail at how desirable developments in the field of energy can be promoted.

The scale ultimately needed will vary from problem to problem. Measured against the agenda of tasks for the world community arising from the sustainability scenarios, there appear to be no great grounds for optimism on the ability to realise the aims set. And yet it must be recognised that, if only the problem is seen as serious enough, new institutions will be set up, sometimes with far-reaching remits. Such 'emerging institutions', in the form of treaties, funds, etc. which link different states are currently being created, partly as a result of the UNCED conference in 1993. The ozone problem is a spectacular example of this. As a solution to this problem an administrative scale has been created, namely the protocol of Montreal (1988) which, following a later tightening-up, stipulates that signatories must have reduced their use of CFCs by 100 per cent in 1996. Another example is the SO_x protocol agreed within the United Nations.

The problem of distribution is closely linked to the problem of jurisdiction. The demand placed on environmental assets is very unevenly distributed in the world, both quantitatively and qualitatively. The industrialised nations consume the greatest part of the world supplies of energy, raw materials, etc., but do so relatively efficiently; the share consumed by the developing countries is small, but the consumption is often very wasteful.

The much greater use of raw materials per unit product in the non-Western world is related to the current development phase of those countries. Their low level of affluence implies inadequate purchasing power to buy more efficient production processes and consumer articles. Production in the West was also much more wasteful during earlier phases of its industrialisation. For example, car manufacturing now uses 50 per cent less metal and energy than 20 years ago, and the possibilities of further improvement through the introduction of new materials have by no means been exhausted.

In order to preserve the world prosperity base, therefore, there is a great deal to be said for ensuring that the non-Western world is not forced to follow the same development path as the West, but is able to 'leapfrog' over it. Where capital goods stocks still have to be built up completely, this is to a certain extent a favourable circumstance. Use of new technology does then not have to entail large-scale destruction of capital. This demands not only an extensive transfer of capital, but also the necessary training and education of the 'human capital' needed for such an accelerated development path. Spectacular results can be achieved here, as illustrated by the rice cultivation industry in Indonesia. Within the space of five years, Java realised a production increase of 15 per cent combined with a simultaneous reduction in the use of pesticides of no less than 50 per cent.

After a policy trend geared to the elimination of evidently unsustainable situations, the further course to be plotted must be considered. Following the instrumental orientation of the present phase of policy development, the debate now needs to be concentrated once again on the targets. It can be concluded from the above that this course is not a self-evident one. Equally, it must be recognised that the institutional conditions for weighing up alternatives and arriving at binding choices in terms of the action perspectives are still largely lacking, both nationally and internationally. Absolute or relative shortages create a need for coordination which breaks through the 'prisoner's dilemma'. International bodies charged with substantially reducing energy intensity or bringing about a change in the structure of fuels do not exist, however; nor do bodies with a say in the allocation of scarce river water to countries dependent on it for their agriculture; nor bodies with a say in the exploitation of tropical rain forests with a view to preserving diversity of species. Where international environmental agreements do exist, they are essentially voluntary and at most 'bind' the signatory countries to making efforts. This is not a denial of the importance of such protocols or treaties. Declarations, such as Agenda 21, or treaties, such as the Climate Treaty, are not pointless. On the contrary, they contribute to the creation of internationally shared criteria. Like the Universal Declaration of Human Rights, however, such norms do not guarantee a match between practice and promises. They can also function as standards, however, to which sanctions can be coupled in international dealings.

In spite of this, there is a wide gulf between the institutional conditions necessary for sustainability as a global concept and the institutional situation as this exists at present. An added factor is that the quality of the environment does not yet 'score' highly in international relations. The energy invested in creating the GATT accord indicates where the priorities lie. This international priority also reflects the national priority. The institutional relations, including in the Netherlands, lead to environmental goals being assessed - if at all - in the light of socio-economic objectives rather than the other way around.

The structure of international agreements which has arisen in this way does not act as a stimulus for the choices which have to be made. Trade treaties and environmental treaties stand alongside each other rather than being derived from each other. In the present situation this may be the best which can be achieved; ultimately, however, sustainability - however defined - demands frameworks within which choices can be made between economy and environment.

It is not impossible that the economic damage suffered by Western countries as a result of trade with countries where environmental requirements place a less heavy burden on the economic process will prove the greatest stimulus to including environmental aspects in the World Trade Organisation (WTO). On the eve of the conclusion of the new GATT accord voices could be heard both in the United States and in Western Europe, calling for 'fair trade' or 'managed trade', pointing to the need for change to avoid a new era of protectionism. In spite of this broadening, choices will obviously be possible only to a limited extent; the WTO ultimately remains a trade organisation. It is also not impossible that such a development will push the WTO, whether it wishes it or not, in the direction of a body with more powers than is now envisaged. Relatively simple rules for trade would then not be sufficient.

In addition to shortcomings in the international coordination structure, there is also the issue of national coordination. Is this coordination in the Netherlands adequate for the choices which are envisaged by the WRR? Section 4.2 made mention of the intersectoral/sectoral situation, which is not conducive to the desired choices and need for coordination. This problem has long been recognised at administrative level, but none of the solutions put forward was ideal. Calls for sectors which are more responsible for the intersectoral objectives are correct from the point of view of 'unity of policy', but fail to recognise the structural aspects of the problem.

Changes in philosophy have to be accompanied by changes in formal powers. This makes it necessary to think about the conditions for giving this 'intersectoral responsibility' a better chance of success. The Wiegel Committee has once again thrown a spotlight on the figure of the 'project minister', who would occupy a higher or more central position in the cabinet [19]. A project minister is a less obvious solution in the environmental field, however: the environment is not a project but a permanent and wide-ranging target of attention. The idea of a project minister only appears to have potential for success in a field of operation which is well-defined, including over time. A related option would be to transfer sector budgets to the Ministry of Housing, Planning and Environment, which would then return them to the sectors concerned under certain conditions. This model suggests a simple distinction between 'green' and 'non-green' guilders, something which is quite foreign to a policy geared to changing structures and processes. Increasing the intersectoral responsibility in the form of a normal process of choosing between the different aims, including those relating to the environment, is also not achieved in this way. In contrast to other similar major operations, the WRR considers strengthening of the environmental departments within the sectors to be the most appropriate way forward. This is not simply a question of increasing staff numbers, as it is currently often interpreted, but should above all relate to powers and accompanying budgets. Changing the power relations within the sectoral departments for the benefit of the environment is necessary to achieve the sector-responsibility required. The Ministry of Housing, Planning and Environment can then focus more strongly on the main environmental policy lines and on interdepartmental coordination. This 'orchestrating' function with respect to the environmental issue is of great importance for the unity of policy.

It is also of elementary importance for any process of choice that the relevant information is available to the participants in the political process. 'Political' should be interpreted broadly here: the commitment to sustainability is not only the subject of parliamentary decision-making, but of decision-making in all ranks of society. This demands openness of information. The call by the WRR in its earlier report on environmental policy for an obligation for institutions to make public information on the environmental impact of their activities can be repeated here [20]. The relevant bill provides for a major condition for the debate on sustainability.

In addition to these formal conditions it is essential that politicians take a stance on the topics which are of strategic importance for the commitment to sustainable development. Only when the priorities adopted and the choices made between the various interests are clear, can organisational schemes function optimally. A subsequent NEPP would have to make a contribution to this process.

A number of issues will be discussed below which, on the basis of the analyses conducted, need to be considered further and on which a position needs to be taken.

Energy

The expected acceleration in the use of fossil energy raises the spectre of exhaustion of oil and gas reserves within the space of half a century. This will undoubtedly cast its shadow over the geopolitical situation in the interim period. Added to this energy supply risk is the risk to the environment at the

19] *Naar kerndepartementen; kiezen voor een hoogwaardige en flexibele rijksdienst* (Towards core departments; opting for a high-grade, flexible public service), report to the fourth external committee on political, administrative and constitutional innovation, The Hague, Sdu uitgeverij, 1993.

20] WRR, *Milieubeleid* (Environmental policy), op. cit.

various levels of aggregation. The emission of CO_2 will be many times higher than at present, particularly if there is an increasing concentration on coal.

The present energy policy is motivated primarily by the potentially far-reaching effects of the anthropogenic CO_2 in the atmosphere. Doubts about these effects described above by the WRR do not alter the fact that there are risks attached to an increasing level of CO_2. In the reference scenario studied by the WRR, the likely level of CO_2 in the future is higher than generally assumed.

The political question is therefore whether these risks, and the risk of scarcity, should be translated into the stimulation now of changes which go beyond the commitments already entered into under the Climate Treaty. The various action perspectives examined the order of reduction in energy consumption needed during production and consumption in order to mitigate the risks of exhaustion and adverse environmental effects. In all cases, the required actions went beyond the currently observable change. The gains made to date, however, have been achieved through a policy based primarily on voluntary action. More far-reaching targets imply greater social risks. Political clarity is needed on the choices to be made.

The action perspectives also explored possible actions relating to the mix of (other) fuels in the longer term. Nuclear energy, biomass, solar energy, coal with CO_2-catchment and 'synfuels' all demand radical changes and long development periods before they can contribute substantially to the energy supply. In a sense, all these options are presently hanging over the market. Gradually, greater clarity will have to emerge regarding the option(s) in which investments will actually have to be made. To this can be added the important question of how the targets for the Third World are to be defined and achieved.

Food supply

The current political debate on food supply, both in the Netherlands and the EU, is focused primarily on tactical implementation issues. At EU level the 1992 MacSharry proposals, in conjunction with growing attention for the adverse external effects of agriculture on the environment, are the determining factors for policy. In the Netherlands a 'National Agriculture Debate' was recently launched, in which all concerned attempt to define a position for the Dutch farming industry in the new situation. This could mean an end in time to the protection given to certain sectors (in particular cereal and dairy farming), perhaps leading to a sharp decline in the competitive strength of Dutch agriculture. At global level, talks on agriculture are situated mainly in the context of the GATT negotiations. In the commitment to greater freedom of trade in agricultural products, the negotiations were targeted at reducing and eventually abolishing protectionist measures which have been maintained to date by countries and trading blocs in favour of their own farming industries.

The questions which emerge from the different action perspectives are partly in conflict with the present political agenda, while some of them do not feature on it at all. The issue of whether local or global agriculture is preferable is barely a subject of discussion. In practice, the outcome of the Uruguay round of the GATT talks means that global agriculture will increasingly become the norm. The abolition of trade barriers is after all aimed at promoting trade in agricultural products, in addition to which each country will be able to derive maximum comparative benefit for the production of specific agricultural crops. Policies geared to a more locally-based agricultural industry are difficult to reconcile with such an approach. If greater emphasis on a local approach is preferred, a route based on local self-sufficiency is a possibility. Various groups are concerned with this issue, including Greenpeace with its report

'Green fields, grey future', though the mainstream of the discussion is still focused on global agriculture [21].

A second important dimension in the action perspectives is the ability of the world to meet its food demands. The reality is that, generally speaking, per capita consumption is gradually increasing, though stabilisation and even a slight fall in the consumption of animal proteins has been observed in the United States in recent years; evidently the saturation point has been exceeded there [22]. In the majority of developing countries, per capita consumption is four times lower than the average for the developed countries. If a moderate food intake for every world citizen is to be a politically feasible option, the debate must in the first instance focus on the desirability of the gradual per capita increase which is now manifesting itself everywhere. At the moment, however, this is not even an item on the agenda.

Nature

The debate on nature conservation focuses on two different issues. First there is the way in which the remaining natural assets in the developing countries can be safeguarded without removing the development opportunities for those countries; this was an important issue in the debate at the UNCED conference in Rio de Janeiro in 1993. Secondly there is the discussion of whether nature conservation should be focused primarily on nature in the wild (as proposed by the Dutch branch of the World Wildlife Fund, for example, in their campaign to create 200,000 hectares of new natural environment), or on specific natural features which have arisen in the past as a result of agricultural activities (e.g. High Natural Value (HNV) farming systems) [23].

The action perspectives also make a distinction between a primary focus on unspoiled or 'free' nature and specific natural features, though there are also differences in the acreages to be set aside for this. This of course raises the question of which of these action perspectives would be 'better' for nature and whether the associated social costs can be met. The discussion on the safeguarding of natural areas in developing countries is an indication that this is a difficult issue. Leaving aside other interests, it is fairly easy to argue that the developing countries 'must not make the same mistakes' as the rich West made during its development. On the other hand, the result of that development process in the Western countries is perceived by developing countries as desirable. The social cost in the form of destruction of remaining unspoiled nature is apparently perceived in an entirely different way by the different parties.

The agenda of the UNCED conference has touched a vein here. In a subsequent round of this conference it will be necessary to present a more concrete picture of the demand in the developed world for unspoiled nature. The discussion so far has focused mainly on ideals. If the impasse is to be broken, this point will have to become a prominent issue on the political agenda over the coming years.

There is currently debate as to whether the Netherlands would do better to aim at certain forms of agriculture in order to safeguard specific environmental assets or whether it would be better to set aside large tracts of land with the aim of developing unspoiled nature. A thorough discussion would also

21) Greenpeace, *Green fields, grey future; EC agriculture policy at the crossroads*, Amsterdam, 1992.

22) J. Bongaarts, *Can the growing human population feed itself?*, Scientific American, March 1994.

23) D. Baldock, G. Beaufoy, *Nature conservation and new directions in the EC common agricultural policy*, Institute for European Environmental Policy, London, 1993.

have to include the other forms of land use in the Netherlands. In practice of course the choice is not simply between (often barely viable) agricultural land-use and the purchase of nature reserves. There is an extremely wealthy and virtually insatiable demand in the Netherlands for building land. Leaving this category arbitrarily out of the discussion threatens to create an administrative stalemate while the urbanisation trends penetrate to every corner of the land. The creeping urbanisation in the 'Green Heart' of the country, for example, shows that retaining the traditional agricultural land designations is not the most reliable guarantee for a 'sustainable rural' land use. High-quality green landscaping of the Green Heart might have more chance of success. The political debate will have to focus on development of this type in the near future.

Water

The discussion of the water policy to be pursued is conducted in several locations. In the Drinking and Industrial Water Supply Policy Plan the government sets out its plan for the 'sustainable safeguarding' of the public water supply [24]. The central plank of the policy is the supply of clean, safe drinking water to the consumer, while it is added that there are opportunities for savings (up to 20% by the year 2020) and that the growth in consumption must be covered by extending the use of surface water. All of these plans must be implemented in the context as set out by the NEPP, the Third Policy Document on Water Management, the Supplement to the Fourth Policy Document on Physical Planning (VINEX), the Nature Policy Plan and a number of other proposals and policy documents. The multitude of publications of this type is an indication that the water issue has many facets and that the political debate can thus rapidly become complex.

The basic principles of the Drinking and Industrial Water Supply Policy Plan clearly impinge on the core of the action perspectives as described in Chapter 3. The main issue is the distinction between the level of consumption (i.e. savings) and the quality standards for surface and groundwater. A striking feature of the opportunities put forward for savings, however, is that only a fraction of what is considered possible is also considered attainable. The division into different types of water ('grey water'), in particular, is pushed to one side. The action perspectives, on the other hand, show that precisely this type of structural change can throw a totally different light on the problem. A more focused discussion on this point is highly desirable for developments in the long term, though it is important to avoid a situation which all too frequently occurs now, where a lack of data is used as an excuse to refer options of this kind back to the exploratory study stage. It must be clear that desirable aims play a primary role here.

The quality discussion is much less prominent. While a good deal of attention is devoted to the quality of drinking water, the quality standards for ground water and surface water in general are addressed mainly through other discussions, such as those on nature conservation. This division of the discussion into drinking water quality and general water quality is heightened by the relationship of the latter with quantity management. A clear political prioritisation with respect to these different quality objectives would be very welcome. This could clearly influence the direction of the policy over the coming years.

24] *Beleidsplan Drink- en Industriewatervoorziening* (Drinking and Industrial Water Supply Policy Plan), Tweede Kamer, 1989-1990, 21 536, nos. 1-2.

Raw materials

The scarcity of raw materials has been removed from the political agenda in the last decade. Nonetheless, a reopening of the discussion appears in order in view of the industrial development in the Third World, which will lead to an increase in the use of raw materials over the coming decades. The rapid population growth and rising affluence will lead to a sharp increase in global consumption, bringing the issue of (relative) exhaustion of world supplies in the longer term right up to date. The discussion needs to focus on the options for conservation and recycling; a discussion on recycling is also important in the light of the waste problem. Moreover, it is likely that the pollution which accompanies mining activities and the amount of energy which has to be invested will only increase.

The political discussion of these topics has got under way to only a very limited extent. The action perspectives and their consequences over time make it clear that there are no grounds for doomsday scenarios. At the same time, however, they make it clear that radical choices are needed.

Chlorine

Chlorine plays an important part in the environmental discussion. A heated debate has raged about chlorine since the 1960s. The environmental movement points to the negative properties of many chlorine compounds and calls for an integral, source-oriented approach to the chlorine problem, geared to the elimination of the majority of chlorine compounds. Industry, on the other hand, seriously doubts these negative properties. The research results on which these alleged negative properties are based are deemed untenable or inadequate in several respects. It is pointed out that other substances and products score no better, and often worse, than chlorine compounds.

The government plays a secondary role in the chlorine debate. No specific policy has been developed for chlorine, though this seems to be changing: since 1993 the Ministry of Housing, Planning and Environment, at the request of the Standing Parliamentary Committee for Environment Management, has been carrying out and coordinating a strategic study of the possibility of closing the chlorine chain. In the United States, President Clinton initiated a study of chlorine in February 1994 'to assess its effects on human health and the environment, with an eye toward restricting or banning it'. This latter study was inspired by reports of reproduction-toxic and carcinogenic effects of oestrogen-imitating chlorine-containing compounds.

This report reveals fundamental uncertainties in virtually every area connected with chlorine. It is therefore debatable whether the relatively short-term activities now being developed in the Netherlands and the United States, for example, will 'bring to light the truth about chlorine'. Reducing the uncertainty through further research is of great importance, though at the same time a policy will have to be developed which does not deny the uncertainties but which takes them explicitly into account in a flexible approach. Issues such as source-oriented versus application-oriented policy, balanced distribution of the risk of uncertainty between the environment and the economy, effective use of environmental information and optimum use of market forces and of the narrow margins in an international context, are all of great importance for the chlorine issue. In developing a policy, the need for and possibility of creating an integral policy will have to be weighed against a more application-oriented policy. The chlorine problem varies widely per application: in many applications, chlorine is relatively environmentally-friendly. The negative properties of chlorine compounds need to be set against the economic benefits and compared with the risks of other human activities and of free nature. In an application-oriented approach, attention focuses more on the individual product chains, a process in which alternatives can also be involved.

4.6 Conclusion

Sustainable development is not a self-evident given, but demands very complex choices which are hedged about with many uncertainties. The choices, too, take the form of processes. New circumstances, knowledge and views necessitate regular adjustment of earlier agreements. Though it is in essence an open process, however, the need for choices based on available knowledge and prevailing views is no less for that.

The WRR feels that the next phase of the environmental policy would benefit from an explicit weighing up of environmental and social interests. This process should include not only diverse positions, such as those identified in this report, but also their consequences in the longer term. It is here that in many respects the core of the sustainability issue lies.

The choices to be made are many and radical. The choices themselves could be vary widely between the different participants in the political process. In the next chapter the WRR will make its own choices.

Towards a policy agenda 5

5.1 Introduction

The existence of divergent action perspectives focused on sustainability does not alter the fact that public choices have to be made. The essence of the political process is to arrive at a consensus, in spite of all the diversity of opinion, on the aims for which the government should strive. It was pointed out in the previous chapter that this consensus cannot be given a single interpretation in terms of the action perspectives. The consequences of the Utilizing or Preserving perspectives, for example, are mutually exclusive in the various areas. This inevitably means a differentiation per area, and this again accentuates the inherent need to make choices.

In this chapter the WRR will make its own choices. Although on the basis of the government's request for advice the description presented here of action perspectives for sustainability and their elaboration in scenarios would be sufficient, the Council wishes to go a step further. Clearly this involves a departure from the analysis and the introduction of the WRR's own preferences and considerations, alongside which others are of course also possible. However, if the WRR adopts its own stance on the basis of the analysis presented, this could stimulate further discussion on these issues.

Before elaborating this standpoint further, the Council would refer to the importance of a factor which is not specific to the various action perspectives but which is highly relevant for an assessment of them, namely the development in the world population. The various population scenarios have a far-reaching impact on the energy supply, the world food supply, the amount of space to be set aside for nature and the use of raw materials. This finding is in line with that of many other future projections in these areas and represents a plea for an active population policy, particularly on the part of the developing countries. However limited the results of this may be in the short term, its significance in the very long term is great.

The problems resulting from rapid population growth are concentrated particularly in East and South Asia and North Africa. The signals are not entirely negative, however. The rising prosperity in the densely populated Asia could be the trigger which helps create conditions favourable to a fall in the population growth. It is not only growth in material wealth which is involved here, but also a range of other factors related to affluence, such as good health care, educational facilities, social facilities and a changing position for women. For these reasons, too, the developing prosperity in these regions is to be welcomed, however disadvantageous it may seem to be for prosperity in the West.

The action perspectives and the scenarios derived from them exhibit wide differences on other issues. Many of these issues demand radical changes, however, and there are good grounds for implementing these changes if the situations to which the reference scenarios lead are studied. The nature of the proposed changes and the demands this places on the different actors and institutions vary widely, however. The standpoint adopted by the WRR is based in part on the following considerations.

A first consideration is that, where many different choices are possible, there must be a commitment in principle to maintaining maximum freedom of action. In the first place this means that irreversible developments with potentially major ecological and/or economic risks must be avoided. The assessment of the reversibility or irreversibility of developments is not simple and cannot always be seen in isolation from the costs: soil and water pollution are reversible, but the degree to which and the timescale within which this is possible depends on the financial efforts which those responsible are prepared to invest. Potential disruptions to the climate, depletion of the ozone layer or the dying out of species, by contrast, can no longer be reversed, whatever efforts are made. The only option is to prevent causative behaviour; once an effect has occurred, it must either be 'sat out' or accepted.

Irreversibility need not be a problem under all conditions: for example in the case of the exhaustion of a raw material for which a substitute is found in time. Here too, choices have to be made; both the exhaustibility and the substitutability of a raw material depend on know-how and costs. The same also applies, for example, to the increase in the CO_2 concentration in the atmosphere. Apart from the uncertainty of the scale of this increase, this is an irreversible process which need not be seen only in a negative light. Chapter 3 examined this point.

A second consideration concerns the relationship between the short and the longer term. The horizon adopted in this report is the coming half-century. It can be assumed that a number of developments will greatly increase the pressure on the environment during this period. Global developments in the use of energy, raw materials and land, as described in the reference scenarios in Chapter 3, illustrate this point. The adage 'time will tell' will certainly hold for some problems. At the same time it is important to try to prevent problems accumulating to such an extent that solving them involves gigantic costs. As stated earlier, this is not an unusual approach in the field of the environment; it is only when the consequences have reached crisis proportions that there is a willingness to accept substantial behavioural consequences. By then, however, the behaviour has become so normal that changing it is extremely difficult, while the costs of bringing about that change have often multiplied. It is often necessary to switch from a reactive to a pro-active or anticipatory policy, though the degree to which and the way in which this occurs varies depending on the action perspectives.

Finally, the WRR considers that an attempt must first be made to make environmental gains by changing the way in which consumer demand is met. Only when these changes in production prove inadequate should modification of the consumption itself be discussed. Various factors play a part in this consideration. Reducing consumption in developing countries is of itself undesirable, not only on social grounds but also for ecological reasons. Changing consumer patterns in the rich West is more appropriate. Where there is evidence of clear wastage or extensive pollution, there is also an obvious need for change. There are no differences between the action perspectives here. However, more radical actions affect the deeply-rooted freedom of consumption. Effectively controlling or moderating this consumption requires heavy instruments, and the social risks of the consequences of their use must not be underestimated. An attempt must therefore be made to achieve the envisaged environmental gains through changes in which the consumer demand is met.

Choices are made below for each area on the basis of the three normative considerations listed above. These considerations are not intended to be used as a litmus test, but do create a distinction when taken together. In each case, the choices to be made involve a weighing up of costs and benefits in an atmosphere of uncertainty, making maximum use of available information and estimations of risks.

5.2 Energy

The reference scenario described in Chapter 3 shows a strong increase in energy consumption resulting from economic growth in the Third World. There is an assumption here of a trend towards saturation in the North and a converging development in the South. If the per capita energy consumption were to develop over the next century in line with the reference scenario, the supplies of oil and gas would run out in the second half of the next century, with most of the currently known stocks of coal being exhausted around the end of that period. This trend takes place in spite of an assumed saturation of the demand for energy.

Under the reference scenario, world relations are radically changed by 2040; where the West and former Eastern Bloc currently use 70 per cent of fossil energy, the positions would be reversed under the trends referred to, with the North then accounting for 30 per cent and the South for 70 per cent of consumption. The total consumption of fossil energy would then be four times higher than now, however. This change in scale and percentages will lead to radical changes in the positions on the world energy market and will have major geopolitical consequences. Exhaustion of energy will manifest itself first in the regions where easily extractable supplies are located. The West, which has to import energy, will have great difficulty in securing an uninterrupted energy supply, even with military intervention such as in the Gulf crisis. The energy market will then be more of a seller's market, rather than a buyer's market as at present. Full account therefore needs to be taken of the fact that the physical exhaustion of energy supplies will be preceded by geopolitically determined scarcities, particularly of oil and gas.

In addition to the threatened exhaustion of fossil reserves, the stocks of uranium will be inadequate if an open cycle system is used. The use of fast breeder reactors could postpone the exhaustion of uranium stocks for many centuries, however. In theory, fast breeder reactors, if installed in numbers which far exceed the present world installed capacity of conventional reactors, could make a substantial contribution to the energy supply. The use of this technology entails substantial risks, however, which will increase proportionately if these reactors are used on a wide scale.

Environmental problems associated with the consumption of fossil energy will also increase enormously according to the reference scenario. The strong increase in global use of fossil energy (initially primarily gas and oil, later mainly coal) is accompanied by a steadily increasing environmental impact, even where advanced technologies are used: problems related to extraction (pollution and landscape effects), emission of harmful substances such as heavy metals and radioactive materials, acidifying emissions such as SO_2 and other waste problems will continue to increase.

In addition to these local and regional environmental effects, there are global environmental risks resulting from the use of fossil fuels. The speed with which human activity is changing the composition of the atmosphere is unparalleled in evolutionary terms. The change of 25 per cent in the CO_2 concentration in less than 100 years is the stuff of fables. According to the reference scenario a population increase, the spread of prosperity across the world and an increasing dependence on coal in the next century could lead to a five or even tenfold increase in CO_2 concentrations.

The consequences of this very rapid and large-scale change in the world carbon dioxide balance are unknown due to insufficient knowledge on the various feedback mechanisms, particularly from the large carbon reservoirs such as the oceans and the subterranean biomass. It appears highly likely, however, that this increased emission of CO_2 will be accompanied by a considerable increase in the concentration of CO_2 in the atmosphere. Such an increase need not always be disadvantageous; the production of some agro-ecosystems can even increase as a result of this 'CO_2 fertilisation'. A rapid rise in the CO_2 concentration can, however, also cause problems, for example where natural ecosystems are not able to adapt with comparable speed. This can lead to impoverishment of the biodiversity. Climatic changes may also occur, with possible temperature changes and an increase in the sea level. It is also possible that the relative stability of the climate will decline, though the risk of this and the social consequences of such a change are uncertain.

The WRR feels that, in spite of these uncertainties, a change of course is absolutely essential. Taking all the factors listed together - the finiteness of the fossil reserves, the geopolitical scarcity risks relating to oil and gas, the risks associated with nuclear energy and the nature of the potential environmental problems in connection with the use of fossil fuels - there is a pressing need for a break with the projected strong increase in the use of fossil fuels. The WRR takes this standpoint in spite of the existing uncertainty regarding stocks, trends in consumption and environmental problems. This change of course is not only desirable but also possible, because there are promising alternatives for fossil energy in various renewable sources of energy. Together, these renewable sources can meet a substantial part of the total energy supply needs in the longer term, provided the necessary steps are taken in good time. The diversity of the generation techniques and the less severe side-effects of renewable sources of energy constitute an important argument in favour of the development of renewable rather than fossil energy.

Each of the four action perspectives foresees increasing use of renewable energy sources in addition to cutbacks - for which there are substantial opportunities - in the use of fossil energy. This is in spite of the fact that increased use of renewable sources will demand storage systems to cope with discrepancies between the supply of renewable energy and the energy demand profile. Considerable conversion losses will also occur, pushing up costs. Developments in the transport and storage of renewable sources of energy can and must therefore be stimulated by the Netherlands.

Energy from renewable sources will not be able to meet more than 15 per cent of the total supply within the next 20 years. The technologies are insufficiently developed and the necessary infrastructural changes too extensive. For the time being, therefore, large-scale use of conventional energy sources will continue. There will initially be increasing emphasis on gas, later progressively switching to coal, the stocks of which are considerably larger than those of either oil or gas. Economic aspects mean it is unlikely that countries such as China will ignore their natural resources, which have so far been explored to only a limited extent. In view of the major environmental objections, however - increased CO_2 emissions, heavy metals, acidification, etc., as well as the erosion of the landscape and pollution as a result of mining activities - there is a need for further development of clean coal technology, an area where much progress can still be made. The joint initiative by the Dutch Electricity Generating Board (Sep) and Shell to build a pilot coal gasification power station in Dutch Buggenum deserves imitation. As long as renewable sources of energy are still being developed and their use remains limited, commercialisation of this technology in development cooperation projects with countries such as India and China is necessary. The required change in energy policy can only be achieved through cooperation with others, particularly multinationals. An increase in worldwide use of coal is unavoidable, and an increase in the atmospheric concentration of CO_2 therefore appears inevitable.

On the basis of the considerations in the foregoing section, the WRR has made a more specific choice within the field covered by the four action perspectives. More specifically, the Council considers a development comprising elements of both Managing and Preserving to be necessary. The WRR supports a long-term pro-active policy which takes full account of future risks. According to the results, the Utilizing scenario provides an inadequate response to this normative consideration. The WRR also feels that the Utilizing scenario does not offer future societies the necessary flexibility. The degree to which the future energy supply is made dependent on the use of coal stocks and nuclear energy in this scenario is undesirable in the view of the Council.

The Saving and Preserving scenarios place too great a demand on public willingness to change, in the WRR's view. The Council feels that a fall in energy intensity must be achieved primarily through changes on the supply side of the energy system. This does not however mean that the drive towards a reduction in energy consumption can be ignored; in areas such as mobility and living comfort the WRR considers changes both necessary and possible. However, the degree to which society relies on nuclear energy in the Saving scenario lacks the necessary flexibility in the Council's view.

The Managing and Preserving scenarios both focus a great deal of effort on the development of renewable sources. The obstacles to large-scale use of renewable energy are considerable, however, and as stated earlier a sharp increase in the use of coal appears unavoidable. This option will have to be used as part of the transition to mainly renewable sources, though a great deal will then have to be invested in technology to mitigate the environmental impact. This will have to be accompanied by a major effort to limit the energy intensity.

Priority in the science and technology policy - as part of an anticipatory policy - can be shifted further in the direction of the development of renewable sources of energy, with attention being given to all aspects: generation, storage and transport. Given both the promising opportunities and the urgency, it is striking that the research funding devoted to solar energy is only a fraction of that spent on R&D to improve the technology for fossil fuels and on nuclear energy (fission and fusion). This is a worldwide problem which - albeit to a lesser extent - also effects the Netherlands. Increased attention for renewable sources in the R&D policy is urgently required. A strengthening of the development and use of fuels based on renewable energy can be promoted by an activating energy policy on the part of the government.

The use of renewable energy sources in the Third World could be encouraged, for example through loans from the World Bank for the realisation of the necessary infrastructure. Here too the Netherlands, which contributes to these loans, can play a role.

While an energy policy based on targeted stimulation of R&D can encourage a shift in the direction advocated by the WRR, it is debatable whether this is sufficient. As with other changes in society which the government seeks to impose, there will be resistance in the energy market to the proposed transition: society has to adapt to a new structure in which existing interests can be damaged and in which higher investment efforts are required of various groups. Energy policy seeks to strike a balance between these 'social costs' and the economic risks of not pushing through the transition. In any event, if the stocks of fossil fuels should become exhausted in the future, this will almost certainly lead to major changes with economic consequences. Furthermore, as these economic risks become more tangible, i.e. as the future shortage is felt more and more, social resistance to a stimulated transition will decrease. The rate at which this transition can take place depends on the urgency of the perceived future shortage.

It might be expected that the market could engineer the necessary changes itself. After all, scarcity is translated into rising prices, and rising prices invite investments in substitutes. Thus as oil and gas, for example, become more expensive, investments will be made in solar energy and other renewable sources.

In practice, however, this is an overly simplistic representation of the case. In the first place the time horizon on which individual energy producers base their decisions is limited. More importance is attached to short-term gain than long-term income. The result is continuing fierce competition between energy producers to obtain the largest possible market share, even when the scarcity of oil and gas becomes visible. It is thus not in the interests of the producers to limit the use of fossil fuels. The sum of individual production decisions is therefore in conflict with a rate of use of finite reserves which is optimal from a societal point of view.

It is not only producers who fail to react according to the book to an imminent shortage: investors, too, show deviating behaviour. Investors are not interested purely in the return on their investment, but also in security. From this perspective, investments in totally new technologies are not attractive. Investors prefer to put their money into incremental improvements in proven technologies than into uncertain new alternatives. Only as the scarcity becomes more severe will investments of this sort be made. However, it is then very debatable whether technological development will be able to take place fast enough to accommodate the increased scarcity. The rate of technological development frequently lags behind the rate at which a scarcity is translated into price rises on the market. The consequence of this is reflected in the price. For example, the continuing rises in the price of energy following the oil crises was only brought to an end after around 10 years by the development of energy-saving technologies and diversification in the use of fuels.

If a transition from fossil energy to renewable energy sources is considered desirable, intervention in the energy market thus appears unavoidable; the market will not be capable of bringing about the desired structural changes in time on its own.

The environmental damage caused by various forms of fuels, and which to some extent is also caused by economic development, is another reason for intervention in the energy market. Environmental damage at the various levels of aggregation is not reflected in current prices. An energy tax could give a major boost to a range of desirable trend breaks. It could cut waste and boost technological development geared to more economical production and consumption of energy. Alternative energy sources would also be more favourably priced compared to fossil energy. Bringing in such a levy in good time could mean that the necessary innovations - which often require several decades of development to reach market maturity - become available at the moment that demand for them manifests itself. A gradual increase in the levy could limit the costs of the economic transition.

Imposing such a levy only in the Netherlands would merely lead to relocation behaviour and would thus have little point. The question then is how the correct scale can be achieved. However unattainable this may appear to be given the conflicts of interest in the world, the growing economic and political interdependencies mean it is not impossible. In its earlier report 'Environmental policy; strategy, instruments and enforcement', the WRR indicated a possible path to achieving this, and draws this to the attention of the government once again here.

An active environmental diplomacy needs to be launched in order to achieve the necessary increases in scale. This relates not only to international discussions, but also to strategic positions for the use of economic power, for example with respect to OPEC and the use of transaction instruments. The existing and growing dependencies between countries and trading blocs should be exploited during negotiations. There is a growing readiness in the countries of North and Western Europe to introduce a European energy tax. The influential Umweltrat (Environmental Council) in Germany, for example, has argued that Germany should take initiatives to encourage the European Union (EU) to implement a steady increase in fuel prices [1]. The Netherlands and other states would have to line up with such an initiative. The EU, as a net importer of fossil energy, must convince the countries of Southern Europe too of the threatened shortage. The need for an active energy policy of this type is felt in many places, and the Netherlands must respond to this. If full agreement can be reached within the EU on an energy tax, an important condition will have been created to convince others, beginning with the other OECD countries, to take similar measures.

If the world has proved capable of achieving a mammoth agreement such as GATT, which ultimately was created through a similar process of negotiation, an achievement such as a worldwide energy tax, or measures with a similar effect, must also be attainable. 'Prisoner's dilemmas', which prevent each individual country from taking rational action, can be broken down by the strategy outlined here. It must be borne in mind however that such an achievement, even if introduced in phases, cannot be realised within the space of ten or 15 years. This once more underlines the need for an early start on the necessary processes.
The global nature of the energy problem does not absolve the Netherlands from the duty to exploit its own options. The recommendations above relating to strengthening the development of renewable energy sources must be seen in this light. The same applies to the policy of energy-saving. Given the proven effectiveness of such a policy during the 1970s, there is every reason to work energetically for such a development. The transition from fossil fuels to renewable energy sources can be markedly influenced by a technology policy tied into those fields where national research offers favourable prospects, implementation of development projects and by pricing fossil energy in such a way that threatened scarcity and environmental impact are reflected.

Incentive programmes and domestic insulation initiatives are typical elements of a realistic anticipatory energy policy. A conservation policy in respect of the relatively environmentally friendly natural gas is also called for rather than the present exploitation policy. Given the need to determine the long-term conservation aims as accurately as possible, it is desirable to explore the mineral reserves in the Netherlands as thoroughly as possible.

5.3 Land use

5.3.1 Introduction

Both the action perspectives aimed at a sustainable food supply and those relating to nature and water have consequences for the division and use of space. Focusing attention on land use can therefore also provide an insight into the conflicts and opportunities in the three areas referred to. The most decisive factor is agriculture. The amount of land set aside for this determines the space which is available for other functions, such as afforestation and nature. There are wide differences between the action perspectives on this point.

1) *De Werkgever,* 10 March 1994.

The present land-use system is a cause of great concern, particularly if the potential consequences of the rapidly growing world population are taken into account. In spite of a fivefold increase this century, the world population is confronted with fewer real food shortages than in previous centuries. The major population concentrations of the world (China, India, Indonesia), for example, have experienced an unprecedented increase in food production over the last 20 years. The food shortages, poor nutrition and malnutrition which are a feature of Africa in particular, are less the result of inadequate farming practices as of political instability, wars and severe poverty.

The reverse of the coin, however, is that this - of itself very positive - development has been accompanied in several places by over-exploitation of farmland. Particularly in areas which are less suitable for agriculture, such as parts of Africa and Western Asia, the negative effects of farming are visible. Large tracts of these continents face major, almost irreversible damage to the production potential of farmland. Restoring the already eroded production capacity is of itself a virtually impossible task, which is magnified when added to the fact that the causes of that erosion have not been eliminated, with the result that the usable area of farmland is continuing to decline at the rate of 60 million hectares per year.

At the same time, a substantial expansion of farmland is taking place, particularly in areas less suitable for farming, for which a considerable portion of the remaining natural environment is being sacrificed at an increasing rate. The rapidly growing world population demands ever more space for its food production and other consumer needs. Where land is made productive, nature generally has to give way. In better farming regions, nature suffers through 'over-exploitation' of farmland. Drainage and fertilisation of Dutch meadowland, for example, has put great pressure on the vegetation and bird population. In the better arable areas, the use of biocides has led to local poisoning of surface water.

Over-use of fertilisers and biocides is more the rule than the exception in North-western Europe. This endangers the habitat of many species of plants and animals. Reversing this impoverishment of nature through human activity does not appear simple; it may in fact be the most resistant of the issues studied in this report. Humans have never been particularly careful with nature, as illustrated by innumerable examples. The destruction of ecosystems has been going on for thousands of years. The rapidity and scale of the erosion of recent years, however, is unprecedented.

Dependence on irrigated farming is increasing strongly, and in the marginal farming regions is accompanied by a highly inefficient use of water. Lowering the water table to facilitate agricultural production can also lead to problems with the water supply due to irrigation. Drought also influences the local flora and fauna. Large-scale irrigation in the countries around the Mediterranean Sea, for example, is currently leading to shortages of drinking water and drying out of whole tracts of land. In Spain, for example, waterworks have been built in the Guadalquivir River in order to meet the demand for water. Four out of five litres of this water are used for irrigation. This is causing the water level in the wetlands in the Danona National Park, located in the river delta, to fall by some 50 centimetres per year, while the bird population in the nature reserve - some 200 species, including a number which are almost extinct in Europe - is under threat [2]. From the point of view of a secure food supply, a safe drinking water supply and the conservation of nature, it is unarguable that these negative developments must be halted or combated.

2] F. Pearce, 'A long dry season ....'; *New Scientist*, volume 139, no. 1882, 17 July 1993, pp. 15-16.

Against the backdrop of the options described in Chapter 3, the WRR adopts the following standpoints.

5.3.2 Food production

As illustrated in Chapter 3, there are excellent opportunities for ensuring a secure world food supply. Even taking the high population scenario and a 'luxury' diet - something which differs strongly from the present diet of 90 per cent of the world population - there is no need for a shortage of food, at least at world level. Only in the Managing scenario, in which the Western demand for food is combined with a locally-oriented farming industry, do global problems arise.

The general conclusion is therefore that a sustainable supply of food at world level faces no physical obstacles. The same applies to forms of agriculture which give priority to closing cycles at local level; in these scenarios, too, demand can be met. In a number of regions there is even a possibility that the demand will be far exceeded in all scenarios. This applies in particular for Oceania, North and South America and Central Africa.

It must be remembered when considering these findings that we are talking here of an optimum use of land for farm production. It is assumed that farming is carried out efficiently in all locations in the world - something which is very far from the case in practice. Social and/or political circumstances mean that the actual production remains far below the potential in many locations, and it is highly debatable whether these parameters can be favourably influenced within the horizon set for this analysis. This may therefore lead to an overly optimistic picture of the opportunities.

On the other hand, the calculations are based on the assumption of production only on suitable land, so as to avoid problems of over-exploitation and the accompanying erosion which is primarily a feature of marginal land. On a world scale this means a reduction of at least 15 per cent in the total agricultural acreage. This is diametrically opposed to the current trend and it is very debatable whether this development can be achieved within the horizon. This condition may lead to an overly pessimistic impression of the opportunities, though two comments can be made to put this into perspective.

Firstly, there is room for a substantial reduction in the acreage because by no means all the land which is deemed suitable for production will be needed. In the Utilizing scenario (low population variant), for example, this suitable land is capable of producing more than three times the amount of food needed. This implies that a large amount of the land does not have to exploited. Which part this is, is not clear from the analysis presented; this requires supplementary assumptions regarding the need for or desirability of irrigation and the preference for production in high-yielding regions, following which transport of food can take place.

Secondly, the average acreage needed for farming is lower on a world scale than today, though there are considerable regional differences. In four regions (Central Africa, North Africa, North America and South America) the area deemed suitable for food production is greater than at present. These regions can thus cope with an increase in the farming acreage. This could, however, lead to increasing conflicts with other forms of land use.

With the exception of the Saving scenario (low population variant), all the scenarios show shortages in some regions. This implies that allowance must be made in all scenarios for the need for international trade flows. Moreover, in all scenarios it is mainly the regions in Asia which show a shortage. Even given the optimistically estimated production opportunities, there is insufficient capacity in these regions for sufficient food production to feed their own population. If it is also remembered that developing the necessary knowledge infrastructure and organisation in these regions will not be without problems (China, India!), the general conclusion that there will be sufficient food for all world citizens clearly needs to be modified. It should be emphasised once again, however, that the diet on which the scenarios are based, even in its most moderate form, is much better than the diet currently consumed in these regions. If there is no development towards this improvement in the diet, the structural shortages in the Asian lands may also not occur.

The starting point for all the scenarios worked out in Chapter 3 is that both locally and globally-oriented farming must be practised efficiently and in an environmentally-friendly way. Environmental problems which could occur due to over-use of crop fertilisers and biocides will thus be avoided. This principle is derived from analyses carried out earlier by the WRR for the European Community [3]; these showed that the use of biocides and the nitrogen surplus could be cut by around 80 per cent. In the Third World too, the introduction of integrated pest and disease control has had successes. Partly on the basis of research which is stimulated worldwide by the Consultative Group of International Agriculture Research (CGIAR), a substantial increase in productivity has been achieved, while at the same time the use of pesticides has been reduced in a number of locations.

Now that the consequences of the different action perspectives have been charted, the WRR will list the considerations which lie at the basis of its own preference.

First, the question of whether it is necessary to run the social risk of modifying the demand for food can be examined. That there is a social risk in trying to reduce this demand is evident. The income elasticity of animal consumption is very low: there is a strong income-related drive in the direction of a Western diet. Trying to combat this trend would therefore demand a great social effort. Moreover, calculations indicate that such an effort is not necessary: even if high population growth is assumed, a Western diet can easily be achieved by implementing globally-oriented farming. This will also reduce the need to transport food, while the need for land which has to be irrigated will also reduce. If it were also possible to influence the extent of the population growth and thus to assume the low variant, the room for manoeuvre would increase still further.

If it is remembered that locally-oriented farming leads to a) a relatively greater use of land; b) a larger area of irrigation; and c) a larger transport flow between regions, and that this is offset by a low impact on the local environment because of the closing of cycles at regional level, the complexity of the choices to be made becomes clear.

In the realisation that the global nature of this analysis means that a well-considered final view cannot yet be presented, the WRR feels that globally-oriented farming on balance offers more advantages. The additional obstacles associated with locally-oriented farming mean that the freedom of choice decreases. This prevents the highest level of efficiency from being reached, and this is reflected in a relatively large area of land and relatively high levels of irrigation being used. Opting for globally-oriented farming appears more appropriate for avoiding the problems associated with this. The WRR's prefe-

3] WRR, *Ground for choices; four perspectives for the rural areas in the European Community*; Reports to the Government no. 42, The Hague, Sdu uitgeverij, 1992.

rence here is based on a food supply variant somewhere between Utilizing and Saving.
There are also geopolitical reasons why the WRR considers it desirable to promote globally-oriented farming. Only then can a structural imbalance between supply and demand, and a structural dependence - and the associated tensions - between continents be avoided. An added advantage is that there would then be no need to transport food all over the world in order to compensate for shortages.

As shown in Chapter 3, a globally-oriented farming industry enables the regional food supply to be safeguarded, on the proviso that the production conditions in a number of regions, particularly Western Asia and North Africa, are improved. On the basis of an enlightened self-interest, it would be to the EU's benefit to promote agriculture in precisely those parts of the world where the population is growing at more than 2 per cent per annum. An EU campaign directed at these regions could be initiated by the Netherlands. The 'fertile crescent' in Western Asia (Iran, Iraq, Turkey, Syria, Lebanon, Israel, Jordan, Egypt and the Sudan) offers potentially sufficient capacity to meet the local demand for food, but is currently greatly under-utilised. Water is used in a highly inefficient way; improving the efficiency of agricultural water use is not only possible, but also very desirable. We can speak here of the need for a 'white revolution' (more efficient water use) following the 'green revolution' (more efficient land use) described in Chapter 3. Here, too, environmental diplomacy on the part of the EU offers opportunities for breaking the present undesirable trend of declining water utilisation efficiency and threatened or actual 'water wars'. The high dependency of a number of Middle-Eastern countries on cooperation with the EU could act as a lever here.

On the basis of the above, the WRR advises the government to develop globally-oriented farming further, to stimulate its introduction in other parts of the world and to provide maximum support for developments in those regions. This will prevent irreversible degradation of farmland, offer good prospects for the long term, and seek to achieve changes mainly in the productive sphere. The first step towards this in the Council's opinion would be the large-scale promotion of efficient farming systems in the most suitable locations. This implies ensuring a better match of the agricultural and environmental optimum on the one hand and the economic optimum on the other. To this end, access to external inputs needed to maintain soil fertility should be increased in large parts of the world. This is only possible if the 'exchange rate' for external inputs and (food) production is improved. The economic interdependence between North and South must thus be focused among other things on the guarantee of reasonable prices for products and, possibly, subsidies on certain inputs. Examples of such influence are the way in which the Netherlands has contributed to the 'green revolution' such as has taken place in India.

Dutch industry can also be encouraged to become involved in the regeneration of farming in China, Indonesia and the CIS republics. There is a paradox here, in that problems of under-utilisation of external inputs can be resolved by shifting exchange rates in favour of the inputs, while at the same time in other regions such as North-western Europe, the exchange rate must be influenced to the detriment of the inputs.

In order to prevent over-use of external inputs, a system of levies needs to be introduced. In its report 'Environmental Policy: strategy, instruments and enforcement', the WRR examined ways of implementing this. At European level there is now a willingness to curb over-use through such a system. Agricultural systems in which inputs such as biocides and artificial fertilisers are completely excluded can be used in a limited number of parts of the world. Regions where there is sufficient good farmland available, such as Europe, America and parts of Africa, can allow themselves the 'luxury' of applying these systems. Globally-oriented farming systems could make use of the various external inputs in a technologically responsible way. This places high demands on the level of training and organisational capacity of those concerned, as well as the willingness of governments to redress the imperfections in the market which arise from the absence of interests focusing on environmental impact. Even then, shortages will arise in a number of locations, and these will have to be covered by trade flows. This in turn demands stable trading relations on the one hand and, by no means the least important condition, a demand which is backed up by the necessary purchasing power. All in all, this presents an enormous challenge for the development of world farming regions which are currently lagging behind in relative terms. It can be done, however: it is a question of political will, and this is something to which even the relatively small Netherlands - which is nonetheless an agricultural superpower - can contribute, for example through its contribution to the FAO. This organisation has many influencing mechanisms at its disposal, and these must be utilised.

The Ministry of Agriculture, Nature Management and Fisheries must also give the Dutch knowledge innovation system in the area of agriculture more opportunity to focus a substantial part of its efforts on development cooperation, including with the CIS republics. In addition, the Ministry of Development Cooperation must support the Consultative Group of International Agriculture Research programmes and National Research Programmes aimed at global farming. This will foster productivity, stability, resilience and equality - typical characteristics of a farming and food supply system which is geared more to sustainability [4]. Building on farming experience and using knowledge and scientific insights, efforts can then be devoted to achieving a productivity increase which enables the food supply to be guaranteed without this having to be accompanied by adverse environmental effects. This is an area where the Netherlands has expertise. Activities by the ILEIA (Institute of Low External Input Agriculture) focusing on the harmonious realisation of an increase in productivity must be encouraged. The process of conversion to global farming will then take place at the right speed, thus avoiding disasters in terms of the security of the food supply as well as adverse environmental effects.

5.3.3 Nature

Domestication of nature inspired by economic interest is a difficult process to reverse, whether it concerns damage to coral reefs as a result of tourism or the destruction of tropical forests based on a desire to survive. In fact, the prospects are only relatively favourable for those natural areas which are so barren that there is little for humans to exploit - though even these regions are no longer entirely unaffected by diffuse influences from human actions elsewhere. Moreover, as crises arise elsewhere these regions, too, will be exploited for the extraction of raw materials.

In most cases, nature conservation comes down to safeguarding areas from human influence. Seen in this way, agriculture is the most direct competitor of nature for land use. This is true not only of the rapidly shrinking tropical rainforests, but also holds for the natural grasslands, the wetlands and the more general disappearance of biotopes. Forms of 'survival farming' in Africa and Asia, in particular, result in the felling of trees, exhaustive farming of land and erosion. Where high-production farming is practised, the original natural environment has long since been displaced. The remaining local

4) L.O. Fresco and S.B. Kroonenberg, 'Time and spatial scales in ecological sustainability', *Land use policy*, July 1992, pp. 155-168.

natural features in these regions are threatened by progressive erosion of their habitat as a result of land use, lowering of levels, use of pesticides and other agricultural techniques. It is therefore essential to promote a form of agriculture which utilises the best technical facilities and has the least harmful side-effects.

The analyses in Chapter 3 revealed that the prospects for nature conservation are more positive in some parts of the world than others. In Oceania, for example, the projected population pressure is so low that the unspoiled nature which still exists there can be preserved. In the two American continents and in Europe, as well as in the former USSR, the prospects for potential expansion of the protected area of nature lie between the positive outlook for Oceania and the negative outlook for Asia and Africa.

More generally, the preservation of as much nature as possible on a world scale thus appears to be furthered most by the globally-oriented farming proposed above. While there is in theory a good deal of room for manoeuvre in most regions, the risk of marginal land being kept in production is not negligible in practice.

Earlier analyses by the WRR in its report 'Ground for Choices' on the future of the rural regions in the European Community showed that the acreage currently in use for food production could technically be reduced to the extent that the area set aside for nature, which in most countries currently varies between zero and six per cent, could increase to more than one-third of the total land area.

The same does not hold without qualification for the world as a whole. In large parts of the world, farming is practised in an even less efficient way than is currently the case in many areas of the EU. A better water supply and agriculturally sound use of external inputs could lead to an enormous productivity gain and allow the growing demands on the scarce nature to be combated and even substantially reduced. This works in two ways. Firstly, the erosion of farmland could be combated; this would prevent local attacks on nature and specific natural features. Secondly, a larger proportion of the acreage could be used for nature conservation, thus fostering the preservation of species: as pointed out in Chapter 3, maintaining or increasing the natural acreage is essential for this preservation, at least if something more than conservation in museums is the aim. In the scenarios for agriculture it appears that sufficient acreage is released to meet the needs of nature conservation. In fact, around 70 per cent of the total land area of the earth is regarded as unsuitable for agricultural production, and at least 15 per cent of the present agricultural acreage could be converted to nature. And yet all four scenarios forecast problems, particularly in Asia. The productivity of present-day farming would have to be increased threefold here in order to avoid conflicts with nature conservation functions.

Conserving nature through efficiency increases in agriculture is diametrically opposed to the image that many have of the relationship between farming, nature and the environment, where an environmentally-friendly, extensive farming industry operates in close harmony with nature. Local production systems - such as those worked out for this report - which rule out the use of a number of external inputs, can lead to less pollution per unit area, but on average the area needed for a given quantity of product proves to be twice as great; if no irrigation is used, as much as three times as much land is needed. Whatever else happens, this greater area is taken at the expense of nature; human activity - however nature-friendly its intentions - always takes place at the expense of original natural functions. This makes it clear that environmental quality is a wide-ranging concept. Seeking to meet local environmental protection standards as far as possible conflicts with the desire to safeguard the greatest possible area for nature conservation. The choice here, therefore, is between environment and nature.

In order to avoid misunderstandings, it should be stressed that the WRR does not share the view that human intervention in nature always takes place at the expense of nature, or that man-made 'nature' no longer deserves that name. Such views over 'what nature actually is' not only feature in the Dutch debate, but also elsewhere. In the Netherlands, with its almost exclusively cultivated landscape, it is undoubtedly the case that cultivated elements are equated by many with nature; this even applies to typical 'culture-carriers' such as the traditional Dutch windmill.

Farming in the form proposed by the WRR can also be set up in such a way that more natural features are protected than those represented by the products themselves. This form of agriculture need not therefore be poor in natural features.

The approach favoured by the WRR is beginning to make an inroad in organisations concerned with agricultural development in the Third World, such as the FAO and the World Bank. The Council recommends that the government energetically stimulates this line of approach by these organisations, as well as making it a feature of development projects initiated by the Dutch government. The resistances which will have to be overcome are considerable, and it will be clear that the risks of this approach lie primarily in the area of political and socio-economic development. In many countries there is great resistance to relinquishing the immediate economic advantages derived from nature itself or of values which it may one day imply for mankind which, though vital, are currently still abstract.

The approach advocated by the Council implies the promotion of a European ecological main structure. There are various options for this, of which a shake-up of the European agricultural policy is the most important. In other parts of the world, regional programmes will first have to be developed which are geared to improving productivity and reducing environmental impact. Secondly, a critical examination will be needed to decide on the sites where agriculture must be developed.

Given the present economic relationships it is unlikely that the generally poorer exporting countries will voluntarily refrain from the exploitation of their natural assets. Behavioural change will have to come primarily from the importing countries, though compensation will have to be offered here, for example in the form of 'debt-for-nature' programmes (e.g. the planting of production forests). Technological improvement, for example increasing the durability of softwood, could lead to substitutes for tropical hardwoods.

The WRR's favoured approach is based on a variant between Preserving and Saving and implies nature conservation chiefly through an increase in the natural area. This preference is inspired primarily by considerations relating to irreversibility, the inclusion of long-term considerations in present action and the preference for modification of production structures. The most important structural means of achieving this aim is efficient use of farmland in Europe, Australia and America, and refraining from further extension of the cultivated area in Asia, Africa and Eurasia. This action perspective can in fact only be combined with the Utilizing or Saving action perspectives in the area of food supply.

Increasing the area set aside for nature offers the best structural guarantee for a reversal of the progressive impoverishment of nature and should provide a basis for the protection of individual plant and animal species. Current practice places the emphasis chiefly on protecting individual threatened species, while the processes which lead to biotope deterioration continue with virtual impunity. From the point of view of nature conservation, the present situation offers a wholly inadequate solution. While it is true that a few regions have been given protected status via treaties, their operation is often weak.

In the Council's view the present policy will not be able to check the progressive impoverishment of nature. As this impoverishment advances, the question will constantly arise of which individual species of plants and animals must be preserved. There is no unequivocal ethical answer to this question; the selection criteria will in practice be strongly determined by public preferences - a doubtful basis for nature protection. Unanimity in these preferences is virtually ruled out: one man's meat is another man's poison. Public preference is also subject to frequent fluctuations and thus offers a weak basis for durable protection. Even if unanimity and durability in the preference profile could be achieved, however, the practical realisation of protection is difficult. Often there is only a very limited scientific insight into the biotopes required for these species and the conditions necessary to sustain them. There is a not insignificant risk that this route ultimately leads to the scenario referred to in Chapter 3 as 'interesting species on a limited acreage', i.e. conservation in museum settings.

Changing agricultural practice is an enormous task, but also a great challenge. The advocated development will take decades to achieve; this means that the pressure on nature will not reduce for the time being - quite the reverse. The political priority given to nature conservation is not great in many countries, and calls for such protection from the West are often seen as hypocritical given the meagre attention devoted to nature conservation here in the past. The figures on the amount of protected nature and unspoiled nature on the various continents (see Chapter 3) illustrate this point. If Europe takes the lead here, for example by making serious attempts to develop an ecological main structure, this could give a powerful boost to calls for nature conservation.

Continuation of the present policy geared mainly to protecting species can only succeed if the process of reducing the area set aside for nature can be reversed. Where possible it can also encourage governments, via treaties or otherwise, to protect valuable natural areas.

5.3.4 Water

The foregoing discussion is marked by a strongly global approach, something made necessary by the nature of the problems, with the specific situation in the Netherlands being dealt with in a few cases. In the case of water, by contrast, a 'bottom-up' approach can be used, and what follows therefore relates almost exclusively to the Netherlands.

It was explained in Chapter 3 that a wide variety of views is possible regarding sustainable water management. In addition to differences over the way in which high-quality water can be supplied, there is currently also a debate regarding whether the problem is mainly a quality or a quantity problem. The alarming reports on the health risks associated with groundwater extraction point to a problem with quality, whereas the threat of to natural areas caused by drought points more to a quantity problem.

There is a strong link between these two problems. For example, the quality of the surface water in large parts of the Netherlands is so bad that the much higher-quality groundwater is used for irrigation purposes. The poor quality of the surface water is also leading to increasing dependence on groundwater for the preparation of drinking water. However, this puts such pressure on the groundwater that there is a threat of drought problems. In areas where both drinking water and irrigation water are extracted from groundwater, the water table has fallen so low that problems are occurring in moisture-dependent natural areas.

Excessive use of fertilisers in agriculture, particularly in the 'high' regions of the Netherlands, causes a further deterioration in the quality of the surface and groundwater. In a number of cases, this has already led to a need for additional measures in order to safeguard the water extraction.

This combination of factors means that clean, safe drinking water has become a rare commodity.

In the specific case of water, totally different approaches are possible in order to ensure an adequate supply of drinking water: efforts can be directed towards keeping the raw material (i.e. groundwater and surface water) as clean as possible, or else faith can be placed in advanced technology for purifying the polluted raw material. Technically, it is a simple matter to prepare drinking water from severely polluted water, though this involves considerable costs.

It is not only the drinking water supply which faces problems. The deteriorating water quality also has an effect on other functions, particularly the function 'nature'. Sustaining what are seen as valuable flora and fauna in the surface water demands a certain quality of that water.

According to the action perspectives described in Chapter 3, widely varying ideas are possible on the most adequate method of approach to both the quality and the quantity problem. This is caused chiefly by the almost total lack of knowledge regarding the relationship between parameters which are normally measured in surface water, such as phosphate, chloride and heavy metals, and environmental quality. Although in many cases the concentrations at which toxicity occurs are known, there is no indication of what concentrations of these substances in the water lead to an acceptable level of damage to the environment and specific natural features. For example, it is not known what the gain for nature would be if the concentration of heavy metals were to reduce by 50 per cent. In the absence of such information, reliance has to be placed on subjective estimates of effects. Statements are then made on the degree of risk which is thought to exist if certain limit values are exceeded. The debate on water quality focuses mainly on the establishment of such limit values. The wide division of opinion on this issue is an indication of the existence of different norm sets alongside each other, each of which is defended with equal vigour. These were used in Chapter 3 by way of specification of the action perspectives.

The avoidance as far as possible of irreversible effects or effects with a very long lag time is the best guarantee of sustainability. As regards the quantity problem, there is a need to modify the permanent extraction of groundwater and the conservation of the precipitation surplus. Of all the uses of the relatively scarce resource groundwater, its use for irrigation is the most debatable. The WRR therefore recommends cessation of the use of groundwater for large-scale irrigation and the process industry in drought-sensitive regions. In addition, drinking water can in the longer term be prepared from surface water. This demands a major switch in infrastructure and an energetic approach is necessary if progress is to be achieved in this area. It is already clear that a rise in the price of water would in this case be inevitable. It would be possible to anticipate this by more actively reducing water consumption by industry and households. Only surface water should be used for cooling in industry.

The quality problem focuses on groundwater; particularly where the quality of this water has to be safeguarded over the longer term, currently polluting activities must be stopped as soon as possible. This will not have any immediate positive impact on the quality, however, because much of the groundwater which is used for drinking water supplies is located in the so-called 25 or even 100-year zone.

In short, the Council recommends measures which boil down to a cessation of irrigation for agriculture, an active policy of reducing water consumption through the introduction of a progressive end-user tariff, banning the use of groundwater for industrial activities such as cooling and the establishment of public health standards for the protection of groundwater.

Irrigation out of favour

Around 200 million cubic metres of groundwater are used in the Netherlands per year for agricultural irrigation - around 10 per cent of the average annual replenishment from the precipitation surplus. The majority of this irrigation water is pumped up for use on grassland. Several studies have shown that, under Dutch conditions, this activity does not lead to an improvement in the operating result [5]. In most cases the costs of irrigation prove to be higher than the costs of the drought damage it avoids. The cost-benefit analysis is slightly more favourable in the horticultural industry where, depending on the crop, the soil type and phase of growth in which irrigation is carried out, a positive operating result can be generated.

This information should boost the drive towards a greater reduction in the use of scarce groundwater for irrigation in agriculture, for example via the transaction mechanism or through the imposition of bans.

Rather than supplementing the highly efficient water quantity management systems with irrigation to prevent drought, a more structural approach to the problem would be a rethink of that quantity management. Canalisation of streams, the creation of polders, drainage and dewatering systems mean that every shower of rain which falls on the higher areas of the Netherlands has disappeared into the North Sea within 72 hours. The water management system has always been geared to removing the precipitation surplus as rapidly as possible. By modifying the drainage system, the water-retaining capacity of the higher areas of the Netherlands could be significantly stepped up. It would then be necessary to accept the existence of marshy lowlands, and that not every form of land use would be possible in every location. If such a policy were to succeed, large-scale irrigation would be entirely unnecessary in most years, and the feared drought effect in the higher natural areas would then be effectively combated. Success would be conditional on an integrated system of regional development. The recent attempts to develop a region-specific policy in the so-called ROM (Regional Development Agency) regions could serve as an example here. The Council therefore recommends further development of this policy line.

An active policy geared to saving drinking water

Recapping, the WRR opts for a water supply scenario which is based on Saving, supplemented with elements from Managing.

5] G.E. Arnold, *Beleidsanalyse landbouw* (Agricultural policy analysis), DBW/RIZA, policy document no. 90 007, 1990.
Provincie Gelderland, *Rentabiliteit van beregening op melkveebedrijven en waterbehoefte van Gelderse landbouwgronden* (Return on irrigation on dairy farms and water requirements of Gelderland farmland), Arnhem, Dienst Waterbeheer, 1985.

The scenarios in Chapter 3 show considerable differences in the growth of mains water consumption. Both in the reference scenario and the high-consumption scenarios the consumption of fresh groundwater exceeds the level of annual replenishment in the longer term. This implies a depletion of the existing groundwater stocks.

In view of all the adverse effects of groundwater exhaustion, measures will have to be taken to make the high level of water consumption possible without over-exploitation of the groundwater. This means that extraction from surface water will have to be stepped up considerably, and this in turn demands a strengthened policy geared to ensuring storage capacity, such as the IJsselmeer lake and the reservoirs in the Biesbosch nature reserve.

Considerable savings percentages are assumed in the low-consumption scenarios. These savings can only be achieved if an incentive is incorporated in the system. A handhold for the policy is necessary both for the switch to surface water extraction and for the envisaged savings. This handhold can be provided by metering consumption of mains water: in the savings variant this builds in a strong impulse to save water without the government having to develop special programmes. For the growth variant, pricing can be used to steer the transition from the relatively cheap groundwater to the relatively expensive surface water. The investments needed for the transition can be financed from higher water prices. An additional advantage is that the regional differences in the price of water would then disappear.

A price increase of this nature would also encourage the effective use of other forms of water. Cost considerations mean that alternatives frequently come no further than the drawing board or experimental phase. Higher prices for mains water could change the situation radically.

Groundwater quality

The quality of groundwater, in particular, suffers greatly from the excessive use of pesticides and fertilisers in agriculture, especially on the higher sandy soils of the Netherlands. These are not only the regions where most groundwater extraction takes place, but are also the areas where farming requires a relatively high input of environmentally-harmful substances because the soils are less suitable for agricultural production. The quality standards set for groundwater could help in the allocation and regulation of land use. The Council feels that the irreversible processes and the long time lags which occur when groundwater is contaminated are so important that avoidance of pollution is the only appropriate way forward. This principle has been pushed aside on several occasions to date using the excuse of lack of feasibility. A credible and effective government policy on water supply in the long term cannot afford such negotiation compromises.

5.4 Raw materials

5.4.1 Copper

Although a good deal of attention has been devoted to the exhaustion of scarce metals in several studies, such as those carried out by the Club of Rome, the policy efforts have to date been few and far between. To the extent that serious initiatives have been undertaken, they have moreover been motivated from the basis of the waste policy. The idea of a threatened metal shortage does not hold strong credence.

In the area of fossil energy, too, the notion of finite reserves has not always been so real as it is today. It was only after the first oil crisis that the exhaustibility of energy began to be seen as a real possibility. Although the oil crises were not caused by physical shortages, they did confront the world with situations which could arise as a result of such shortages. It is equally possible that a similar shortage of metals could occur in the future.

Given the expected growth in the world population, and certainly in view of the expected increase in prosperity in parts of the Third World, the WRR felt it would be useful to examine the issue of the exhaustion of scarce metals and of how policy should contribute to a sustainable development in the use of these metals. The sustainability approach is illustrated using copper as an example.

On the basis of existing knowledge it is practically impossible to make well-founded statements on the ultimately extractable reserves of the scarce metals. In the case of copper these reserves are probably many times greater than the currently known reserves of barely 500 million tonnes, since the extent of the known reserves is totally dependent on the explorations carried out. These explorations are in turn geared to the reserves which are extractable given the current economic parameters. This leads to a distorted picture of the actual reserves present.

It is equally impossible to make predictions with any certainty regarding the future energy-intensity of the extraction of raw materials. In all probability the energy-intensity of extraction will increase due to the exploitation of other ores where extraction is more difficult. As the energy supply itself begins to demand more resources due to the increasing scarcity of energy, this will also have an effect on the copper supply.

Particularly in view of this latter consideration, and given the trend in demand for copper, especially in parts of the Third World, there is a need for change on the demand side. In the WRR's view this requires a policy geared to recycling, saving and substitution. While this will obviously not prevent the exhaustion, it will enable that exhaustion to be considerably delayed.

In the Netherlands and in the world in general, recycling is still in its infancy; on a world scale, the recycling percentage is no more than 18 per cent. There are several reasons for this, some economic and some institutional. As the recycling fraction increases, the costs of recycling also rise, and the costs of the last fraction of recycling will be more or less in balance with the costs of extracting the primary product. This is currently below 50 per cent, but could be raised to more than 50 per cent of the total use by an active policy.

Recycling could be given a permanent boost by channelling the cycle of material consumption on various fronts. Product instructions outlining the possibilities of disassembly could push down the costs of recycling and increase its yield. Streamlining the waste collection system could also increase the recovery yield. Technological developments geared to reducing leakage in raw materials' cycles should also be strongly promoted in the WRR's view.

There are great opportunities for savings and substitution by less scarce materials. The trend in the demand for copper illustrates the point. The use of copper is being concentrated increasingly on the conduction of electricity. Aluminium, which geologically is much less scarce, could be used as an alternative for this; however, substitution of copper by aluminium is currently hampered on many fronts by a series of technical drawbacks. In many respects, therefore, this is an example of an insufficiently developed technology. Research aimed at increasing the usability of aluminium for electrical applications is potentially one of the greatest contributions to avoiding a severe copper shortage.

The WRR feels that the use, recycling and exploitation of raw materials should not represent a problem for a sustainable society, provided the following conditions are met.

Firstly, it is sensible to continuously monitor the urgency of the exhaustion problem. Participation in international activities aimed at cataloguing reserves and identifying trends in use are therefore logical steps. Given these trends in use and the uncertainty regarding the reserves, there also appears to be a need for measures to promote the recycling of scarce metals. Such a policy would not only help to combat the exhaustion of these raw materials, but would also help to reduce waste flows. Curbing the growth in the use of scarce metals would also be boosted by encouraging research into efficient use and substitution technology.

The problem of the exhaustion of scarce metals impinges on the economic world order and the distribution of wealth between North and South. In large parts of the world the demand for scarce metals such as copper will rise sharply and radically as a result of increasing affluence, which inevitably will be accompanied by a certain degree of electrification. For the time being the use of copper in the North is higher than in the South, however, both in absolute terms and in per capita consumption. The scale of consumption in the North is so large that there are grounds for concern about the much larger scale of copper use which will accompany the increase in material affluence in the South. If the present low recycling fraction continues, the quantity of primary copper needed could be a limiting factor. It is sometimes said in this connection that the affluence pattern of the industrialised world stands in the way of sustainable development. The need for a change in the Western lifestyle is then pointed out. This is the case in the Preserving and Managing action perspectives, for example.

Until much more powerful attempts are made to achieve savings and substitution, the WRR is not convinced of the need for a change in the consumer patterns based on the availability of the raw materials. The Netherlands possesses promising expertise in the area of copper-substitution aluminium technology; this must be further developed. Temporary government support could be granted to help bear the risks.

5.4.2 Chlorine

Chapter 3 focuses attention on chlorine. While this may seem a very specific choice, there are a number of good reasons for this. Today's affluence is based to a large extent on the use of chlorine, and the production and consumption of this element therefore involves major interests. Few will realise that more than 60 per cent of consumer goods either contain chlorine or are produced using a process involving chlorine.

In addition, rightly or wrongly, chlorine has attracted a great deal of attention in recent decades in the environmental debate. Chlorine compounds play a key role in several - sometimes serious - environmental problems such as depletion of the ozone layer and erosion of the quality of air, water and soil.

It is clear that a 'chlorine policy' is of itself of little use. More sensible is the pursuance of a policy for specific applications derived from the action perspectives. As regards the open applications of chlorine, i.e. applications in which the element or product is released into the environment unhindered, the WRR adopts the standpoint of the Managing action perspective, opting for a flexibility strategy. An essential component of this is the avoidance as far as possible of harmful irreversible processes. While these can obviously never be completely ruled out, this offers a useful criterion for making choices. For closed applications, i.e. applications in which the potentially harmful substances remain within the industrial chain, the present policy is adequate.

In concrete terms, this position comes down to the following. A substantial quantity of the chlorine produced - around 55 per cent in Europe - is used in virtually closed applications. The majority of these do not pose an irreversible threat to the environment and can therefore be maintained. The definition of closed processes does need to be tightened up: an activity - production, transport, consumption and final processing - is referred to as closed if the regular and accidental emissions do not exceed the natural background levels. If emissions do exceed these levels, there must be a clear demonstration that they are harmless.

The remaining 45 per cent of chlorine used for products supplied to external customers (processors, consumers, etc.) largely entail open applications. In many cases there is evidence of excess emissions whose harmlessness has not been convincingly demonstrated. In some of these chlorine applications closing the cycle within a reasonable term appears quite possible: by reducing the emissions, by creating facilities for recovery or recycling, or by convincingly demonstrating the 'harmlessness' of these emissions. In those cases where it is not possible to reduce the emissions sufficiently and where they cannot be proven to be harmless, it will be necessary to eliminate the chlorine product concerned. It is probable that roughly 25-35 per cent of the present applications of chlorine can be eliminated over the coming years. For the remaining applications it will probably be possible to take steps to ensure that they can be maintained within the framework of the outlined strategy.

An important factor here is the speed with which the above steps have to be taken. Given the typical times necessary for change in industry, a period of 10 to 15 years would probably enable a realistic and correct balance to be found between economic and ecological risks.

Technology plays an important part in these recommendations by the Council. A reservoir of technical options makes it possible within certain limits to respond to changing circumstances and insights. Change can be accelerated by stimulating technological development - including both management and replacement technology - in certain directions. Examples include techniques for further reductions in emissions (incinerators, strippers, biological treatment plants, advanced forms of process control, etc.) and cycle closure, research into alternative materials and products, development of a better destruction technology, techniques for separating the production of chlorine and sodium hydroxide and improved techniques for preventing and dealing with calamities.

In addition social, institutional and cultural factors all play a role. Flexibility cannot be isolated from issues such as distribution of responsibility, clarity regarding the objectives, the level of communication and a sense of urgency. The right social parameters must be created and there must be a commitment to the internationalisation of action and information-provision (ending information shortages and creating structures in which information is actually used). The motto here is 'change, not a ban'.

5.5 Conclusion

In this chapter the Council has attempted to arrive at its own interpretation of sustainable development while taking into account the results of the analyses presented in earlier chapters. This standpoint is limited to the extent that this report does not devote attention to all themes relevant to sustainability. It also has a general character; a more specific interpretation would require much more detailed analyses than those carried out for this report. However elementary these analyses may be, they nevertheless offer pointers for strategic policy formation.

The fact that sustainability demands a policy geared to the long term is self-evident. The objectives advocated by the WRR in this chapter accordingly deviate widely in most cases from the current situation and trends. This does not mean that they are unattainable, however. If nothing else, history has taught us that major changes are possible within the space of a few generations. If these changes are initiated early enough and the necessary steps have a cumulative nature, these tasks need not be impossible to achieve.
The approach adopted does not lead obligatorily to a certain position. The contours of the WRR standpoint outlined earlier are based largely on normative choices. The preference for seeking sustainability first and foremost through changes in production methods and structures is an example of such a choice. Although it is apparent in various areas that modification of consumption is essential, it is also clear that sustainability does not inherently demand total frugality. The situation in the areas studied varies widely, however, and overgeneralisation is best avoided.

A broad view is also necessary when considering the action perspectives contained in this report. As the scenarios showed, it is not possible to adopt a single perspective for any length of time across the full spectrum of all the areas studied. Conflicts eventually arise between the objectives for the different areas, and it is therefore not surprising that the WRR standpoint developed in this chapter presents a mixed picture in which each of the individual perspectives plays a role. This fact once again draws attention to the need to make choices; the road to sustainability is not set out in advance. In fact, this is the central message of this report.

Appendix

Text of the request of the Dutch Government for recommendations on the relationship between environment, economy and administration of 5 September 1990

The need to solve of environmental problems has grown in recent years into a policy issue of the first order. An unceasing flow of information shows that new problems are continually emerging while old ones are frequently not adequately solved. The reduction of excesses, such as soil pollution, etc., is already an enormous task for the short term. For the long term, however, more is needed. Like the report 'Our Common Future', the National Environment Policy Plan asserts that environmental problems can most effectively be tackled by a commitment to sustainable development. This principle is elaborated in the NEPP in the form of a commitment to a minimum input of energy, the closing of substance cycles and an improvement in the quality of production processes and products. In order to achieve these aims, a large number of measures and rules are discussed which often have to be introduced through legislation. Great reliance is placed on the adequacy of the traditional tools available to the government.

However, questioning whether the administration will be capable with the resources currently at its disposal of bringing about a behavioural change in the private and market sector, either through incentive or compulsion, which is sufficient to ensure that the envisaged short and long-term aims are indeed achieved, does not appear entirely unjustified. It is possible that the familiar arsenal of legal and administrative means of intervention will be inadequate and that other mechanisms and resources will have to be sought in order to achieve environmental objectives. Technological options and resources will play a particularly vital role here.

A constitutional state which pursues an active, broad and radical policy of 'sustainability' encounters structural barriers which cannot be broken through by more and stronger regulations, nor through more government resources or a larger implementation and enforcement apparatus. It is not correct to attribute the scope of the present environmental problem to a lack of government attention; compared with the legislation in other fields, environmental legislation has seen by far the most rapid growth in scope and impact over the last twenty years. Accusations that the quality of the government's action is inadequate are equally unfounded.

Nonetheless, the quality of the environment has indubitably deteriorated, sometimes seriously, in a large number of components and respects, in spite of the relatively intensive policy effort. This can be attributed primarily to the fact that the causes of many environmental problems have increased even more rapidly in scope and number than the measures aimed at combating them. Nevertheless, policy continues to be based on the principle that the traditional instruments - more money and more rules - offer the best chance of achieving the policy aims of the NEPP and its follow-up document, the NEPP+. The question is whether this is actually the case.

As regards instruments geared to influencing behaviour, a distinction between physical regulation, financial regulation and social regulation (self-regulation, consciousness-raising) introduces an element of clarity. Less usual instruments which tie in directly with market operation, such as increasing private liability, introducing zoning, compensatory or regulatory levels, compulsory exchange of environmental assets, and forms of social regulation, could be investigated further.

The government therefore requests the WRR to produce recommendations on the relationship between the environment, economy and administration, in which the first phase should investigate the factors referred to above as well as other administrative and legal options for achieving sustainability targets in the medium and longer term. In abstract terms, this essentially means an investigation into how a society which is ruled according to the principle of parliamentary democracy, and in which the allocation of products, production factors and income is provided by the operation of market forces - plus global adjustment - can find a solution for the implementation of this policy.

However, the analysis cannot be restricted to instruments and their implementation. There is a clear mutual relationship between instrument and objective: a change in the topic or the operation of an instrument can throw new light on the objective to be achieved with it. A given objective can be achieved more effectively using one instrument than another. Moreover, it is debatable whether a package of instruments produces the same results as might be expected on the basis of an evaluation of individual instruments; there may be synergetic and/or antagonistic effects. The key issue is to achieve a good mix of instruments, in which the aspect of enforceability of regulations is of great importance.

In essence, the demand for sustainability requires a definition of what needs the present generation must safeguard both for itself and for future generations. Sustainable development as defined in the Brundtland report leaves room for varying interpretations in its elaboration.

In meeting this demand, objectively recordable ecological requirements play an important role, though radical normative choices are also important. These relate for example to the relationship between man, environment and nature, and the responsibility for future generations. The extent to which the various aims of sustainability are mutually reconcilable in the long term should be examined. It is important to bear in mind here that various conceptions of the term 'sustainability' are possible.

In the second phase of its study Environment, economy and administration the WRR is therefore requested to set out a number of possible options for sustainable development, taking into account initiatives to this end which have been taken in other countries. Use will be made here of the collaboration with various institutes and research establishments. These definitions will then be elaborated quantitatively, making use of the results of studies on sustainable development by the National Institute for Public Health and Environmental Protection (RIVM) and the Central Planning Office (CPB). Elaboration of the different conceptions is necessary primarily because visualisation of the consequences can give an indication of how far-reaching the realisation of the various options is and can create clarity on the level of conflict or incompatibility between the objectives, both seen from different angles and from within the same perspective. For the economic extrapolations, the WRR will call on the assistance of the Central Planning Office.

In fact, the following three subareas can be distinguished. they can be subdivided into two phases, both concluding with an advisory report to the government:

Phase I:

1. Compiling an inventory, evaluating and where possible putting forward proposals for implementation of a range of administrative/legal instruments in relation to the prevailing objectives, with special attention for the less usual instruments, such as those operating through market forces. This will involve an investigation of the extent to which financial and 'social' regulation can

play a role alongside the more traditional direct physical regulation within the environmental policy. The aim is to achieve a good mix of instruments, in which the aspect of enforceability of regulation is of great importance.

Phase II:

2. Elaboration, in conjunction with others, of various concepts of sustainable development and accompanying objectives, taking into account the results of initiatives taken in this field in other countries.
3. A global quantitative elaboration of the above in the form of a number of alternatives for each sector or level of aggregation in order to investigate the consequences of the various elaborations. The results of the first phase will be incorporated in the drawing up of the alternatives in an iterative process.

The Council has published the following Reports to the Government

First term of office

1 Europese Unie (European Union), 1974.

2 Structuur van de Nederlandse economie (Structure of the Netherlands Economy), 1974.

3 Energiebeleid op langere termijn (Long-term Energy Policy), 1974. Reports 1 to 3 are published in one volume.

4 Milieubeleid (Environment Policy), 1974.

5 Bevolkingsprognoses (Population Forecasts), 1974.

6 De organisatie van het openbaar bestuur (The Organization of Public Administration), 1975.

7 Buitenlandse invloeden op Nederland: Internationale migratie (Foreign Influence on the Netherlands: International Migration), 1976.

8 Buitenlandse invloeden op Nederland: Beschikbaarheid van wetenschappelijke en technische kennis (Foreign Influcence on the Netherlands: Availability of Scientific and Technical Knowledge), 1976.

9 Commentaar op de Discussienota Sectorraden Wetenschapsbeleid (Comments on the discussion Paper on Sectoral Council of Science Policy), 1976.

10 Commentaar op de nota Contouren van een toekomstig onderwijsbestel (Comments on the White Paper on the Contours of the Future Education System), 1976.

11 Overzicht externe adviesorganen van de centrale overheid (Survey of External Advisory Bodies of the Central Government), 1976.

12 Externe adviesorganen van de centrale overheid, beschrijving, ontwikkelingen, aanbevelingen (External Advisory Bodies of the Central Government: Description, Developments, Recommendations), 1977.

13 'Maken wij er werk van?' Verkenningen omtrent de verhouding tussen actieven en niet-actieven ('Do we make Work our Business?' An Exploratory Study of the Relations between Economically Active and Inactive Persons), 1977.

14 Overzicht interne adviesorganen van de centrale overheid (Survey of Internal Advisory Bodies of the Central Government), 1977.

15 De komende vijfentwintig jaar, een toekomstverkenning voor Nederland (The Next Twenty-Five Years: a Survey of Future Developments in the Netherlands), 1977.

16 Over sociale ongelijkheid, een beleidsgerichte probleemverkenning (On Social Inequality: a Police-oriented Study), 1977.

Second term of office

17 Etnische minderheden – A. Rapport aan de Regering; B. Naar een algemeen etnisch minderhedenbeleid? (Ethnic minorities – A. Report to the Government; B. Towards on Overall Ethnic Minorities Policy?), 1979.

18 Plaats en toekomst van de Nederlandse industrie (Industry in the Netherlands: its Place and Future), 1980.

19 Beleidsgerichte toekomstverkenning: deel 1. Een poging tot uitlokking (A Policy-oriented Survey of the Future: Part 1. An Attempt to Challenge), 1980.

20 Democratie en geweld – Probleemanalyse naar aanleiding van de gebeurtenissen in Amsterdam op 30 april 1980 (Democracy and Violence – an Analysis of Problems in Connection with the Events in Amsterdam on April 30, 1980), 1980.

21 Vernieuwing in het arbeidsbestel (Prospects for Reforming the Labour System), 1981.

22 Herwaardering van welzijnsbeleid (A Reappraisal of Welfare Policy), 1982.

23 Onder invloed van Duitsland. Een onderzoek naar gevoeligheid en kwetsbaarheid in de betrekkingen tussen Nederland en de Bondsrepubliek (The German Factor, A Survey of Sensitivity and Vulnerability in the Relationship between the Netherlands and the Federal Republic), 1982.

24 Samenhangend mediabeleid (A Coherent Media Policy), 1982.

Third term of office

25 Beleidsgerichte toekomstverkenning: deel 2; Een verruiming van perspectief (A Policy-oriented Survey of the Future: Part 2: Towards a Broader Perspective), 1983.

26 Waarborgen voor zekerheid; een nieuw stelsel van sociale zekerheid in hoofdlijnen (Safeguarding Social Security), 1985.

27 Basisvorming in het onderwijs (Basic Eduaction), 1986.

28 De onvoltooide Europese integratie (The Unfinished European Integration), 1986.

29 Ruimte voor groei (Scope for Growth), 1987.

30 Op maat van het midden- en kleinbedrijf (Tailoring Policy to the Needs of the Small and Medium-sized Business), 1987.

31 Cultuur zonder grenzen (Culture and Diplomacy), 1987.

32 De financiering van de Europese Gemeenschap (Financing the European Community), 1987.

33 Activerend arbeidsmarktbeleid (An Active Labour Market Policy), 1987.

34 Overheid en toekomstonderzoek (Government and Future Research), 1988.

Fourth term of office

35 Rechtshandhaving (Law Enforcement), 1989.

36 Allochtonenbeleid (Immigrant Policy), 1989.

37 Van de stad en de rand (Institutions and Cities; the Dutch Experience), 1990.

38 Een werkend perspectief (Work in Perspective), 1990.

39 Technologie en overheid (Technology and Policy), 1991.

40 De onderwijsverzorging in de toekomst (Educational Support in the Future), 1991.

41 Milieubeleid; strategie, instrumenten en handhaafbaarheid, (Environmental Policy: Strategy, Instruments and Enforcement), 1992.

42 Grond voor keuzen; vier perspectieven voor de landelijke gebieden in de Europese Gemeenschap (Ground for Choices), 1992.

43 Ouderen voor Ouderen; demografische ontwikkelingen en beleid (Demographic Developments and Policy), 1993.

Fifth Term of office

44 Duurzame risico's: een blijvend gegeven (Sustained Risks: a Lasting Phenomenon), 1994.

45 Belang en beleid; naar een verantwoorde uitvoering van de werknemersverzekeringen (Interest and Policy; to a Responsible Implementation of Employee Insurances), 1994.

46 Besluiten over grote projecten (Decision-making on Complex Projects), 1994.

47 Hoger onderwijs in fasen (Higher Education), 1995.

Reports nos. 13, 15, 17, 18, 28, 31, 32, 42 and 44 have been translated into English; English summaries are available of Reports nos. 16, 18, 19, 20, 25, 26, 27, 29, 30, 33, 34, 37, 38, 41 and 47; Report no 23 has been translated into German. Of Report no. 42 a German and a Spanish Summary is available, as well as a full French translation.

The Council has published the following Preliminary and background studies (in Dutch)

First term of office

V1 W.A.W. van Walstijn, Kansen op onderwijs; een literatuurstudie over ongelijkheid in het Nederlandse onderwijs (Educational Opportunities: a Literature Study of Inequality in the Netherlands Educational System) (1975)

V2 I.J. Schoonenboom en H.M. In 't Veld-Langeveld, De emancipatie van de vrouw (Women's Emancipation) (1976)

V3 G.R. Muster, Van dubbeltjes en kwartjes, een literatuurstudie over ongelijkheid in de Nederlandse inkomstenverdeling (Dimes and Quarters: a Literature Study on Inequality in the Distribution of Income in the Netherlands) (1976)

V4 J.A.M. van Weezel a.o., De verdeling en de waardering van arbeid (The Distribution and Appreciation of Work) (1976)

V5 A.Ch.M. Rijnen a.o., Adviseren aan de overheid (Advising the Government) (1977)

V6 Verslag Eerste Raadsperiode 1972-1977 (Report on the First Term of Office) (1972-1977)*

Second term of office

V7 J.J.C. Voorhoeve, Internationale Macht en Interne Autonomie International Power and Internal Autonomy) (1978)

V8 W.M. de Jong, Techniek en wetenschap als basis voor industriële innovatie – Verslag van een reeks van interviews (Technology and Science as a base for Industrial Innovation) (1978)

V9 R. Gerritse, Instituut voor Onderzoek van Oveheidsuitgaven: De publieke sector: ontwikkeling en waardevorming – Een vooronderzoek (The Public Sector: Development and Valuation) (1979)

V10 Vakgroep Planning en Beleid/Sociologisch Instituut Rijksuniversiteit Utrecht: Konsumptieverandering in maatschappelijk perspectief (Shifts in Consumption in a Social Perspective) (1979)

V11 R. Penninx, Naar een algemeen etnisch minderhedenbeleid? Opgenomen in rapport nr. 17 (Towards an Overall Ethnic Minorities Policy? Attached to Report nr. 17) (1979)

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