The DPSIR Framework

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Background[1]

In recommendation to the European Environment Agency (EEA) on how they should proceed with the development of a strategy for Integrated Environmental Assessment, RIVM[2] proposed the use of a framework, which distinguished driving forces, pressures, states, impacts and responses. This became known as the DPSIR framework and has since been more widely adopted by the EEA, acting as an integrated approach for reporting, e.g. in the EEA's State of the Environment Reports. The framework is seen as giving a structure within which to present the indicators needed to enable feedback to policy makers on environmental quality and the resulting impact of the political choices made, or to be made in the future.

According to the DPSIR framework there is a chain of causal links starting with '*driving forces*' (economic sectors, human activities) through '*pressures*' (emissions, waste) to '*states*' (physical, chemical and biological) and '*impacts*' on ecosystems, human health and functions, eventually leading to political '*responses*' (prioritisation, target setting, indicators). Describing the causal chain from driving forces to impacts and responses is a complex task, and tends to be broken down into sub-tasks, e.g. by considering the pressure-state relationship.

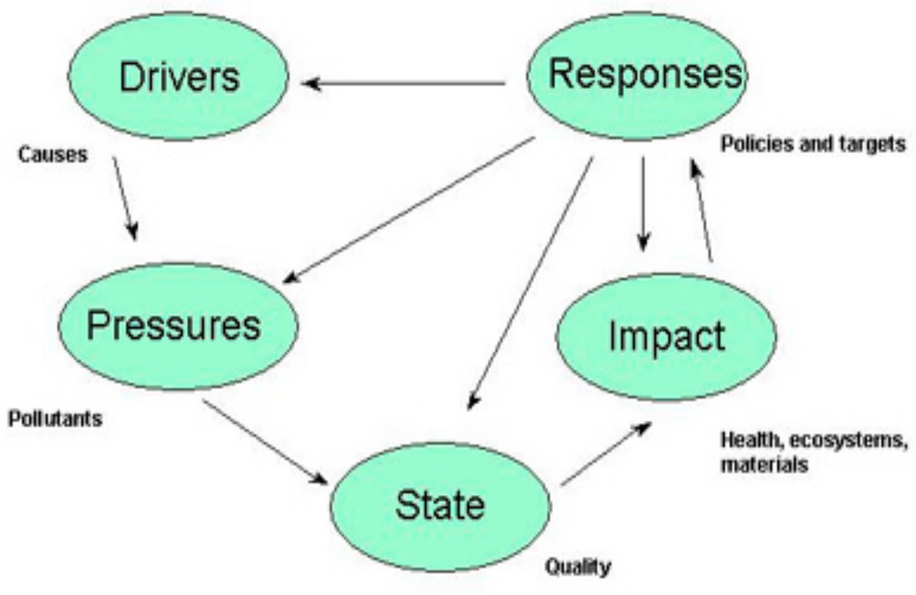


Figure 1. The DPSIR assessment framework

[1] Based on EEA 1998: Guidelines for Data Collection and Processing - EU State of the Environment Report. Annex 3.
[2] National Institute of Public Health and Environment, Bilthoven, Netherlands

The components of the DPSIR framework are defined in the following. Classes of data on the past and present situations are listed after each definition.

Driving Forces

A ‘driving force’ is a need. Examples of primary driving forces for an individual are the need for shelter, food and water, while examples of secondary driving forces are the need for mobility, entertainment and culture. For an industrial sector a driving force could be the need to be profitable and to produce at low costs, while for a nation a driving force could be the need to keep unemployment levels low. In a macroeconomic context, production or consumption processes are structured according to economic sectors (e.g. agriculture, energy, industry, transport, households).

- Population (number, age structure, education levels, political stability)
- Transport (persons, goods; road, water, air, off-road)
- Energy use (energy factors per type of activity, fuel types, technology)
- Power plants (types of plants, age structure, fuel types)
- Industry (types of plants, age structure, resource types)
- Refineries/Mining (types of plant/minings, age structure)
- Agriculture (number of animals, types of crops, stables, fertilisers)
- Landfills (type, age)
- Sewage systems (types)
- Non-industrial sectors
- Land use

Pressures

Driving forces lead to human activities such as transportation or food production, i.e. result in meeting a need. These human activities exert 'pressures' on the environment, as a result of production or consumption processes, which can be divided into three main types: (i) excessive use of environmental resources, (ii) changes in land use, and (iii) emissions (of chemicals, waste, radiation, noise) to air, water and soil.

- Use of resources
- Emissions (per driving force for numerous compounds)
  - direct emissions to air, water and soil
  - indirect emissions to air, water and soil
- Production of waste
- Production of noise
- Radiation
- Vibration
- Hazards (risks)

States

As a result of pressures, the ‘state’ of the environment is affected; that is, the quality of the various environmental compartments (air, water, soil, etc.) in relation to the functions that these compartments fulfil. The ‘state of the environment’ is thus the combination of the physical, chemical and biological conditions.

- Air quality (national, regional, local, urban, etc.)
- Water quality (rivers, lakes, seas, coastal zones, groundwater)
- Soil quality (national, local, natural areas, agricultural areas)
- Ecosystems (biodiversity, vegetation, soil organisms, water organisms)
- Humans (health)
- Soil use

Impacts

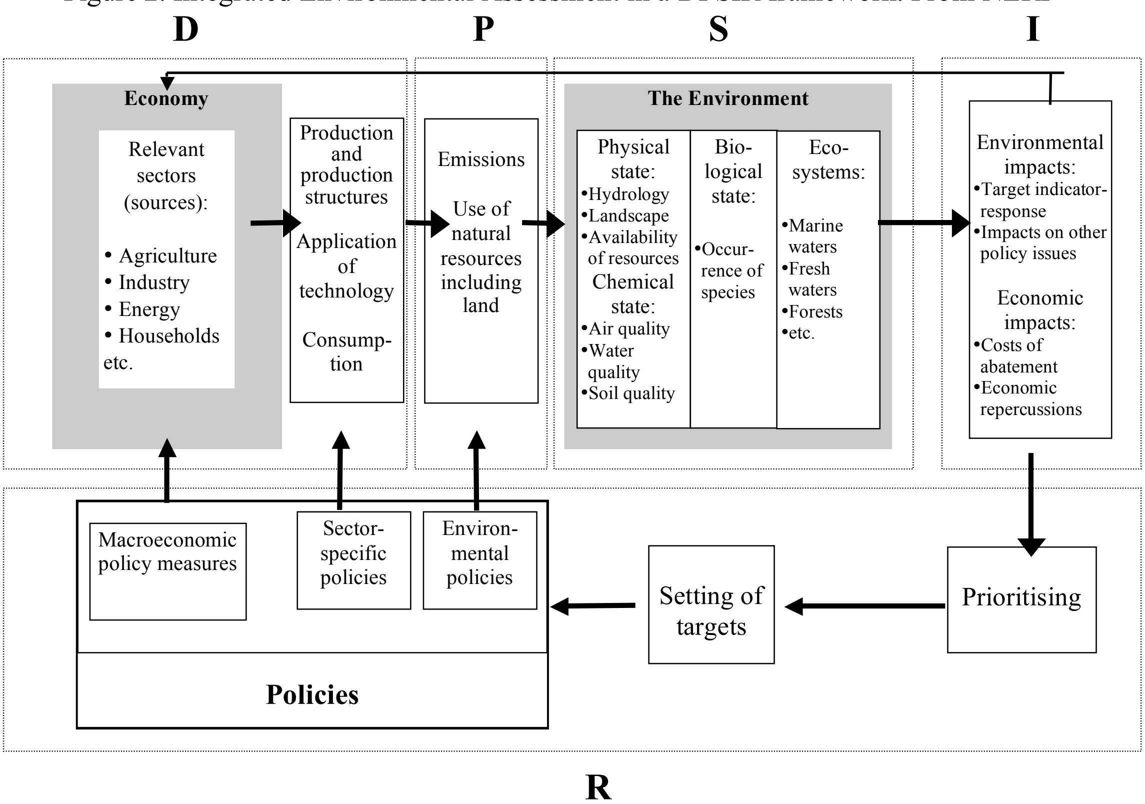
The changes in the physical, chemical or biological state of the environment determine the quality of ecosystems and the welfare of human beings. In other words changes in the state may have environmental or economic 'impacts' on the functioning of ecosystems, their life-supporting abilities, and ultimately on human health and on the economic and social performance of society.

Responses

A 'response' by society or policy makers is the result of an undesired impact and can affect any part of the chain between driving forces and impacts. An example of a response related to driving forces is a policy to change mode of transportation, e.g from private (cars) to public (trains), while an example of a response related to pressures is a regulation concerning permissible SO_2 levels in flue gases.

Figure 2 depicts the complete DPSIR framework. In addition to defining the components of DPSIR, it is useful to describe the various cause-effect relationships (because it is often difficult to attribute ecosystem changes unambiguously to human pressures). NERI[3] has proposed a methodology in which environmental problems are defined and structured in such a way that a clear relationship to pressures emerges. This often uses physical or chemical state indicators as the target variable, while the associated changes in biological state variables are treated as derived effects. A similar argument can be presented for the causal links between the driving forces (i.e. the basic socio-economic development of the different sectors of society) and the environmental pressures in terms of emissions, resource use and land use.

Figure 2: Integrated Environmental Assessment in a DPSIR framework. From NERI



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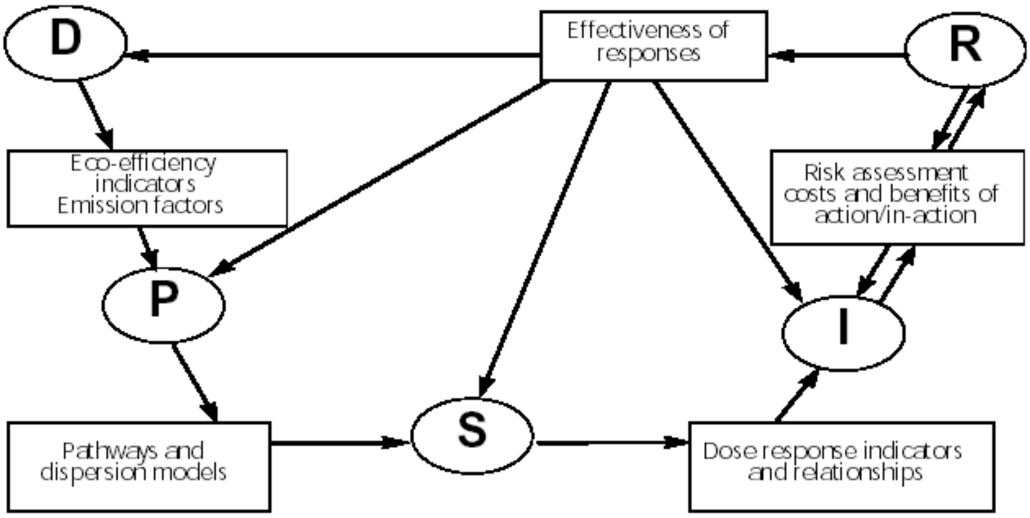
[3]National Environmental Research Institute, Denmark

Linking DPSIR elements

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 (see Figure 3). 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.

Figure 3: Indicators and information linking DPSIR elements.



Source: EEA 1999.

Driving Force - Pressure Relationships

The environmental pressures resulting from human activities (emissions, resource use and land use) are a function of two types of variable: (i) the level of these activities, and (ii) the technology applied in these activities. For example an emission of a given compound from an economic activity is the product of the level of activity and an emission factor, which reflects the technology of the process under scrutiny. Discharge of waste water from domestic sources, for instance, depends on the size of the population and their consumption (activity) and on the proportion of population connected to sewers and different kinds of waste water treatment (technology).

The technology variables will be reflected by emissions factors, resource use factors or land use factors. The variables accounting for the level of activities are of an economic nature, because they reflect the level of production and consumption.

DPSIR framework in relation to water issues[4]

The aim of managing water resources is to safeguard human health whilst maintaining sustainable aquatic and associated terrestrial ecosystems. It is, therefore, important to quantify and identify the current state of, and impacts on, water environment and how these are changing with time. In water assessment at global, regional, national and by river basins level the following generic questions could be asked:

[4] Based on the European Environment Agency's work on water

State of waters
- How is it? (Nutrients, pesticides, heavy metals, ecological quality..............)
- How much is there? (Runoff, availability, demands, water stress.........)

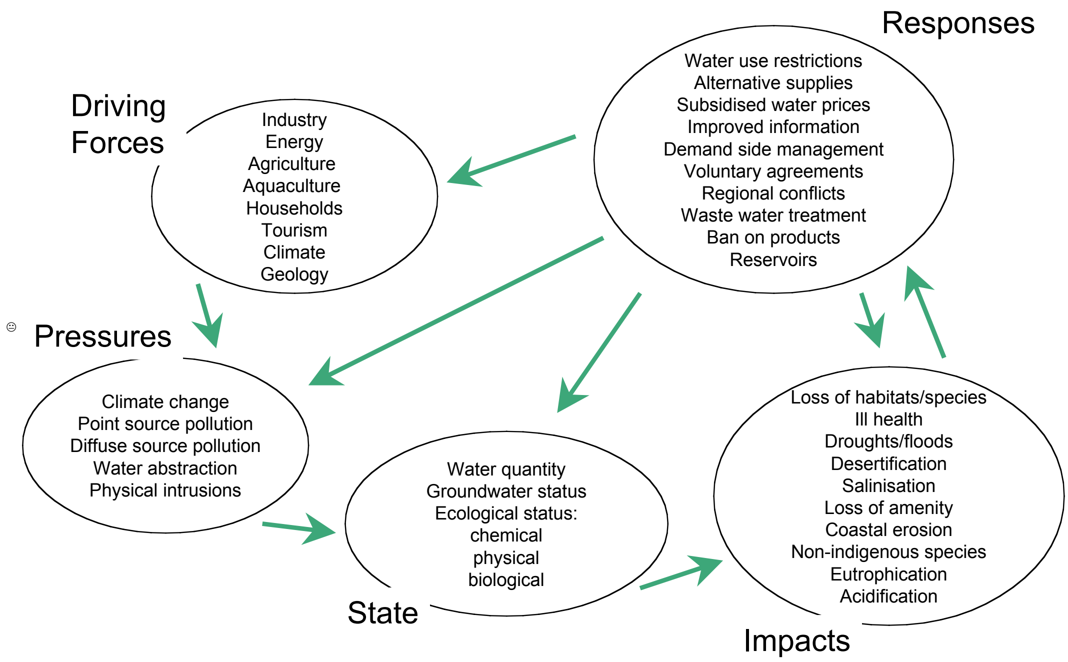
Time trends
- Getting better or worse?
- Within or outside agreed limits?

What is causing the problems?
Pressures on the environment
- Human - domestic
- Industrial
- Agricultural

State of Action on policies
- Are they working towards targets?

The DPSIR model can be used as an analytical framework for assessing water issues. This allows a comprehensive assessment of the issues through examination of the relevant **D**riving forces and **P**ressures on the environment, the consequent **S**tate of the environment and its **I**mpacts, and the **R**esponses undertaken, and of the interlinkages between each of these elements. A generic DPSIR framework for water is shown in Figure 4.

Figure 4: A generic DPSIR framework for water



The state of water is determined by natural factors such as geology and climate and also by the pressures exerted by human activities. Many of the pressures and the underlying driving forces are common to all or a number of the issues. For example, agriculture is a significant driving force in terms of ecological quality, nutrient and organic pollution, hazardous substances and water quantity.

DPSIR frameworks in relation to specific water issues

In the following the DPSIR framework is illustrated by more specific conceptual frameworks in relation to water quantity and organic pollution and eutrophication.

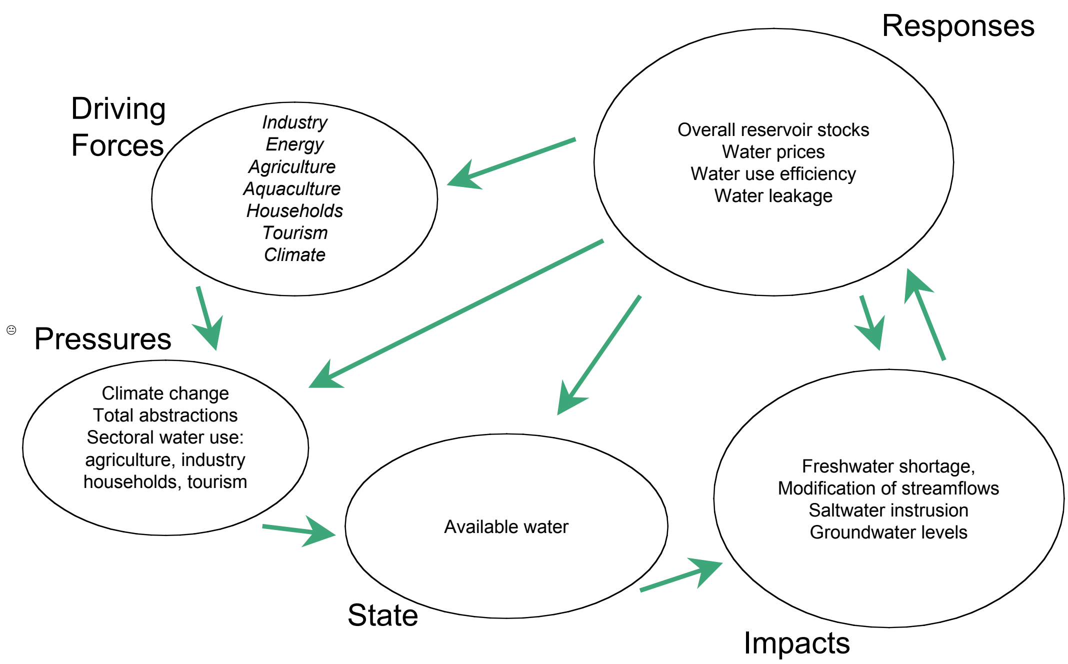
Water quantity
The following storyline and DPSIR framework (Figure 5) can be used to describe the issue of water quantity. Water availability problems occur when the demand for water exceeds the amount available during a certain period. Freshwater shortages occur frequently in areas with low rainfall and high population density and in areas with intensive agricultural or industrial activity.

There are large spatial and temporal differences in the amount of water available (***state***). These differences are expected to change due to climate changes. Other ***pressures*** on water quantity arise from the main sectoral users of water such as agriculture, households, energy production and industry. The seasonal demand from tourism is a significant pressure.

The ***impacts*** of over-abstraction of available water include decreases in groundwater levels that in turn can lead to impacts on associated aquatic and terrestrial ecosystems such as wetlands. In addition, over-abstraction of groundwater can lead to the intrusion of saltwater into coastal aquifers.

Measures (***responses***) to increase the amount of available water include the construction of storage reservoirs to safeguard supplies when other sources are stressed. Other measures are aimed at reducing or controlling the demand for water including water pricing, water-saving devices and reduction of water leakage in distribution systems.

Figure 5: DPSIR conceptual framework for assessing water quantity resources

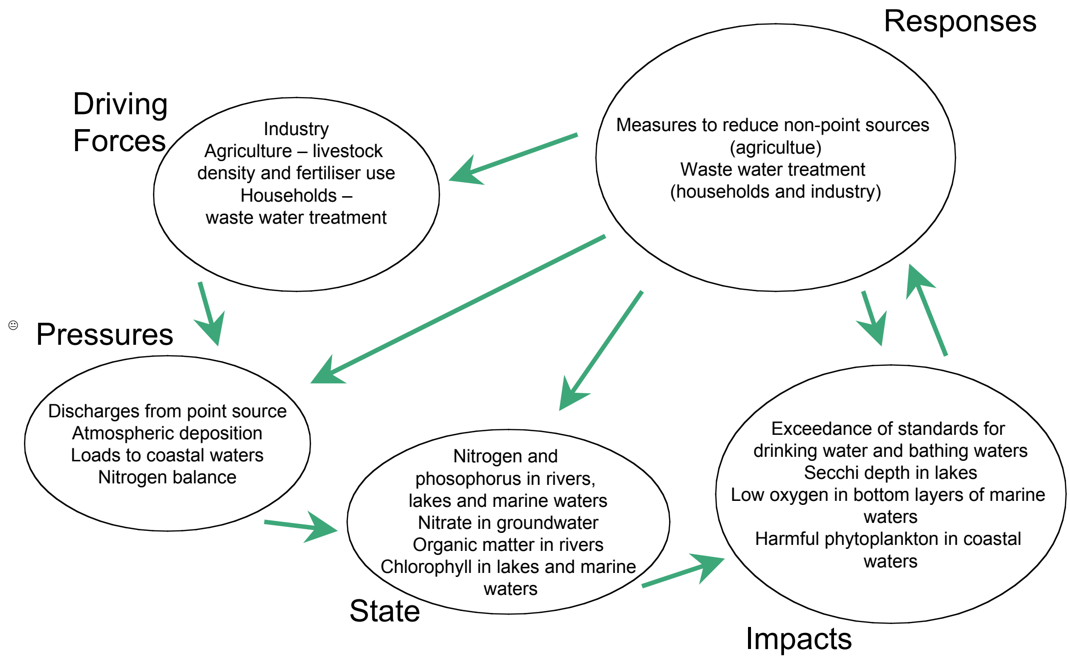


Organic pollution and eutrophication
The effects on the aquatic environment of organic pollution, caused by discharges from waste water treatment plants, industrial effluents and agricultural run-off, include reduced river water chemical and biological quality, as well as impaired biodiversity of aquatic communities and microbiological water quality. Increased industrial and agricultural production, coupled with more of the population being connected to sewerage systems will result in increases in discharges of organic waste and nutrients into surface water.

The overloading of seas, coastal waters, lakes and rivers with nutrients (nitrogen and phosphorus) can result in a series of adverse effects known as eutrophication. In severe cases of eutrophication, massive blooms of planktonic algae occur. Some blooms are toxic. As dead algae decompose, the oxygen in the water is used up; bottom-dwelling animals die and fish either die or leave the affected area. Increased nutrient concentrations can also lead to changes in the aquatic vegetation. The unbalanced ecosystem and changed chemical composition make the water body unsuitable for recreational and other uses such as fish farming, and the water becomes unacceptable for human consumption. The main source of nitrogen pollution is run-off from agricultural land, whereas most phosphorus pollution comes from households and industry.

The DPSIR framework for assessing eutrophication and pollution from organic matter is shown in Figure 6.

Figure 6: Assessment of progress in meeting policy objectives for eutrophication and organic pollution



Other causal chain frameworks

In the following is listed other examples of use of causal chain

GIWA causal chain analyses[5]

The Global International Waters Assessment (GIWA) is using causal chain analyses as an important tool for their assessments. Causal chain analyses are used to identify and better understand the causal chains between perceived problems and their societal root causes.

The GIWA causal chain analyses cluster into five major problem areas of concern for the aquatic environment:

Freshwater shortage

Modification of stream flow - Pollution of existing supplies - Changes in the water table

Pollution

Microbiological - Eutrophication - Chemical - Suspended solids - Solid wastes - Thermal - Radio nuclide - Spills

Habitat and community modification

Loss of ecosystems - Modification of ecosystems or ecotones, including community structure and/or species composition

Unsustainable exploitation of fisheries and other living resources

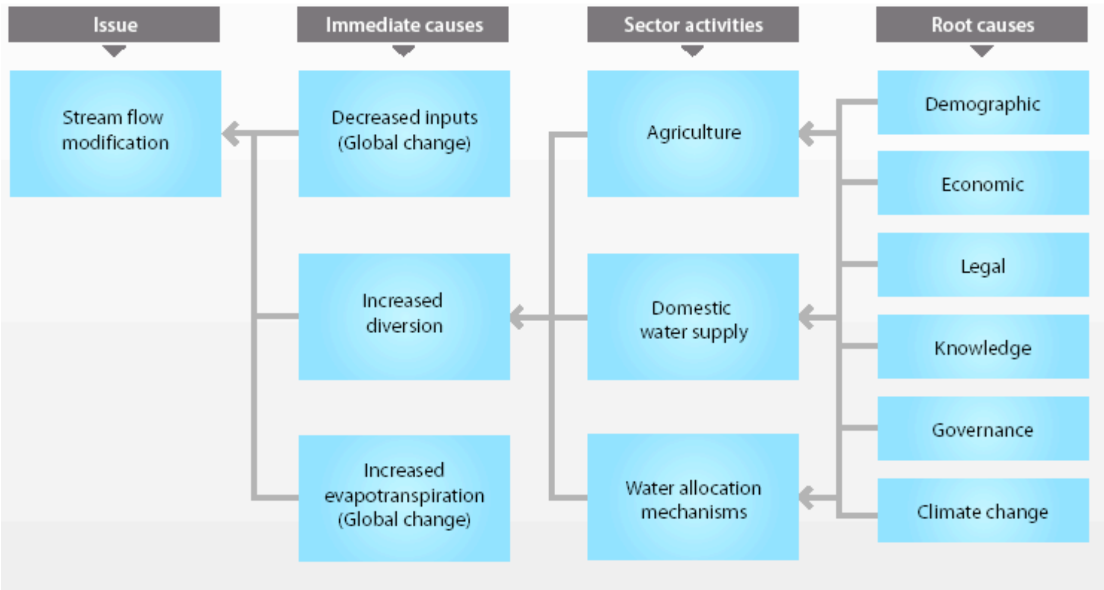
Over-exploitation - Excessive by-catch and discards - Destructive fishing practices - Decreased viability of stock through pollution and disease - Impact on biological and genetic diversity

Global change

Changes in hydrological cycle - Sea level change - Increased uv-b radiation as a result of ozone depletion - Changes in ocean CO_2 source/sink function

The causal chain is an assessment of the linkages between problems and their underlying (root) causes. It includes immediate causes, sector activities/intermediate causes, and the root causes i.e., human activities leading to the creation of the problem (Figure 7).

Figure 7: Example of a GIWA causal chain analysis model.



[5] See http://www.giwa.net/caus_iss/causual_chain_analyses.phtml

South Africa

South Africa used the DPSIR framework for identifying core indicators for inland waters.[6]

Inland water systems are affected by two main drivers, natural (e.g. climate) and anthropogenic (e.g. development). These drivers cause certain pressures on inland waters, which result in impacts on freshwater resources, either by changing the *quantity* of ground and/or surface water, and/or by changing the *quality* of ground and/or surface water.

The main drivers of change on inland waters and the main areas of impact of these drivers were presented in the 1999 State of Environment Report for South Africa (DEA&T, 1999) and are presented below (Figure 8).

Six identified issues of concern were further unpacked into possible causes, how the issue is reflected and management actions, i.e. (DPSIR framework). The issues identified were:
Environmental Issues pertaining to Inland Waters:
1. Limited freshwater resources (surface and ground water)
2. Changing freshwater quality (surface and ground water)
3. Degradation and loss of freshwater ecosystem integrity
4. Flood and drought management of inland water resources
Socio-Economic & Political Issues pertaining to Inland Waters:
5. Inadequate and Inequitable distribution of services (reflected on inland waters)
6. Conflicting interests over water sharing (national and international) (reflected on inland waters). With the two marked in bold as the main issues.
Figure 9 illustrate the DPSIR conceptual framework for issue 1: limited freshwater resources.

Figure 8: Diagram showing the main driving forces affecting South Africa's inland water resources (modified from DEA&T, 1999).

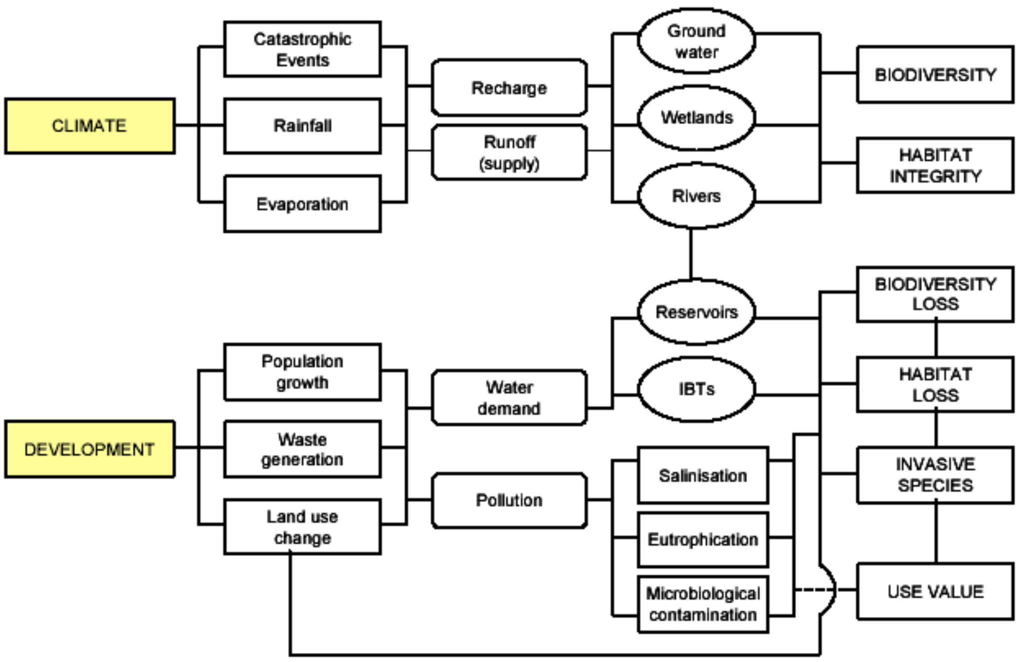
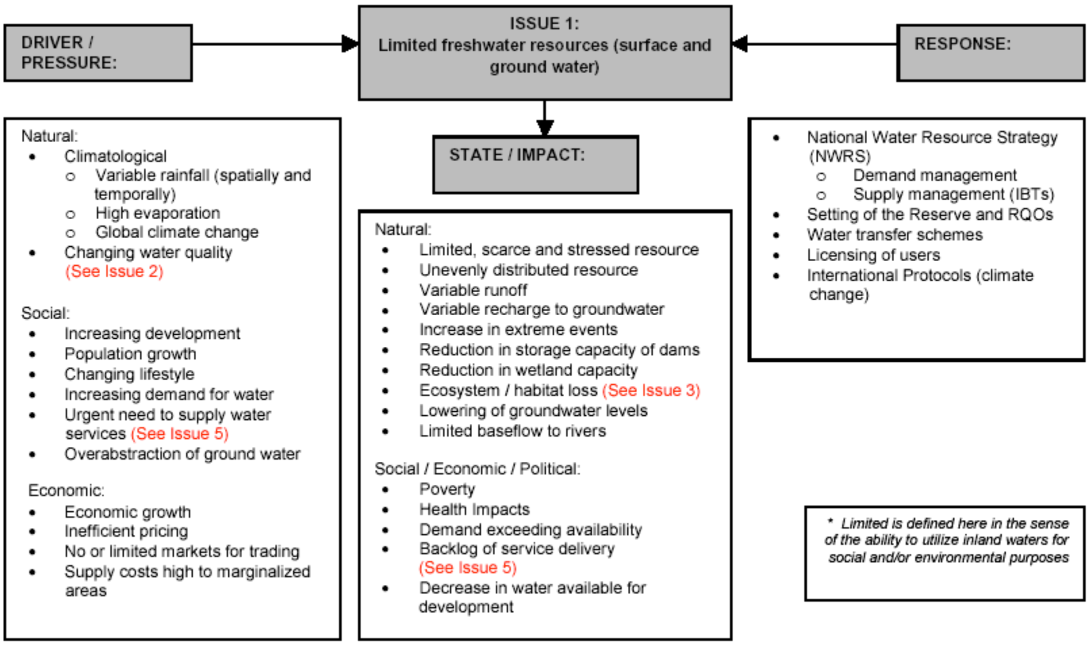


Figure IW1 Diagram showing the main driving forces affecting South Africa's inland water resources (modified from DEA&T, 1999).

[6] See http://www.environment.gov.za/soer/indicator/Inland_Water.htm & http://www.environment.gov.za/soer/indicator/docs/Volume1.pdf

Figure 9: Conceptual DPSIR framework for issue 1: Limited freshwater resources.



References and further readings

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EEA 2003: Europe's water: an indicator-based assessment:
http://reports.eea.eu.int/topic_report_2003_1

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EEA 1999: Environmental indicators:Typology and overview
Technical report No 25. Available at http://reports.eea.eu.int/TEC25/en/tab_content_RLR

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http://water.eionet.eu.int/

GIWA Causal chain analysis
http://www.giwa.net/caus_iss/causual_chain_analyses.phtml

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South Africa - State of the Environment Reporting: Indicators
http://www.environment.gov.za/soer/indicator/index.htm
Inland water indicators http://www.environment.gov.za/soer/indicator/Inland_Water.htm