Framework for system understanding - DPSIR

Framework for system understanding (DPSIR)

Type: Framework

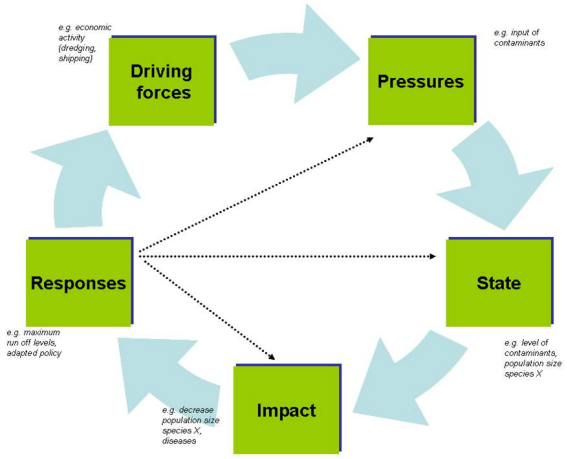
Project Phase: all – most effective in initiation phase

Purpose: Identifying cause-effect relations within a system (environmental & socio-economic)

Requirements: Systems thinking, data availability

Relevant Software: none

About



The DPSIR (Driving Forces-Pressures-State-Impacts-Responses) describes the assumed chain of causal links between **Driving forces** (D) and the resulting environmental **Pressures** (P), their effects on the **State** of the environment (S), the **Impacts** (I) and the societal **Responses** (R) resulting from these changes in the environment. DPSIR has been developed by OECD, the Organisation for Economic Cooperation and Development (OECD, 1993). The DPSIR framework helps to design environmental assessments, to identify indicators, and to communicate results. It can be applied by a wide range of different users. A thorough understanding of the system is vital to the design process of BwN projects. DPSIR has provided the basis for national and international initiatives and is commonly used by the European Environment Agency in the execution of integrated environmental risk assessment studies. It is used to integrate socio economic and ecological processes to understand the forces that drive patterns of ecosystem changes (e.g. EEA, 1999).

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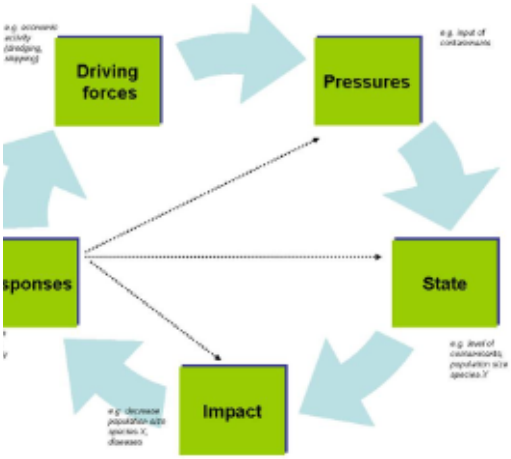
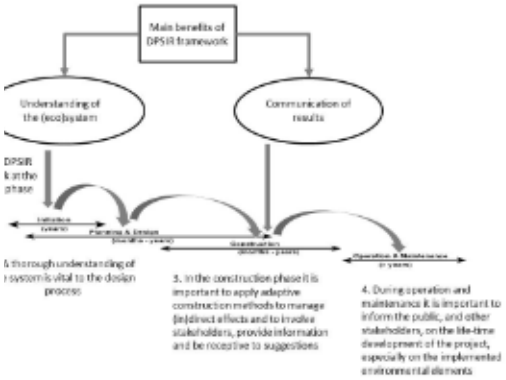


ition of DPSIR elements

Driving forces: the socio-economic and socio-cultural forces driving human activities, which increase or mitigate pressures on the environment. In this report human activities are taken into account as Drivers.
Pressures, the stresses that human activities place on the environment, such as pollutant emissions.
State, or state of the environment, the condition of the environment.
Impacts, the effects of environmental degradation, e.g. biodiversity loss (relative to a previous State).
Responses, refers to the responses by society to the environmental situation, e.g cleaner production.



DPSIR and project phases

This tool has proven to provide a basis for identifying the main activities (drivers), pressures, state descriptors, impacts and responses, and for visualising causal chains. It is possible to use the DPSIR framework within all phases of a project:

Note: Although in the figure an example of a negative cause-effect chain is visualised, DPSIR is also applicable to positive cause-effect chains.

Initiation phase Ideally, DPSIR should be applied early in the project, i.e. in the initiation phase, because this is where it will be the most effective. The goal of BwN-involvement in this phase is to guarantee that scoping goes beyond sectoral interests and limited problem perceptions, focusing on opportunities and win-win solutions. During this phase sufficient insight into the functioning of the system needs to be achieved, including the identification of functional links between the project aims, the ecosystem, related stakes and the economy. DPSIR can be used to bring socio-economic and ecological aspects together in order to understand the forces that drive ecosystem changes.

Planning and design A thorough understanding of the system (complete mapping of D, P and S) is vital to the design process, in which impact estimates play a crucial role.

Construction In the construction phase it is possible to apply adaptive construction methods in order to manage direct (and if possible indirect) effects of the works and to involve stakeholders, provide information and be receptive to suggestions. The DPSIR framework provides support to both. Insight into the Impact and Response are particularly important here.

Operation and maintenance During the operation and maintenance phase it is important to inform the public, and other stakeholders, on the life-time development of the project, especially on the implemented environmental aspects. Clear information, e.g. through modern media, will add to the perception and potentially to the use of the project and its integration in society. Here, too, the DPSIR framework provides support to both.

Decommissioning Decommissioning phase can be regarded as a “driver” or activity within a project. In this respect, the specific DPSIR usage as described in the prior phases (describes above) can be taken into account within the decommissioning phase. Thus, as visualised in Figure 2, applying the DPSIR framework in the early stages of a project will benefit the whole project.

How to Use

DPSIR should be seen as a descriptive, not a prescriptive framework. It helps to structure on-going investigations. In this sense it can be used qualitatively as well as quantitatively. Qualitative application helps to further define the scope and relevant aspects of an environmental assessment, quantitative description helps to establish the significance of each aspect. The tool can be used by governmental organisations, (marine) construction companies, scientists, consultants and NGO’s to get grip on various aspects of the effects of human activities on the environment.

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A stepwise approach can be followed to structure ongoing analysis:

1. Define the objectives of the assessment.
2. Delineate the scope of the assessment: what are the drivers, specific pressures, states or impacts to focus on in the project?
3. Gather information on each of the aspects of D-P-S-I and R. This can be done by literature search, by expert and stakeholder interviews, or by applying auxiliary tools, such as models.
4. Analyse, correlate and discuss the relevant aspects in the light of the environmental issue at hand.
5. Explore potentially suitable response measures.

Recommendations and advice

Applying a DPSIR framework to a project is strengthened by a solid knowledge base, and the result highly depends on data availability. It is recommended to address various sources of information, including industry sectors, science, NGO’s and government. If data are lacking, it is advised to use auxiliary tools (models, GIS, expert judgement) if available.

In the case of Building with Nature projects, the lack of data on environmental issues is a concern, in particular if BwN measures are taken in an area with many other activities. Building with Nature measures meant to achieve positive effects on the environment may then be annihilated by negative effects resulting from other activities. In order to fully exploit the potential of Building with Nature measures it may be good to consult government agencies and private parties dealing with the specific issue at hand, to raise mutual awareness and to join forces to improve ecosystem performance. DPSIR helps to identify and analyse the relevant aspects.

Practical Applications

The tool was applied in the Singapore case of the BwN programme to structure information on environmental risks and impacts ensuing from various activities in the coastal zone (other than dredging). Here we focus on water quality aspects, with the emphasis on pressures, state and impacts.

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The marine ecosystems of Singapore are exposed to pressures resulting from a large number of human activities, such as land reclamation and coastal protection works. Around Singapore, marine ecosystems such as sea grass meadows, coral reefs and mangroves are in decline, possibly as a result of altered hydrodynamic, sedimentation and turbidity patterns in the coastal waters. Ecodynamic infrastructure development, aimed at maximising the potential of the local ecosystems, are taken to improve the status of these ecosystems. Furthermore, the quality of the marine waters around Singapore is key to the ecosystem health. Poor water quality may hamper the recovery of ecosystem elements, and reduce or annihilate the effectiveness of ecodynamic infrastructure development. The actual water quality is therefore important to put BwN-measures in the right context. Water quality factors considered in Slijkerman et al. (2011) are contamination and nutrient status. The DPSIR framework was used to structure information on water quality for each aspect by structuring the information via the DPSIR elements. By doing this, the most relevant relationships between activities and ecosystem impacts could be designated through water quality aspects.

Drivers
Singapore has a highly developed and successful free-market economy. The economy depends heavily on exports, particularly in consumer electronics, information technology products, pharmaceuticals, and on a growing service sector (CIA 2009). The Port of Singapore, one of the world's largest in terms of shipping tonnage, is key to Singapore's prosperity and economic health (EIA 2007). All these activities will exert pressures on the environment (see Table 1). Drivers in Singapore affecting water quality can be onshore or offshore based. Land-based activities responsible for nutrient emissions are e.g. sewage treatment plants, but indirect emissions from agricultural activities, entering the coastal waters via Singaporian or Malaysian rivers, are important to consider. Aquaculture and shipping are the main activities for nutrient emissions offshore. The input of contaminants to the environment relates to many activities. Depending on the compound, specific sources can be identified.

Table 1: Overview of activities in Singapore and (potential) related pressures on water quality

	Pressures	
Drivers	**Input of contaminants**	**Nutrient enrichment**
Agriculture	X	X
Aquaculture	X	X
Oil refineries and petrochemical industry	X	
Desalinitation facilities	X	
Docking	X	
Port activity	X	
Shipping	X	X
Wastewater treatment plants	X	
Dredging	X	
Coastal reconstruction & Land reclamation, including land fills	X	
Construction of dams (and causeways)	X	
Land based activity (includes various activities that contribute via run off and atmospheric deposition)	X	X

Pressures

Pressures are defined here as the stresses human activities exert on the environment. Pressures can be described in terms of habitat damage or loss, due to e.g. smothering, underwater sound, marine litter, contamination or nutrient enrichment. In Slijkerman et al. (2011) only pressures related to chemical water quality are addressed, the aim of the study being to assess the impact of water quality deterioration due to human activities on the local coastal ecosystems. The main pressures known to determine the quality of the marine environment of Singapore are listed in Table 2 and described in chapter 3 of Slijkerman et al. (2011). It should be noted that information on pressures, thus the actual emissions to the environment per activity, is limited and a comprehensive overview is therefore not provided in the report.

Table 2: Overview of pressures in Singapore's marine ecosystem and (potential) related state descriptors of the marine environment.

Pressures	**State**							
	level of nutrients	**Contaminant concentrations in water and sediment**					**Ecosystems**	**Contaminant concentrations in biota**
		Heavy metals	**Phenols**	**Pops**	**Pahs**	**Antifouling compounds**		
Nutrient enrichment	X						X	
Input of antifouling compounds						X	X	X

Input of heavy metals		X					X	X
Input of PAHs					X		X	X
Input of POPs (PCBs, pesticides				X			X	X
Input of petrochemicals/oil			X		X		X	X

POPs (Persistent Organic Pollutants); PAHs (Polycyclic Aromatic Hydrocarbons); PCBs(PolyChlorinated Biphenyls)

State

The state of Singapore's marine environment can be described by several state descriptors. A number of such state descriptors and the related impacts are presented in next Table 3. Extensive information of the state of the marine environment of Singapore regarding nutrient levels, contaminant concentrations (in water, sediment and biota) and ecosystems can be found in Slijkerman et al. (2011). As studies on state and contamination are relatively recent and isolated, no historical trends could be deduced. Note that most reported studies were performed in 2000-2006, so the actual water quality may differ from the reported one.

Table 3: State descriptors for Singapore waters, including the related impact.

State	**Impact**		
	Eutrophication	**Contamination effects***	**Contaminants in biota****
Nutrients	X		
Heavy metals		X	X
Phenols		X	X
POPs		X	X
PAHs		X	X
Antifouling compounds		X	X
Ecosystems		X	
Contaminants in biota**		X	

* Contaminations of water and sediment (i.e. state descriptor) could lead to contamination effects and/or contaminansts in biota (i.e. impact).

** Contaminants could be measured in water, sediment and/or biota as State descriptors. In Slijkerman et al. 2011 indicators are provided.

Impact

Nutrient influxes may stimulate primary production that in turn may lead to an increase in phytoplankton biomass and sustain elevated levels of phytoplankton standing crop. Further nutrient increase can lead to the formation of Harmful Algal Blooms (HABs) and subsequent oxygen depletion. The magnitude and extent of the impacts of nutrient enrichment in Singapore's coastal waters is usually determined by complex local factors. Toxicity effects observed in the marine environment of Singapore could be attributed to different contaminants, such as heavy metals, petroleum compounds and organotin compounds.

Due to the limited availability of local information on impacts of water quality aspects, additional evaluations were performed to fill in data gaps. Interviews with local experts were held and an environmental risk assessment for both nutrient state and contaminant state was carried out. Interviewed experts generally agreed that turbidity and sedimentation are the most important factors affecting the viability of coral reefs and sea grass meadows, but water quality may also be an important factor. So far, the latter has not been considered extensively, by lack of data. Chemical water quality aspects (nutrients, heavy metals and other toxic compounds) are considered less important, but an overview of concentrations of pollutants and their effects is lacking and conclusions cannot easily be drawn.

In Slijkerman et al. (2011) the evaluation of possible impacts of nutrients enrichment in the Singapore marine environment was performed using two approaches: ASSETS and OSPAR. Both assessments were strongly hampered by the limited data availability, but it was concluded that for the entire Johor Strait the susceptibility to eutrophication remains high. The analysis indicates that the situation in Singapore Strait is likely to worsen. A relative increase in nutrients originating from a much larger region and numerous river inputs is to be expected. This may increase the impact of eutrophication. Only if pressures (over a much wider area than the Singapore region alone) are reduced and natural biological communities have the opportunity to recover, the situation may improve.

The evaluation of the impact of contaminants is performed using the PEC/PNEC approach . This methodology is commonly used as a first tier in ecotoxicological studies. This first-tier environmental risk assessment leads to the conclusion that the marine environment of Singapore faces a high risk to be affected by water quality, as reported in various scientific references. Especially the alkylphenol concentrations are of serious concern, as calculated risk factors are extremely high. No risk of heavy metals is to be expected, and PAHs are of minor concern. TBT risk factors are high, but due to the ban on TBT-containing paints, this risk will phase out with time.

Response
Since the lack of data made it impossible to assess the water quality impacts very well, the Response element in the DPSIR framework is not addressed in Slijkerman et al. (2011). The Response element deals with questions such as “What are we doing about it, or what can be done about it?” and reflects the societal and political response to the previous element in the framework. One societal response to the issue of water quality in the Singapore coastal waters would be better regulation, but this requires much more information than presently available.

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