1.2: DPSIR

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Learning objectives

You should be able to:

- list and describe the five categories of DPSIR;
- structure a simple environmental problem using the DPSIR framework;
- describe the position and role of environmental toxicology within the DPSIR framework;
- indicate the most important advantages and disadvantages of the DPSIR framework.

Keywords: Drivers, pressures, state variables, impacts, responses

On the one hand, environmental toxicology is rooted in more fundamental scientific disciplines like biology and chemistry where curiosity is an important driver for gathering new knowledge. On the other hand, environmental toxicology is a problem-oriented discipline. As such, it is part of the broader field of environmental sciences which analyses the interactions between society and its physical environment in order to promote sustainability. Within this context, knowledge about the interactions of substances with the biotic and abiotic environment is being generated with the ultimate aim to prevent and address potential pollution problems in society. To be able to contribute optimally, an environmental toxicologist should know how pollution problems are structured and what the role of environmental toxicologists is in analysing, preventing and solving such problems. A widely used framework for structuring environmental problems is DPSIR. DPSIR stands for Drivers, Pressures, State, Impacts and Responses (Figure 1). The aim of the current section is to explain the DPSIR framework.

Communication tool

Communication is essential when analysing and addressing societal issues such as environmental pollution. As an environmental toxicologist, you will have to communicate with fellow scientists to develop a common understanding of the pollution problem, and with policy makers and stakeholders (e.g., producers of chemicals and consumers that are being exposed to chemicals) to explain the scientific state of the art. It is likely that you will use terms like "cause", "source" and "effects". However, not everybody will use and perceive these terms in the same way. Some people may argue that a farmer is the main cause of pesticide pollution, whereas others may argue that it is the pesticide manufacturer, or even the increasing world population. Likewise, some people may perceive the concentration of pesticides in water as an effect of pesticide use, whereas others may refer to the extinction of species when talking about effects. These differences may result in miscommunication, complicating scientific analysis and the search for appropriate solutions.

The DPSIR framework is a tool that helps preventing such communication problems. It provides a common and flexible frame of reference to structure environmental issues by describing these in terms of drivers, pressures, state (variables), impacts and responses (Figure 1). Flexibility is an important characteristic of the framework, enabling adaptation to the problem at hand. The DPSIR framework should not be considered a panacea or used as a mould that rigidly fits all environmental issues. Its main strength is that it stimulates communication between scientists, policy makers and other actors and thereby supports the development of a common understanding.

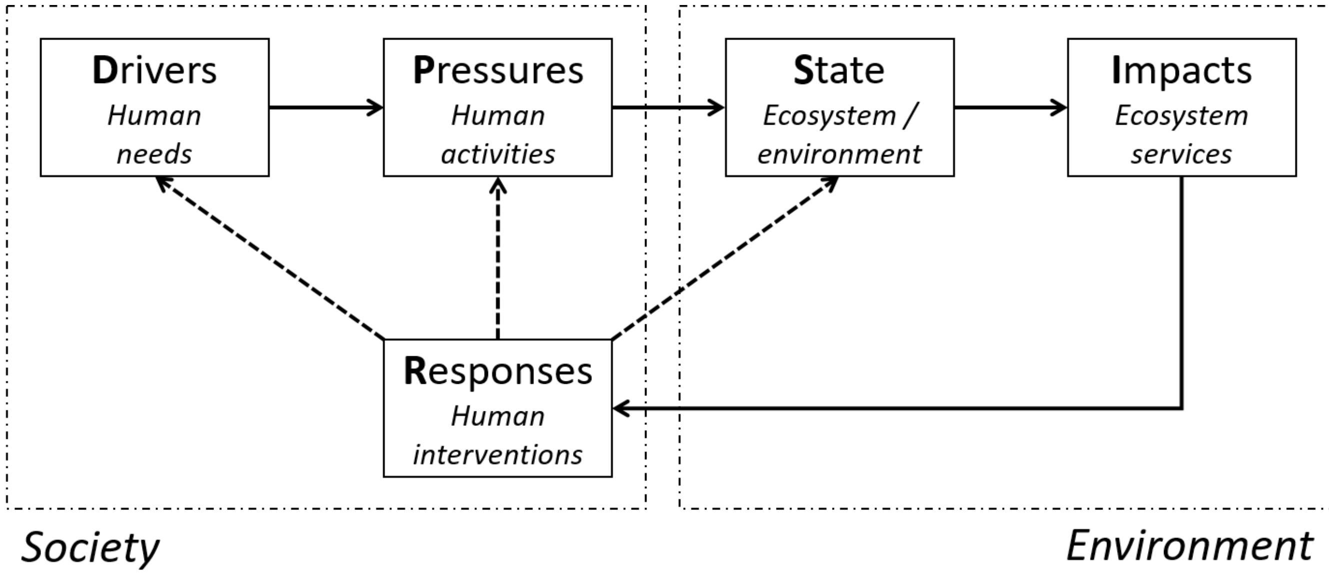

Figure 1. The DPSIR framework is a tool to structure environmental issues by organizing the processes in Drivers, Pressures, State (variables), Impacts and Responses. Source: Ad Ragas.

The framework

The DPSIR framework essentially is a cause-and-effect chain that aims to capture the main processes involved in an environmental issue; from its origin to the changes it triggers in the environment and in society. These processes are organized in five main categories, i.e.:

- are the human needs underlying the human activities that ultimately result in adverse effects. An example is the human need for food resulting in the use of pesticides such as neonicotinoids.
- are human activities initiated to fulfil human needs and resulting in changes in the physical environment that ultimately lead to - often unforeseen - adverse consequences for the environment or certain groups of society that are perceived as problematic, either now or in the future. An example is the use of neonicotinoids in agriculture.
- refers to the status of the physical environment. The state of the environment is often quantified using observable changes in environment parameters, e.g., the concentration of neonicotinoids in water, air, soil and biota.
- are any changes in the physical environment or society that are a consequence of the environmental pressures and that are perceived as problematic by society or some groups in society. An example is the increasing bee mortality that is, at least partly, attributed to the use of neonicotinoids. Or the human health effects of pesticides.
- are all initiatives developed by society to address the issue. These can range from gathering knowledge to developing policy plans and taking measures to mitigate effects or reduce emissions. Examples include the introduction of a risk-based admission procedure for neonicotinoids, the introduction of more efficient spraying techniques, and the development of environmentally friendly pest control techniques.

In principle, any environmental issue can be captured in a DPSIR. But it is important to realize that the labelling of processes as either drivers, pressures, state (variables), impacts or responses is likely to differ between people since the categories are broadly defined and the level of detail in the processes considered may vary. For example, some people may argue that "agriculture" should be classified as a driver, whereas others may argue it is a pressure. Yet other people may deal with this issue by adapting the DPSIR framework, i.e. by adding a new category called "human activities" that is placed in-between the drivers and the pressures. Another typical issue is the labelling of consecutive changes in the physical environment such as rising CO_2 levels, increases in temperature and changes in species abundance. These changes can be labelled as changes in consecutive state variables, i.e. state variables of 1st, 2nd and 3rd order. The idea is that 1st order changes trigger 2nd order changes, e.g. rising CO_2 levels triggering a rise in temperature, and 2nd order changes trigger 3rd order changes, in this case a shift in species abundance. The change in species abundance may also be labelled as an impact, provided this change is perceived as problematic by (groups in) society. The category "impacts" is closely related to the protection goals of risk assessment (see the Section Ecosystem services and protection goals). If there is consensus in society that an impact should be prevented, it becomes a protection goal. All these examples illustrate that the DPSIR framework should be applied in a flexible way and that communication is essential.

Environmental toxicology mainly focuses on the Pressures, State and Impacts blocks of the DPSIR chain. The use of chemicals by society, e.g. in agriculture or in consumer products, and their emission to the environment belongs to the Pressure block. The fate of chemicals in the environment and their accumulation in organisms belongs to the State block. And the adverse effects triggered in ecosystems and humans belong to the Impact block. An important step in risk assessment of chemicals (Chapter 6) is the derivation of safe exposure levels such as the Predicted No Effect Concentration (PNEC) for ecosystems or the Acceptable Daily Intake (ADI) for humans. In terms of DPSIR, this boils down to defining an acceptable impact level (e.g. a zero effect level or a 1 in a million tumor risk) and translating this into a corresponding state parameter (e.g. the chemical concentration in air or water). Fate modelling (Section on Modelling exposure) aims to predict soil, water, air and organisms (all State parameters) based on emission data (a Pressure parameter).

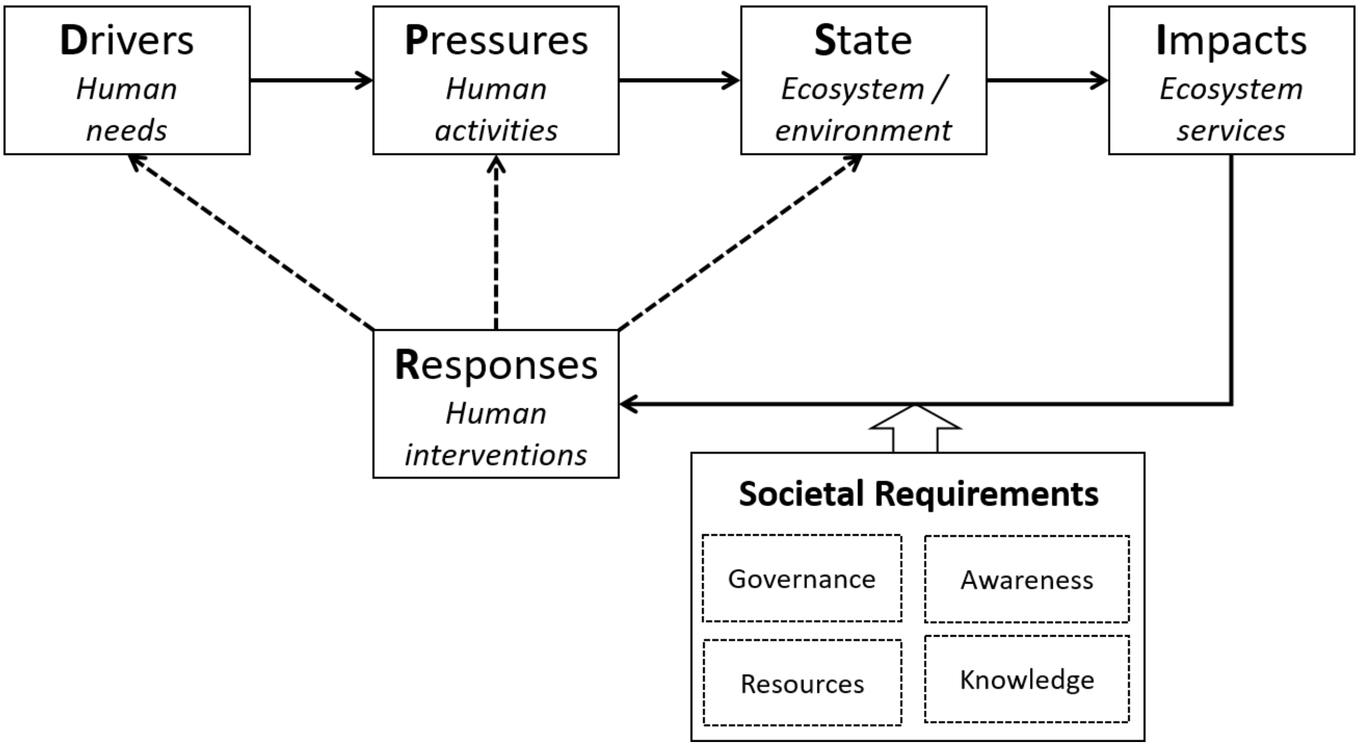

Figure 2. The extended DPSIR framework to put more emphasis on the societal dimension, i.e. governance, awareness, resources and knowledge. Source: Ad Ragas.

The DPSIR framework has been criticized because it tries to capture all processes in cause-and-effect relationships, resulting in a bias towards the physical dimension of environmental issues, e.g. human activities, emissions, physical effects and mitigations measures. The societal dimension is less easily captured, e.g. knowledge generation, governance structures, resources needed to implement measures, awareness and societal framing of the problem (Svarstad et al., 2008). Although the DPSIR framework can been adapted to accommodate some of these aspects (e.g., see Figure 2), it should be acknowledged that it has its limitations. Several alternative frameworks have been developed, and some of these better capture the societal dimension (Gari et al., 2015; Elliott et al., 2017). Nevertheless, DPSIR can be a useful framework to contextualize the problems that are addressed in environmental toxicology. It nicely shows why knowledge on the fate and impact of chemicals (state and impacts) is needed to address pollution issues and that the use of this knowledge is always subject to valuation, i.e. it depends on how society values the adverse effects triggered by the pollution. DPSIR is also widely used by national and international institutes such as the European Environment Agency (EEA), the United States Environmental Protection Agency (US-EPA) and the Organisation for Economic Cooperation and Development (OECD). The DPSIR framework is sometimes also used as a first step in modelling, especially its physical dimension. Once relevant processes have been identified, these are then described quantitatively resulting in models that can be used to predict environmental concentrations or ecological effects of substances based on knowledge about human activities or emissions.

References

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1.2. Question 1

Indicate whether the following phenomena should be labelled as drivers, pressures, state (variables), impacts and responses.

1. The number of fish in a water body
2. The pesticide concentration in a water body
3. The development of a new spaying technique to reduce pesticide emissions
4. The need for food
5. Crop cultivation
6. Spraying pesticides

1.2. Question 2

Pharmaceuticals are being used to protect the health of humans, farm animals and pets. After use, part of these pharmaceuticals may reach the environment where they may trigger adverse effects in ecosystems. In theory, humans may also be affected, e.g. after swimming in polluted surface water or consumption of polluted drinking water. Besides direct toxic effects, antibiotics may also result in the emergence of antibiotic resistance, which threatens human health.

List the most important drivers, pressures, state (variables), impacts and responses for the issue of "pharmaceuticals in the environment".

1.2. Question 3

On which blocks of the DPSIR framework do you focus when you work as an environmental toxicologist?

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