RIVM Report 402001010 CONFIDENTIAL

A contribution to UNEP's strategy for monitoring and assessment

J.A. Bakkes, M.M. Berk, F. Langeweg,
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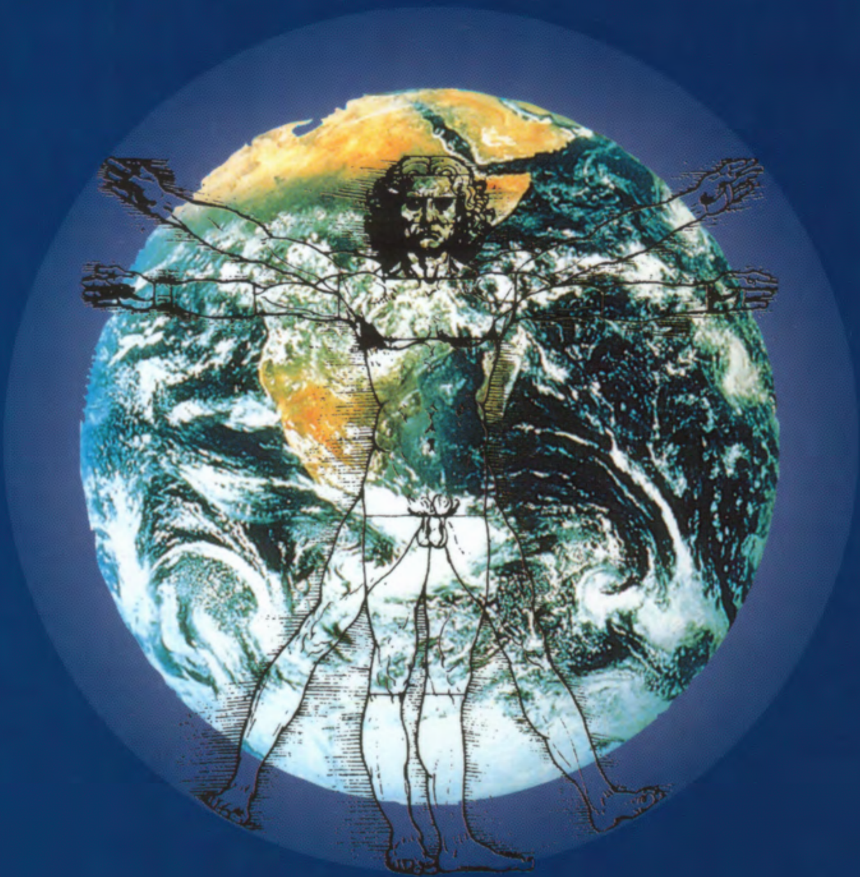

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Programme

research for
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research for man and environment
RIJKSINSTITUUT VOOR VOLKSGEZONDHEID EN MILIEU
NATIONAL INSTITUTE OF PUBLIC HEALTH AND THE ENVIRONMENT

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EXECUTIVE SUMMARY

Mandate and tasks

UNEP has paraphrased its mission as: "To provide leadership and encourage partnerships in caring for the environment by inspiring, informing and enabling nations and people to improve their quality of life without comprising that of future generations". In this spirit, its mandate was reaffirmed in 1997.

On this basis, the present study concludes that it is UNEP's task to inform the UN General Assembly about:
◊ key developments in the state of the world's environment;
◊ environmental problems ahead;
◊ how environmental problems relate to other issues and sectors;
◊ possible options for control.
Thus, there seems to be no need to seek a change in UNEP's mandate.

This study recommends that UNEP directs its assessments to the policy questions of four primary target groups. In addition to the General Assembly and UNEP's Governing Council, these target groups are:
◊ specialized UN bodies (e.g. FAO, UNDP, WHO and CSD);
◊ international environmental conventions;
◊ multilateral financing agencies.

Focus and requirements

UNEP should focus its monitoring and assessment activities on:
◊ global environmental issues (governance of the global commons and transboundary issues);
◊ environmental aspects of international trade, finance and aid;
◊ regional issues that pose a threat to environmental security.
Its assessments should fit within the overall framework of environmentally sustainable development.

This definition of focus and target groups leads to requirements for UNEP's monitoring and assessment activities, including:
◊ the scope of UNEP's monitoring and assessment activities should be broad, covering not only the environment proper but also policy responses and their adequacy; UNEP's assessments should include scenario analysis and risk assessment;
◊ UNEP's environment assessment activities should reach across environment issues and sectors; they should be based on a participatory approach;
◊ linkage to monitoring must be strengthened and modern tools for processing, modelling and presentation of UNEP's information should be put in place.

Critical gaps

Over the past five years, UNEP's assessment programme has made important progress by establishing the GEO series and its related network of collaborating centres. By the same token, this has revealed critical gaps in expertise and data. Without claiming to be comprehensive, the present study provides a comparatively detailed overview of these gaps. At a more strategic level, these gaps relate to:

◊ lack of guidance and co-ordination of environmentally related monitoring (fragmented, incomplete and overlapping);
◊ too little emphasis on monitoring of causes and impacts;
◊ too little attention for problem solving, i.e. existing and alternative policies and actions.

Objectives

To meet the requirements of its target groups, UNEP should adopt the following strategic objectives for its monitoring and assessment programme:

◊ To establish a line of reporting with each of UNEP's target groups, including a regular review of information needs and discussion of relevant findings of UNEP's assessments.
◊ To consolidate UNEP's network of collaborating centres, spread over the world's regions.
◊ To organize UNEP's data logistics to function solely for its assessments.
◊ To enhance the availability of assessment methods and analytical tools in support of UNEP's broadly defined assessment function.
◊ To pursue concrete collaboration with other international bodies, governments and convention secretariats with the aim of consolidating global monitoring.

A strategy to reach the objectives

To reach the objectives proposed, UNEP should strengthen three types of linkages.

Linkage to policy, including:

◊ a strict focus on UNEP's four target groups;
◊ establishing an advisory group composed of government representatives to the Governing Council; regional policy consultations; selection of indicators by the target groups;
◊ establishing a reporting series composed of:
    ⇒ Four-yearly Global Environment Outlooks. (The basis for re-assessing the environmental agenda, including early warning signals. They would put regional developments and efforts in global context.)
    ⇒ Yearly statements on the environment by the Executive Director of UNEP. (These focus on progress in policy, and emerging new findings. They would contain an indicator-based segment and would be focused on set priorities.)

Linkage to expertise, including:

◊ consolidating UNEP's network of collaborating centres;
◊ establishing a long-term (approximately five years) working programme with predictable funding;
◊ working with multilateral funding agencies and key scientific bodies in order to address gaps in knowledge, such as methods for assessing risks of extreme events;
◊ maintaining a good assessment team within UNEP itself.

Linkage to monitoring:
UNEP should rely on monitoring by others wherever possible. Thus, its strategy is centred around collaboration. This study recommends a strategy with respect to:
◊ data logistics centring around a redefinition of the role of GRID;
◊ regional quality enhancement of input data, involving a key role for UNEP's collaborating centres;
◊ interagency collaboration, including a periodic report on the state of monitoring. Of special interest here are earth observation (the "G3OS" system), monitoring of policies, and monitoring of progress towards the objectives of the whole body of international conventions.

Indicative costing

Based on a number of important assumptions, this study indicates what the annual costs to UNEP would be of implementing the monitoring and assessment strategy recommended. One particularly important assumption is that UNEP will not be charged significantly for data, including earth observation data (cost estimates are given in given in brackets, in millions of US dollars per year).

The linkage to policy requires:
◊ arrangements for global and regional consultations (0.6)
◊ maintaining a structured dialogue with target groups on the required content of assessments (0.4)

Linkage to expertise on integrated assessment requires:
◊ improving and expanding the capabilities in UNEP-DEIA (2.4)
◊ strengthening the collaborating centres (3.0)
◊ establishing centres of excellence, or method development with collaborating centres (2.5)
◊ peer review of draft assessments (0.1)

Linkage to monitoring will require:
◊ organization of the global process of information supply for UNEP's assessments (4.0)
◊ technical reporting on the state of monitoring (0.5)
◊ regional quality control (1.0)
◊ secretariat for selected monitoring programmes (3.0)
◊ catalytic promotion of advanced monitoring systems (2.5)

Integration, assessment and reporting requires:
◊ programme management (0.5)
◊ contributions to UNEP's assessments (3.0)
◊ production of yearly and four-yearly assessments (1.5)

The total annual cost is estimated at approximately US$ 25 million.

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Abbreviations

C	Carbon
CC	Collaborating Centre (of network for GEO)
CDIAC	Carbon Dioxide Information Analysis Centre
CEC	Cation Exchange Capacity
CEOS	Committee on Earth Observation Satellites
CEU	Central European University
CIESIN	Centre for International Earth Science Information Network
CFC	Chlorofluorocarbon
CGIAR	Consultative Group on International Agricultural Research
CGIEC	Canadian Global Emissions Inventory Centre
CH_4	Methane
CO_2	Carbon dioxide
CRU	Climate Research Unit
DG XI	Directorate-General XI of the (Environment, Nuclear Safety and Civil Protection) of the Commission of the European Communities
DG XII	Directorate-General XII (Science, Research and Development) of the Commission of the European Communities
DIN	Dissolved Inorganic Nitrogen
DPSIR	Driving Force - Pressure - State - Impact - Response Framework
ECE	Economic Commission for Europe
ECLAC	Economic Commission for Latin America & the Caribbean
EDC	EROS Data Centre
EDGAR	Emission Database for Global Atmospheric Research
EEA	European Environment Agency
ENRIN	Environment and Natural Resources Information Network
ESCAP	Economic and Social Commission for Asia and the Pacific
EU	European union
FAO	Food and Agricultural Organization of the United Nations
FCCC	Framework Convention on Climate Change
G3OS	Global Observing Systems of GCOS, GOOS and GTOS
GCOS	Global Climate Observing System
GC	UNEP Governing Council
GDP	Gross Domestic Product
GEF	Global Environment Fund
GEIA	Global Emissions Inventory Activity
GEMS	Global Environmental Monitoring Systems
GEO	Global Environment Outlook (UNEP)
GIS	Geographical Information Systems
GOOS	Global Ocean Observing System
GRID	Global Resource Information Database
GTOS	Global Terrestrial Observing System
HYDE	A Hundred Year (1890-1990) Database on the Environment
IEA	Integrated Environmental Assessment
ICSU	International Council of Scientific Unions
IGBP	International Geosphere Biosphere Program
IGFA	International Group of Funding Agencies for Global Change Research

IHDP	International Human Dimensions Program
IIASA	International Institute for Applied Systems Analysis
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
JRC	Joint Research Centre (of EU)
LTRAP	Convention on Long-range Transboundary Air Pollution
mln	million
N	Nitrogen
NASA	National Aeronautics and Space Administration
$NO/NO_2/NO_x$	Nitrogen monoxide; nitrogen dioxide; nitrogen oxides.
NH_3	Ammonia
NCGIA	National Centre for Geographic Information and Analysis
NGO	Non-Governmental Organization
OECD	Organization for Economic Cooperation and Development
P	Phosphor
PACs	Program Activity Centres
RIVM	National Institute for Public Health and the Environment
SCOPE	Scientific Committee on Problems of the Environment
SEI	Stockholm Environment Institute
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UNCSD	United Nations Commission on Sustainable Development
UN-ECE	United Nations Economic Commission for Europe
UNESCO	United Nations Educational, Scientific and Cultural Organization
UN-DESIPA	United Nations Department
UNEP	United Nations Environment Program
UNL	University of Nebraska-Lincoln
UNSTAT	United Nations Statistical Office
UNDP	United Nations Development Program
USGS	United States Geological Service
IGOS	Integrated Global Observing Strategy
WCRP	World Climate Research Program
WHO	World Health Organization
WMO	World Meteorological Organization

1. Introduction

This paper is a contribution of RIVM to UNEP to help it develop a new comprehensive environmental monitoring and assessment strategy. It sets out RIVM's views on enhancing the relevance and effectiveness of UNEP's environmental monitoring and assessment activities. It will be used by UNEP's Division of Environmental Information and Assessment in the preparation of a draft strategy paper, which will serve as input for a consultations workshop to be held in autumn 1998.

The time available for drafting this paper was limited. It did not allow for a comprehensive review of the work UNEP carried out in the past, nor for paying due attention to all monitoring and assessment activities carried out by other UN bodies and other organizations outside the UN, and how UNEP interacts with them. Consequently, the paper does not provide a systematic overview of ongoing activities and remaining gaps.

Foremost, the paper aims at supporting UNEP in defining a strategic vision on "where to go and how to get there". It is based upon RIVM's extensive experience in the area of policy-oriented environmental assessment, both at the national and international level. A key part of the analysis presented in this paper is devoted to the connection between the why and the how of UNEP's monitoring and assessments. This is critical because environmental monitoring and assessment never can be an aim in themselves but should serve in attaining UNEP's mission and goals.

This paper, therefore, starts out in Chapter 2 reflecting on UNEP's mission and stated goals, and the development of UNEP's position in the UN system over the last few decades. In Chapter 3, UNEP's goals are linked to the needs of its targets groups. Next, implications for UNEP's environmental monitoring and assessment system are evaluated and translated into mid-term objectives. Chapter 4 provides a methodological framework for operationalizing such a system and identifies some critical gaps in expertise and data. Chapter 5 outlines a strategy for attaining UNEP's monitoring and assessment objectives and a first estimate of the budget required for implementing the strategy.

2. UNEP's monitoring and assessment goals

2.1 Mission and evolution of UNEP

UNEP's mission has been formulated as: "To provide leadership and encourage partnerships in caring for the environment by inspiring, informing and enabling nations and people to improve their quality of life without compromising that of future generations." (UNEP, 1998)

This mission statement reflects generally acknowledged insight in what it takes to get from problems to solutions: first people need to know the problem; then they need to develop the will to change; and finally they need levers for change. This seems true at both the personal and international level. The mission statement stresses that UNEP's task is not just to provide people and nations with information about the state of the environment, but also to take an active role in bringing about the changes needed to protect the global environment. In a world with a common environment but more than 150 nation states, leadership is also very important to overcome differences in perceptions and interests and to inspire people to create and make use of opportunities available.

The mission statement could therefore be further elaborated:

- "informing" about the state of the environment, about causes for environmental deterioration, about problems ahead (early warning), about possible solutions and strategies to avoid, limit and mitigate environmental problems, and about whether progress is being made;
- "inspiring" by indicating possible solutions, disseminating positive experiences and providing feedback on the benefits of action;
- "enabling" through helping in setting priorities, with facilitating international policy development and enhancing capacities for policy implementation.

In 1997, UNEP's Governing Council in its so-called Nairobi Declaration (UNEP, 1997) reformulated the core elements of UNEP's mandate as follows:

"To analyze the state of the global environment and assess global and regional environmental trends, provide policy advice, early warning information on environmental threats, and to catalyze and promote international co-operation and action, based on the best scientific and technical capabilities available;

To further the development of its international environmental law aiming at sustainable development, including the development of coherent interlinkages among existing international environmental conventions;

To advance the implementation of agreed international norms and policies, to monitor and foster compliance with environmental principles and international agreements and stimulate co-operative action to respond to emerging environmental challenges;

To strengthen its role in the co-ordination of environmental activities in the United Nations system in the field of the environment, as well as its role as an Implementing Agency of the Global Environment Facility, based on its comparative advantage and scientific and technical expertise;

To promote greater awareness and facilitate effective co-operation among all sectors of society and actors involved in the implementation of the international environmental agenda, and to serve as an effective link between the scientific community and policy makers at the national and international levels;

To provide policy and advisory services in key areas of institution-building to Governments and other relevant institutions."

This declaration restates UNEP's comprehensive mandate in international environmental policy making. All items of the Nairobi Declaration, not just the first one, have implications for UNEP's monitoring and assessment and should be taken into account when formulating a strategy for its environmental monitoring and assessment functions. In order to formulate an effective environmental monitoring and assessment strategy for UNEP, its position in the UN system and the international environmental policy-making process needs to be taken into account.

2.2 UNEP's position in the UN system

UNEP was established as one of the outcomes of the UN conference on the Human Environment, held in Stockholm in June 1972. During the 1970s and 1980s, the organization very effectively played a leading role in putting on the environmental agenda many urgent and emerging issues, such as ozone depletion and trade in hazardous wastes, and facilitated the creation of many important international environmental conventions on, for example, ozone depletion, climate change and biodiversity (Porter & Brown, 1996). It also was able to set up global environmental monitoring systems (GEMS) (see Gosovic, 1992).

In the 1990s, however, UNEP was confronted with the entry of many new players in the field, both at policy and assessment levels. On the policy level, UNCED created the Commission on Sustainable Development and installed of a new
co-ordinating mechanism within the UN, the Inter-Agency Committee on Sustainable Development; and a special body, the International Negotiating Committee, was given the mandate to negotiate the Climate Convention. Although UNEP still plays an important role in the scientific assessment of climate change (as co-host of the IPCC (with the WMO), the overall result is a policy framework that is rather detached from UNEP (FCCC). More generally, the proliferation of issue-oriented multilateral conventions has resulted in an increase in the number of institutional players and policy fora and has exacerbated the problem of policy co-ordination between the various conventions.

On the assessment level, especially after UNCED, many governmental (World Bank, UNDP, regional organizations, development banks, etc.) and non-governmental organizations engaged in global and regional environmental data collection and assessment activities. At the same time, UNEP was faced with a structural shortage of the financial means to execute its working programs, including its monitoring and assessment activities. As a result, UNEP lost the leading role it had had during the 1970s and 1980s. This resulted in a weakening of UNEP's position in the UN system and a need for reviewing UNEP's role in international environmental policy making.

In response to the adoption of AGENDA 21, UNEP started to gear its assessment activities to the evaluation of the implementation of AGENDA 21 by setting up a new series of biannual reports, the Global Environment Outlook. This also revealed a need for a better integration of UNEP's monitoring and assessment activities, which historically had followed rather separate tracks. It also resulted in a need to redefine monitoring activities that reach beyond the state of the environment proper.

In response to UNEP's political and financial difficulties, the UNEP Governing Council formulated in the 1997 Nairobi Declaration a new policy to revitalize the Programme. It restated that UNEP should "continue to be the principal United Nations body in the field of the environment" and that "the role of the United Nations Environment Program is to be the leading global environmental authority that sets the global environmental agenda, that promotes the coherent implementation of the environmental dimension of sustainable development within the United Nations system and that serves as an authoritative advocate for the global environment".

At the same time, the Governing Council decided to change the governance structure of UNEP by establishing a High-Level Committee of Ministers and Officials as a subsidiary organ of the Governing Council. In this way it sought to both strengthen UNEP's executive powers, to enable it to act more swiftly and effectively, and to enhance its policy support, through increased high-level policy involvement and participation. The decision also reflects the wish for a strengthening of regionalization and decentralization within UNEP "through the increased involvement and participation of regional ministerial and other relevant forums within UNEP, complementary to the central co-ordination role of the Program's headquarters in Nairobi". Even more important for UNEP's effectiveness was that the Governing Council succeeded in agreeing on policy priorities and a corresponding allocation of budgets, while the previous decline in the fulfilment of financial commitments by donors was halted.

So after a difficult period, UNEP may again gain its former leading role, but only if it is able to adjust to new circumstances and policy needs. Its role in raising awareness and initiating the development of new international environmental policies and law has become relatively less important. For most issues, some global or regional frameworks have been developed. Although the identification of newly emerging issues remains important, many issues have matured to the policy formulation or policy implementation stages of the policy life-cycle.

As a consequence, assessment of policy options and monitoring of policy implementation and environmental progress have become more important. Moreover, priority setting, policy co-ordination (between issue-oriented policies) and the integration of environmental issues into sector policies have become prominent matters to be addressed in (integrated) environmental assessments. This was clearly illustrated in GEO-1.

More than before, UNEP's monitoring and assessment activities should serve the attainment of all of the above-stated goals and not just those related to continual review of the global environment. However, at the same time it becomes more important to demarcate clearly its working field, also in monitoring and assessment. This is essential if it is to keep activities focused and effective and for defining its relations with other actors in the field.

The noted maturity of the international environmental policy development not only has implications for the contents of environmental monitoring and assessment, but also for their methodologies. The assessment of policy options and the development of effective strategies for their implementation require more and more the involvement of stakeholders in the policy development process and a gearing of environmental monitoring and assessment activities to their needs. As the stakeholders are the ones on which the effectiveness of environmental policies depend, their involvement in policy development is crucial for securing support for the implementation of policies. Moreover, by involving the envisaged users of the outcomes of the assessment in the process there is a better guarantee that the information produced is properly geared to their information needs and that it will be used in the policy development process. A third reason to include stakeholders is because they have expert knowledge about their own domain and/or region that is very relevant to the assessment process (e.g. to assess the vulnerability of sectors or regions to climate change or the feasibility and acceptability of particular policy options).

Consequences for UNEP's monitoring and assessment strategy

1. UNEP's monitoring and assessment strategy should be viewed in the **context of its overall mandate** and its position in the UN system to prevent a monitoring and assessment strategy being defined that does not serve the attainment of its overall goals, that does not help in strengthening its role as the leading global environmental authority within the United Nations system for setting the global environmental agenda and promoting the coherent implementation of the environmental dimension of sustainable development.

2. Both UNEP's mandate, as restated by the Governing Council and subsequently confirmed by the UN Generally Assembly (UN, 1997b; see § 123-125) as well as an analysis of the evolution of UNEP's position in the UN system and international environmental policy development confirm the need for a **broad definition of its assessment and monitoring mandate**. Its mandate should extent far beyond the monitoring and assessment of the state of the environment to include the assessment of policy options, the monitoring of the implementation and effectiveness of environmental policies, and the identification of options for linking various environmental policies and integrating environmental policies in other, sectoral policies.

3. To support UNEP's efforts to regain a leading role, its environmental monitoring and assessment strategy should be more closely linked to environmental policy making by paying more attention to the monitoring of and reporting on **environmental progress and policy implementation**, by taking a more active role in the formulation and adoption of international **policy goals**, by focusing on integrated assessments that highlight the **linkages** between the various environmental issues and with sectoral policies, and by a greater involvement of regional and sectoral **stakeholders** in the assessment process.

To translate these insights into operational goals for UNEP's environmental monitoring and assessment strategy, UNEP's goals first need to be related to its targets groups and their specific needs.

3 UNEP's targets groups and their monitoring and assessment needs

For a policy-relevant and effective role in international environment policy making, UNEP's environment monitoring and assessment effort must be adequately geared to the needs of all its target groups and not just its Governing Council. While UNEP's environment monitoring and assessment should provide its Governing Council with adequate information to guide it in defining policies and making decisions, it should reach out to the whole UN system and well beyond if it is to support UNEP's mission. In this respect, UNEP monitoring and assessment activities should be looked at more from a marketing than a management information perspective: its monitoring and assessment activities are among its key service products, which to be successful should be tailored to its clients. It also implies that UNEP's monitoring and assessment strategy should define clear products for its customers.

3.1 Targets groups and their assessment needs

Although it is a specialized program of the UN, created to address particular issues, UNEP's work should be directed at overall policy making within the UN. This has been clearly acknowledged in the Nairobi Declaration, also adopted by the UN General Assembly, which states that UNEP is the principle organization within the UN system to promote the interests of the global environment.

To fulfil this pivotal role, UNEP's environment monitoring and assessment activities should in the first place be directed at the centre of UN policy making, the **UN General Assembly**. Whereas UN member states are usually represented by their ministers of environment in UNEP's Governing Council, UNEP is able to reach out to many other branches of government through the General Assembly, as it is attended by much more broadly composed delegations. UNEP should provide the UN General Assembly with comprehensive, yet easily accessible information about key developments in the state of the world's environment, about emerging environment problems, about the causes of these problems, about how they relate to other issues and sectors, and about possible options for their control. UNEP should help in evaluating general progress in improving the environment, in identifying emerging issues (agenda setting), and in setting policy priorities in international environment policy making.

UNEP's products could be a comprehensive forward-looking report very four years to support an in-depth General Assembly evaluation of progress and effectiveness of policies, to review and adjust policy priorities and to facilitate agenda setting for emerging issues. In addition, UNEP should provide the General Assembly with annual reports on trends, current issues and policy initiatives needed.

UNEP's next target groups are **specialized UN agencies** such as UNDP, WHO, FAO and, of course, the Commission on Sustainable Development (CSD) of the UN Economic and Social Council. Such specialized agencies need UNEP's information to integrate environment knowledge into their sector policies. The CSD needs UNEP's information to advise the UN on how to incorporate the environment dimension of Sustainable Development in effective, integrated policies.

To serve the specialized agencies, UNEP's monitoring and assessment activities could provide support to sectoral environment assessments, especially those aimed at analysing and addressing various environment issues at the sectoral level in an integrated way. UNEP should serve the CSD by participating in the drafting of its Trend reports, with a primary responsibility for providing the necessary environment data and analysis.

The third target group of UNEP is the various international (global and regional) **environment Conventions**. Some of these are institutionalized within UNEP or other specialized UN agencies, while others have their own institutional structure (e.g. FCCC). Here, UNEP's monitoring and assessment task is to organize the assessment of the state of science and to provide guidance on the collection of data, to monitor progress in the implementation of the conventions and the attainment of their stated goals, and to assess options for the integration of policies for implementing the various conventions. Products for this group are providing advise to the Conference of Parties of the various conventions on how to improve monitoring and assessment activities, analysis of cross-linkages between issues-oriented policies and recommendations for enhancing the integration of the Conventions' policy regimes.

A fourth target group consists of **multilateral financial agencies** such as the World Bank, IMF, regional development banks, as well as GEF and the co-ordination group of donors of international aid (OECD-DAC). These agencies need advice on how to incorporate environment in their policies, about policy priorities for funding sustainable development, and how to spend their means as effectively as possible with regard to environment protection. UNEP's monitoring ands assessment activities could provide (independent) environment impacts assessments of the activities and policies of these agencies, and advice on how to improve their environment performance.

Obviously, materials addressed to the various targets groups should also be accessible to actors with major influence on policy setting within the target groups, such as national governments, environment NGOs and representatives of the business community.

3.2 Implications for UNEP's monitoring and assessment strategy

Gearing UNEP's monitoring and assessment activities to the needs of its target groups has implications for the focus, content, and organization of UNEP's environment monitoring and assessment strategy.

With respect to Focus:

- **Assessments should be linked to targets groups and products**. This implies that UNEP's assessment function should have a prevalence over its monitoring function. Assessments should be driven by policy demands instead of by the (science-oriented) supply of monitoring activities.

- **UNEP's assessment and monitoring domain should be more clearly demarcated**. The broadening of the scope of its monitoring and assessment activities (see below) would necessitate a focusing of its activities on those areas where UNEP's activities have their highest added value when compared to activities of national and regional assessment efforts. Therefore it is suggested to limit UNEP's domain to:

(a) global environment issues (governance of the global commons, transboundary issues), including their linkages to other issues and sustainable development;
(b) environment aspects of international sectoral policies on issues such as trade, finance and aid;
(c) regional environment issues that pose a threat to environment security or otherwise have significant implications for the global environment.

The latter item (c) is a response to the growing need for addressing environment issues of an universal or local nature that concern the international community due to their (possible) social and political implications, such as regional/ethnic conflict and environment refugees. They can be compared with cases of local threats to international peace addressed by the UN Security Council.

With respect to Contents:

- **The scope of UNEP's monitoring and assessment activities should be broad.** Its monitoring should cover both the state of the environment and the review of (the adequacy of) policy responses (including conventions). Its assessment should include analysis of causes of environment deterioration, linkages between environment issues, and alternative policy options and strategies. The results of the assessment should support priority setting.

- **UNEP's assessment activities should include environment forecasting and risk assessment**. This entails assessment of the full implications of past, present and possible future human behaviour, facilitating the timely signalling of emerging problems, and evaluation of the effectiveness and implications of alternative policy options.

- **UNEP's environment assessment activities should reach across environment issues and sectors.** In this way the assessments should help in the formulation of co-ordinated policies between the issue-oriented conventions and in the integration of environment policies in sectoral and general areas of international policy making, such as finance, trade and sustainable development policies (to provide advice to other UN agencies/programs).

With respect to Organization:

- **Monitoring should be organized in support of assessment activities**. Monitoring activities should be steered by data and information needs identified by experts involved in assessment activities. It is UNEP's task to identify these needs and to communicate them to the various international scientific programmes . With the greater focus on assessment UNEP will have to reduce its involvement in monitoring activities and rely more heavily on the various Conventions and related expert groups/centres for thematic scientific assessments and data acquisition. This implies that for these activities other, non-UNEP sources of structural funding should be found.

- **UNEP's assessments activities should be based on a participative approach.** To secure both political support as well as the scientific credibility of the results the assessment and monitoring activities should be a open and participative process. There is a need for a stronger involvement of regional assessment centres and societal groups to capitalise on their expertise and stimulate policy support. At the same time assessment activities should be open processes that allow for extensive scientific and public review.

3.3 Objectives for UNEP monitoring and assessment strategy

Taking into account the requirements for UNEP's monitoring and assessment activities, the short-term (1999-2005) strategic objectives for UNEP's environment monitoring and assessment programme are:

- To establish a structured dialogue with each of UNEP's target groups based on a regular review of information needs and line of assessment activities and reporting.
- To consolidate UNEP's network of collaborating centres, spread over the world's regions, and to enhance their capabilities and expertise to match the substantial requirements of UNEP's assessment activities.
- To (re)organize UNEP's data logistics to function solely for its assessments[1].
- To enhance the availability of assessment methodologies and analytical tools in support of its broadly defined assessment function.
- To pursue concrete collaboration with other international bodies, governments and convention secretariats to consolidate and strengthen global monitoring, in support of various environment-related assessment activities.

How the objectives can be achieved will be discussed in Chapter 5. First, Chapter 4 will look into the methodological implications of the identified requirements for UNEP's monitoring and assessment activities. These will be included in the proposal for operationalising UNEP's new monitoring and assessment strategy in Chapter 5.

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[1] This corresponds to the shaded area in Figure 4.8.

4 Methodology of policy-orientated environment assessment

This chapter focuses on the general methodology of policy-oriented environment assessment. This should form a basis for the formulation of the main components of UNEP's strategy for monitoring and assessment (Chapter 5). Section 4.1 describes the most relevant concepts and methodologies. Section 4.2, in contrast, identifies a few major gaps in both current assessment (expertise) and monitoring practices. Finally, Section 4.3 addresses some topics related to collaboration for improved assessment and monitoring. Annex 1 discusses for some selected topics the current assessment methodologies in more detail.

In terms of methodology, three levels of environmental assessment can be identified, each requiring a higher level of integration: (i) *describing* the current physical state of the environment; (ii) *explaining* the changes - which requires changes in the physical state to be related to their main causes; and (iii) *advising* actual policy making processes - which also requires information on possible impacts of environmental change and potential responses. Finally, one could see the scope of environmental assessment in the context of *sustainable development assessment*; here economic and social objectives also need to be taken into account.

The distinction between these different levels also has a historic context. In the late 1980s, environmental assessment tended, world-wide, to focus mainly on the quality of the environmental media (largely descriptive, concentrating on past trends and current conditions). In the same period, international activities were oriented towards building up monitoring networks and harmonizing monitoring activities. Although it is still necessary to produce such information, many institutes soon found that this information alone is of limited value for decision makers. In response, two additional steps were gradually made to expand environmental assessment to include the *explaining* and *advising* levels discussed above. On the basis of the objectives identified for UNEP's monitoring and assessment activities, we conclude that further development should focus on these levels. In addition, for future success, information on environmental issues should also be clearly positioned within a sustainable development context (Rump, 1996)[2].

These changes in monitoring and assessment needs are in fact also related to changes in the general position of environmental problems in the decision making cycle. During the past few years, several global and regional environmental problems have moved from the stage of problem identification to the stages of policy setting and implementation. These stages require a more integrated type of information and environment assessment in many countries has started to respond to this need.

[2] Although a general trend can be observed as described above, a recent meeting of SoE institutes in Europe showed that within this region - with a relatively large tradition of assessment - several institute still simply concentrate on describing changes in the environment.

Table 4.1: Levels of environment assessment

Level	*Main question*	*Assessment*	*Examples of data needed*
1. Describing	What is happening ?	Describe state of environmental media in physical parameter.	• Air quality data
2. Explaining	Why is it happening ?	Relate physical parameters to their causes	1 and • Emissions from transport
3. Advising	Are these changes significant and what could be our responses ?	Relate changes in the environment to driving forces, impacts and solutions	1, 2 and • Economic growth • Impacts on human health • Possible effect of an ban on leaded petrol
4. Sustainable development assessment	Are environmental, social and economic objectives being met sufficiently ?	Combine and deliberate environmental, economic and social objectives.	1,2, 3 and information regarding the implementation of economic and social objectives.

4.1 Methodological framework

Assessment of complex global and regional issues with a large environmental component requires an assessment framework that goes beyond traditional disciplinary boundaries of the natural and social sciences. Integrated Environment Assessment aims to incorporate the tools and insights of different sciences and different detailed issues into an overall assessment framework. In addition, the methodology is directly aimed at distilling practical messages for policy from available scientific understanding and data. Integration within the context of UNEP's assessment activities captures many dimensions, among them (i) capturing of the cause-effect relationships of a phenomenon as many as possible, (ii) addressing the cross-linkages between different phenomena, and (iii) integration across the different relevant geographical scales (Swart and Bakkes, 1995).

For Integrated Environment Assessment, communication is an essential element. On the one hand, integrated insights from the scientific community are communicated to the decision makers (or other target groups), in particular, and to society in general. On the other hand, specific questions, experiences and lessons learned by decision makers are an input for scientific assessment. This means that the ideal Integrated Environment Assessment is a cyclical and participatory process.

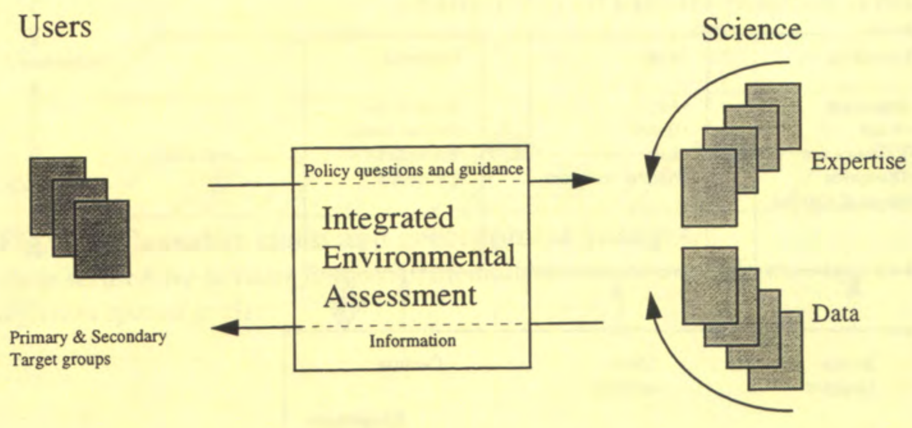

Figure 4.1: Integrated Environment Assessment as a two-sided dialogue between scientists and users.
Integrated Environment Assessment aims to integrate expertise and data in order to provide concise messages for policy making.

To support international decision making processes, it is important to explore how the insights of scientific exercises and their meaning for policies can be communicated adequately to decision makers. The development of appropriate indicators plays an important role in this. Assessment should be made with the specific target groups in mind and - as far as possible - in an dialogue with those groups. The need for a participatory approach is already a key element in the current Global Environment Outlook process, for example through the use of regional expertise (collaborating centres) and involvement of regional policy makers and target groups in regional and global consultation processes.

There are several analytical tools and methods available for combining information from the various disciplines and sources for Integrated Environment Assessment. We focus on: the conceptual framework of Driving Force-Pressure-State-Impact-Response; data for Integrated Environment Assessment; the role of modelling tools and scenario construction; presentation and indicators; and key areas of expertise.

4.1.1 DPSIR framework

During the past few years, the Driving Force - Pressure - State - Impact - Response (DPSIR) framework has become accepted as an organizational framework for structuring environmental assessment and forecasting activities (see also Box 4.1).

Box 4.1: DPSIR - The conceptual assessment framework

The Driving Force - Pressure - State - Impact - Response (DPSIR) framework is basically a simplification of the interrelated cause-effect chains that are found in the human-environment system. Within the framework, *driving forces* represent social and economic activities, such as energy use, underlying the *pressures* on the environmental system. Examples of *pressures* are emissions to air, water and soil, resource use and changes in land use. These pressures in turn determine the *state of environment* in terms of the quality of various environmental compartments. Degradation of the state might cause *impacts* on the social, economic and ecological functions of the environment, such as the provision of adequate conditions for health. Finally, policy makers or society at large can *respond* with policies and programs to prevent, mitigate or repair the damage. The DPSIR framework can thus be conceived as a dynamic cycle. An important element of DPSIR is that is able to identify the linkages between the different environmental problems themselves, the forces that drive those problems, and the options available for responses. This information is absolutely essential for policy making.

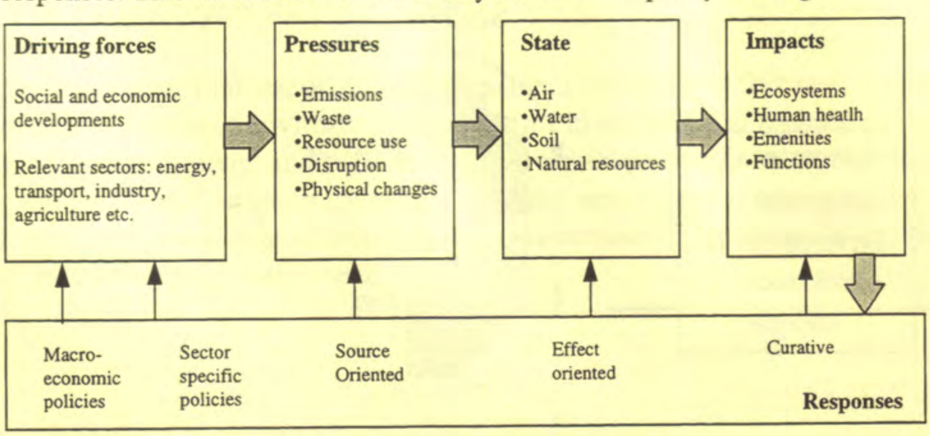

Figure 4.2: The Driving Forces - Pressure - State - Impact - Response (DPSIR) framework

It should be noted that the DPSIR scheme can also be related to different types of broad "assets", such as social capital (communities, individuals and government), support capital (economic system, infrastructure) and natural capital (environment, natural resources) (World Bank, 1997). As such, the scheme can also be used in the broad context of sustainable development.

The main advantage of this framework is its simplicity and its focus on causal relationships. Looking at activities identified earlier in this chapter, *describing* requires only knowledge on the state of the environment; *explaining* requires information on state and the main pressures and, finally, *advising* requires full knowledge of the total DPSIR framework.

4.1.2 Data for Integrated Environment Assessment[3]

To perform assessment, data for a large number of variables are needed for the present as well as for the past situation. In Section 4.2 we pay attention to the monitoring activities that generate these data. Integrated assessment often involves combining data on different things, for example, acid deposition and vulnerability (is the critical load being exceeded ?) or pollution loading and population health (are the trends in the same direction ?) or banning a group of substances and ambient concentrations (does banning help ?). In order to carry out this sort of analysis, even roughly, the available data should permit to compare over time, between things at different levels of scale (e.g. urban - regional - global), between different steps in the causality chains (e.g. driving force - impact) and between different issues (e.g. climate change - fresh water availability). Therefore, consistent measurement schemes are absolutely essential to get beyond first crude estimates and to proceed to evaluation of progress.

Figure 4.3 illustrates two of the three important dimensions along which cause-effect relationships and linkages exist, viz. the causality chain (DPSIR) and geographical scales. For instance, in case of land use, clear linkages exist between land tenure changes (local scale) and national policies (country) and international markets (see e.g. Winograd ,1997). Thus, a proper environmental analysis would contain cross-checks comparing, for example, energy use data from one data source with carbon dioxide emissions from another source of data.

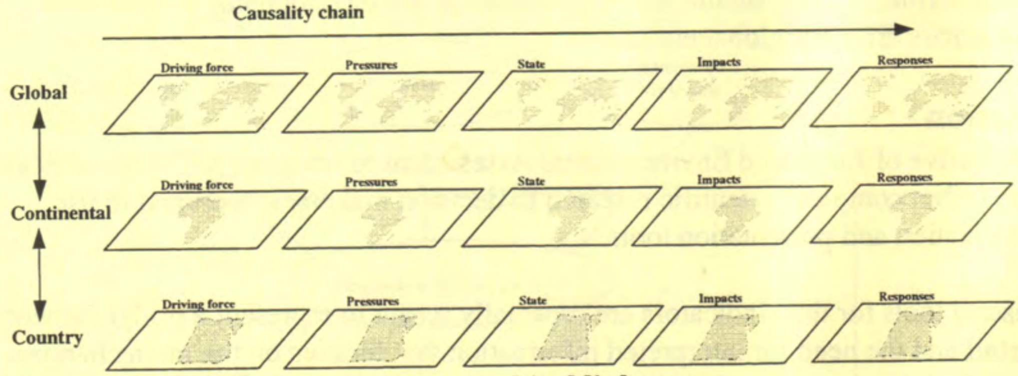

Fig. 4.3: Causality chain and geographical linkages.
Data series have to cater for consistent analysis combining different steps in the DPSIR scheme and different spatial scales.

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[3] Section 4.2 pays attention to critical gaps in monitoring activities; Section 4.3 pays more attention to collaboration for monitoring and data handling.

4.1.3 Modelling tools and scenarios; dynamic analysis

Some changes in natural or societal systems can only be properly assessed if sufficiently long time scales are taken into account. This is both true for assessing the impacts of human disturbance of natural systems (e.g. the carbon and nitrogen cycles or the stock of natural resources) as well as for the impact of the penetration of new technologies, governed by capital turnover rates. Here, models and scenario analysis are useful tools in assessing these structural changes in a coherent and consistent way.

Models are tools for organizing knowledge at the proper time/space levels. There are several ways in which models can add to environmental reporting and assessment (Swart and Bakkes, 1995). These include:

- analysis of the dynamic linkages and interactions between driving forces, responses, state of the environment, impacts and responses. Moreover, models can also link different scales of analysis.
- development of forecasts and early warning by extending an analysis in time and space and by implicitly showing time delays in environmental and social processes. This corresponds with the objective formulated in Chapter 3 that UNEP's assessment should include forecasting and risk assessment.

The Global Modelling Group was set up in the context of GEO to encourage further use of modelling in global environmental assessment and to disseminate knowledge among the various modelling groups. Scenarios, in combination with models, can also help in providing a consistent frame for analyzing potential developments. Scenarios are mostly used to identify different potential future pathways and their implications and conditions. It should be noted that most scenarios do not actually predict, but instead try to paint a set of consistent images of possible futures. A typical approach to scenario development is the development of a business-as-usual or reference scenario, complemented by different options for policy intervention. As for modelling, a Global Scenario Group has been set up in the context of GEO. In its assessment activities, UNEP should strive to encourage the development of consistent scenarios for use across different global regions.

4.1.4 Presentation

In view of the objective of Integrated Environmental Assessment to integrate and communicate the insights from (often complex) scientific research to decision makers, it is crucial to use appropriate visualization and presentation tools.

Indicators are useful tools for this. Indicators are especially meant to represent a bridge between the wealth of detail and the need for interpreted information that focuses on the main changes and interactions. Much has been done by various organizations in developing and selecting environmental indicators (in international context among others OECD and UN.CSD). Above all, one important lesson from indicator development work is that indicators should be developed in the context of the particular assessment at hand. In fact, a list of indicators could be agreed upon with each specific target group as part of the guidance to the assessment process.

More dynamic presentation methods also exist, among which the interactive "meta-models". These simple models contain the results of much larger models, and present them in an interactive way to target groups. They allow by means of easy-to-use interfaces the change of parameters and variables for the visualization of modelling results under various assumptions. For example, this has been used successfully in support to international environment negotiations. In this way, the underlying behaviour of a system can be communicated to target groups as clearly as possible.

4.1.5 Key areas of expertise

Bearing in mind the goals of UNEP's monitoring and assessment activities, the assessment methodology should be applied to several major areas of expertise of the natural and societal system and their interactions. In Figure 4.4 we have tried to characterize some of these essential areas for global Integrated Environmental Assessment.

- Economy	background scenario's, sector interactions; economic impacts
- Population/health	demographic trends, determinants for health, health impacts;
- Land/food	land use and cover, food production potential, interaction with economic measures, terrestrial ecological effects;
- Water	water use, main quality components, demand and supply policies, aquatic ecological effects;
- Energy/materials	demand and supply policies, effects of economic measures;
- Cycles	changes in the cycling of water, nitrogen, sulphur and carbon through the environment and their interactions; issues here include climate change and acidification.

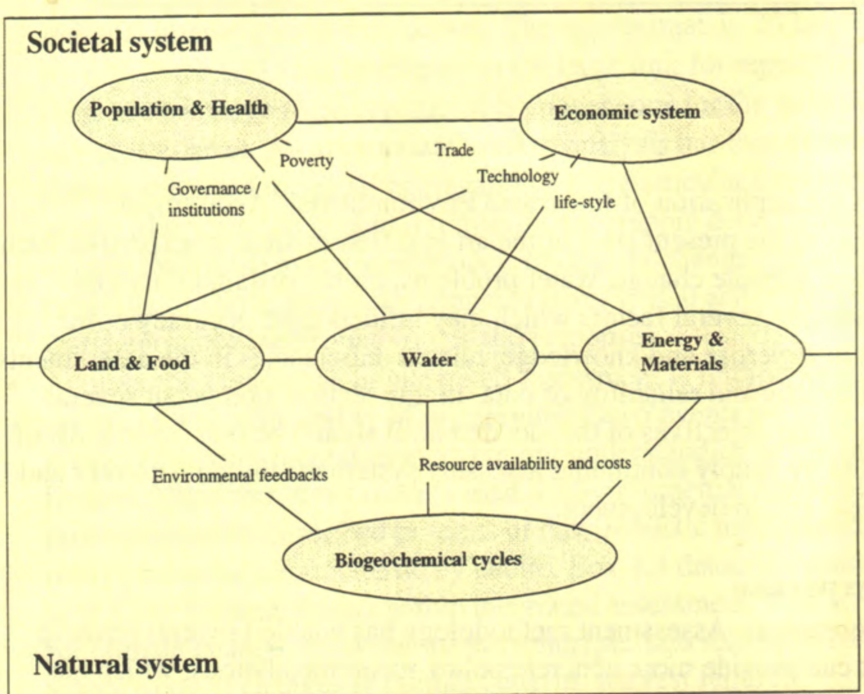

Fig 4.4 Key areas of expertise for global Integrated Environmental Assessment.

Finally, in Box 4.2 we have summarized some of the key aspects of Integrated Environmental Assessment.

Box 4.2: Key aspects of Integrated Environment Assessment

In the past few years, considerable experience has been built up in Integrated Environmental Assessment.

On the basis of this experience, a few principles for successful Integrated Environment Assessment have been derived.

- For assessment, adequate data and monitoring is an absolute prerequisite. This is even more true for evaluating and projecting trends.
- There is a need for co-ordination of monitoring and assessment activities in order to fulfil the objectives of Integrated Environmental Assessment. The compilers of assessments should play an active role in identifying needs for monitoring data.
- Partnerships are essential for success. Co-operation with sectoral/regional centres of excellence not only taps addition sources of information (both data and expertise), but should be used to maximize consensus on the scientific basis of the assessment, on aspects such as consistency and trustworthiness of the information. This improves its usefulness enormously.
- Combining retrospective reports and outlooks offers the possibility of generating information that is relevant for several different stages in the policy-making cycle.
- Assessments should try to aim for as much consistency in time as possible with respect to indicators, data and methodology.
- Integrated Environmental Assessment should be a demand-driven process, although demand can seldom be specified in advance with enough detail. Programs should therefore be in close contact with clients.

4.2 Critical gaps

There are many examples of the application of Integrated Environmental Assessment. Annex 1 gives some examples of the present state of the art in different areas of expertise, such as acidification, eutrophication, climate change, water problems, global sustainability and assessment of responses. There are several factors which may influence the accuracy of the assessments, including gaps in expertise and knowledge, related deficiencies in the assessments themselves, and limited availability and reliability of data. In this section, points out several critical gaps - in the context of the objectives of this document. It should be noted that most of these "gaps" can only be filled by simply continuing assessing systematically both current and future risks to the environment and to development.

4.2.1 Critical gaps in expertise

The use of Integrated Environmental Assessment methodology has enabled several positive developments. One is that it can provide more concrete policy recommendations, which has been identified as an important focus in the context of GEO. It also enables illustration of the role of specific societal sectors - and the formulation of specific sectoral policies, e.g. for transport, agriculture and industry.

- For most global environmental issues, expertise seems to be best developed for state, **while uncertainties and gaps in expertise increase towards the outward ends of the DPSIR chain**. This is in particular true for driving forces (in which economic and social expertise should play a key role), impacts (both in terms of impacts on humans and ecosystems) and responses. The understanding of the dynamics of relevant processes, the empirical data to describe trends, and knowledge about interactions and feedback currently all limit the application of integrated assessment methodologies.

- Most of the **models** currently used for Integrated Environmental Assessment are either based on a natural science approach or on an economic approach. Physical processes have been subjected to formal modelling for a long time now and consequently the results are often listed as "strong knowledge". This is also true to a certain extent for the economy - but there great controversies exist between various modelling traditions. The complexity of the assessments significantly increases if an attempt is made to include the human and social domains. Because of the importance of human behaviour in environmental issues, it is tempting to include these domains in assessment methodology, but at the same time understanding the dynamics of social systems is difficult (e.g. due to the variety of cultural values, beliefs and attitudes) and developing predictive capabilities almost impossible. The science is therefore often labelled as "weak". In the past few years, the search for methods to bridge the gap between the different layers of knowledge has intensified and interesting approaches have been developed. Nevertheless, further research in this field still needs to be done. Often different tools will have to be used to deal with assessment of human behaviour. Such tools include scenario development (e.g. using the POLESTAR environment), expert panels, and perspective-based scenario analysis.
- An important factor for assessment is the selected **geographical scale** (e.g. country; region; world). Obviously, global environmental assessment needs to focus on a high level of aggregation. However, for most processes in the environmental, economic and human domains, the underlying analysis needs to be more detailed to respect important local and regional interactions and responses. The approximately 20 large sub-regions as distinguished by UNEP for GEO can be chosen as the basic unit for reporting, but for most assessments these are too large to be considered homogeneous for the inclusion of processes acting at a sub-region level. An appropriate level of analysis has therefore to be determined. The problems related to spatial aggregation are in particular important for climate change and water. Many models should improve on geographic detail. The coarse resolutions of the current integrated assessment models of climate change and acidification do not allow coverage of all the necessary administrative, spatial and temporal heterogeneity and diversity that determines the driving forces and responses.
- An important challenge in integrated assessment is finding a way to address **catastrophic events of low probability of occurrence**. Such events are often extremely important in the impact of environmental change, but our understanding of the relevant processes is still limited. Moreover, most models used in environmental assessments assume that real-world processes can be described in terms of deterministic mathematical equalities, while in reality many processes are stochastic by nature. Box 4.3 discusses some approaches for dealing with these extreme events within integrated assessment. This is, for instance, very relevant for climate change and water assessments (perhaps related to forest fires, extreme water scarcity due to changes in rainfall patterns, harvest failure).

Box 4.3: Extreme events: challenge to expand assessment methods

Impacts of environmental change are not only a result of long-term processes, but also by instantaneous fluctuations. Generally one speaks here of extreme events, such as flooding, storm excesses, fire, etc. The global economic losses and human suffering as a result of such events are high and appear to be becoming greater over the years. The inclusion of them in trends-based assessment models is not straight-forward since such events are stochastic and impossible to predict. How to best address the complexities surrounding the occurrence and aftermath of these events requires novel approaches, not based on deterministic models that project/extrapolate trends but the simultaneously inclusion of a valid risk assessment to adequately manage vulnerable regions and locations. Here, the assessment will (by definition) be hampered by an additional level of uncertainties related to factors such as natural variability at different scales. To describe and analyze this variability other types of environmental and socio-economic databases and monitoring are needed: it must be possible to link events directly to patterns of change. Risk-analysis based on statistical approaches and expert panels should be used as complementary tools in such assessment.

Vulnerability can be defined as a continuous scale. At one extremity there are the unexpected or unforeseen catastrophic events with a low probability of occurrence and at the other extremity the impacts of long-term trends and processes, whose characteristics can readily be quantified. To evaluate this vulnerability continuum requires different information and assessment approaches. Hence, the assessment of vulnerable areas ("hot spots") could be enhanced by a further integration of the deterministic systems approach and stochastic risk-analysis (e.g. by projecting present distribution/variability functions on projected changes of long-term averages). In this way the early warning capability of UNEP's assessment function could be enhanced. This is, however, only possible when environmental and socio-economic data and its analysis also allow for the assessment of variability.

- Obviously, there are also **specific gaps in expertise** for the various environmental issues. For acidification, for instance, only recently attention has been paid to the sensitivity of ecosystems to acid deposition outside Europe and North America. In the case of fresh water assessment, assessment of nutrients is still under development. Several of these gaps are described in Annex 1. Some months ago RIVM identified gaps in assessment to be addressed in the context of GEO – Annex 2 comprises a list of these gaps.
- Limitations in **model calibration due to lack of historic data** present yet another problem. Even if one can find relevant data, these data sets are often not comprehensive enough or are too unreliable to apply in a thorough calibration and validation process. We will come back to the issue of data availability in the next section.
- As integrated assessments evolve over time and include policies in their analysis, it becomes obvious that the **links between policies and the environment** are often difficult to quantify. The first and basic problem is that the degree of implementation of policies is hardly measured. This problem is encountered in attempts to characterize current policy initiatives in GEO-1 and GEO-2, in assessing the effect of multilateral agreements and in defining a scenario without additional policies (e.g. the baseline scenario in Van Vuuren and Bakkes, 1998). In order to better integrate the fragmentary measurements of policy implementation, and repeat the assessment over time, a widely applicable and accepted conceptual framework is needed.
- Finally, our knowledge of the **integration of different issues** is still limited. It is extremely important to continue building expertise here, since in reality ecosystems do not experience stress from single environmental problems in isolation but rather from, simultaneously, stress caused by nitrogen eutrophication, acidification (by sulphur and ammonia), climate change, forest clearing, burning, etc.

It is simply impossible to identify and describe in detail all critical gaps in knowledge and data for all environmental issues in the context of this study. Here we will do so for some examples included Annex 1 i.e. climate change, acidification, and water (Box 4.4).

Box 4.4: Critical gaps in the assessment of climate change, acidification and water.

Climate change
Our understanding of the climate system, and thus our assessment capabilities, is still limited , important uncertainties are e.g. future emissions and concentrations, regional impacts and responses. Assessment models have to find some kind some compromise between comprehensiveness, complexity and detail, e.g. by using relatively coarse resolutions. The coarse resolutions of the current integrated assessment models of climate change do not allow the coverage of all the necessary administrative, spatial and temporal heterogeneity and diversity that determines driving forces and responses. Data present several problems. First, large gaps exist in socio-economic and environmental data with regard to availability of historic data sets over longer time period. A globally comprehensive system for both socio-economic and environmental data is not yet available. Secondly, reliable gridded environmental data is very difficult to obtain. The IMAGE-2 model, for example, relies greatly on global compilations by individual researchers and international projects.

Acidification
In the case of acidification, Integrated Environmental Assessment has been applied for more than a decade. However, here too gaps still exist in data collection and integration. Typical inconsistencies relate to differences in definition of contents (e.g. what exactly is labelled as 'forest' or 'grassland' in the case of ecosystems delineation), differences in spatial resolution (country statistics, soil units, river catchments, gridded emissions and deposition data), and differences in reference years or simply not having up-to-date data (within and among layers). For the assessment of sulphur-related acidification, critical gaps include: i) knowledge of ecosystem sensitivities to acid deposition (local expertise); ii) integration with nitrogen deposition; iii) long-term monitoring of concentrations and deposition for model validation; iv) coarse spatial resolution of global/regional deposition models and emission databases; v) different geographical scales among DPSIR elements; and vi) availability and consistency of underlying data on economic and anthropogenic driving forces, including derived data for gridded population density and urbanization.

Fresh water
The availability of safe water is being recognized more and more as a global priority issue (e.g. UN, 1997; UNEP, 1997b). Still, most assessments are limited in the sense that only part of the problem is addressed (e.g. water quantity), that the problem is analyzed in geographic isolation and that little attention is given to underlying causes and to policy responses. The water issue prompted the UN General Assembly recently to propose to: "Strengthen the capacity of Governments and international institutions to collect and manage information, including scientific, social and environmental data, in order to facilitate the integrated assessment and management of water resources, and foster regional and international co-operation for information dissemination and exchange through co-operative approaches" (UNGASS, 1997). For such integrated assessment, the following shortcomings can be identified: i) many data sources on pressures and underlying causes are on a country level, yet for fresh water assessments data on a catchment level are essential; (e.g. in US there is on average more than enough water available due to huge resources in Alaska, yet various regions suffer from water shortages); GIS tools may help in translation from one level to another but many data sources lack enough spatial resolution; ii) present state of demand modelling water needs upgrade e.g. extreme events are mostly not covered and modelling of competition between users needs to be improved; iii) the social and economic consequences of not meeting demand (quantity and quality) are uncertain; iv) data on actual application of nutrients are scarce, v) a widely applicable procedure for joint assessment of water problems in international catchments is lacking.

4.2.2 Critical data gaps

The foundations for the empirical base for integrated environment assessment - the basic layer of core data sets - has by and large already been laid out by the IEA/GEO Core Data Working Group in 1995/96 (UNEP, 1997) on the basis of early work by RIVM (van Woerden et al.,1995). The challenge before UNEP now is to make explicit the need for specific data for the Intergrated Environmental Assessment programme activities and subsequently to match demand and supply. In practice this results in collection and conversion of huge and highly diverse data sets into usable formats, verification of the data at the national or regional level, filling gaps in data and, finally, making the data available in a form convenient for those performing the assessments.

Integrated Assessment tools require vast amounts of empirical data for calibration and validation, not only state-of-the-environmental data as such , but also data on underlying driving forces. A broad, consistent and spatially detailed historical database for integrated assessment over a long time period deserves, therefore, high priority and should include reliable gridded data sets.

A summary of the original IEA/GEO core data set matrix is given in Annex 3. To illustrate the major data shortcomings for current monitoring and to define priorities for action, the core data list is discussed below, following the DPSIR framework. A critical factor is the need for data consistency and harmonization. Typical inconsistencies relate to differences in definition of content, spatial resolution and references years. Often different geographical scales are used in different DPSIR elements. GIS tools may help translate these from one level to another, but sometimes the raw collected data simply lack enough spatial resolution.

Fortunately, in the past few years some progress has also been made in data collection and monitoring, including the development of:

- Grid-based population maps, although spatial detail, updating and extension with demographic data still need attention (UNEP/NCGIA/CGIAR and UNEP/CGEIC);
- Improved, multipurpose, comprehensive databases, such as the World Development Indicators (World Bank) and FAOSTAT (FAO); in addition to their further improvement, they have been extended and are readily available to the public;
- The new 1 km x 1 km global land-cover map (DISCover), currently being validated (USGS/EDC/UNL/JRC);
- Comprehensive environmental data reporting systems in an increasing number of countries; these have benefited from development of UNSTAT methodology and they open up a potential wealth of data at the country level.

Driving forces

Most of the information on the forces driving environmental change comes from statistical data that countries, regional bodies and global agencies (UN and others) collect, i.e. size and composition of human population (the 'consumers') and production and consumption patterns within the economy. In addition, population size and density are widely used as a tool to scale environmental pressures from the country or district level to grid cells. Such 'gridding' needed to address the local variation in environmental pressures and in the sensitivity of ecosystems. Existing global population data (UN-DESIPA, UNEP/NCGIA, etc.) need to be made consistent, improved, updated and extended with attributes including rural/urban split, age distribution and health indicators. Furthermore, the method for distributing economic activities (data from UNDP, World Bank, UNSTAT) over grid cells needs to be checked against available information on physical parameters within the economy (e.g. production) and compared with geographic layers (e.g. land cover)

Pressures

The most important information source for environmental pressures are derived data on emissions and resource abstraction, resulting from the combination of economic data with emission factors (as is done by IGBP/GEIA and RIVM/EDGAR), plus data reported through National Communications (IPCC). The gridded emission data layers, still quite coarse and usually only available for a single year in the past, urgently need verification with historical information and updating to recent years and levels of higher detail. Deposition of emitted substances on ground and water surfaces also remains a rather weak area, partly because of the poor gridded emission data available, but also because of uncertainties in the atmospheric transport models used.

State

The most important data for the 'state' element are measurements of environmental quality (and quantity) of water, air and soils from station and/or remotely sensed data. This includes data on soils and land use (FAO), land cover (e.g. IGBP/USGS.), climate (CRU, RIVM/IIASA), water and air (UNEP/GEMS). Within the broad realm of monitoring (see Figure 4.4), the empirical base for "real" environmental data is still weak. Soils and land use/cover are relatively well off (FAO Soil Map, FAOSTAT, 1 km^2 land cover), but global water and air monitoring are still very weak For global monitoring of biophysical issues, co-ordinating and steering bodes are being set up at the moment, i.e. GTOS (land), GCOS (climate) and GOOS (oceans), together labelled as G3OS and guided by the CEOS/IGFA Integrated Global Observing Strategy (IGOS). Such co-ordination needs further strengthening and enlargement into all environmental compartments and to be made an active component of UNEP, feeding the assessment and early warning activities.

Impacts

Data needed on environmental impacts includes the results from calculations that combine exposure and sensitivity (see also Annex 1). For health impacts, this can be done by combining demographic data with dose-effect relations for specific pollutants, resulting in impacts on human health in terms of mortality, morbidity and disabilities. Poor demographic and health data at the country level are the main bottleneck (WHO, World Bank). Better country coverage and higher spatial detail is needed to cater for the geographic differences in population characteristics. The generation of a comprehensive, harmonized mortality database would require a major effort, as witnessed by the compilation of the global Mortality Database (WHO, 1996) and also recently confirmed by the development of a European Mortality Atlas (WHO, 1997).

Impact indicators for critical loads of acidification, climate change and soil erosion are under development now (RIVM, SEI), although much more work still needs to be done to develop consistent and reviewed risk maps. Increasing emission levels coupled with highly variable vulnerability of ecosystems require much more analysis for completion of the global picture with enough detail. In addition, new methodologies are required to express the dimensions of biodiversity (habitat area and ecological quality), stimulating at the same time new data collection activities (habitat areas, occurrence of species).

Responses

Efforts to promote and organize measurements of the effects of conventions and other policies have only just begun, and there is very little data available on societal response to environmental problems. This type of assessment requires ample information on environmental policies and conventions in place as a starting point. Then the effect on pressures and state of the environment needs to be estimated. An example of work underway is included in Annex 1, Section 1.3. Overviews of current environmental policies and directives are available for some countries, regions and the world as a whole (UNEP, CIESIN, EEA, CEU), but these are far from complete and certainly not available in a form that policy efforts can be related to changes in environmental impacts. There is a need to improve, extend and link current efforts at regional and global levels and to start monitoring the effects of the policies in place. GEO-2 now shows how difficult, but also how useful, this is.

4.3 Collaboration for improved monitoring and assessment

The identification of the critical caps described points to several important matters:

- There is a need for further development of networks of Integrated Environment Assessment practitioners (involving both generators of core data and assessment institutes) and for links to actual users. Such networks may promote a dialogue and the exchange of ideas, and provide a network to place individual activities in their broader context. The network of Collaborating Centres could play an important role in this.
- Centres of expertise could play an important role in both actual assessment and in filling critical gaps in expertise on real issues and in regional knowledge and data.
- Monitoring activities should be targeted towards actual assessment in order to reduce critical gaps here. As has been mentioned (see Table 4.1), most international monitoring efforts were originally set up in the tradition of a technically-oriented monitoring of environmental compartments (*describing*). As assessment is moving towards the levels of *explaining* and *advising*, it is now time to reconsider monitoring activities.

Organization of data monitoring and handling

This section discusses the recommended approach towards data and monitoring in the context of UNEP's activities (see also Section 5.3).

Figure 4.5 shows the "iceberg model of information": environmental assessment is based on a large body of underlying data. By means of assessment methodologies, these data are condensed and interpreted into the final information as reported in the assessments themselves (see Annex 1 for examples).

It is important to realize that assessments of other bodies (such as FAO and UNDP) use to a large extent similar input data as UNEP. This means that overlapping activities can be avoided if monitoring is regarded as generic activity: the particular core data generated by one body can be used in the context of several assessments (Figure 4.6). Such collaboration also helps in ensuring consistency and building up consensus. As is discussed in Section 4.2, the supply of data currently for UNEP's assessment, and probably also for related international assessments, still contain several critical gaps.

The collective input data for global assessments in generated by an "underlying layer" of monitoring activities. In accordance with the strategy mentioned in the previous section, UNEP should lead only a few monitoring systems. Their results feed into global environment assessments as well into related assessments by other agencies (Figure 4.7).

For the environmental assessment process itself a collection of consolidated collection of input data is needed. The UNEP GRID system could be used to generate such a collection (Figure 4.8). In order to do so, the GRID centres need to collaborate with the providers of core data and the organizations involved in the assessment process itself.

Finally, a key element in the assessment processes in authorization. In the GEO processes the Policy Consultations have been used to allow national governments to comment on assessment activities and the data used. In future, the Collaborating Centres could be used more systematically to channel comments regarding data back to the original compilers (Figure 4.9).

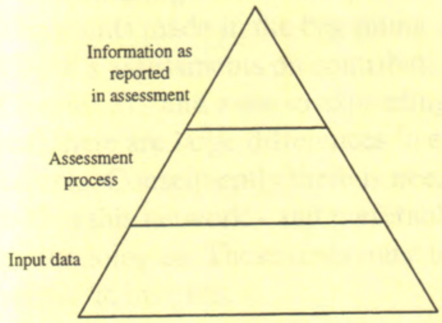

Figure 4.5: The iceberg model of information processing
Environment assessments are based on a large body of underlying data. The assessment process involves models, scenarios, user consultation and further data processing.

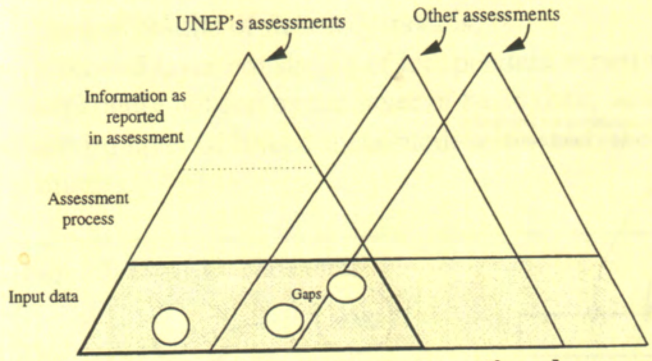

Figure 4.6: A joint basis for international assessments
Assessments by other bodies than UNEP use to a large extent similar input data

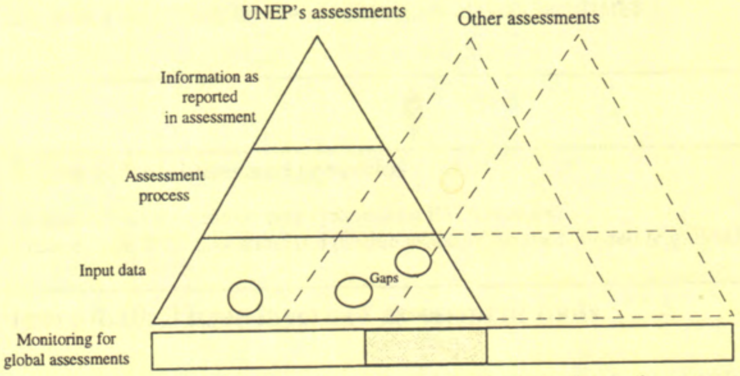

Figure 4.7: Monitoring in support of global environment assessments
UNEP's strategy should lead only a few monitoring systems. These are often systems for UN-wide use. Their results feed into global environment assessments as well into related assessments by other agencies.

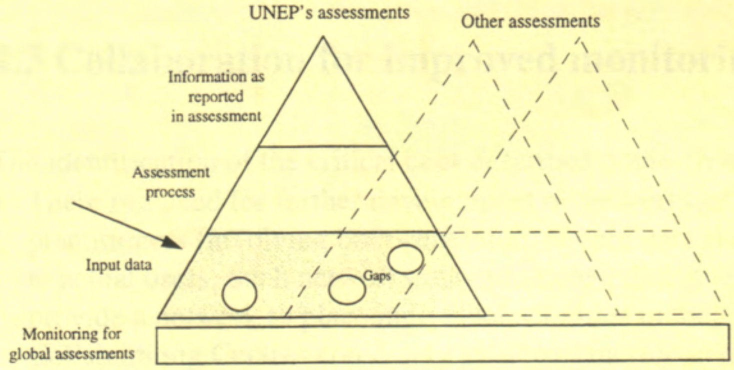

Figure 4.8: Data logistics for UNEP's assessments (GRID role)
In addition to the collaboration with other data providers and users, UNEP's assessments require separate consolidation of input data first, dedicated to IEA.

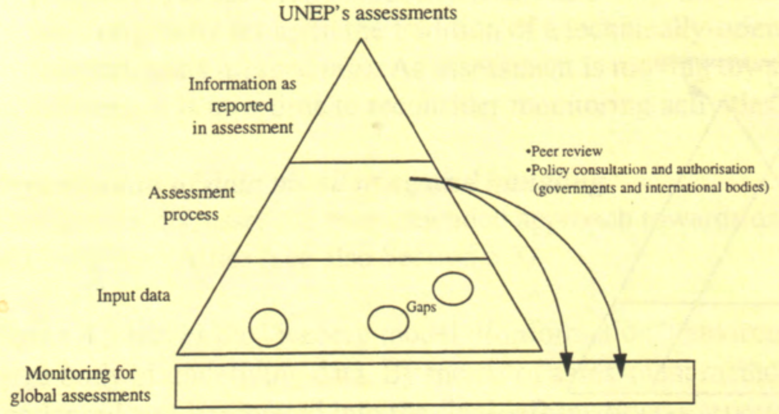

Figure 4.9: Data enhancement in the course of the assessment process
Collaborating centres take into account any criticism on input data, but only at the assessment stage, and only if relevant for assessment conclusions. Feedback is channelled to the original data compilers.

Disseminating data and expertise between collaborating centres

The points made in the beginning of this section lead us to recommend continuing to base UNEP's assessments on contributions by the network of Collaborating Centres (see also Chapter 5) - and even to expanding the role of this network. At the same time, one should note that there are large differences in experience and type of expertise between these different centres. Consequently there is need for specific tools to disseminate knowledge and expertise within this network - and preferably to harmonize as much as possible assessment methodologies. These tools must accommodate a wide range of experience, focal areas and scientific insights.

Encouraging the dissemination of knowledge and expertise within the network is primarily the responsibility of UNEP. This could be supported by the development and application of a comprehensive, generic assessment tool, conceivably composed of three layers (see Figure 4.10):

- a basic layer of data from monitoring systems consisting of exogenous inputs, scenarios and pre-run results of detailed models;
- a second layer consisting of independent expert models for priority issues, to be run separately but fed by the layer of basic data;
- a third layer of linked meta-models in which the expert models are represented by simplified images.

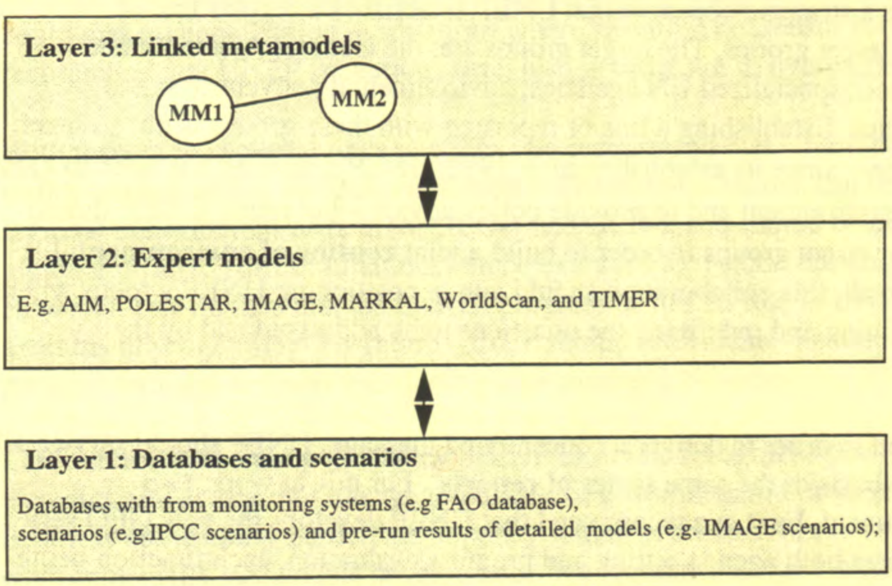

Figure 4.10: Three layers of assessment tools

Such an approach could provide a high degree of integration of harmonized monitoring data with assessment methods. This purpose of this is to disseminate the resulting information to UNEP's collaborating centres. Use can be made of tools existing or being developed at Collaborating Centres and other institutes (e.g. AIM, POLESTAR, IMAGE, MARKAL, WorldScan, and TIMER). Each of these modelling tools is useful in its own right (i.e. for dealing with specific issues or regions). The third layer of linked meta-models is added especially for policy dialogue and presentation purposes but also for quick turn-around scoping exercises when designing UNEP's assessment in interaction with its multiple target groups.

5 Strategy to reach UNEP's monitoring and assessment objectives

We have argued in Chapter 3 that UNEP's strategy for monitoring and assessment should focus on assessments for specific target groups, and UNEP's target audiences and proposed strategic objectives for the next five years are reported there. Key to UNEP's strategy is that it positions itself as the interface between science and global/regional policies for the environment.

In Chapter 4 we have summarized key requirements for UNEP's assessments, in terms of content, input and process. That methodological intermezzo describes the strategic objectives in somewhat more concrete terms, among other things in order to identify at least some important gaps in present data and expertise. With the foundations firmly laid in Chapters 3 & 4, the present chapter, Chapter 5, turns to the question of how UNEP can achieve its strategic objectives.

5.1 Linkages to policy

We have recommended as a strategic objective that UNEP establishes a regular line of reporting with each of its target groups. The target groups are: the General Assembly and UNEP's Governing Council; specialized UN agencies; environmental conventions; and multilateral financing bodies. Establishing a line of reporting with these groups is not so much a matter of formal mandate – since its establishment in 1972, UNEP's mission has been to keep under review the earth's environment and to provide policy advice – but rather UNEP should work with each of the four target groups in order to build a joint **routine of environmental reporting** to them. Above all, this collaboration should aim at positioning UNEP's focus where this is most useful, by defining and redefining the questions to be addressed and by the selection of indicators.

For practical purposes, and in order to deliver a concentrated message, UNEP should service all of its target groups on the basis of the same **series of reports**[4]. For this to work, two recommendations are pertinent. First, we recommend that UNEP develops the new GEO series in such a way that it services both agenda setting and progress evaluation, each function being met with an appropriate periodicity:

- Four-yearly Global Environment Outlooks, to be the basis for re-assessing the environmental agenda, and including early warning signals. These should put regional and national developments and efforts in a global context.
- Yearly statements on the environment, by the Executive Director of UNEP. These should focus on progress in policy and report new findings that have emerged. Each statement should contain an indicator-based segment. Statements should focus on priority areas as defined below.

[4] Conceivably, specific messages on the basis of the assessments can be formulated in letters of transmittal.

Second, a mechanism is required for providing policy guidance as to the focus for assessment, taking the needs of all four target groups into consideration.
For this purpose, we recommend that an **advisory group on UNEP's monitoring and assessment programme** be established. This group should be made up of government representatives and should report to the Governing Council. It should advise on policy questions to be addressed by UNEP's assessments (in the light of expressed policy questions), on the choice of indicators and on the selection of monitoring programmes for UNEP to participate in. On a formal note, as UNEP's reports would be directed towards the General Assembly, the advisory group would operate under a delegation of responsibilities from the General Assembly to UNEP's Governing Council[5].

With regard to **indicators** (now stated as a goal in its own right in the terms of reference for the present study), we recommend that UNEP's initiatives in designing and producing indicators be **fully integrated** in the process of designing and producing the assessments described above and in reporting under environmental conventions. UNEP should consider indicators as an information contract between itself and the body it reports to.

In relation to **international environmental conventions**, UNEP should work through the proposed annual meetings of heads of secretariats (UN, 1998). As with specific groups of countries, UNEP's approach and network hold a large potential for application in more specific settings. Specifically, because the network of collaborating centres is regionally balanced, it could make a contribution in situations where scientific consensus is critical. However, we recommend that UNEP is cautious here, also in order not to overburden its network.

With respect to **regional** links to policy, we recommend that UNEP concentrates on **regional policy consultations** on draft assessments. These consultations can be developed from the regional consultations as held for GEO-1 and GEO-2 and should be organized by UNEP's regional offices. The consultations can be extended to include standing groups as necessary. However, this implies that the ENRIN programme has no role in UNEP's monitoring and assessment programme. Therefore, UNEP should re-evaluate the necessity of ENRIN in its present form and consider transferring it to another UN body.

Last but not least among the policy links, it has to be recognized that the above strategy elements aim at assuring linkage to policies of governments. But increasingly, **NGOs and the business community** participate in policy setting processes for the environment and environmentally sustainable development. We recommend that UNEP explores ways to involve key organizations from these groups in its monitoring and assessment programme, perhaps in a reviewing role.

[5] In this connection it is relevant that the UN Task Force on Environment and Human Settlements recommended that the membership of UNEP's Governing Council is made Universal (UN, 1998). If there is no longer difference in membership between the two bodies, it would be easier in a formal sense for the Governing Council to guide UNEP's Monitoring and assessment programme on behalf of the General Assembly.

UNEP should **focus on global assessments**, including regional assessments in a global context. In other words, UNEP should assess[6]:

- global environmental issues (governance of the global commons, transboundary issues), including their linkages to other issues and sustainable development;
- environmental aspects of international trade, finance and aid;
- regional environmental issues that pose a threat to environmental security.

Although this focus corresponds to an apparent trend in policy questions, it also means **limiting the domain** of UNEP's assessment and, therefore, its monitoring. Strictly local issues, even if they are universal (e.g. air pollution), should in these assessments not be addressed as such but only in their relation to other issues. The primary reason for this limitation is that it is UNEP's unique position to provide global overviews, and policy advice on this basis. By the same token, UNEP is not in a position to issue free-standing regional assessments that will add critically to policy advice as developed by regional bodies and processes. (For example, *Ecoasia* or *Environment for Europe*.) But UNEP should continue to differentiate its global assessments regionally, thereby offering regional and subregional policy setters valuable contextual information. We recommend maintaining approximately the current level of resolution in UNEP global assessments, i.e. based on five global regions with a finer differentiation into fifteen to twenty subregions. In addition, it is critical that UNEP involves the best of regional expertise in the compilation of its assessments (see recommendation in Section 5.2).

5.2 Linkages to expertise

We have recommended as a strategic objective that UNEP consolidates its network of **collaborating centres**, spread over the world's regions, and develops the centres' expertise to match the substantial requirements of UNEP's assessment.

Although a backstage development, the building up of UNEP's network of collaborating centres for "'assessment, reporting and forecasting'" has probably been the most significant step forward during the past five years. UNEP should hold on to this asset and develop and use it. The network should **not be expanded in number** (except for correcting the present absence of linkage to expertise in Australasia). The network's optimal size is probably between fifteen and twenty centres.

The role of the centres is to bring to bear the best available knowledge and regional perceptions in the compilation of UNEP's assessments. This includes the analysis of current and alternative policies. UNEP should consider assigning its centres **global topical roles** (for example, land-related issues, or multilateral environment agreements), reflecting UNEP's long-term priorities. It should **emphasize somewhat less** that the centres represent the expertise of a region because, strictly speaking, the centres are not meant to <u>represent</u> regions.

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[6] See section 3.2 for background.

A **multi-year working programme** for the network of collaborating centres should be set up and stable funding assured to carry the programme out. The working programme should comprise:

1. Further development of methods to make policy-oriented, integrated assessments. This should be targeted at robust methods to meet the shifting need for more comprehensive policy-oriented assessments, instead of single-issue reports or purely descriptive reporting. Moreover, such methods should also enable linking of UNEP's environment assessments with developments in the economic and social domains, as is increasingly required. Because UNEP has adopted a participatory approach to the compilation of its assessments (thus adding greatly to their acceptance), it is important to use relatively simple methods that can be shared among centres in the various regions. In addition, the same demand for simplicity, or rather transparency, follows from the requirement to involve not just one, but four target audiences, as well as other stakeholders, each with different regional perspectives[7].
2. Methods for improving the quality of available input data for UNEP's assessments with respect to the region in which a centre is located. This aspect of the work programme should focus on methods for confronting global "top-down" with local/national "bottom-up" data, incorporating available expertise.[8]

The programme should build on existing strong points of each of UNEP's collaborating centres and create links between centres in the various global regions.

UNEP's network of collaborating centres for environment assessment, reporting and forecasting currently receives incremental funding (i.e. for added services to UNEP), as opposed to integral funding[9]. Moreover, funding is organized by project and through project revisions for additional work. Assuming that by necessity **funding will continue to be incremental**, UNEP should pursue arrangements on the basis of multi-annual commitments by donors and contracts with all of the centres for periods of approximately five years - the latter similarly to European Environment Agency's topic centres.

If it is felt that regional balance and topical balance are difficult to combine in the network of centres for assessment, reporting and forecasting, UNEP may consider setting up an additional and somewhat smaller network of thematic **centres of excellence**. Such centres would be entrusted the task of adapting innovative monitoring and assessment methods for use in UNEP's area of work. As outlined below, they would also help UNEP to work with global and regional science organizations and funding agencies. The combined topical coverage of such a network should match approximately the diagram in Figure 4.4.

The centres of excellence would relate to UNEP's Programme Activity Centres, or their contemporary equivalent. (At the same time, good professional relations with relevant

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[7] As an example of methods that have been designed to meet these requirements, see the Safe Landing Analysis (Alcamo and Kreileman, 1996) and the Scenario Scanner (Berk and Janssen), both developed in the context of support to climate negotiations, or the critical loads approach, developed in the context of long range transboundary air pollution in ECE Europe. Suggestions for further developing this and sharing it between UNEP's collaborating centres are provided in the last subsection of Chapter 4.

[8] For example, such methods are now being developed with respect to greenhouse gas emissions. They prove very promising in order to improve national reporting capacities to produce good National Communications as well as global estimation methods. Obviously, UNEP's assessments require such techniques to be applied on many more topics where national and worldwide data seem to contradict each other.

[9] The funding philosophy is one of the two key differences between UNEP's network of collaborating centres for environment assessment, reporting and forecasting and the CGIAR, that is otherwise very similar. While the CGIAR's existence and activities are The CGIAR (Consultative Group on International Agricultural Research) has been established in 1971and is the group that research-wise facilitated the Green Revolution (see *http://www.cgiar.org*). The second key difference with UNEP's network of collaborating centres for environment assessment, reporting and forecasting, next to the way of funding, is that the CGIAR centres have a scientific role, while UNEP's centres operate at the science/policy interface.

convention secretariats are important.) However, it is also conceivable that UNEP would prefer the simplicity of a single network of collaborating centres. Obviously this would not make much difference in overall costs as the single network option requires additional strengthening of the capabilities in the existing network. For clarity, the tentative costing in Section 5.5 has been set up as if there would be a separate network of centres of excellence.

UNEP should collaborate with important **funders of environment related research** to help address gaps in knowledge and data that are particularly important for the enhancement of the policy relevance of UNEP's assessments in the coming years. Useful starting points for such agenda setting are the lists of knowledge gaps based on the experiences with GEO-1 and GEO-2 (see Section 4.2) and on the SCOPE project on sustainability indicators (Moldan and Bilharz, 1997). Key bodies for UNEP to collaborate with are: World Climate Research Programme (WCRP), International GeosphereBiosphere Programme (IGBP), the International Human Dimensions Programme (IHDP) and also the Diversitas programme (of ICSU). In particular, UNEP should work with the global structure set up by these three organizations to achieve co-ordinated funding, called International Global Change Funding Agencies (IGFA). The current collaboration between UNEP and DG XII of the European Commission should also be continued. UNEP's network of collaborating centres (or centres of excellence) can help UNEP to play its part *vis à vis* these organizations.

We recommend that UNEP **discontinues the three global forums** it has set up centering on the three key instruments for integrated environment assessment: i.e. data, scenarios and models. In practice, the work of these groups, although not unuseful, has not been related closely enough to the assessments that they were supposed to support. To some extent, this followed a lack of focused funding. The data group has been closest in meeting the needs of UNEP, but it was probably ahead of its time in this respect. We suggest that the group be transformed into a reporting body with higher formal status, as described in Section 5.3. The work on scenarios should be integrated in the development of UNEP's assessments and concentrate on scenarios for use jointly with other global assessment processes - in particular IPCC. The work on models should be transposed into broader and possibly thematically organized working programme for UNEP's collaborating centre.

Finally, UNEP should maintain its own high quality **assessment team** of five to ten people. The team's primary tasks are to manage the assessment process and to synthesize and process the multitude of contributions and reactions. UNEP should not compromise on the level of skills and experience in this team. If necessary, in order to maintain high quality staffing, this operation should be located at a convenient place in the world, perhaps being attached to the secretariat of another programme.

5.3 Linkages to monitoring

In Chapter 3, we recommended as a strategic objective that UNEP should pursues concrete collaboration with other international bodies, governments and convention secretariats aimed at consolidated global monitoring and serving various environment-related assessments.

The underlying principle to these objectives is that **UNEP relies on measurement by others** wherever possible. Obviously, this makes UNEP's assessments dependent on monitoring by others - in terms of data coverage, quality and timeliness. However, as a relatively small co-ordinating agency UNEP can hardly avoid being data-dependent. What is more, assessments of the type UNEP is supposed to deliver anyway require input data far beyond environment proper in order to cover relevant driving forces, impacts and policies.

Thus, **collaboration** should be at the heart of UNEP's monitoring strategy. It hinges on arrangements for:

- data logistics for UNEP's assessments
- regional quality enhancement involving UNEP's network of collaborating centres
- feedback to global actors with respect to monitoring.

In a way, our recommended strategy implies that the **Earthwatch approach** (UN system-wide collaboration to keep the Earth's environment under review (see UNEP, 1995) is energetically revitalized. The key step forward, relative to the previous 25 years, is that UNEP's strategy now aims for rather specific arrangements, distinguishing between (i) the collaborative effort to generate the input data for all sorts of assessment and reporting; and (ii) specific arrangements in relation to UNEP's assessments. (See Section 4.3) Precisely the fact that UNEP's assessment programme is now taking shape provides it with a credible reason for determining the monitoring focus, and the priorities of its interagency arrangements.

The measures UNEP should implement to achieve the monitoring objectives described above are described in the Subsections 5.3.1–5.3.3.

5.3.1 Data logistics and processing

UNEP should **limit the task of GRID** centres solely to providing a consolidated collection of input data for UNEP's global assessment. The GRID system should be managed accordingly; funding or cofunding for the system should be for this task only.

To acquire the necessary data, the GRID centres should **collaborate** with the following groups of organizations:

- Key providers of global and regional data sets. This includes true monitoring organizations (such as WMO, FAO, NASA, CDIAC) ; repackagers/consolidators (such as the World Bank's World Development Indicators); organizations related to international conventions with their own monitoring
- Regional economic commissions (such as ECLAC, ASCAP)
- UNEP's collaborating centres, especially thematic centres of excellence.

Of the above partners, UNEP should consider seeking direct **operational collaboration** with the World Development Indictors Programme of the World Bank, as this comes closest to what UNEP needs. UNEP should consider incorporating its support for the data collection aspects of the World Resources Reports/World Resources Database in the task of the GRID centres.

5.3.2 Regional quality enhancement of input data

To allow its assessments to be used for priority setting, UNEP should wherever possible base assessments on **harmonized global or regional data sets**. *(For example, FAO's land-use statistics).*

However, national entries in such harmonized global databases are by definition not always identical to what countries have reported. Moreover, many currently available data sets have problems that need correcting before the data can be used as input for policy-oriented assessments. Therefore, UNEP's collaborating centres should exert **quality control on input** for UNEP's assessments, taking into account the region where they were collected. This involves consulting regional and national scientific sources where necessary. It should result in correction of input data when necessary to avoid wrong conclusions, in filling data gaps, and in feedback to the specialized organization supplying the data.

This step optimizes the advantage of the existence of harmonized data sets[10] while retaining the possibility of collaborating centres and governments improving input on the basis of superior knowledge (and governments' authority as the bottom line). However, for this delicate system to function, UNEP should work with the collaborating centres on a long-term basis and strengthen their expertise as indicated in Section 5.2.

5.3.3 Interagency collaboration

UNEP should work with other global bodies to **report periodically on the state of monitoring** in relation to environmentally sustainable development. This reporting should be based on findings of UNEP and other bodies with respect to the input data they need. It should translate these findings into the identification of critical monitoring gaps, possible changes in the type of data required, and priority of action to be taken. The reporting should be of a technical nature and address data suppliers and funding agencies.

We recommend that UNEP takes the initiative for such reporting and explores the possibility of carrying out an exercise jointly with UNDP and the World Bank, possibly in the context of the GEF. Apart from UNEP, UNDP and World Bank, the reporting should involve FAO, WHO, WMO, UN Statistical Commission and possibly UNESCO, DESIPA and OECD. Input from the private sector and from governments with important monitoring operations can be considered. In taking this initiative UNEP can find enough material in reports of the Data Working Group, which should be subsumed in this activity, and Earthwatch inventories.

It is recommended that UNEP hosts the secretariat of a limited number of **joint UN monitoring programmes**. Here, UNEP should focus on the Integrated Global Observing Strategy (see: Committee on Earth Observation Satellites, 1997). In view of its focus on issues that require decision making at the global or regional level, we recommend that UNEP leaves responsibility for GEMS Air and GEMS Water to WHO.

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[10] This has been dubbed a top-down approach. However, that is a misleading expression as most of the global data sets have been build using a bottom-up flow of information to global/regional organizations through specialized channels.

Table 5.1 Elements to be put in place for UNEP's monitoring and assessment

	Central[11]	Decentralized[12]	In collaboration with
Integration, assessment and reporting	Programme management		
	Production of integrated annual and four-yearly assessments *[GEO secretariat]*	Contributions to integrated assessments *[by approximately 20 GEO collaborating centres]*	
Linkages to policy	Linkage to governments via Governing Council *[Advisory Group]*	Yearly regional policy consultations *[Organized by regional offices]*	
	Structured dialogue with target groups		
Linkages to expertise	Peer review of GEO and GEO technical reports	Incremental working programme of the GEO collaborating centres, to strengthen and disseminate methods	*"PACs"* and a maximum of 10 *thematic centres of excellence*, for linkage to expertise on specific environmental themes
	improving and expanding capabilities in UNEP-DEIA		
Linkages to monitoring	Data logistics and processing for UNEP's assessment *[newly programmed GRID system]*		Other sources[13]
	Technical reporting on the state of environmental monitoring, including data gaps. Environmental data working group		Other actors[14]
		Regional quality control and gapfilling/smoothing *[by GEO collaborating centres]*	National experts if required
	Secretariat of selected UN monitoring programmes		
	Catalytic participation in advanced monitoring systems		

[11] Located at UNEP HQ or an other UNEP node.

[12] I.e.: in all UNEP regions.

[13] Convention secretariats; analogous operations of UN specialized agencies, UN regional economic commissions World Bank; possibly also governments.

[14] Other sources (see earlier note) and also UN Statistical Commission; IAC

5.4 What's new?

Interestingly, many of the elements mentioned in the preceding sections have already been developed by UNEP over the years. Particularly UNEP's persistent work on UN system-wide collaboration in environmental monitoring and reporting (Earthwatch) needs to be mentioned in this respect. In addition, since 1992, the development of the Global Environment Outlooks (GEO) has meant a breakthrough. This new style of UNEP's assessments, in particular, has at last provided a means for concluding what data would be need - at least in principle. The GEO programme has begun to shape many of the strategy elements that the our paper recommends. What is new, then, in the recommended strategy, is "simply":

- coherent management of all programme elements, focused at delivering periodic assessments for a specific policy audience;
- matching budget and effort;
- wider use of networks of collaborating centres, situated in the various regions of the world and co-ordinated by UNEP.

5.5 Indicative costing

Mutatis mutandis, costs can be estimated using experience from EU-15 and some countries where arrangements along the same lines have been set up in support of environmental policy. Although UNEP's spatial coverage is larger, this has to be compensated by a more limited selection and less detail. Moreover, there is probably a natural limit to parameters such as the number of centres and the frequency of reporting. On balance, the total cost is likely to remain in the **order of magnitude of USD 25 mln** (with approximately hundred people employed).

UNEP should contract the collaborating **centres for a period of about five years**. It has been assumed that core funding for all centres comes from other sources, UNEP providing incremental funding for incremental activities to its benefit. This is an important difference with the CGIAR, which otherwise has served as a model for the network of GEO collaborating centres.

We have **assumed** that actual monitoring is carried out by other agencies than UNEP, or by governments, and that the right to use any data will be granted at relatively low cost. Nevertheless, linkages to monitoring constitute the largest cost item.

Table 5.2 Estimated budget for UNEP's new monitoring and assessment strategy

		Central[15]	Decentra-lized	Other UNEP programmes	Total
		Million US$			
Integration, assessment and reporting	Programme management	0.5			**5.0**
	Production of integrated annual and four-yearly assessments	1.5			
	Contribution to integrated assessments		3.0		
Linkages to policy	Linkage to governments via Governing Council [*Advisory Group]*	1.0			**1.0**
	Yearly regional policy consultations (regional offices)		0.5		
	Structured dialogue with target groups	0.4			
Linkages to expertise					**8.0**
	Peer review of GEO and GEO technical reports	0.1			
	Incremental working programme of GEO collaborating centres.		3.0		
	Improving and expanding capabilities in UNEP-DEIA	2.4			
	A maximum of 10 thematic centres of excellence			2.5	
Linkages to monitoring	Data logistics and processing for UNEP's assessment	4.0			**11.0**
	Technical reporting on the state of environmental monitoring, including data gaps. (Environmental data working group)	0.5			
	Regional quality control and gapfilling/smoothing (by GEO collaborating centres)		1.0		
	Secretariat of selected UN monitoring programmes	3.0			
	Catalytic participation in advanced monitoring systems	2.5			
Total		**15.0**	**7.5**	**2.5**	**25**

[15] Located at UNEP HQ or an other UNEP node.

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Annex 1. Integrated environmental assessment: addressing policy questions by combining data and expertise. Some examples.

As outlined in Chapter 4, the assessment methodology requires the clear definition of policy issues, and subsequently the availability of models and data, as well as interfaces to communicate answers to policy makers. Major global and regional environmental issues relate to energy, land use and water management, from which in recent years problems such as climate change, acidification, eutrophication, water stress, soil degradation, biodiversity loss and ozone depletion have been singled out. If assessments are to answer policy questions, and if the concept of environment is broadened to sustainablity, then we need to take into account the pressures on the environmental state and the socio-economic forces behind those pressures, as well as impacts on human welfare and natural ecosystems and policy responses to the environmental problems at hand. The need for truly integrated assessment is being recognized more and more, as witnessed by the first GEO assessment, IPCC's climate assessments and current EU/EEA studies.

This annex presents several examples of such (integrated) assessments, which use the DPSIR approach. These examples not only show how environmental assessments are undertaken in practice, but also serve to identify major critical gaps in integrated assessment and monitoring, i.e. gaps in scientific understanding and in availability and integration of data (as summarized in Chapter 4.2). To begin, three rather straightforward environmental issues, i.e. acidification, eutrophication and climate change, are presented. An assessment of water stress (also along DPSIR lines, but emphasizing the issue of geographical scale) follows. Subsequently a recent attempt to address responses to environmental problems is described. Finally, the need to broaden the concept of environment to sustainability is illustrated.

Annex 1.1 Pressure, state and impact analysis for acidification, eutrophication and climate change

Annex 1.1.1 Acidification

Increasing industrial production, transport, agriculture and other economic activities result in higher emission levels of acidifying compounds, mainly sulphur and nitrogen. Acidifcation occurs when terrestrial ecosystems can no longer absorb the deposition of SO_2, NO_x, and NH_3 without showing damage to soils and vegetation. When critical levels have been exceeded the existence of the ecosystem is at risk.

Acidification is being studied for Europe within the framework of the UN-ECE convention on LTRAP, as co-ordinated and presented by CCE on the EMEP raster on the basis of the RAINS model results. This is a robust framework, showing that clear policy questions and concerted action for data collection, modelling, validation and assessment result in relevant information for the formulation of environmental policy. Similar calculations are now also being made for Asia within the RAINS-Asia project.

At the global level, SEI has recently analyzed sulphur-related acidification, using as core data sets the GEIA/EDGAR databases for emissions, the MOGUNTIA model for deposition, and the FAO Soil Map for ecosystems characterization (Kuylenstierna et al., 1998). Figure 1 shows emissions of sulphur (SO_2) for 1990 from the EDGAR database with a spatial resoltuion of 1 degree (Olivier et al., 1996). To derive such a consistent global grid map is a major effort in itself, needing the integration of data on underlying driving forces.

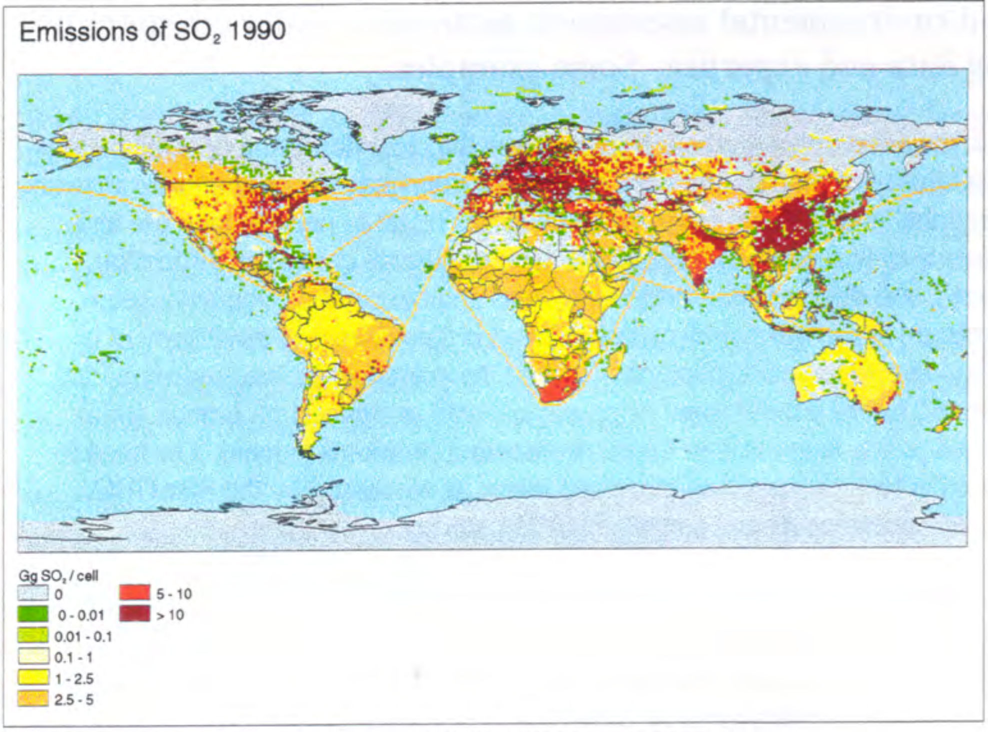


Figure 1. Emissions of SO_2 in 1990 (EDGAR database)

Vast amounts of statistical data at the country level need to be coupled with emission factors, distributed over small grid cells with the help of population density, and validated against reported emission data (i.e. IPCC National Communications). In turn, the collection, maintenance, integration and verification of underlying country statistics and population density are all sizeable jobs in themselves as well.

Total emission of SO_2 in 1990 amounted to some 148 Tg (IPCC: 150 Tg), derived mainly from production of heavy metals, cement and H_2SO_4, as well as from biomass burning and local fires. To calculate sulphur deposition, the emission data are applied to information on the transport of substances (climate, weather) using atmospheric models like MOGUNTIA. Figure 2 shows deposition for 1985 derived from this model with a spatial resolution of 10 degrees (10°x10°).

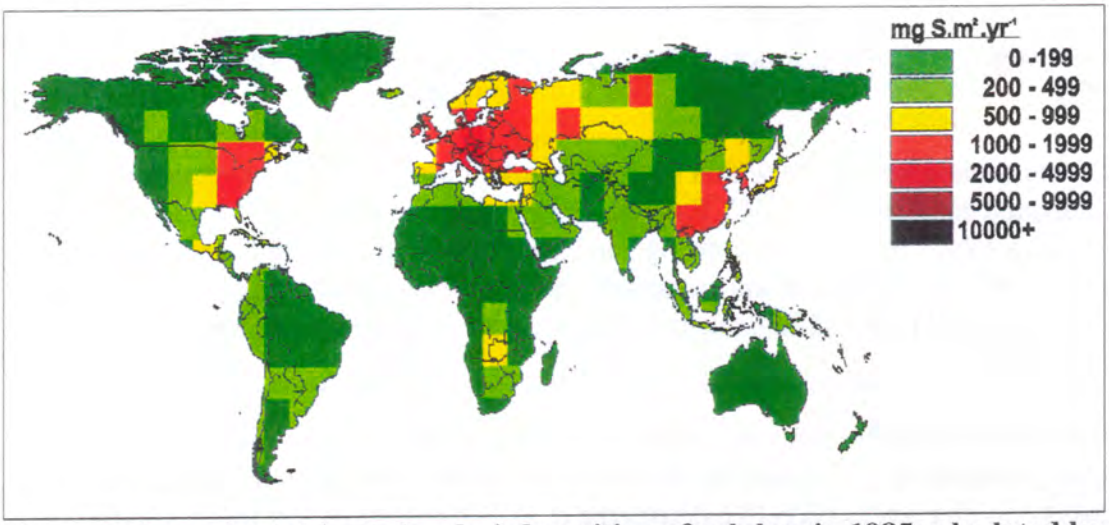


Figure 2. Annual total (wet plus dry) deposition of sulphur in 1985 calculated by the MOGUNTIA model

The critical load or sensitivity of ecosystems has been derived from applying the buffer ability of different soil types (using base saturation and CEC) to the FAO/UNESCO Soil Map of the World. Figure 3 shows the result, representing a process of consultation with developing countries, ecologists and experts (Kuylenstierna et al., 1998).

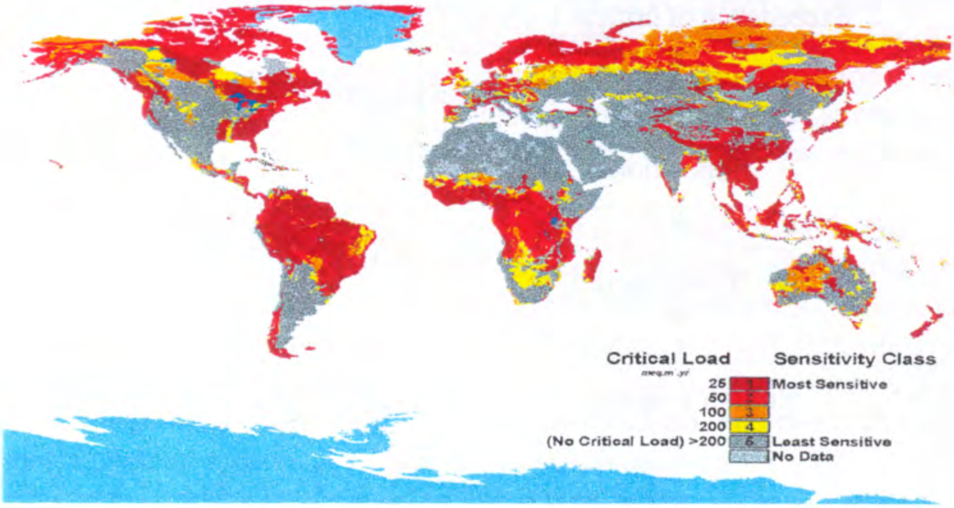


Figure 3. The global distribution of five classes of relative sensitivity to acid deposition.

Finally, the sensitivity and deposition maps are combined to produce the exceedance of critical loads or an acidification risk map as shown in Figure 4. In addition to the already well-studied regions of Europe and SE Asia, acidification poses a major problem in the western part of North America. A scoping of future trends, together with projections for 2050 on the basis of the IPCC IS92a scenario, indicate that large areas in South America and southern Africa will exceed critical levels of sulphur deposition (Kuylenstierna et al., 1998).

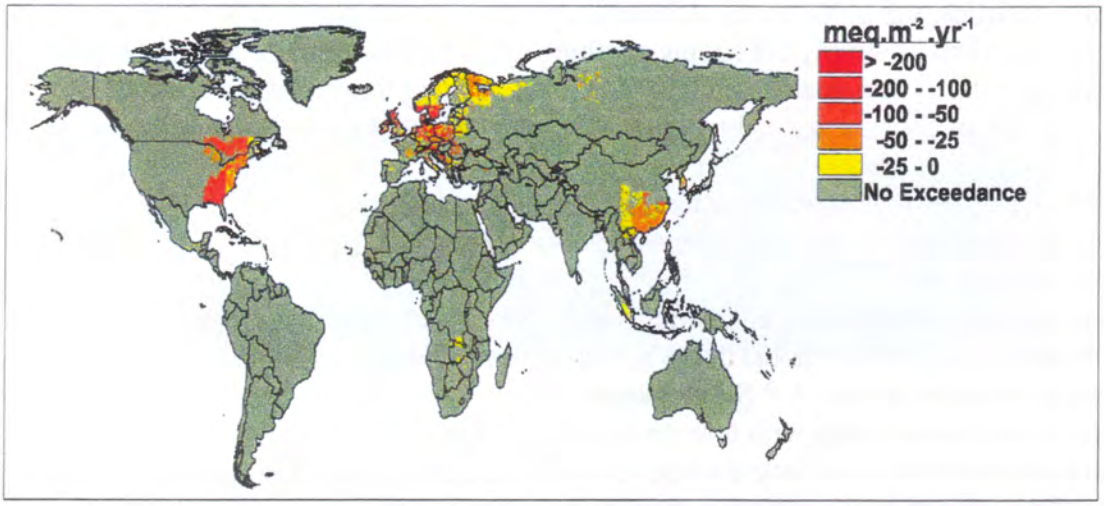


Figure 4. Global risk of acidification-related damage to terrestrial ecosystems from sulphur deposition in 1985 derived from global-scale modelling.

The main steps of this data-to-information process for the assessment of acidification can be summarized as follows:

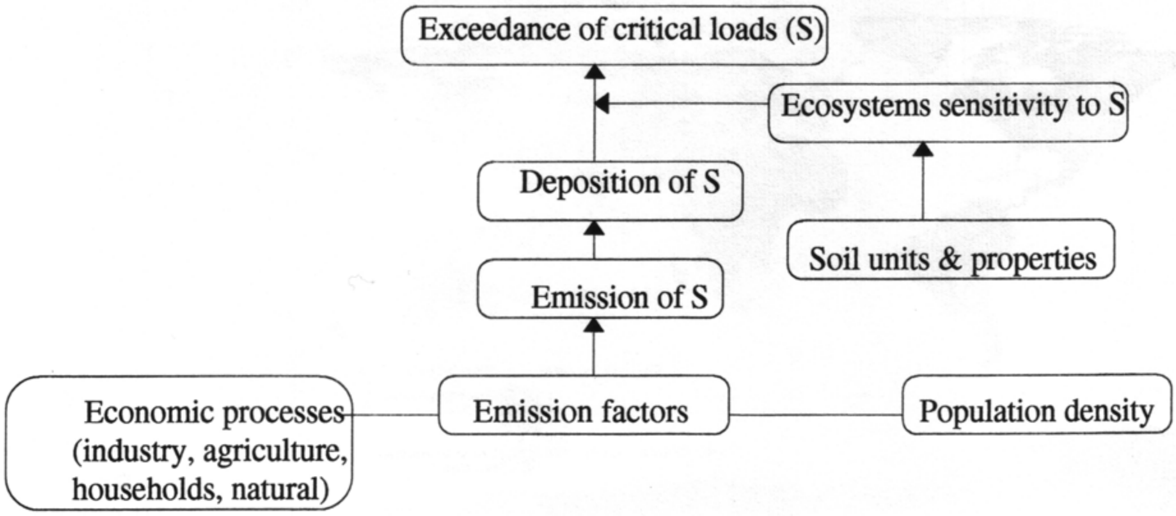


Figure 5. Data integration for acidification assessment

Discussion

It goes without saying that these data collection and integration processes are very complex and flawed with (gap-filling) approximations and uncertainties. To produce each layer in itself is already a major undertaking, while the integration of layers for environmental assessment is yet another tricky exercise. Typical inconsistencies relate to differences in definition of contents (e.g. what is labelled as 'forest' or 'grassland' in the case of ecosystems delineation), differences in spatial resolution (country statistics, soil units, river catchments, gridded emissions and depositions) and differences in reference years or simply not having anything up-to-date (within and among layers). The all-encompassing issue of data quality can be added here, pointing to inconsistencies and incompleteness, and lack of documented references, calibration and validation of data and models.

For the assessment of sulphur-related acidification, critical gaps include:
- knowledge on ecosystems'sensitivity to acid deposition (local expertise)
- integration with N deposition
- long-term monitoring of concentrations and deposition for model validation
- coarse spatial resolution of global/regional deposition models and emission databases
- different geographical scales among D-P-S-I elements
- validation of top-down pressure data with bottom-up information
- availability and consistency of underlying data on economic and anthropogenetic driving forces, including derived data for gridded population density and urbanization

Annex 1.1.2 Global nitrogen eutrophication of ecosystems

Industrial, agricultural and other anthropogenetic activities have modified global bio-geochemical nitrogen (N) cycles by doubling the natural rate of N fixation. This is reflected in increasing emissions of N gases into the atmosphere, increasing riverine transport of N into the oceanic environment, accumulation in inland aquatic systems, and deposition to natural ecosystems. Because N is the primary nutrient limiting biological production in many terrestrial and freshwater and marine environments, increases in N inputs (in any form) can alter those ecosystems through eutrophication.

We present in this section a global analysis of the eutrophication hazard based on best available data on emissions, deposition, and critical N loads for terrestrial ecosystems.

Emissions. The main N substances emitted by human activities are nitric oxide (NO) and nitrogen dioxide (NO_2) (together denoted as NO_x), and ammonia (NH_3) (Figure 1). Global emissions of NO_x and NH_3 amount to 56 and 54 million t N yr-1, respectively. Livestock production is by far the dominant source for atmospheric NH_3, while industrial sources and fossil fuel combustion are the most important sources of NO_x. Regionally, this pattern varies, for example in regions with extensive rural areas or where large-scale burning is in progress.

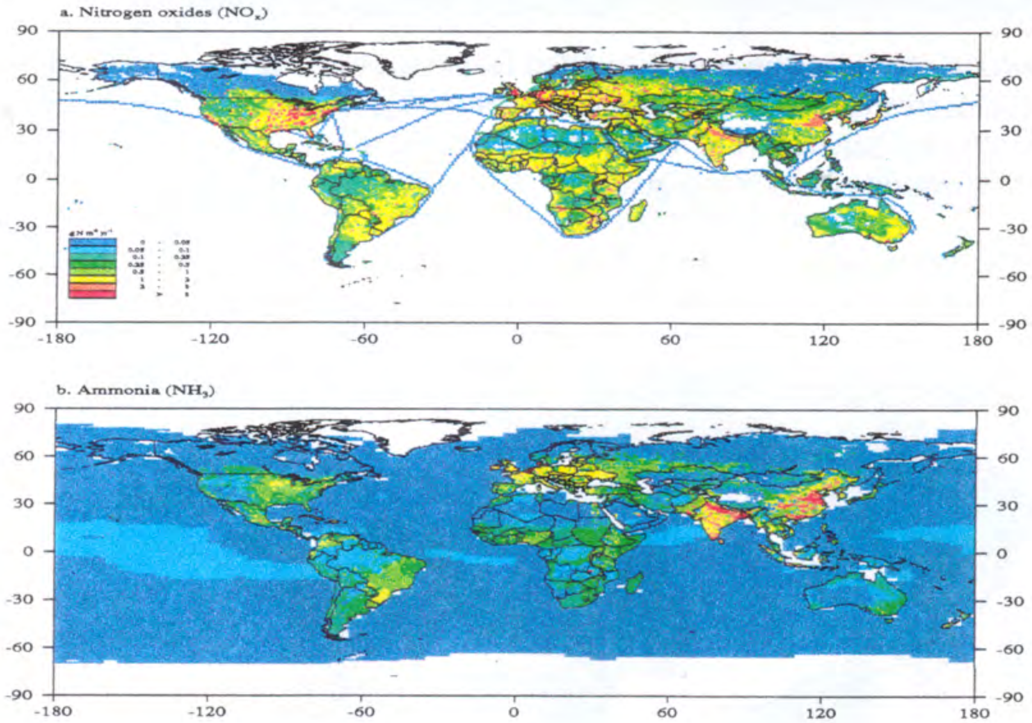


Figure 1. Global distribution of emissions of a) nitrogen oxides (NO_x) and b) ammonia (NH_3) from all anthropogenic and natural sources, including oceans.
Source: RIVM-EDGAR (Olivier et al.. [1996] for NOx and Bouwman et al.. [1997] for NH_3. For NO_x , the emissions from soils were derived from Davidson and Kingerlee (1997), which is an update on the basis of recent measurements and a detailed stratification scheme of the current Global Emissions Inventory Activity-inventory of Yienger and Levy (1995).

Deposition. Deposition of N onto global land areas amounts to ~53 million t N yr-1 (Figure 2). Highest mean regional deposition rates of 12 kg N ha-1 yr-1 occur in Eastern Europe. Southern

Asia and OECD Europe have mean deposition rates of 9 kg N ha-1 yr-1. Other regions with somewhat lower deposition rates are Japan and Eastern Asia. Maximum deposition rates (~30 kg N ha-1yr-1) occur in OECD Europe and Eastern and Southern Asia, and somewhat lower rates occur in North and Central America, Southeast Asia, North Africa and Japan (15-20 kg N ha-1yr-1).

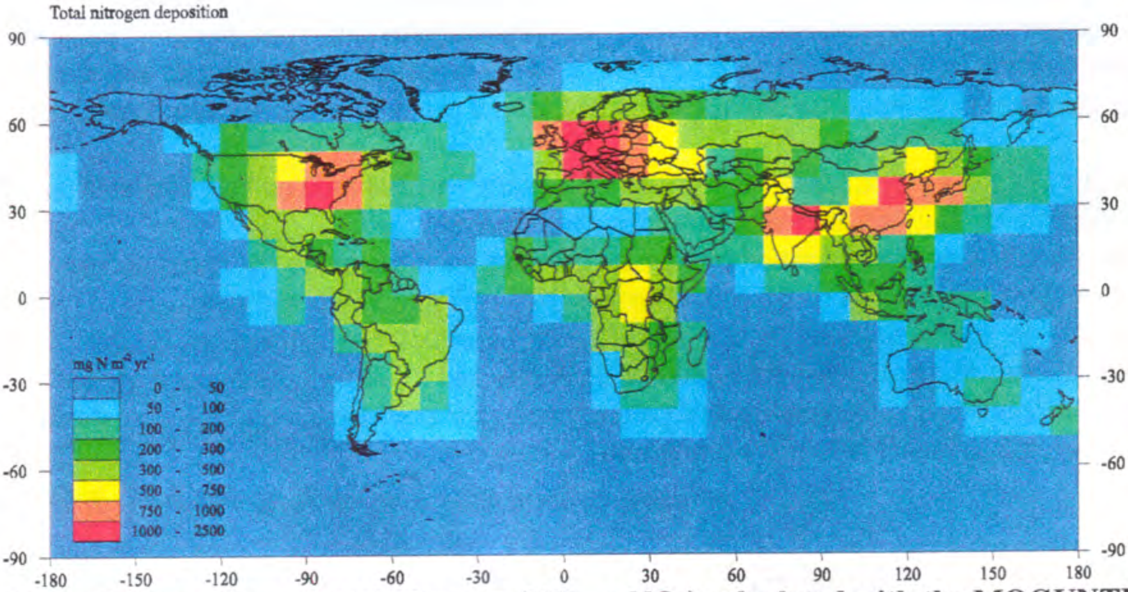


Figure 2. Deposition of total nitrogen (NH_x + NO_x) calculated with the MOGUNTIA model. NH_x deposition fields are from Dentener and Crutzen (1994); NO_x deposition fields are from Holland et al.. (1997) and Lelieveld et al.. (1998). For this study the NH_x deposition fields were modified using NH_3 emission fields from Figure 1.

Critical loads. The regions with the highest potential susceptibility to N deposition (2.5-5 kg N ha-1yr-1) are in northern Canada, Scandinavia and northern Russia, all host to tundra-taiga systems (Figure 3).

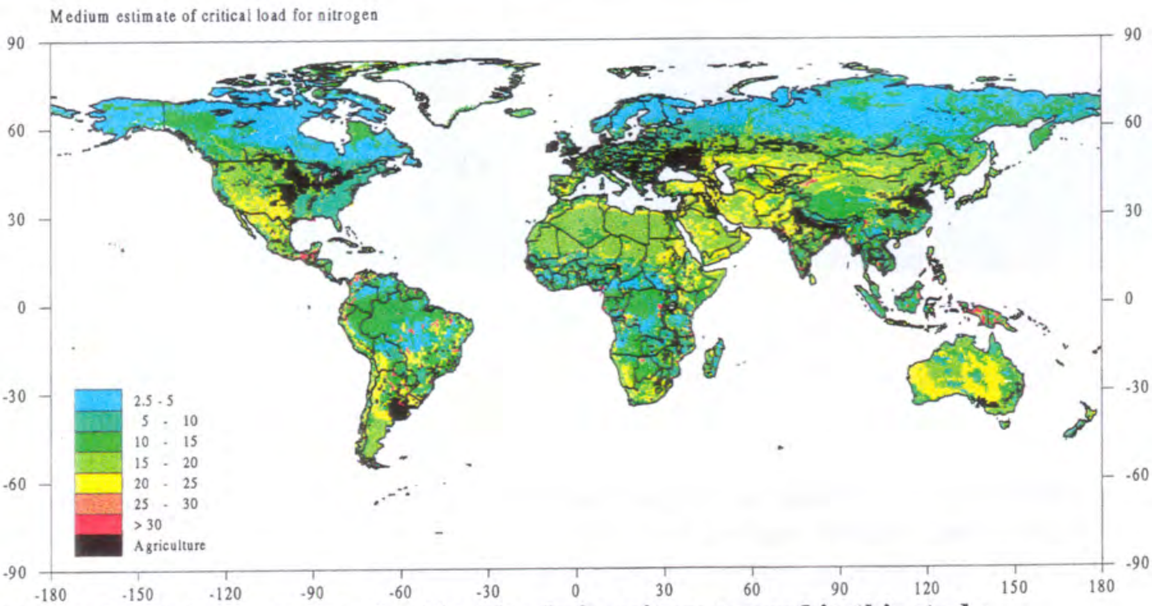


Figure 3. Medium ranges of critical loads for nitrogen used in this study.
NB In the original report, three ranges were compared. Source: RIVM (Bouwman, in prep.). Scattered regions of high susceptibility occur in South America and Africa. In tropical forests the low soil pH is the major cause of low critical load values, while in other parts the ecosystem itself (savanna and other dry and semi-arid vegetation types) is highly susceptible, locally exacerbated by low soil pH. Intermediate susceptibility occurs in western USA, Europe and Russia.

Table 1. Percent of the area of natural and semi-natural ecosystems with at least a moderate risk of eutrophication (ratio N deposition:critical N load > 0.75) and at least a moderately high risk (ratio > 1.25), and the major ecosystem affected.

Region	Ratio N deposition: critical N load		Ecosystem most affected
	>0.75	>1.25	
Canada	6-14	1-6	Temperate forest
USA	12-28	10-22	Temperate forest
South America	7-18	0-2	Tropical seasonal and dry forest, savannas
western Africa	9-21	0-10	Savannas
eastern Africa	5-12	0-5	Savannas
southern Africa	4-20	0-5	Savannas
OECD Europe	29-68	14-50	Temperate forests
Eastern Europe	57-71	19-43	Temperate forests
former USSR	2-14	0-4	Tundra and taiga ecosystems
South Asia	14-29	4-13	Tropical forests
East Asia	10-21	2-11	Tropical forests
Southeast Asia	7-31	2-11	Tropical rainforests
Japan	14-25	0-13	Temperate forests
World	7-17	2-8	

Eutrophication risk. Comparison of deposition fluxes and critical loads gives an estimate of the eutrophication hazard. Globally 7-17% of the area of natural and semi-natural ecosystems has at least a moderate risk of eutrophication (ratio deposition:critical load of >0.75), and 2-8% may have at least a moderately high risk (ratio N deposition : critical load > 1.25) (Table 1; Figure 4). Regions with extensive areas with at least a moderately high risk occur in many parts of the world (Table 1), mainly in the USA, OECD Europe and Eastern Europe. Regions where potential risk to eutrophication may occur include South and East Asia and Southeast Asia.

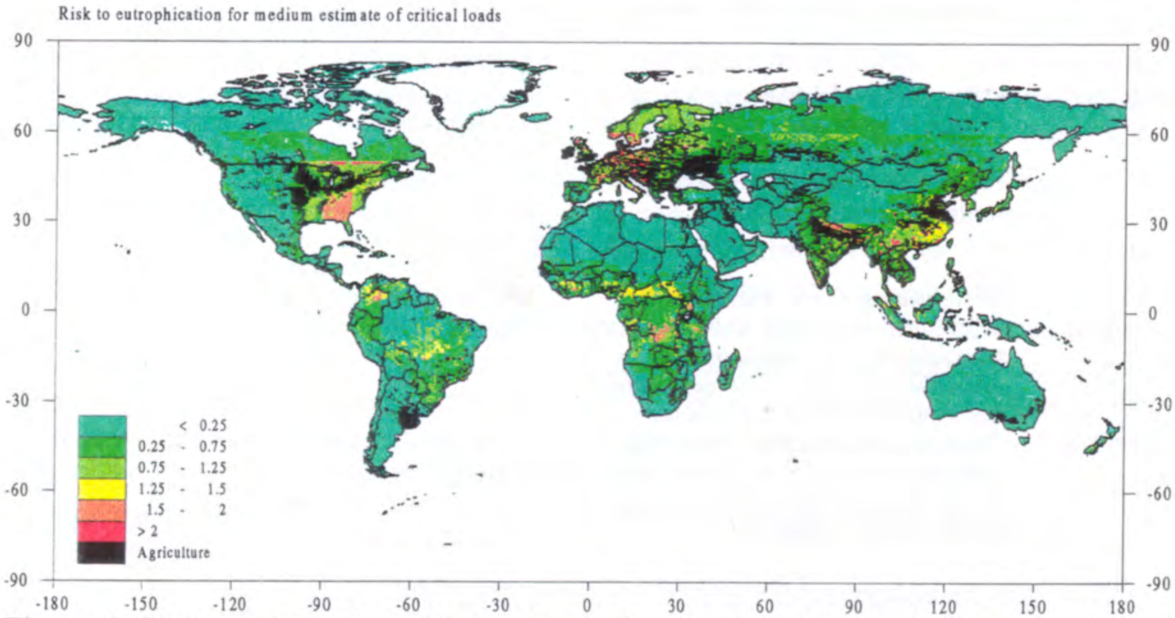


Figure 4. Global distribution of the ratio of nitrogen deposition and critical load, for the medium estimate of critical loads. Source: RIVM (Bouwman, in prep.)

The results of the analysis also suggest that a number of regions with low population densities, such as in South America and Africa, and remote regions in Canada and the former USSR, may be affected by N eutrophication.

Future trends. Scenarios indicate that agricultural N (fertilizer and animal waste), which is the dominant source of NH_3, may double between 1995 and 2025 in tropical countries. Scenarios for anthropogenic NO_x emissions excluding agriculture indicate an increase of 50%, with no or only slight increase in North America and Europe. Major increases come from South, East and Southeast Asia, Middle East, Africa and Latin America. This suggests that in many tropical regions N emissions and deposition may strongly increase in the near future, and that problems of N eutrophication may aggravate and expand over larger areas in these regions.

Discussion. Major uncertainties in the results of this study stem from (i) uncertainties in the deposition fluxes and their spatial distribution, which strongly depend on the emission fields and the atmospheric-chemistry transport model used; (ii) scaling errors caused by differences in the spatial detail of the various data used; (iii) regression models used for extrapolation riverine N loading which are nonrobust; (iv) lack of information on spatial distribution of agricultural N use within countries; and (v) scant quantitative information on effects of enhanced N deposition on terrestrial and aquatic ecosystems; data are available only for Europe and North America; there are major knowledge gaps for the tropics. Critical loads for arctic and alpine heathlands, steppe grasslands, Mediterranean vegetation types, high altitude forests, ecosystems on neutral and calcareous soils, permafrost regions, taiga and tundra ecosystems, and practically all tropical ecosystems are highly uncertain. In particular, quantified effects of N enrichment on ground vegetation and (ground) fauna are required.

Table 2. Major uncertainties and recommendations for future global assessments in the field of emissions, deposition fluxes, critical loads, and riverine N loading.

	Major uncertainties	Recommendation for future global studies
Emissions of NH_3 and NO_x	Lack of measurement data; scarcity of data on agricultural management; scarcity of information on spatial and temporal distribution of fluxes within countries	As in the near future no data will be available to improve currently available emission inventories, one approach is to validate emission fields where possible using forward and inverse atmospheric chemistry transport models
Deposition fluxes	Low resolution of deposition fields which are used in combination with a high resolution vegetation database; errors in emission fields (see above) and chemistry transport models	Three alternatives approaches may be used: (i) use of source receptor matrices on a 1° grid for (sub-)continental calculations; (ii) refine the chemistry transport model to 1°x1° resolution by accounting for sub-grid effects; (iii) Simple source-receptor matrix to be used in combination with country data on emissions.
Cricical N loads	Eutrophication effects of enhanced N deposition in permafrost, arctic, tundra and taiga systems, high-altitude forests, calcareous soils, and tropical ecosystems, mainly tropical forests and savannas	Stimulate field research, or consultation of experts world-wide
General	Uncertainty resulting from omission of acidifying effects of N and S, which may interact with eutrophication and climate change in certain regions..	Consider eutrophication coupled with acidification, rising atmospheric CO_2 concentration and climate change

The analysis of eutrophication needs to be integrated with the assessment of other environmental stresses, including acidification and climate change. In future studies not only N deposition should be addressed, but also S deposition, climate change and rising atmospheric CO_2 concentrations. Eutrophication studies could then also consider effects of increasing nitrogen inputs, changing climate and the CO_2 fertilization effect on ecosystem net primary production. Recommendations for future research on these topics are summarized in Table 2.

Annex 1.1.3 Global Climate Change

The increasing atmospheric concentrations of greenhouse gases (GHGs: CO_2, CH_4, N_2O, CFCs and others) will lead to a change in radiative forcing and, hence, to changes in global and regional climate. **Emissions** of GHGs stem from several natural processes and ecosystems, and from human activities. Currently, emissions are dominated by human activities, such as the burning of fossil fuels for energy and land use. Central to the DPSIR chain of climate change are the global bio-geochemical cycles of carbon and nitrogen. These cycles determine the final atmospheric **concentrations** through a broad number of processes and their interactions. For example, plants absorb CO_2 through photosynthesis, which ecosystems can either store or release (CO_2 photosynthesis is larger or smaller than respiration and decomposition, respectively). The rate of most processes is dependent on locally prevailing climatic **conditions**. The resulting change in climate has **impacts** on many natural and human systems. For example, the potential to produce food and other resources may change, sea levels may rise, distribution of plant and animal species may shift, the frequency and magnitude of storms and other extreme weather events may change. All this, again, alters many economic and demographic activities and subsequently leads to changes in emissions, thus closing the DPSIR loop.

The main conclusion of IPCC's second assessment report (SAR) was that the balance of evidence suggests a discernible human influence on climate (Houghton, 1996). This conclusion was based on the resemblance of simulated patterns by GCMs (theory) and observed climatic change over the last century. The SAR further concluded that there are large uncertainties with respect to process understanding and assessment capabilities for future emissions and concentrations, regional climate change and impacts and responses. Thus these uncertainties increase toward the outward ends of the DPSIR chain.

A decade ago, the first Integrated Assessment Models (IAM) for the climate system emerged. Initially, these models were straightforward energy-balance models which were coupled to emission-energy model. Fluxes from land-use change (i.e. deforestation) were generally prescribed. Impact models were sometimes attached as well (e.g. IMAGE, Rotmans et al.., 1990). These early IAMs were still strongly natural science based but showed that without climate policies emissions would continue to increase, leading to a doubling of the concentration of greenhouse gases by the middle of next century (Pepper, 1992). Gradually, the IAMs were further developed. The first broader integration of the DPSIR chain in climate-change models has been achieved in IMAGE 2 (Alcamo et al.., 1998) and TARGETS (Rotmans, 1997). These models includes more advanced routines that determine changes in energy use and land use, and include technology improvements and changes in demand and resource availability. They further incorporate a wide range of impacts on sea level, ecosystems and agriculture, and also calculate many important feedback's within the climate system. The TARGETS model, moreover, emphasizes different responses by explicitly including several cultural perspectives. The models project environmental change over the next century.

The environmental and societal data sets needed to initialize these models are obtained from international organizations (e.g. World Bank, OECD and FAO) and research programmes (e.g. IGBP and IHDP). Scenarios with largely different assumptions on demographic, economic and technological developments, and with or without dedicated climate policies, have been developed and used to support negotiations with the Framework Convention on Climate Change (FCCC) and the scientific assessments of IPCC and IGBP. The scenario simulations illustrated that there are major negative consequences if no action is taken on climate policies. These include:

- A doubling of current atmospheric levels of CO_2 by 2050, and important negative impacts on crops, natural vegetation and sea levels in all regions.

- The rate of increase of impacts on world vegetation could be larger in the first half of the next century than before or after.
- Impacts on vegetation (agricultural and natural) slow down in the second half of next century, but sea levels continues to rise exponentially.

Discussion

This short summary of the climate change problem illustrates that the DPSIR chain of climate change is complex and dominated by feedback's and other interactions. The study of climate change should, therefore, be directed by multidisciplinary assessments. No individual discipline can claim to fully comprehend climate systems. However, many different disciplinary models have been developed to simulate (part of) climate systems (Harvey et al.., 1997; Figure 1). The most frequently cited models are the General Circulation Models (GCM) for the Atmosphere. These climate models use (the change in) atmospheric concentrations of greenhouse gases to simulate the transient pattern of climate change. The models solve the complex process equations that describe 3-dimensional circulation in the atmosphere. The most recent models interact with ocean circulation and include a simple parameterization of the biosphere. Emissions, bio-geochemical cycles, atmospheric chemistry and impacts are not considered in these models. The GCMs are thus computationally complex but not very comprehensive with regards to the entire DPSIR chain. Other models that cover parts of the climate system are the biome models, the sea-ice models, and the C-cycle models (Figure 1).

Although climate-change science and assessment capabilities have developed rapidly over the last decade, the quality of climate-change assessments is still strongly dependent on the data used. The IMAGE 2 model, for example, is dependent on data and assumptions for 13 coarse administrative regions for its socio-economic energy and land-use simulations, for some 63 000 cells of 0.5° x 0.5° longitude and latitude for the environmental and land-cover simulations, and for 10° latitudinal belts for the atmospheric simulations. These coarse resolutions do not allow the necessary coverage of all the administrative, spatial and temporal heterogeneity and diversity that determines the driving forces and responses.

The required administrative data can be derived from harmonized compilations of national statistics, such as those compiled by authoritative international organizations. These data sources are relatively well documented, up-to-date and of relatively high quality (e.g. World Development Indicators and FAOSTAT). Reliable spatially disaggregated (often gridded) environmental data is more difficult to obtain. Usually one has to rely on global compilations of individual researchers and international projects. The quality is often unknown, the data is based on difficult-to-interpret classification schemes, and documentation is sparse. Positive exceptions are the FAO Soil Map of the World (FAO, 1991) and the recently published global 1 km x 1 km DISCover dataset for land cover (Loveland and Belward, 1997), although even these widely used data sets have their limitations.

More serious data problems arise, however, when attempts are made to create historic data sets over longer time periods in order to validate the assessment models that describe relevant trends. The HYDE database, covering the period 1880-1990 was envisioned (Klein Goldewijk and Battjes, 1997) to be of use in a long-term validation experiment over a period with known outcomes (the last century). This experiment failed mainly due to large gaps in available socio-economic and environmental data. Some regional and global data collection systems have been improved but a globally comprehensive system for both socio-economic and environmental data is not yet available. Blueprints for such a global observation strategy have only recently been drawn up. A good data archive of regional historic and contemporary data is invaluable. Not only does it describe trends, but it would also allow the evaluation of changes in means and their variability. This would improve the integration between the monitoring and assessment systems and help in quantifying current and future rates and magnitude of climate change, thus creating the required confidence in the accuracy of IAMs that cover all important aspects of the DPSIR chain and enable adequate projection of future environmental change. Such information is a prerequisite if global leaders are to initiate the political and economic redirection's required to alleviate large-scale environmental problems.

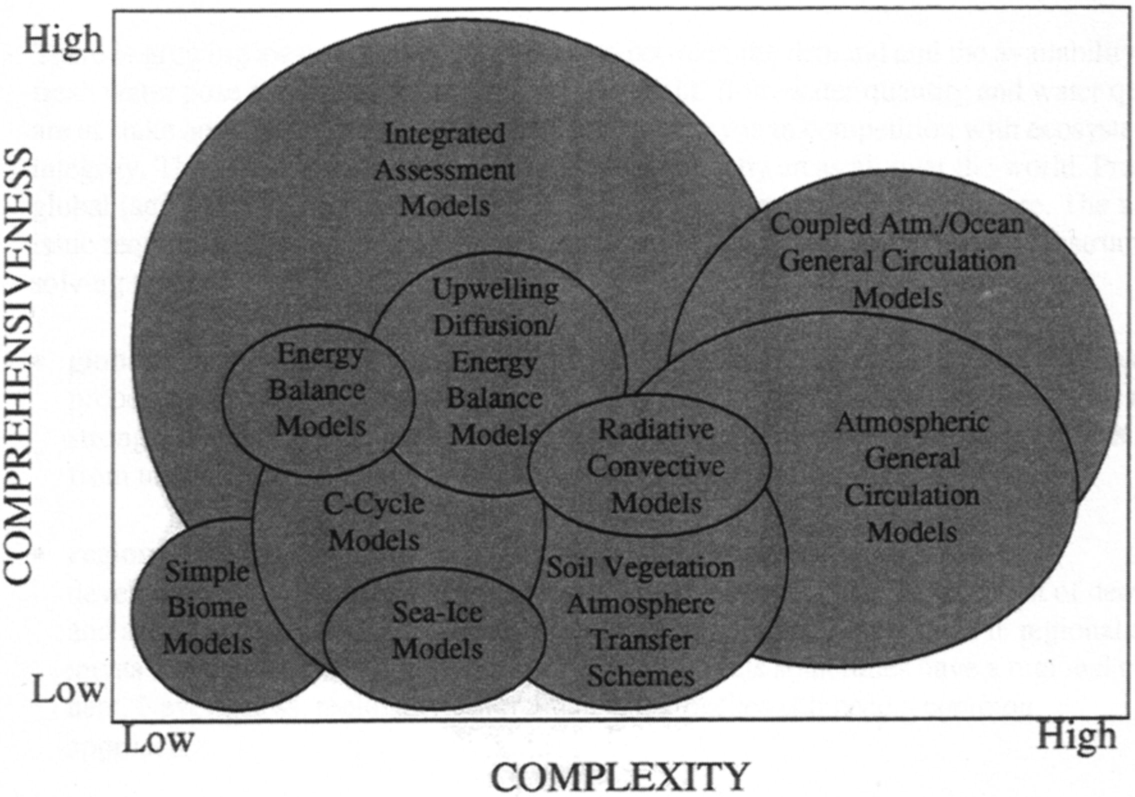


Figure 1. Different models to assess climate change and its components

Annex 1.2 The issue of geographical scale: an assessment of water problems at the global, regional and catchment levels

There is growing awareness that discrepancies between the demand and the availability of fresh water pose a threat to sustainable development. Both water quantity and water quality are at stake here. Development of society and economy is in competition with ecosystem integrity. The situation seems to be getting worse in many areas all over the world. Predicted global (and especially climate) changes may aggravate water stress in the future. The water issue requires research and assessment at different levels if these are to serve as instruments in solving the problem:

- **global:** assessment of the nature and magnitude of water problems in order to prepare for proper policy actions at the international level (UNEP, CSD); some quality aspects are strongly connected with global issues; e.g. the nutrient impairment between regions stems from uneven distribution of demand for and supply of food.

- **regional:** assessment of the consequences of large-scale economic and social developments for the aquatic environment, and assessment of the impairment of demand and supply, both in time and place; possible solutions are to be obtained in regional agreements and conventions (e.g. EU); water quality aspects sometimes have a regional component. Nevertheless, regionally differentiated approaches still need a common approach.

- **catchment:** assessment of management options to support actual management in catchments; especially for international rivers, a comprehensive approach is challenging; management at this level has to be agreed upon in treaties; at this level a comprehensive approach incorporating quality and quantity aspects is necessary. Guidance and supportive methods provided by international bodies like UNEP can strengthen such assessments substantially.

In support of these assessment and management challenges, various institutes (e.g. RIVM, SEI, WRI) have developed databases, models and other tools. Applications have been made at various levels of detail and for various regions. It seems that much can be gained by furthering international co-operation in this field; at the moment co-ordination is weak.

A central instrumental challenge in fresh water assessments is how to deal with different scales. Much information on driving forces and socio-economic developments is available at the country level. Fresh water assessments are only meaningful when based on calculations at catchment level. Translations back and forth requires the use of a GIS. Tools have already been developed which use hydrological linkages between grid cells to perform these translations in a sophisticated way. Figure 1 illustrates the relation between different geographical scales.

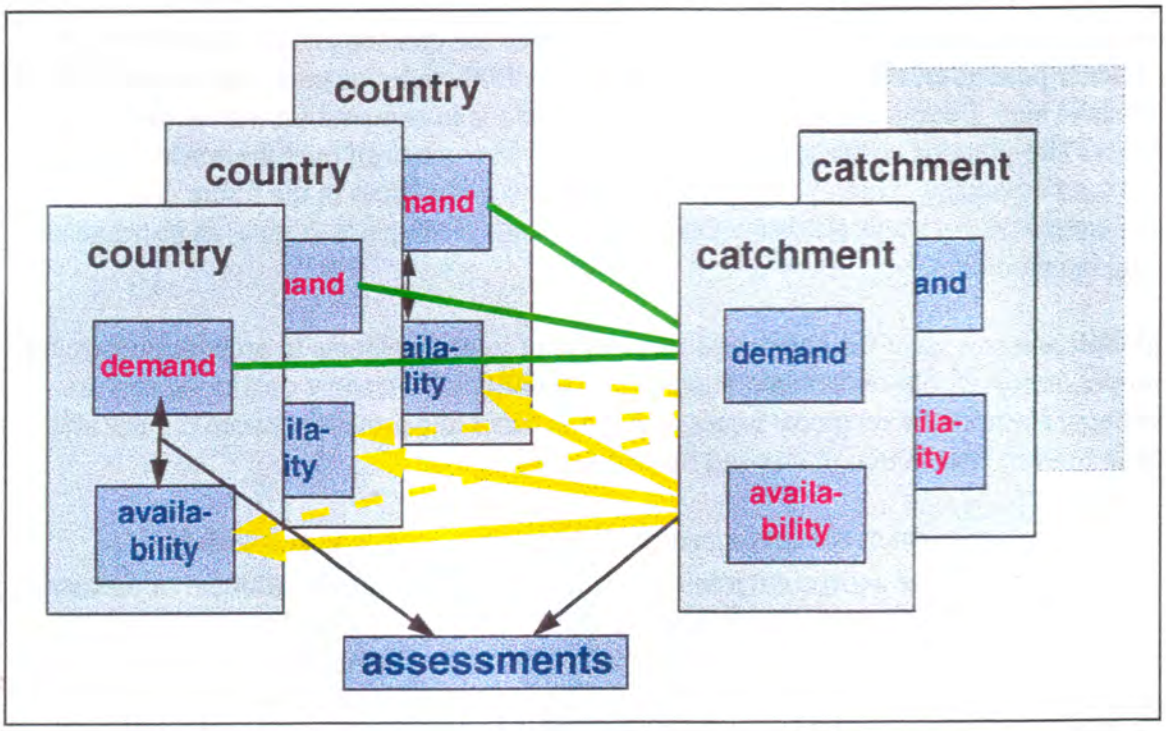


Figure 1: Relation between country and catchment scales

I Assessing global water problems

- quantity: scarcity in some regions; in urban areas linked with quality problems; conflicts over water between regions/countries and users (environmental security); abundance and safety problems elsewhere;
- quality: a variety of problems, such as health (microbiological); eutrophication and toxification

The comprehensive assessment of the fresh water resources by the UN-DPCSD (with background documentation by SEI) compared present and future water withdrawal and availability on a country by country basis. This already provides insight into a number of the problems to be expected with water supply for personal consumption and irrigation. For various regions, however, the full extent of water problems are not recognized because of the scale of assessment.

For the world as a whole, water stress was analysed for GEO-1 using WARiBaS calculations at catchment level. Presently, global water problems are more thoroughly assessed at the catchment and even sub-catchment level, using clustering techniques to recognize similarities between problems in different regions. Similar approaches will probably help clarifying aspects of global water problems and thus contribute to solutions.

Use-to-resources, calculated on a catchment level (model WARiBaS)

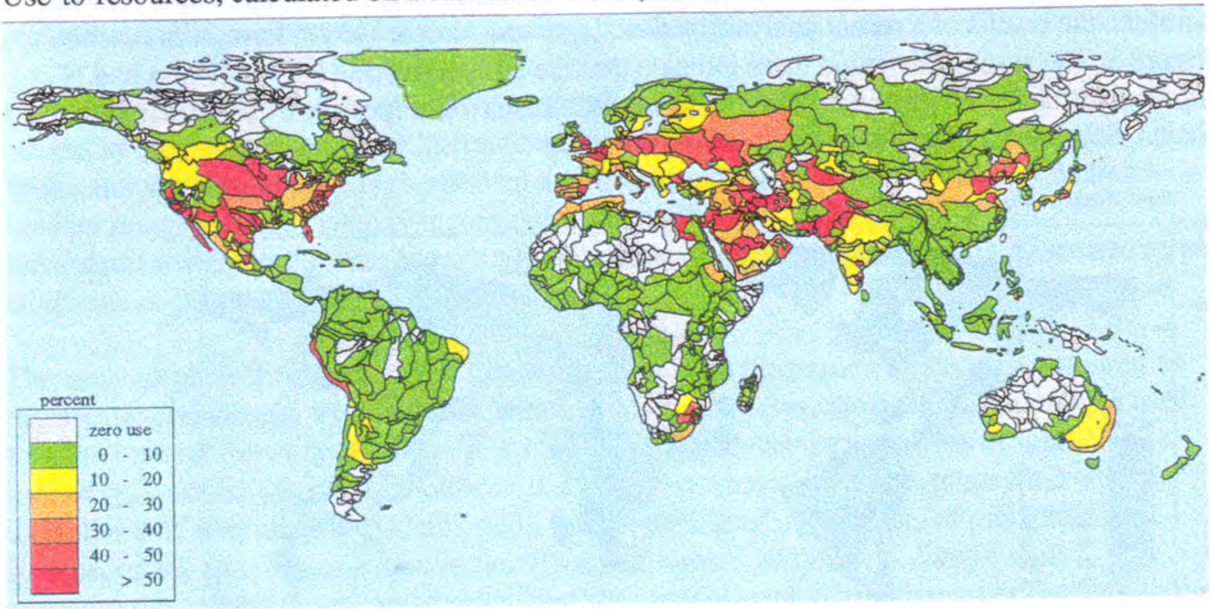


Figure 2: Water stress (total use / total resources)

With the distinct possibility of global climate change, various areas around the world will have to cope with a different water situation than is now the case. A first global scenario analysis has been made to broaden the scope of water assessments into the socio-economic domain (interactions with societal developments) using the TARGETS sub-model AQUA. Within the IMAGE climate model, a water sub-model is under development in co-operation with the University of Kassel.

At the moment available instruments at this level focus on water quantity. Future work will expand this to some water quality issues, as exemplified by the case of nitrogen. Nitrogen (next to phosphorus) is the primary nutrient limiting plant, algae and microbial production in many freshwater and marine environments. Increases in N inputs (in any form) can alter those ecosystems. For example, shifts in plant and algal species composition, increased productivity, decreased species diversity, changes in foodweb structure, as well as development of hypoxic (low oxygen) and anoxic (no oxygen) conditions in aquatic systems (with consequences for fish and other higher organisms) can result from increased N inputs. World-wide, about 58% of the total export of Dissolved Inorganic Nitrogen (DIN) of 20.8 Mt N yr^{-1} stems from fertilizers, while human sewage and deposition account for 24 and 18%, respectively. The contributions to N export from fertilizer use, deposition and human population show very similar patterns, with highest N export in OECD Europe, Eastern Europe and South and East Asia, largely reflecting the distribution of agricultural production intensity and human population.

Given human-caused acceleration of N fixation and other changes in N cycling, it is no surprise that N concentrations in surface waters have increased over time. Historical data indicate that nitrate fluxes and concentrations in the large rivers of the world are correlated with human population densities in watersheds (Cole et al., 1993). Using relatively undisturbed areas as references, Howarth et al. (1996) estimated that riverine total N fluxes from most of the temperate regions surrounding the North Atlantic Ocean have increased from pre-industrial times 2- to 20-fold To illustrate the magnitude of global N inputs to rivers and aquifers, the results of a recent analysis by Seitzinger and Kroeze (1998) have been used in Figure 3. The results presented there indicate that the largest riverine DIN transport and N inputs to estuaries are found in OECD Europe and Eastern Europe, north-eastern United States, South Asia, East Asia and South-East Asia.

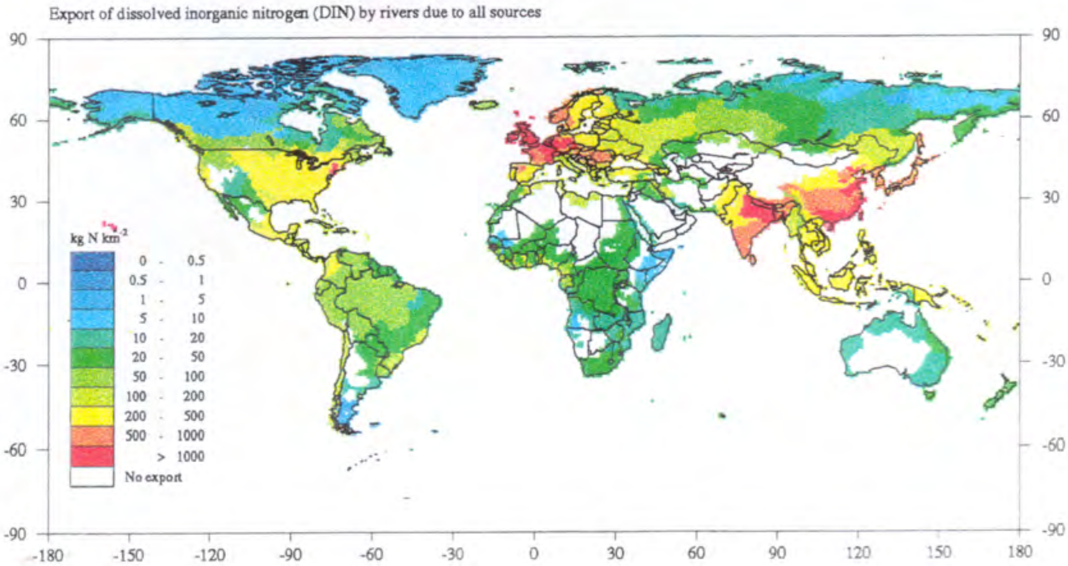


Figure 3: Export of Dissolved Inorganic Nitrogen by rivers due to all discharges (Seitzinger and Kroeze 1998)

II Assessing regional water problems

- Water as one of the environmental compartments is subject to thematic analysis (eutrophication, acidification, desertification, erosion)
- The DPSIR approach as developed at RIVM is used (Driving forces, Pressure, State, Impact, Response)
- Quantity and quality aspects have to be considered in an integrated or comprehensive assessment
- Analyses are performed for regions with common economic policy (e.g. EU).

In freshwater systems with sufficient P, addition of inorganic N can cause eutrophication. This can occur either independently or coupled to acidification (Schindler et al., 1985). Decreased diversity of both animal and plant species generally accompanies both eutrophication and acidification. Most often, eutrophication in estuaries and coastal seas is caused by anthropogenic N loading, in sharp contrast with freshwater systems in which P is the element limiting net primary production and controlling eutrophication (Schindler, 1977). Eutrophication can cause anoxia and hypoxia, both of which appear to be becoming more prevalent in many estuaries and coastal seas. Conditions of low oxygen concentration have resulted in significant losses of fish and shellfish resources. Increasing anoxia has been observed in the Baltic Sea, Black Sea and Chesapeake Bay, while hypoxic events have increased in the North Sea, the Kattegat and Long Island Sound; eutrophication is also associated with a loss of diversity both in the benthic community and among planktonic organisms, as manifested by the incidence of nuisance algal blooms in many estuaries and coastal seas (Vitousek et al., 1997; and references therein).

For aquatic ecosystems, it is difficult to establish a system of critical loads for N. This is caused by the complexity of the interactions between N and P in the eutrophication of freshwater systems, and the high seasonal and interannual variability of weather conditions causing runoff and associated N inputs and water discharge. Therefore, for aquatic ecosystems the anthropogenic N export (here assumed to be represented by DIN) is used as an indication of the potential for eutrophication.

The analysis of riverine DIN export to estuaries is a good illustration of the distribution of estuaries and coastal seas with potential eutrophication. However, the method can only be used to estimate total river export at the river mouth. To calculate concentrations of total N in freshwater systems, in combination with P, a similar but more advanced approach could be used. For this, river discharge at any point can be calculated on the basis of precipitation surplus, runoff and flow to groundwater. Together with N and P in the runoff, their concentrations in the water can be calculated. The model used to calculate river discharge also calculates water percolation through the soils into aquifers. Hence, the same method could be used to calculate N and P leaching to groundwater.

On a regional scale calculations have been carried out for Europe using the CARMEN model (Klepper et al., 1995) on a 10 x 10 min. resolution. From the total N load of surface waters in watersheds, the retention within watersheds and atmospheric deposition the export to European coastal seas has been calculated (Figure 4). Results indicate that concentrations strongly depend on the hydrologic conditions of coastal waters, with high concentrations in the Baltic and Black Seas (having less contact with oceanic waters), and lower concentrations in the North Sea, where water is constantly refreshed with oceanic water.

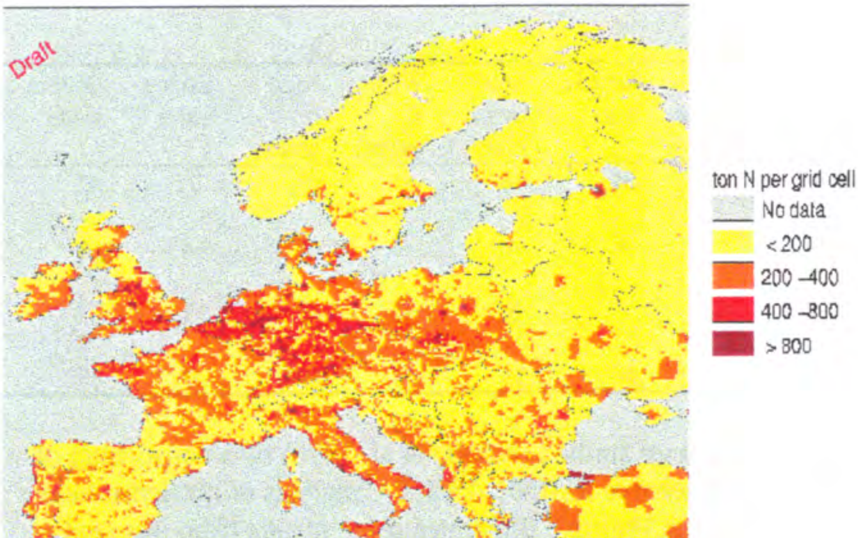


Figure 4: Total Nitrogen load in surface waters in 2010

Using the CARMEN model, the nutrient fluxes in the European region have been recently analyzed, as well as other aspects of water stress (EU, EEA). Currently European water assessment work is taking a step forward through the development of the Eutrophication Network.

III Fresh water assessments at catchment level

- analysis has to be done in collaboration with the countries that have interests in a particular catchment; interactive scenario analysis is a powerful tool to reach acceptable conclusions.
- groundwater and surface water quantity, level and quality have to be included in a comprehensive assessment to obtain balanced solutions.
- the entire DPSIR chain has to be analysed.

The third phase is a more thorough assessment of actual water problems in individual catchments. A Five Step Approach, a tool to assist relevant parties in catchment analysis, has been developed together with UNEP (Bannink et al, 1997). Basically, the five steps are:

1. Setting the scene (characterization of the catchment)
2. Introducing the actors (characterization of socio-economic pressures)
3. Choosing the script (defining the system; quantifying the status and problems; "Business as Usual")
4. Playing possible futures (scenario analysis and assessment of possible measures)
5. Re-writing the script (implementation and management).

This approach has been used to study, for example, the Zambezi catchment and the sub-national catchment of a tributary to the Pearl River, the Dong Jiang River (China). Results are presented in Table 1.

Table 1. Water Policy Score Card - 2025 for the Zambezi River System (% Change in index values by 2025 compared to 1995 levels, for 8 scenarios)
(Bannink et al., 1998 in prep.)

Index	BaU	No measures	Supply max	Sanitation max	Waste w. treatm	High irrigation	Saving water	Selling water
Pressure (demand+waste water)	44	92	64	44	-53	67	-21	43
State (availability+quality)	-4	4	-4	-4	-3	-7	-4	-5
Functions (power+food+ supply+sanitation)	-2	-20	7	8	-2	-2	-1	-3
Response	32	7	40	38	44	108	0	32

Earlier, the Rhine river basin has been studied (Knoop et al, 1996) by a consortium of European institutes in the comprehensive RHINE -DELTA analysis of nutrients, heavy metals and organic micro-pollutants. Figure 5 illustrates some results from this study.

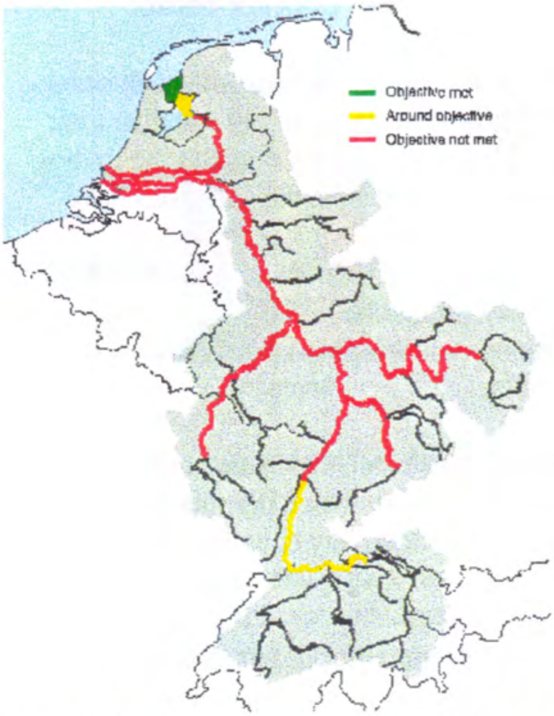


Figure 5: Lindane concentrations in surface waters in 2000, Rhine river basin

Annex 1.3 Assessment of responses: the effectiveness of financial and economic instruments as applied to the climate issue.

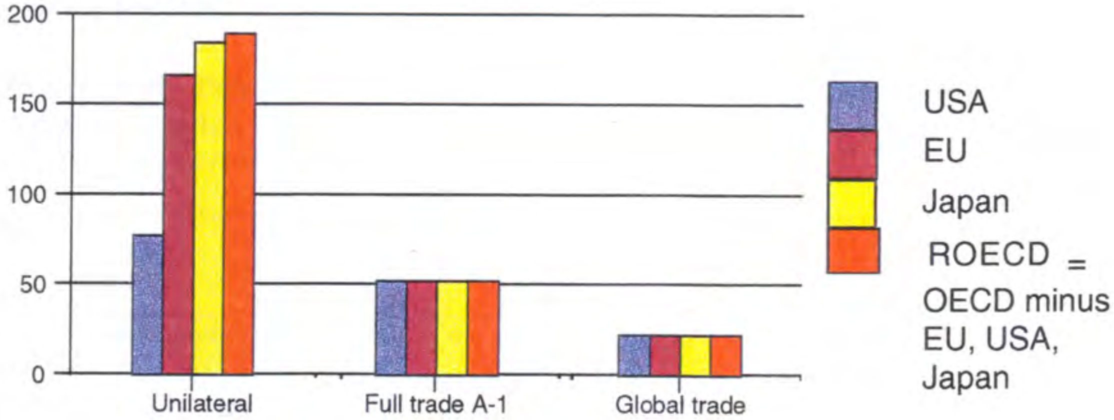
Demonstrated here is the effectiveness of applying flexible policy instruments in order to curb the continuing increase of emissions of greenhouse gases and to stabilize their levels in the atmosphere in the coming decades. These instruments relate to the trading of hypothetical emission permits among countries. Different possible situations have been analyzed:

- the case that no trade at all will take place in permits for emissions of greenhouse gases, and that each country adopts its own policy (unilateral policy)
- the case that permit trading will only occur among industrialized countries[1];
- the case of full global trading of emission permits.

Preliminary analyses with the WorldScan model (Geurts et al., 1995) show that marginal cost reductions can be achieved through markets in which permits for emission of greenhouse gases are traded. Such trading effectively equalizes the marginal cost of emission reduction among countries.

Figure 1 shows the permit price (i.e. marginal cost of reduction) in 2015 and 2050. Prices are expressed per unit of avoided emission, in tonnes of carbon, assuming carbon dioxide as the greenhouse gas. All three cases are considered for 2015 (A), and only the last two for 2050 (B). For the medium term (Figure 1A) it is assumed that Annex-1 countries (A-1) will reduce emissions in accordance with the levels agreed in Kyoto plus an additional 3% of 1990 levels by 2015.

A. 2015 Kyoto



[1] That is. the countries which appear on Annex-1 of the Framework Convention on Climate Change.

B. 2050 Stabilization

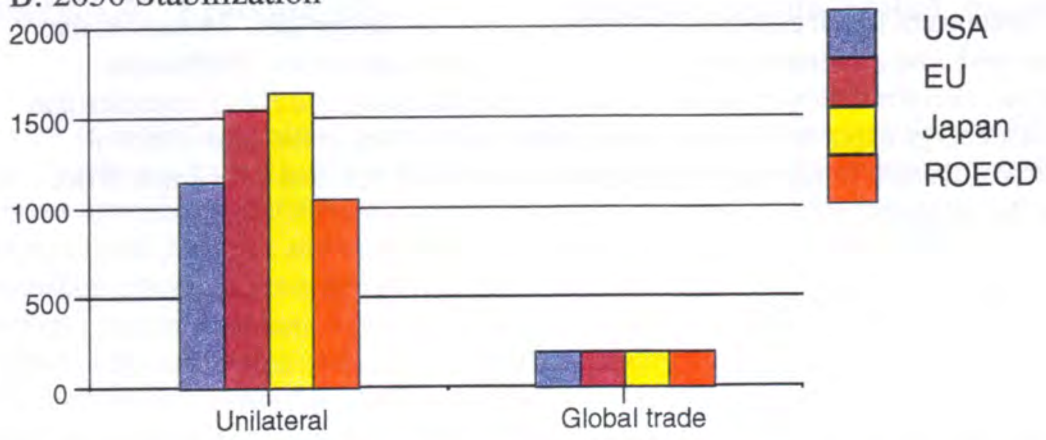


Figure 1. Carbon prices for stabilization: influence of flexible instruments (in 1992 USD/t C), 2015 (A) and 2050 (B).

In the case of unilateral policy (no permit trading), regional differences exist in the marginal cost to achieve the targeted emission level: up to USD 75 /t C and USD 160 /t C in USA and the EU, respectively, by 2015.

In the case of full permit trade in A-1 countries, the marginal costs of abating carbon dioxide emissions will be equalized through the competitive supply of and demand for permits on the market. The marginal costs of abatement in 2015 are lower in most regions when compared to the unilateral policy case; they would fall to USD 50 /t C. For this case, Eastern Europe and the former Soviet Union will become large exporters of emission permits on the A-1 permit market.

If, however, a global permit market is established, the marginal cost of abatement will fall even further, to USD 20 /t C. For the case of global trade, permits of Non-Annex-1 countries (NA-1) have been set equal to a Business-as-Usual scenario, while A-1 countries will receive permits up to the level agreed in Kyoto. Most of the NA-1 countries will then be exporters of permits on this global permit market.

For the longer term (Figure 1B), binding targets for both A-1 and NA-1 countries are assumed. Global emission levels are supposed to result in stabilization of concentrations of greenhouse gases in the atmosphere at 550 ppmv by the year 2100 (IPCC, 1996, Wigley et al., 1995). In 20 years, until 2045, regional permits will move from the 2025 regional emission levels (in NA-1) or the permitted levels (in A-1) to equal per capita emission levels.

Calculations show that a global permit market equalizes regional marginal costs of reducing emissions of carbon dioxide and will lead to a substantial reduction of the marginal costs. As can be seen from Figure 1B, in the unilateral policy case the A-1 countries would incur marginal costs for abatement greater than USD 1000 /t C, whereas this would be reduced to approximately USD 200 /t C in the case of global trade. In the latter case, the non-energy exporters among NA-1 countries are large permit exporters. Thus in the long term NA-1 countries gain by participating in a global permit market if they are granted appropriate amounts in their permits.

This preliminary case study shows that flexible instruments can substantially reduce the costs of abatement for all countries, both in the short and longer term. Moreover, the countries with low-abatement costs are likely to be absolute winners, i.e. Eastern Europe and the former Soviet Union (in the A-1 permit case), and NA-1 countries that are not net-energy exporters (in the global permit case). Even in the case of global permit trade, Eastern Europe and the former Soviet Union will still incur lower costs than for the unilateral policy case.

Annex 1.4 Framing environmental analysis within global sustainability issues

In view of UNEP's mandate, we have paid most attention in this strategy document to topics directly relevant for integrated environmental assessment. However, experiences over the last decades have shown that there are several important relationships between global and local environmental problems and other issues such as human and economic development, population growth, poverty and changing political structures. In fact, many environmental problems largely arise from fundamental social or economic problems and cannot be solved by isolated measures in relation to environmental technology and legislation. The concept of 'sustainable development' has been put forward as a guiding concept for policy making to design development policies that appropriately address the economic and social needs and aspirations of a growing global population while maintaining the quality of the environment and its resource base. It will become increasingly important to clearly position information on the environment within a sustainable development context.

The first Global Environment Outlook has mainly addressed environmental issues as such. GEO-1 indicated the relative importance of these issues at the regional level and presented current trends. Environmental concerns appear to change over time, depending on the transitional stage of society. Human and ecosystems' health and global environmental issues are of less importance in mainly agriculturally-based economies. Environmental concerns related to urbanization and the use of natural resources are becoming more important in transitions towards industrialized and rich service-oriented economies. The environmental policy responses to these problems arise accordingly from sectoral policies for market-based initiatives.

Assessment for sustainable development requires a broadening of both the assessment and policy horizon. It requires a comprehensive approach of all the economic, social and ecological issues involved. This is a difficult task, in part because sustainable development is a concept linked to values that depend on one's cultural perspective. If one considers nature to be fragile, a precautionary type of environmental policy seems to be appropriate. However, if one considers nature to be robust, a virtually unlimited exchange of natural capital for economic and social capital is appropriate. In the end society, and therefore politics, will have to decide what is sustainable and what is not. The uneven distribution of problems and opportunities in time and space will have to be taken into account when these decisions are made.

Many authors now agree that sustainable development simultaneously includes social, economic, environmental and institutional objectives. Consequently, assessment for sustainable development needs to address these four domains and their interaction. During the past few years several organizations and institutes have paid attention to assessment for sustainable development, in particular through the use of indicators. An interesting step was made by the World Bank, which proposed to focus on different types of capital. Indicators of sustainable development will have to reflect the size of economic, ecological and social/human capital and the degree to which people actually have access to such capital. A system of indicators for meeting these requirements is not yet available. The Wuppertal Institute for Climate, Environment and Energy (Spangenberg, 1998) has proposed a set of indicators based on earlier work of the World Bank (Figure 1) and CSD.

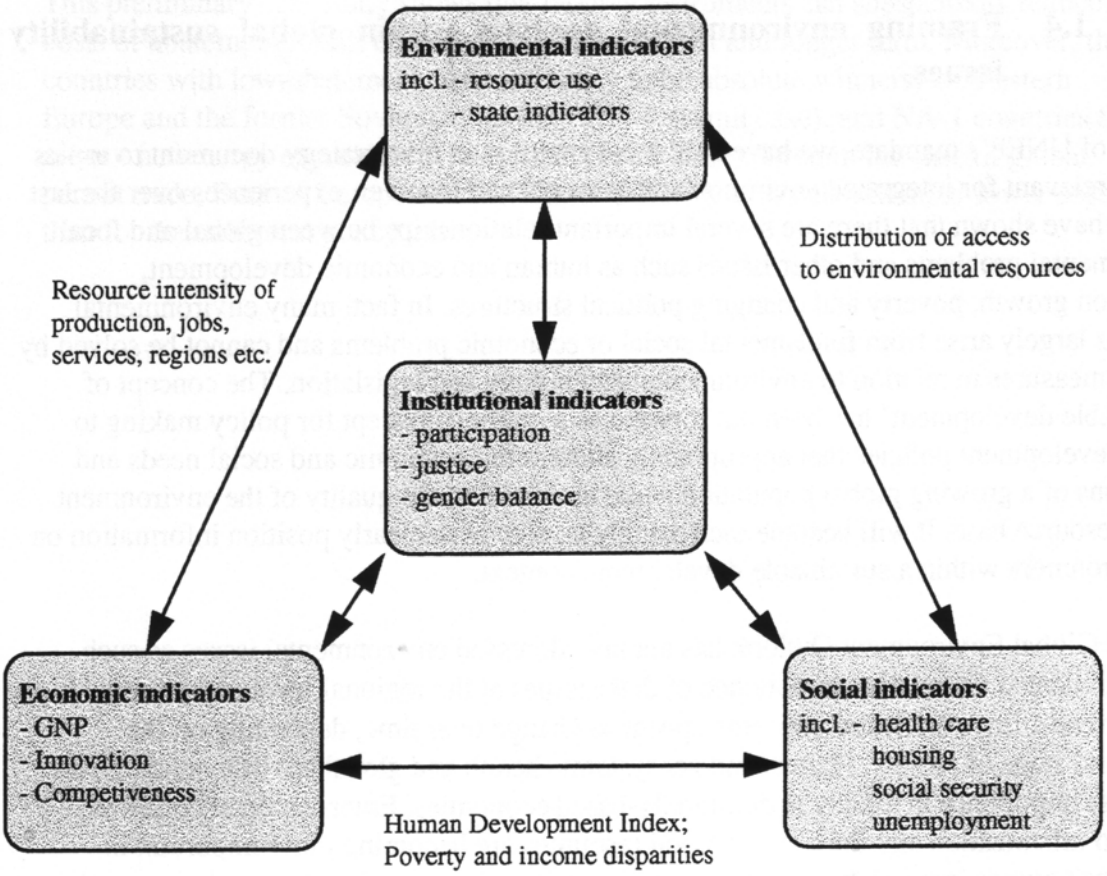


Figure 1. Integrating indicators for new approaches to sustainable development.

The World Bank is relatively advanced in developing a system of indicators reflecting the monetary aspects of economic, social and natural capital. UNDP is using indicators in its reporting system about human development that address a number of social aspects. The Convention on Biodiversity may benefit from a set of indicators for natural capital as currently under development at RIVM.

The potential use of indicators of sustainable development can be illustrated to a certain extent by some indicators currently accepted among the international community.
The savings rate could indicate the vitality of an economy because it illustrates its capability of investing in new developments. The World Bank advocates the use of the 'genuine savings' rate, in which the investments and depreciation (or sales) of all forms of capital is accounted for. However, this methodology is not yet generally accepted. In summary,
Sub-Saharan African, the Middle East and North Africa currently show a negative genuine savings rate of about 10 percent of GDP per year, while Latin America also experienced a negative genuine savings rate, but there this trend has been reversed. According to the World Bank, genuine savings rates in rich regions are currently positive,. It should be noted that the costs to solve environmental problems are - in comparison with national income - relatively low in these regions. Figure 2 shows the development of GDP in major world regions; as the main and most widely used economic indicator for which data is readily available.

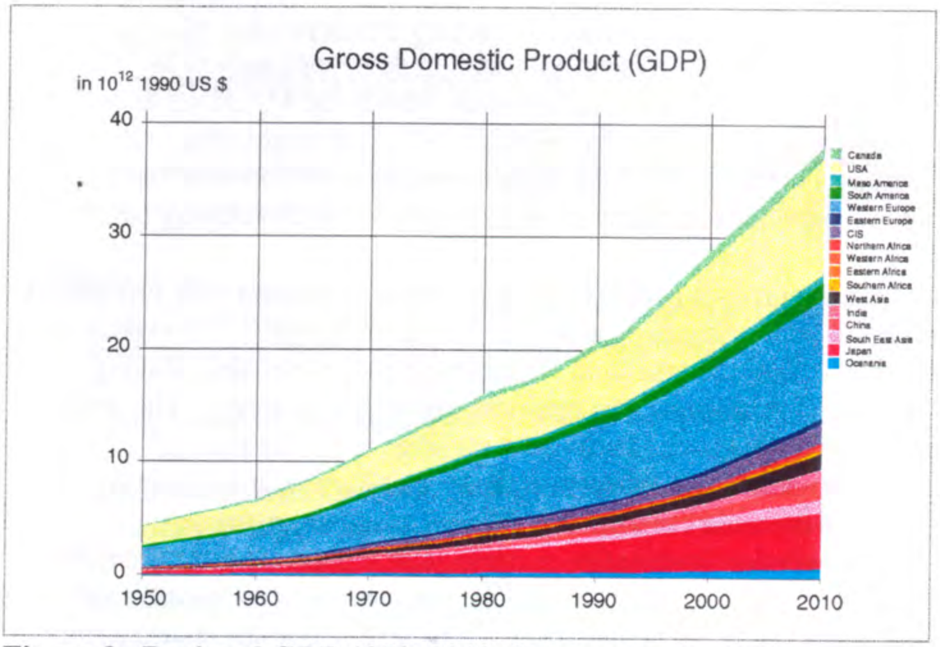


Figure 2. Regional GDP 1950–2010 (Summers et al., 1994)

The social dimension of sustainability can be illustrated by the Human Poverty Index (HPI) developed by UNDP (UNDP, 1997) (Figure 3). This index represents sets of variables expressing the percentage of people expected to die before the age of 40, access to social resources (education and health services) and access to natural resources (food and safe drinking water). Modelling results show that the number of people living in poverty - following the HPI definition – is likely to decrease from 1.5 billion to 1.2 billion in the period 1960–2010 (Niessen and Hilderink, 1997). However, the numbers in Africa and India will be still increasing. Only a minor part of the African population is not facing poverty at all. The relative importance of access to natural resources as a cause for poverty will increase in developing countries. Access to healthy food and water is also an important factor in the promotion of public health.

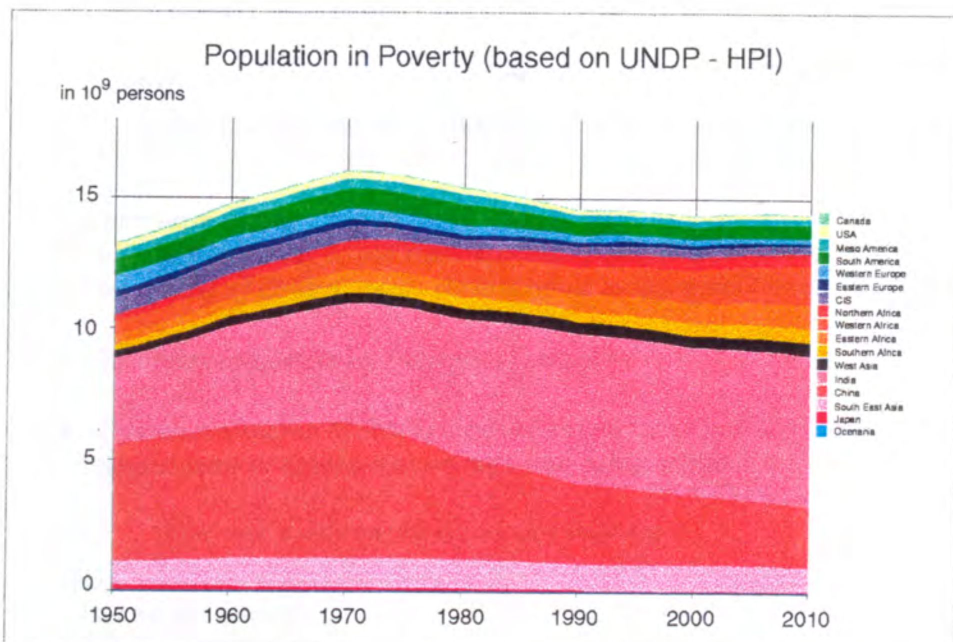


Figure 3. Population in poverty 1960–2010 (Niessen and Hilderink, 1997)

Another major environmental health problem is air pollution, in developed as well as developing countries. Air pollution by Suspended Particulate Matter (SPM) causes about 6% of the 50 million global deaths that occur annually (WHO, 1997). Due to growing fossil fuel combustion, as well as increases in traffic and industrial emissions, air pollution is expected to become even more important, especially in countries in transition and in developing countries

The area of land used for human purposes in an extensive or intensive manner may increase by about 20 % in the period 1970–2050. Assuming a business-as-usual scenario, it is expected that in the next century some 40 % of the total land will have been domesticated, leaving around 35 % for forest, grassland or savanna (the remainder being ice or desert). The most rapid decrease in natural land takes place in Africa and Asia (Figure 4). The pace of conversion of land is already slowing down in North America and Europe; it might even be reversed. Agricultural reform is the main cause of this change in land use patterns. World-wide, however, land conversion from nature to agriculture will be the most prominent cause of loss of natural capital. In addition, also physical factors - salinization, erosion and lowering of water-tables, and pollution, i.e. acidification, eutrofication and smog - may have detrimental effects on ecosystems health. Finally, climate change could result in substantial changes in ecosystems. All these problems are intensively interlinked both from the perspective of their causes and from the effects they cause.

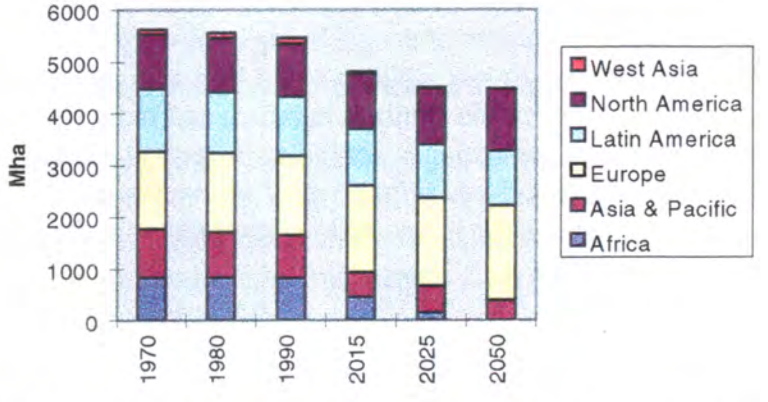


Figure 4. Natural land area 1970–2050 (forest, grassland, savanna (Alcamo et al., 1998, Klein Goldewijk et al., 1997). Note: total land area equals 13 000 Mha

Annex 2: Identified gaps in knowledge for global environmental assessment (for RIVM/EU Workshop)

The following important gaps in knowledge for global and regional integrated environmental assessment have been identified by RIVM on the basis of work for GEO-1 and GEO-2[1].

Urgent issues

- Quantification of changes in impacts on environment and resource use that would result from reforming environmentally damaging subsidies
- Incorporation of land degradation in land use modelling (*)
- Global water stress assessment at the level of drainage basins: calibration and validation of models; incorporation of groundwater; incorporation of water quality (*)
- Agricultural efficiency projections: plausible bandwidth; dependency on social, economic and cultural context
- Conceptual framework and measurability of response assessment: are policies being implemented?

Medium term issues

- Operationalization of aggregate indicators for environmental impacts on human health and on terrestrial biodiversity in a scenario context (*)
- Incorporation of urban environment in scenario analyses that go beyond air pollution
- The data gap: exactly where is it? Possible introduction of quality labelling to data sets?
- How to share integrated modelling tools with partners institutes (*)
- Indicators for degradation of coastal zones (*)
- Operational indicators for fragmentation of habitat on the basis of earth observation
- Incorporation of natural resource and infrastructure aspects in macroeconomic modelling

Longer term issues

- Capital estimates (World Bank approach): good estimators for rate and sign of change in total wealth? Critical levels for individual components? Basis for land valuation?
- Summary indicators for institutional capacity
- Operationalization of subregional indicators for access and deprivation, in support of assessments of human security and well being, in relation to the IHDP program

(*) Some work is underway but this is only a beginning

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[1] This list was originally drawn up by RIVM for a workshop with DG-XII of the European Union and selected scientists (September 1998). The purpose of this meeting was to determine whether these knowledge gaps are indeed considered to be important gaps, and to determine promising ways of address these gaps.

Annex 3: Summary of IEA/GEO Core Data Set Matrix

Data set name	Source	Time period	Geographical coverage	Spatial resolution
Agriculture, forestry, fishery				
AGROSTAT 1992	FAO	1961-1990	world	countries
Animal stocks European Union	Eurostat	1977-1995	Europe/EU	NUTS-0/1
Crop areas European Union	Eurostat	1975-1995	Europe/EU	NUTS-0/1
FAOSTAT 1995	FAO	1961-1993	world	countries
Growing season database Europe	RIVM	1992	Europe	thematic areas, 10" x 10"
Historical agricultural indicators (HYDE)	RIVM	1890-1990	world	countries, regions
International fertilizer statistics	IFA	1971-1994	world	countries
Time series state of food and agriculture world (SOFA'94)	FAO	1961-1993	world	countries
World fishery production (FISHSTAT-PC)	FAO	1950-1994	world	countries
Climate				
Climate database Europe	CEC	1930-1987	Pan-Europe/EU	stations
CLIMATE global database (temp., precip., evapo., cloudiness)	RIVM	1931-1960	world	0.5^{o} x 0.5^{o}
IIASAClimate Database	IIASA	1991	world	0.5^{o} x 0.5^{o}
Monthly surface air temperature and precipitation world	NCAR	1920-1980	world	0.5^{o} x 0.5^{o}
Observational Data Sets (ODS) of weather stations	ECMWF	1980-1989	world	stations
Precipitation excess Europe	RIVM	1991	Europe/EU	0.5^{o} x 0.5^{o}
Wind Vector Grids in Europe	KNMI	1983-1996	Pan-Europe	stations
Demography, health				
Demographics of the republics former Soviet Union (FirstBookDIS) 1992	New World Demographics	1950-1990	CIS	sub-national
Global Mortality Database	WHO	1950-1995	world	countries
Global population density	NASA, Harvard University, UNEP	1984, 1985	world	1^{o} x 1^{o}
Global population density and totals	NCGIA	1994	world	5" x 5"
Gridded population data world per country	CIR/CIESIN	1971-2005	world	20" x 30", 5"x 7.5"
Health for all, Europe	WHO	1970-1990	Europe	countries
Health for all, global indicators	WHO	1983-1994	world	countries
Historical population indicators (HYDE)	RIVM	1890-1990	world	various
International Data Base (global demographic and socioeconomic data)	CIR	1950-2050	world	countries, provinces
Mortality for sub-national administrative units of Europe	Eurostat	1980-1990	Europe/EU	NUTS-2
OECD-CREDES Health data programme	AEA	1960-1990	OECD	countries
Population density Africa	UNEP	1991	Africa	5" x 5"
Population density China	NGS	1987	China	sub-national
Population density Europe	RIVM	1989-1992	Pan-Europe	10" x 10"
Sub-national boundaries and population of Latin America, US, Europe, Africa, CIS	CIAT,ESRI, Eurostat,UNEP, NWD	1971-1990	Latin America	sub-national
World cities population database WCPD	UNEP	1990	world	places
World cities populations	Bartholomew	1991	world	places
World population prospects: the 1992 revision	UN-DESIPA	1950-2025	world	countries
World population prospects: the 1994 revision	UN-DESIPA	1950-2050	world	countries

Data set name	Source	Time period	Geographical coverage	Spatial resolution
Economy				
Africa Development Indicators	World Bank	1970-1994	Africa	countries
Historical economic indicators (HYDE)	RIVM	1890-1990	world	countries, regions
Time series European Union: Eurostat-CD, Panorama of EU-Industry	Eurostat	1983-1993	Europe/EU	NUTS-2
Trade Analysis System PC-TAS	UNCTAD/ITC/ GATT	1990-1994	OECD	countries
World Debt Tables 1993-94	World Bank	1970-1993	world	countries
Environment				
Acid deposition in Europe	RIVM	1989	Europe/EU	thematic areas
Agricultural waste burning	RIVM	1991	world	$1^o \times 1^o$
Air Quality in Major European Cities	RIVM	1985-1992	Pan-Europe	places
AIRBASE Air Pollution Information System	CEC	1968-1995	EU, Pan-Europe	stations
Aluminium concentrations in groundwater in Europe	RIVM	1990	Pan-Europe	10" x 10"
Areas with saline seepage in the European Union	RIVM	1996	Pan-Europe	thematic areas
Biomass burning	Max Planck Institute	1975-1980	world	$1^o \times 1^o$, $5^o \times 5^o$
CORINAIR	CITEPA	1985, 1990	Europe/EU	NUTS-1/2/4
Critical loads/levels in Europe	RIVM	1996	Pan-Europe	150 x 150 km
EDACS: European Deposition Maps of Acidifying Components on a Small scale	RIVM	1989, 1993	Pan-Europe	10" x 10"
EDGAR: Emission Database for Global	RIVM	1971-1992	world	$1^o \times 1^o$
Endangered ecosystems Europe	RIVM	1992	Pan-Europe	thematic areas, 10"x 10"
Environmental statistical database (IEDS)	UN-ECE	1980-1992	OECD	countries
Erosion database Europe	ISRIC	1992	Pan-Europe	thematic areas, 10" x 10"
European Air Quality Maps	RIVM	1989-1990	Pan-Europe	5 0 x 50 km
Forest soil ecosystems database	SC-DLO	1992	Pan-Europe	$0.5^o \times 1^o$
Global assessment of human induced soil degradation (GLASOD)	UNEP/ISRIC	1991	world	thematic areas
Global distribution, characteristics, methane emission natural wetlands	NCAR	1986	world	$1^o \times 1^o$
Global Ecosystems Database	USDOC/NGDC/ EPA	1992	world	10" x 10"
Global ecosystems database 1992, 1994	NOAA-NGDC/ ERL/ EPA	1992-1994	world	10" x 10"
Global environmental research data (Global Grass CD II)	US-ACE	1993	world	5" x 5"
Global ozone data (TOMS)	NASA	1978-1991	world	$1^o \times 1^o$
Groundwater nitrate concentration Europe	RIVM	1992	Europe	thematic areas
Groundwater resources in the EC	RIVM	1992	Europe	thematic areas
Halons and methyl chloroform production and emission data	ICI	1960-1992	world	thematic areas
Holdridge Life Zone Classification	IIASA/RIVM	1931-1960	world	$0.5^o \times 0.5^o$
Hydrogeology Africa (RIVM)	UNDP	1994	Africa	thematic areas
Landfills in Europe	Eurostat	1991	Europe/EU	NUTS-2
LOTOS emission database 1986	TNO	1986	Pan-Europe	$1^o \times 2^o$
Methane emission from animals	NCAR	1984	world	$1^o \times 1^o$
NASAglobal distribution of aircraft emissions	NASA	1990	world	$1^o \times 1^o$
Nitrogen excretion by various categories of animals	RIVM	1985	world	$1^o \times 1^o$
Nitrogen loads Europe	RIVM	1991	Europe/EU	various
Nitrogen pollution in Europe	RIVM	1991	Europe/EU	thematic areas
Pesticides loads Europe in soils and groundwate	Eurostat/FAO/ RIVM	1991	Pan-Europe	countries, 10" x 10"

Data set name	Source	Time period	Geographical coverage	Spatial resolution
Production and Emission data on CFCs and HCFCs	AFEAS	1931-1991	world	places
Protected areas Africa	UNEP	1989	Africa	thematic areas
Risk map of European nuclear powerplants	RIVM	1992	Pan-Europe	$0.5^o \times 1^o$
Road traffic: fuel consumption and emissions	TNO	1990	world	countries
SO_2 concentrations Europe	RIVM	1992	Europe/EU	5" x 5"
Socioeconomic impacts study environmental problems (SEIS)	RIVM	1994	India	country
Soil Organic Matter Map of Europe	RIVM	1993	Europe/EU	10" x 10"
Soil Water Holding Capacity	NASA	1990	world	$1^o \times 1^o$
Total Ozone Mapping Spectrometer (TOMS)	NASA	1978-1991	world	$1^o \times 1.25^o$
Tropospheric Ozone Research (TOR)	Eurotrac/EMEP	1988-1995	Pan-Europe	stations
Wetlands Africa	ESRI	1993	Africa	thematic areas
Wetlands in the European Communities	CEC	1991	Europe/EU	thematic areas
World ecosystems (Olson)	NOAA	1970-1989	world	$0.5^o \times 0.5^o$
World wilderness areas	UNEP	1989	world	thematic areas
WSL global distribution of aircraft emissions at 5 x 5 degree	WSL	1989-1990	world	$5^o \times 5^o$
Industry, energy				
BP Statistical Review of World Energy	BP	1965-1993	world	countries
Energy Statistics and Energy Balances	IEA	1960-1992	OECD	countries
Historical energy/emissions indicators (HYDE)	RIVM	1890-1990	world	countries, regions
Historical industrial indicators (HYDE)	RIVM	1890-1990	world	countries, regions
IISI Steel Production and ConsumptionI Statistics	ISI	1983-1992	OECD	countries
Industrial Areas in the EU	RIVM	1992	Europe/EU	thematic areas
UN Energy Statistics and Population Database	UNSTAT	1950-1991	world	countries
UN-ECE Buildings Statistics	UN-ECE	1980-1990	world	countries
UNSO Commodity Production Statistics	Aristotle University	1970-1990	world	countries
Land cover				
Experimental calibrated global vegetation index ECGVI 1994	NOAA	1985-1991	world	10" x 10"
Global distribution of rice paddies	RIVM	1994	world	$1^o \times 1^o$
Global distribution of wetlands	Max Planck Institute	1988	world	$2.5^o \times 2.5^o$
Global soils for climate research (Zobler)	NGDC		world	$1^o \times 1^o$
Global vegetation database (Matthews)	NASA/GISS	1992	world	$1^o \times 1^o$
Historical land cover indicators (HYDE)	RIVM	1890-1990	world	various
Monthly generalized global vegetation index	NOAA	1985-1988	world	10" x 10"
Natural Vegetation of the European Communities	CEC	1989	Europe/EU	areas
Normalized Difference Vegetation Index (NDVI)	NOAA	1983-1984	world	$1^o \times 1^o$
Pan-European 10 minutes land use database	RIVM	1975-1990	Pan-Europe	10" x 10"
Pan-European land use statistical database	RIVM	1985-1990	Pan-Europe	various
Pan-European land use vector database	RIVM	1975-1985	Pan-Europe	thematic areas
Soil database for Europe	RIVM	1993	Europe/EU	10" x 10"
Soil Map of the European Communities	CEC	1985	Europe/EU	thematic areas
Soil map of the world	FAO/UNESCO	1974, 1994	world	thematic areas
Vegetation map of Brazil 1988	USGS/EDC	1988	Brazil	thematic areas
Vegetation, land use and seasonal albedo	NCAR	1950-79	world	$1^o \times 1^o$
World Soils for Global Climate Modelling (Zobler)	NASA	1974-1981	world	$1^o \times 1^o$

Data set name	Source	Time period	Geographical coverage	Spatial resolution
Broad data sets				
Global socioeconomic indicators (World Data) 1994, 1995	World Bank	1962-1992	world	countries
Global topographic database: digital chart of the world (DCW) 1992, 1993	ESRI	1993	world	various
Human Development Report database 1994-1995 (UNDP)	RIVM	1992	world	countries
Social Indicators of Development 1993-1994	World Bank	1965-1992	world	countries
World development indicators (WDI) 1994	World Bank	1970-1992	world	countries
World resources database 1992-1993	WRI	1970-1993	world	countries
World Tables 1993, 1994	World Bank	1970-1992	world	countries
Global topographic database: ArcWorld 1: 3M 1992	ESRI	1992	world	various
Support information				
Chemical Evaluation Search And Retrieval System (CESARS)	Mich.Dep. of Nat.Resources	1983-1995	world	---
CHEMINFO	Mich.Dep. of Nat.Resources	1983-1995	world	---
Delta Study	IIASA	1950-1988	Rhine basin	catchment
Development activity information world (DAI) 1994,1996	IDRC	1930-2013	world	world
ECOTOX aquatic ecotoxicological database	RIVM	1993-1994	world	---
European emission sources	RIVM	1980-1994	Pan-Europe	0.5^{o} x 1^{o}
Global elevation map ETOPO-5	NOAA/NGDC	1986	world	5" x 5"
Global relief data	NOAA/NGDC	1980-1990	world	various
Global river basins database	RIVM	1996	world	catcments
Global topographic grids	RIVM	1996	world	various
Hydrogeology Europe (RIVM)	RIVM	1993	Pan-Europe	thematic areas
Major settlements Pan-Europe	CEC/EEA	1989	Pan-Europe	places
Maps 'n'Facts (PC Globe). World Edition, Version 1.0	Broderbund Software	1989-1991	world	countries
Monthly river discharge of major rivers	GRDC	1996	world	stations
River basin Ganges, Bramaputra	RIVM	1994	India	catchments
River basin Rhine, Meuse	RIVM	1995	Pan-Europe	catcment
River basins Africa	UNEP	1984	Africa	catchments
River basins Europe	RIVM/Eurostat	1994	Pan-Europe	catchments
River basins world (GGHYDRO)	Trent University	1994	world	catchments, 1^{o}x 1^{o}
River basins world (Global Grass)	Rutgers University	1993	world	catchments, 5" x 5"
RTECS - Registry of Toxic Effects of Chemical Substances	NIOSH	1983-1996	world	---
Topographic index of world places (Times World Index)	Bartholomew	1991	world	places
UNCED Earth Summit Rio de Janeiro 1992 / Agenda-21 / Treaties	IDRC	1972-1992	world	world
World boundary databank WBDII 1972	DMA/ESRI/ UNEP	1972	world	various
World boundary databank WBDII 1972 - PC version	UNEP	1993	world	various
Worldwide digital terrain data (TerrainBase)	NGDC	1994	world	various

Annex 5: Terms of Reference

Account No.: FP/5510-96-01-2210
Amount : US$15,000

MEMORANDUM OF UNDERSTANDING

This Memorandum of Understanding (herein referred to as the Memorandum) is concluded between:

The National Institute of Public Health and the Environment (RIVM)
PO Box 1
3720 BA Bilthoven, The Netherlands

and

The State of the Environment Unit
Division of Environmental Information and Assessment
United Nations Environment Programme (UNEP)
P.O. Box 30552
Nairobi
Kenya

Background

1. Strategic planning exercise for UNEP's environmental assessment activities

The development of a comprehensive environmental monitoring and assessment strategy is not a trivial task. The process must take into account the many initiatives being implemented worldwide. A necessary first objective, therefore, is to ensure the implementation of a process, involving relevant UN agencies and other partners, to produce a new global coordinated monitoring and assessment system incorporating the roles of external partners, and defining UNEP's specific catalytic and coordinated role in this new system. UNEP intends to produce such a strategy during the second half of 1998. As a first step four senior advisors will be requested to prepare an advisory paper which will be used to prepare a first draft strategy for discussion during a first brainstorming workshop in September. At that stage the UN system will become involved as well.

2. *Questions to be answered during the strategic planning exercise*

1. A statement of the goals for UNEP's environmental monitoring, analysis and reporting;
2. A review of the work that UNEP has carried out in the past and is currently undertaking;
3. A summary of what and how other entities are engaged in monitoring, analysis and reporting work, and UNEP's interaction with them;
4. An analysis of which data collection efforts have resulted in useful data, and which in less useful data (describing such data);
5. An identification of the critical gaps in environmental data collection globally;
6. A description of what UNEP's particular role in monitoring, analysis and reporting should be; and

7. A description of how UNEP's various monitoring and analysis functions could work together to reach defined goals (e.g. with hard data feeding into policy documents, such as the GEO report).

3. UNEP's environmental assessment mandate and goals

UNEP's environmental assessment programme must guide and facilitate international environmental priority setting, policy making, action planning and resource allocation through the following goals:

I. providing state of the environment reports and other relevant information including those on emerging environmental issues;
II. evaluating the adequacy, performance and global environmental impacts of societal responses and development programmes;
III. making realistic recommendations for improving these responses and programmes;
IV. defining key data gaps and promoting collaborative environmental assessment programmes to address them;
V. playing a leadership role in the field of environmental indicators; and
VI. facilitating access to, and exchange of, environmental data and information with and between nations and environmental agencies and programmes, for the purposes of environmental assessment.

Terms of Reference for contributions to the strategic planning exercise

4. Tasks to be undertaken by RIVM

1. RIVM will write an advisory memo which will cover:

- a review of and if need be suggestions for amendments in the above described mandate and goals (see section 3);

- a discussion for each of the major goals, incorporating the following items:
    a. the importance of the goal;
    b. a review of what has already been done;
    c. an identification of gaps;
    d. objectives, outputs and their projected use;
    e. a strategy as to how it will be accomplished;
    f. the relevant partners and what is expected from them;
    g. a methodology and criteria spelling out how the impact will be assessed (performance evaluation); and
    h. the roughly estimated cost to cover UNEP's role in catalyzing and coordinating the implementation of the programme to attain the stated objectives.

2. Informally consult other experts and programmes, specifically targetting European institutions and certain major international organizations such as CSD, OECD, World Bank, IPCC, IIASA, GxOS Secretariats, UN-ECE and other relevant UN Economic Commisions, EU (EEA and several DGs in the EC), and the like. A list of names of people to approach will be proposed early on and will be finalized in close consultation with the DEIA/SOE unit at UNEP-Head Quarters. The latter also to ensure that different advisors will not approach the same people.

3. Participate in follow-up discussions in UNEP on the development and implementation of a new global monitoring and assessment paradigm, which may include attending meetings (dates and venue to be decided later, travel funds not yet included in this contract) and reviewing future draft strategy documents.

5. Timing

Task 1 + 2: A first draft paper will be delivered no later than 28 August 1998, also incorporating the result of the informal consultations

Task 3: Meetings and reviews will take place between August and December 1998.

6. Funding

UNEP will provide to RIVM a sum not exceeding US$15,000 to carry out the activities of this Memorandum. The disbursement of funds by UNEP to RIVM will be as follows:

(i) US$10,000 will be paid upon signature of this Memorandum.

(ii) US$5,000 will be paid upon receipt by UNEP of all the required inputs and a detailed statement of expenditures.

7. RIVM will maintain a separate account for any disbursements pertaining to this memorandum and shall submit to UNEP upon the completion of the work a detailed breakdown of expenditures incurred, duly certified by an authorized official of RIVM. The expenditures will be reported by object of expenditure as per the attached budget (Annex I) of this Memorandum. Any portion of cash advances remaining unspent or uncommitted by RIVM on completion of the activities under this Memorandum will be reimbursed to UNEP within one month of the presentation of the expenditure report. In the event of any delay in such reimbursement, RIVM will be financially responsible for any adverse movement in exchange rates.

8. RIVM shall retain, for a period of three years, all supporting documentation relating to financial transactions under this Memorandum. If requested, RIVM shall facilitate an audit by the United Nations Board of Auditors and/or the Audit Service of the accounts of the Memorandum.

9. Without prejudice to paragraph 6 above, the question of the title rights, copyright, royalties all other rights of whatsoever nature in any material produced under the provisions of this agreement shall be agreed upon by UNEP and RIVM.

10. All correspondence regarding this Memorandum between RIVM and UNEP should be addressed to:

<u>At RIVM</u>

Dr. Fred Langeweg
National Institute of Public Health and the Environment (RIVM)
PO Box 1
3720 BA Bilthoven
The Netherlands

Tel: 31 30 274 3112
Fax: 31 30 274 4435

All correspondence regarding substantive and technical matters between RIVM and UNEP should be addressed to:

<u>AT UNEP</u>

Ms. Veerle Vandeweerd
Chief, SOE Reporting
United Nations Environment Programme,
PO Box 30552, Nairobi, Kenya
Tel: 254 2 623527
Fax: 254 2 623943

with a copy to the Chief, Fund Programme Management Branch.

All correspondence regarding administrative and financial matters should be addressed to:

Mr. E.F. Ortega
Chief, Budget and Funds Management Service
United Nations Office at Nairobi
P. O. Box 30552, Nairobi, Kenya
Tel: 623637
Fax: 623755

11. RIVM shall indemnify, hold and save harmless and defend at its own expense UNEP, its officers, agents and employees from and against all suits, claims, demands and liability of any nature or kind, including costs and expenses arising out of negligent misconduct of RIVM or its employees in the performance of the terms of this Memorandum.

12. RIVM shall be considered as having the legal status of an independent contractor. Agents or employees of RIVM shall not be considered in any respect as being officials or staff members of UNEP.

13. RIVM shall neither seek nor accept instructions from any authority external to UNEP in connection with the performance of its services under this Memorandum. RIVM shall refrain from any action which may adversely affect UNEP or the United Nations and shall fulfill its commitments with fullest regard for the interest of the United Nations.

14. Any controversy of claim arising out of, or in accordance with this Memorandum of breach thereof, shall, unless it is settled by direct negotiation be settled in accordance with UNCITRAL Arbitration Rules as at present in force. The Parties shall be bound by any arbitration award rendered as a result of such arbitration as the final adjudication of any such controversy or claim.

15. Nothing in or relating to this Memorandum shall be deemed a waiver of any of the privileges and immunities of the United Nations.

16. This Memorandum shall be in effect from the day this agreement is signed by both parties until the draft sections are submitted and other tasks are completed.

17. This Memorandum may be terminated by either party before the expiry date of the Contract by giving notice in writing to the other party. The period of notice shall be fourteen days.

    In the event of the Memorandum being terminated prior to its due expiry date in this way, RIVM shall be compensated on a pro rata basis for no more than the actual amount of work performed to the satisfaction of UNEP. Additional costs incurred by UNEP resulting from the termination of the Memorandum by RIVM may be withheld from any amount otherwise due to RIVM from UNEP.

18. **No change in or modification of this Memorandum shall be made except by prior written agreement between UNEP and RIVM. RIVM shall not assign, transfer, pledge, sub-contract or make other disposition of this Memorandum or any part thereof, or of any of RIVM's rights, claims or obligations under this Memorandum except with the prior written consent of UNEP.**

Signed on behalf of RIVM

R.B.J.C. van Noort
Director General

Date: 22/7/98

Signed on behalf of the Environment Fund

E.F. Ortega
Chief, Budget and Funds Management Service
United Nations Office at Nairobi

Date: 3.7/98

Annex 4: Mailing list

1. D. Claasen, UNEP, Kenya
2. V. Vandeweerd, UNEP, Kenya
3. D. Mitchell, UNEP, Kenya
4. A. Dahl, UNEP, Geneva
5. Directors RIVM
6. F. Langeweg
7. L.H.M. Kohsiek
8. R.J.M. Maas
9. L.C. Braat
10. A.H.M. Bresser
11. R. van den Berg
12. G.J. Heij
13. D. van Lith
14. B. Metz
15. J.H. Hettelingh
16. K.Wieringa
17. J.A. Hoekstra
18. H.J.P.A. Verkaar
19. J.A. Bakkes
20. M.M. Berk
21. H.B.M. Hilderink
22. D.P. van Vuuren
23. J.W. van Woerden
24. J.C. Bollen
25. A.F. Bouwman
26. R. Leemans
27. H.J.M. de Vries
28. H.P.J. van Schaik
29. R.M. van Aalst
30. B.A. Bannink
31. B.J.E. ten Brink
32. B.J. de Haan
33. E. Lebret
34. A. Minderhoud
35. A.R.Bergen
36. R. Thomas
37. SBD/Voorlichting & Public Relations
38. Bureau Rapportenregistratie
39. Secretariaat S5
40. Secretariaat MNV