Technical report No 25

Environmental indicators: Typology and overview

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Printed in Copenhagen

Printed on recycled and chlorine-free bleached paper

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1. Introduction

A wide variety of environmental indicators is presently in use. These indicators reflect trends in the state of the environment and monitor the progress made in realising environmental policy targets. As such, environmental indicators have become indispensable to policy-makers.

However, it is becoming more and more difficult for policy-makers to grab the relevance and meaning of the existing environmental indicators, given the number and diversity of indicators presently in use. And new sets of environmental indicators are still to be expected. Therefore, some means of structuring and analysing indicators and related environment/society inter-connections is needed.

The purpose of this paper is to introduce the EEA 'Typology of indicators' and the DPSIR framework (Driving forces, Pressure, State, Impact, Response) used by the European Environment Agency in its reporting activities. This report should help policy-makers to understand the meaning of the information in indicator reports. In addition, we hope the paper will be useful in helping to define common standards for future indicator reports from the EEA and its member states.

2. Why do we need environmental indicators ?

Communication is the main function of indicators: they should enable or promote information exchange regarding the issue they address. Our body temperature is an example of an indicator we regularly use. It provides critical information on our physical condition. Likewise, environmental indicators provide information about phenomena that are regarded typical for and/or critical to environmental quality. The abundance of Black Terns in a certain area and the total volume of substances emitted by industry over a certain period are only two of the numerous indicators that enable communication on environmental issues.

Communication demands simplicity. Indicators always simplify a complex reality. They focus on certain aspects which are regarded relevant and on which data are available. But their significance goes beyond that obtained directly from the observed properties. To know the number of Black Terns in a certain area may be satisfying in itself. It may be more relevant to compare the number in this specific area with the abundance of Black Terns in a similar, but less disturbed area. Then, the real significance is in the message the abundance of these birds conveys regarding environmental quality in that specific area. Environmental indicators communicate those aspects regarded critical or typical for the complex interrelation between natural species and abiotic components of the environmental system.

In relation to policy-making, environmental indicators are used for three major purposes:

1. to supply information on environmental problems, in order to enable policy-makers to value their seriousness;
2. to support policy development and priority setting, by identifying key factors that cause pressure on the environment;
3. to monitor the effects of policy responses.

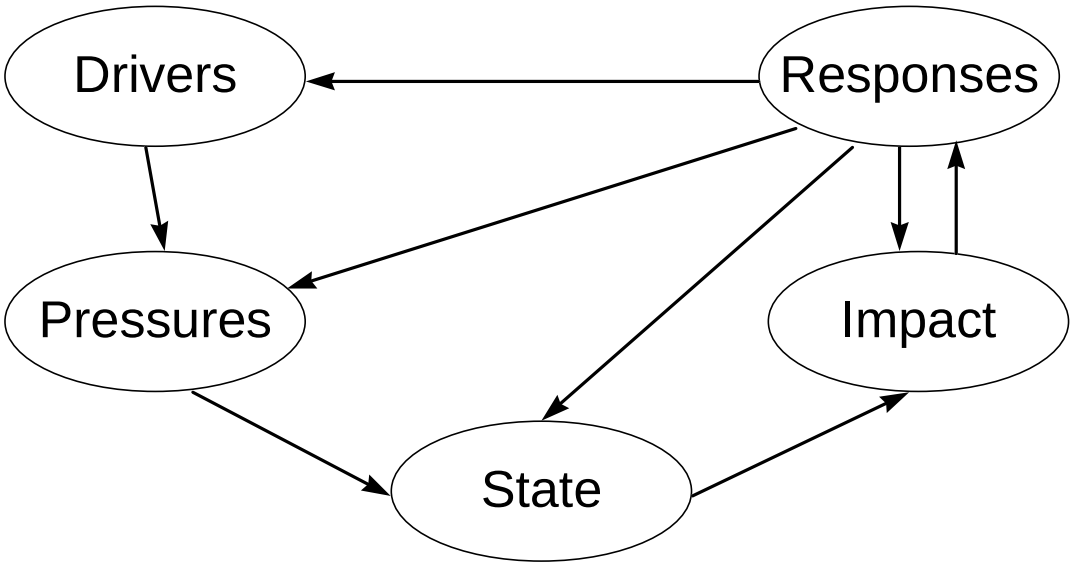
In addition, environmental indicators may be used as a powerful tool to raise public awareness on environmental issues. Providing information on driving forces, impacts and policy responses, is a common strategy to strengthen public support for policy measures.

3. Classifications of environmental indicators

The DPSIR framework

At present, most indicator reports compile sets of physical, biological or chemical indicators. They generally reflect a systems analysis view of the relations between the environmental system and the human system (see Figure 1).

Figure 1: The DPSIR Framework for Reporting on Environmental Issues



According to this systems analysis view, social and economic developments exert Pressure on the environment and, as a consequence, the State of the environment changes, such as the provision of adequate conditions for health, resources availability and biodiversity. Finally, this leads to Impacts on human health, ecosystems and materials that may elicit a societal Response that feeds back on the Driving forces, or on the state or impacts directly, through adaptation or curative action.

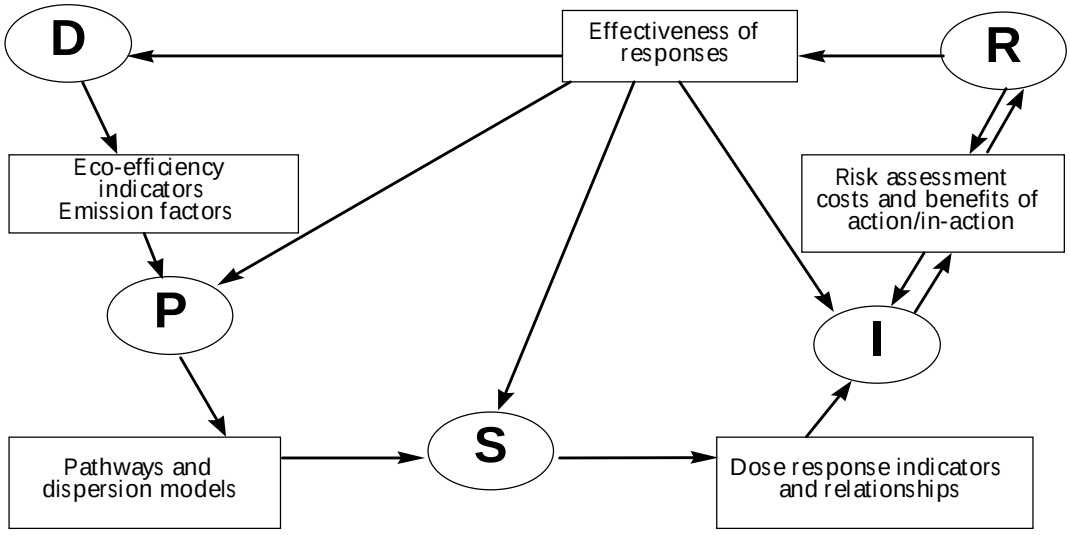
Obviously, the real world is far more complex than can be expressed in simple causal relations in systems analysis. There is arbitrariness in the distinction between the environmental system and the human system. And, moreover, many of the relationships between the human system and the environmental system are not sufficiently understood or are difficult to capture in a simple framework. Nevertheless, from the policy point of view, there is a need for clear and specific information on

(i) Driving forces and
(ii) the resulting environmental Pressures, on
(iii) the State of the Environment and
(iv) Impacts resulting from changes in environmental quality and on
(v) the societal Response to these changes in the environment.

In order to meet this information need, environmental indicators should reflect all elements of the causal chain that links human activities to their ultimate environmental impacts and the societal responses to these impacts.

The DPSIR framework is useful in describing the relationships between the origins and consequences of environmental problems, but in order to understand their dynamics it is also useful to focus on the links between DPSIR elements. For instance, the relationship between the 'D' and the 'P' by economic activities is a function of the eco-efficiency of the technology and related systems in use, with less 'P' coming from more 'D' if eco-efficiency is improving. Similarly, the relationship between the Impacts on humans or eco-systems and the 'S' depends on the carrying capacities and thresholds for these systems. Whether society 'Responds' to impacts depends on how these impacts are perceived and evaluated; and the results of 'R' on the 'D' depends on the effectiveness of the Response. (see Figure 2).

Figure 2: Indicators and information linking DPSIR elements



The EEA Typology of Indicators

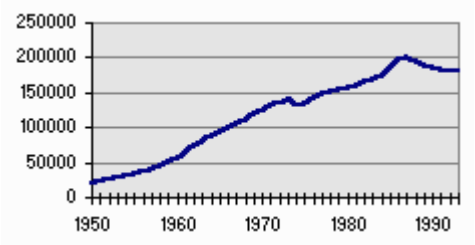
Indicators can be classified into 4 simple groups which address the following questions:

- 'What is happening to the environment and to humans?' (Type A or Descriptive Indicators)
- 'Does it matter?' (Type B or Performance indicators)
- 'Are we improving?' (Type C or Efficiency indicators)
- 'Are we on the whole better off?' (Type D or Total Welfare indicators)

Descriptive indicators (Type A – What is happening to the environment and to humans?)

Most sets of indicators presently used by nations and international bodies are based on the DPSIR-framework or a subset of it. These sets describe the actual situation with regard to the main environmental issues, such as climate change, acidification, toxic contamination and wastes in relation to the geographical levels at which these issues manifest themselves.

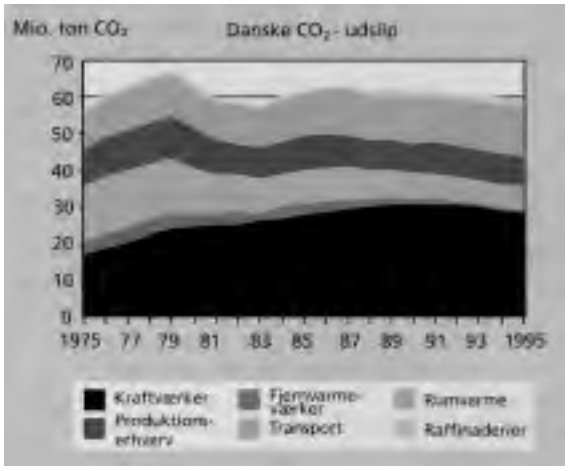
Figure 3: Number of private cars and light commercial vehicles in Oslo



State of the Environment Norway; update 27/9/96
http://www.grida.no/prog/norway/soeno95/index.htm

Indicators for *driving forces* describe the social, demographic and economic developments in societies and the corresponding changes in life styles, overall levels of consumption and production patterns. Primary driving forces are population growth and developments in the needs and activities of individuals. These primary driving forces provoke changes in the overall levels of production and consumption. Through these changes in production and consumption, the driving forces exert pressure on the environment.

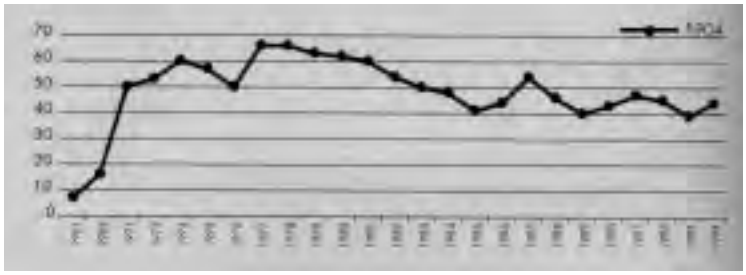
Figure 4: Danish CO_2-emissions in key sectors



Miljøindikatorer 1996, Miljø- & energiministeriet 1996 Denmark

Pressure indicators describe developments in release of substances (emissions), physical and biological agents, the use of resources and the use of land. The pressures exerted by society are transported and transformed in a variety of natural processes to manifest themselves in changes in environmental conditions. Examples of pressure indicators are CO_2-emissions per sector (see figure 4), the use of rock, gravel and sand for construction and the amount of land used for roads.

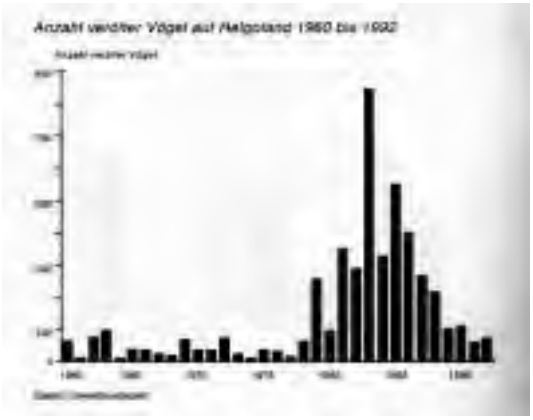
Figure 5: Eutrophication of Lake Como, 1961-1994 (µg/l P-PO_4)



Ambiente Italia 1996, Rapporto sullo stato del paese e analisi ambiente delle città e delle regioni italiane. Edizione Ambiente 1996

State indicators give a description of the quantity and quality of physical phenomena (such as temperature), biological phenomena (such as fish stocks) and chemical phenomena (such as atmospheric CO_2-concentrations) in a certain area. State indicators may, for instance, describe the forest and wildlife resources present, the concentration of phosporous and sulphur in lakes, or the level of noise in the neighbourhood of airports.

Figure 6: Amount of birds contaminated with spilled oil

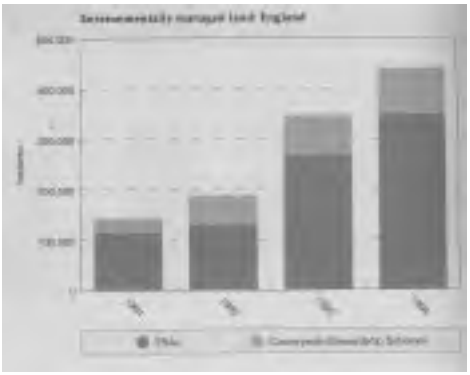


Daten zur Umwelt 1992/93, Umweltbundesamt. Germany.

Due to pressure on the environment, the state of the environment changes. These changes then have impacts on the social and economic functions on the environment, such as the provision of adequate conditions for health, resources availability and biodiversity. *Impact* indicators are used to describe these impacts.

Impacts occur in a certain sequence: air pollution may cause global warming (primary effect), which may in turn cause an increase in temperature (secondary effect), which may provoke a rise of sea level (tertiary impact), which could result in the loss of biodiversity.

Figure 7: Environmentally managed land: England

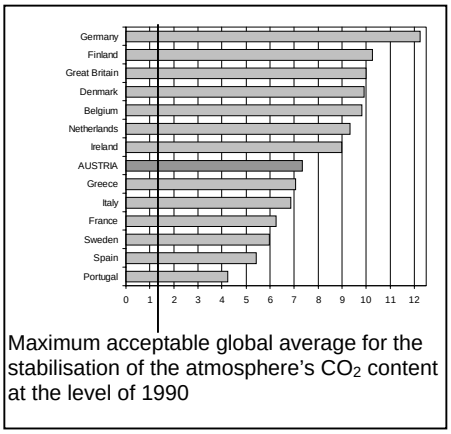


Indicators of sustainable development for the United Kingdom. Department of the Environment, 1996

Response indicators refer to responses by groups (and individuals) in society, as well as government attempts to prevent, compensate, ameliorate or adapt to changes in the state of the environment. Some societal responses may be regarded as negative driving forces, since they aim at redirecting prevailing trends in consumption and production patterns. Other responses aim at raising the efficiency of products and processes, through stimulating the development and penetration of clean technologies. Examples of response indicators are the relative amount of cars with catalytic converters and recycling rates of domestic waste. An

often used 'overall' response indicator is an indicator describing environmental expenditures.

Figure 8: Per-capita CO_2-emissions (1990) of EU member states, tonnes CO_2/capita



State of the Environment in Austria. Federal Environment Agency. Vienna, Federal Ministry for Environment, Youth and Family, 1997

Performance indicators (Type B – Does it matter?)

The indicators mentioned above all reflect the situation as it is, without reference to how the situation should be. In contrast, *performance* indicators compare (f)actual conditions with a specific set of reference conditions. They measure the 'distance(s)' between the current environmental situation and the desired situation (target): 'distance to target' assessment. Performance indicators are relevant if specific groups or institutions may be held accountable for changes in environmental pressures or states.

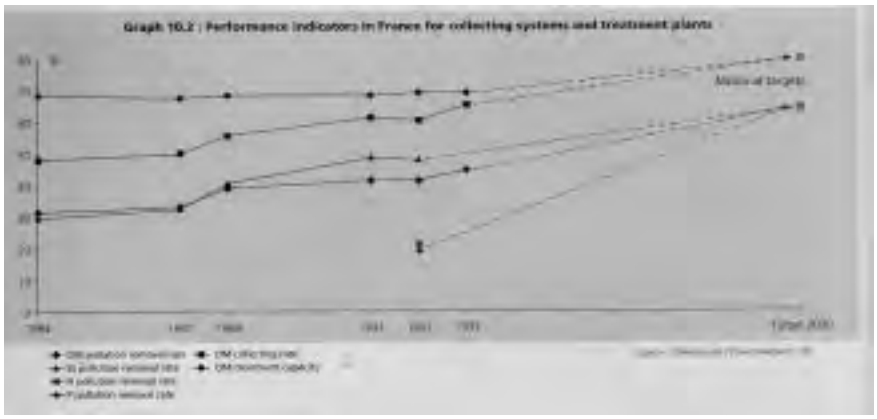
Most countries and international bodies currently develop performance indicators for monitoring their progress towards environmental targets. These performance indicators may refer to different kind of reference conditions/values, such as:

- national policy targets;
- international policy targets, accepted by governments;
- tentative approximations of sustainability levels.

The first and second type of reference conditions, the national policy targets and the internationally agreed targets (Policy Target Values, or PTVs), rarely reflect sustainability considerations as they are often compromises reached through (international) negotiation and subject to periodic review and modification. Up to now, only very limited experience exists with so-called sustainability indicators that relate to target levels of environmental quality set from the perspective of sustainable development (Sustainable Reference Values, or SRVs). Interesting examples have been suggested for the issues of acidification and climate change. The EEA 'STAR' database contains an inventory of PTVs and SRVs for 15 environmental themes and 8 sectors. It is accessible on http://star.eea.eu.int/.

Two examples of performance indicators are shown in this section. The first indicator (Figure 8) shows CO_2-emissions per capita for EU Member States and includes a tentative level for maximum acceptable global average CO_2-emissions for the stabilisation of the atmosphere's CO_2 content at the level of 1990, according to IPPC (performance). The second indicator (Figure 9) compares the pollution removal rate for nitrogen (N) and phosphorus (P) with national targets in the year 2000.

Figure 9: Performance indicator on removal rates for collecting systems and treatment plants in France



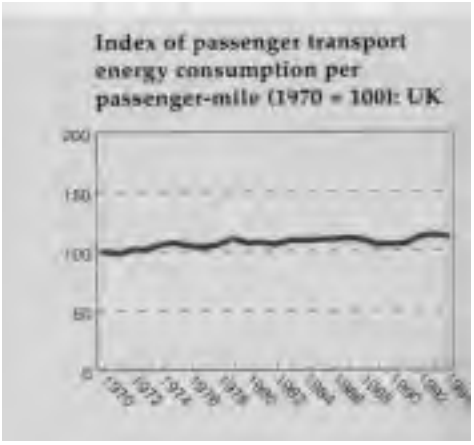
Environmental performance indicators in France. French Institute for the Environment, 1996-1997 edition.

Efficiency indicators (Type C – Are we improving?)

It is important to note that some indicators express the relation between separate elements of the causal chain. Most relevant for policy-making are the indicators that relate environmental pressures to human activities. These indicators provide insight in the efficiency of products and processes. Efficiency in terms of the resources used, the emissions and waste generated per unit of desired output.

The environmental efficiency of a nation may be described in terms of the level of emissions and waste generated per unit of GDP. The energy efficiency of cars may be described as the volume of fuel used per person per mile travelled.

Figure 10: Index of passenger transport energy consumption per passenger mile



Indicators of sustainable development for the United Kingdom. Department of the Environment, 1996

Apart from efficiency indicators dealing with one variable only, also aggregated efficiency indicators have been constructed.

The best-known aggregated efficiency indicator is the MIPS-indicator. It is used to express the Material Intensity Per Service unit and is very useful to compare the efficiency of the various ways of performing a similar function. E.g. MIPS may be used to compare the amounts of energy and resources used for transporting one person one hundred miles by means of the present day car, by hyper-car, by aeroplane and by light rail.

The relevance of these and other efficiency indicators is that they reflect whether or not society is improving the quality of its products and processes in terms of resources, emissions and waste per unit output.

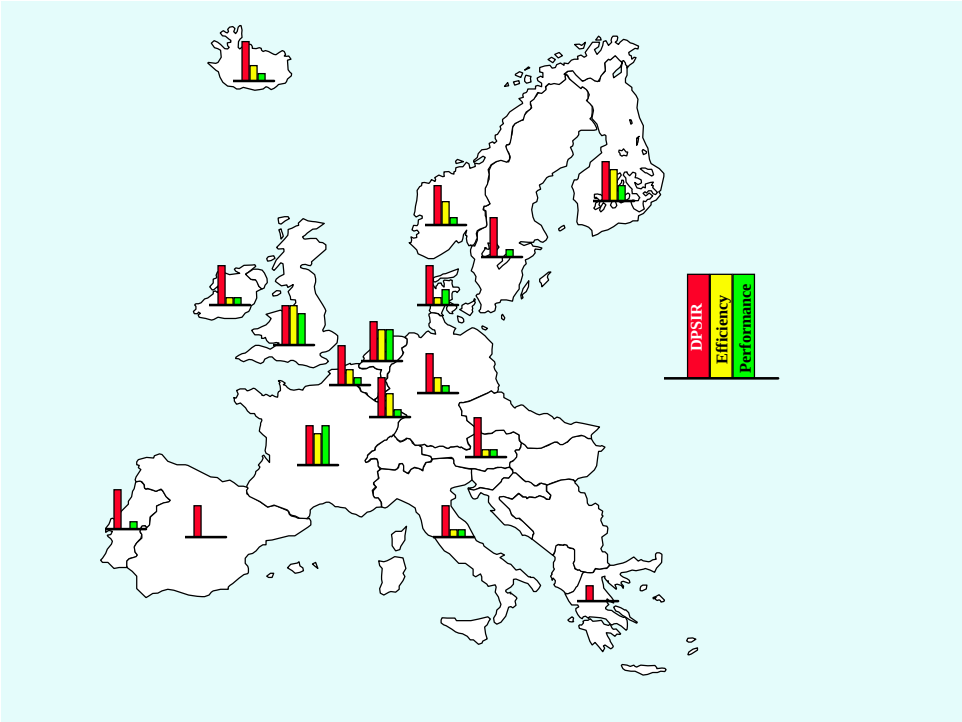
Total welfare indicators (Type D – Are we on whole better off?)

Some measure of total sustainability is needed in order to answer this question, for example, a kind of 'Green GDP', such as the Index of Sustainable Economic Welfare (ISEW). These are, however, currently outside of the EEA's work programme and therefore not further investigated here.

4. Types of indicators used in state-of-the-environment reports

The member states of the European Environment Agency produce state-of-the-environment reports. Various types of indicators are used in these reports. The reports analysed are listed in the reference list. Please note that the inventory of State of the Environment reports has been completed in the summer of 1997. The figure below gives an overview of the main results. The length of the column indicates to what extent indicators are used in the SoE reports. Four different lengths have been used: The tallest column represents indicators that are widely used in a country's SoE report, and for the DPSIR column, it means that all five types (D,P,S,I,R) are widely mentioned. When the appearance of the relative amount of indicators is lower, but indicators are still used fairly often, they get the second highest column. In terms of DPSIR: not all five types are mentioned. The next length of columns means that indicators are used, but significantly fewer than in the first two cases. The shortest columns then indicate that just one or two indicators are mentioned.

Figure 11: Overview of various kind of indicators, used in state-of-the environment reports of European countries



Based on the results of the inventory, we may draw the conclusions which follow.

First of all, it is obvious that all SoE reports make use of *descriptive indicators*. Indicators for driving forces (D), pressure (P) and state (S) are mentioned most often, followed by response (R) indicators. Impact (I) indicators are merely used for a few specific issues, such as changes in

human health due to an increase in concentration of pollutants, damage to forests due to emissions and disturbance of people due to noise.

In most State-of-the-environment reports, **efficiency indicators** are also used, although not as often as the descriptive DPSIR-indicators. The most commonly used efficiency indicators express the amount of emissions or energy used per capita or per unit of GDP. It should be noted that the UK report 'Indicators of Sustainable Development for the United Kingdom' (1996) gives numerous examples of efficiency indicators.

The third conclusion is that **performance indicators** are mentioned less than either descriptive indicators or efficiency indicators. Most common is the performance indicator for the environmental issue 'acidification' which compares emissions and depositions to critical loads. The French report 'Environmental performance indicators in France, edition 1996-1997' offers the best overview of performance indicators for all types of environmental issues.

Implications for future indicator reports

Answering in State-of-the-environment reports the question 'What is happening to the environment' is not enough. Policy makers are keenly interested in having information on performance and efficiency as well.

Efficiency indicators present information that is important both from the environmental and the economic point of view. 'Do more with less' is not only a slogan of environmentalists. It is also a challenge to governments, industries and researchers to develop technologies that radically reduce the level of environmental and economic resources needed for performing societal functions. Since the world population is expected to grow substantially during the next decades, raising environmental efficiency may be the only option for preventing depletion of natural resources and controlling the level of pollution.

Performance indicators monitor the effect of policy measures. They indicate whether or not targets will be met, and communicate the need for additional measures.

The European Environment Agency will stimulate the development and use of both performance and efficiency indicators in European environmental reporting. To support performance indicators a database with environmental targets has been developed that can be accessed through the Internet at http://star.eea.eu.int/ (after October 1999 at http://eea.eu.int). A selection of efficiency indicators will be included in the next report on the State of the Environment in the European Union.

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