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Notes on its definition and application

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The DPSWR Social-Ecological Accounting Framework: Notes on its Definition and Application

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Introduction

Social-ecological accounting frameworks organise information on aspects of social (i.e. human) and ecological systems relevant to representing the interactions between them. By using standardisation of information categories as an organising principle, these frameworks make the understanding of such interactions and environmental decision-making more tractable.[1]

These qualities have been recognised for some time – the DPSWR framework described here is evolved from the DPSIR (Driver-Pressure-State-Impact-Response) framework, which in turn can trace its heritage back to the S-RESS (Stress-Response) framework of Friend (1979). More recently, the usefulness of such frameworks, with their inherent recognition of the interconnection between social and ecological systems, has been reinforced by the adoption of the "ecosystem approach" in various management contexts (see, for example, Farmer et al., 2012; EU, 2008; CBD, 2000; Environment Canada, 1995). The ecosystem approach similarly entails recognition of the essential interconnectedness of human activities and the ecological systems that support them.

The DPSIR framework is similar to its predecessors in that its information categories are based on causal relationships and these categories are intuitively understandable, e.g. distinguishing between human activity and ecosystem change. Unlike some of its predecessors, DPSIR aims for comprehensiveness in that its information categories seek to encompass the full cycle of interaction: the human causes of ecosystem change, the nature of that change, and its consequences. This comprehensiveness has no doubt contributed to its popularity, manifested in its adoption in the study of a wide range of environmental issues from soil erosion (Gobin et al., 2004) to coastal zone and marine management (Atkins et al., 2011; Bowen and Reilly, 2003; Cave et al., 2003). However, the usefulness of the DPSIR framework more generally is circumscribed by its lack of a universally agreed set of definitions for its information categories and lack of a clear conceptual underpinning.

These definitional and conceptual limitations are outlined in the next section in the context of an effort to adopt DPSIR in a single project, the European Commission FP6 project ELME (European Lifestyles and Marine Ecosystems), which involved various environmental issues over a broad geographic range, requiring a standardised set of informational categories meaningful for policy analysis. The following section sets out a modified form of DPSIR that seeks to overcome these limitations. This modified framework, referred to as mDPSIR, was employed in the ELME project and, with a minor

[1] As a contribution to these processes, social-ecological accounting frameworks may also support modelling of social-ecological interactions but they are *not* intended to constitute models in themselves.

change in nomenclature to become the DPSWR framework, is being employed in the FP7 project KnowSeas. The penultimate section provides some guidance on the application of the DPSWR framework and the final section highlights its advantages and the scope for further development. Although attention is directed towards marine ecosystems in this brief, it is stressed that DPSWR is defined in general terms so that it may be used in the investigation of a wide range of human activities and ecosystem changes.

In summary, the purpose of this brief is to define the DPSWR framework and comment on its application. A separate publication will provide a more detailed justification of the framework and expand the discussion of its application.

DPSIR and its Limitations

A precisely defined set of information categories may be argued to be unnecessary to the practical application of an accounting framework, provided there is a generally understood concept of what each category represents, since this allows users the opportunity to refine the framework to meet their particular needs. However, this approach means there is scope for a lack of comparability between studies, even of the same issue, which obstructs the accumulation of knowledge, for example about the consequences of specific human activities or the causes of specific ecosystem changes.

These challenges were highlighted in the ELME project, which involved teams of researchers working independently on a range of issues, including eutrophication, habitat loss and fisheries, in each of Europe's four seas. A common set of information categories was therefore essential to the aggregation of results in this case. Furthermore, in defining this set of categories, the opportunity was taken to seek to improve the conceptual underpinnings of the framework, particularly with a view to supporting economic analysis and accountability. These modifications to the DPSIR framework, based on the challenges faced in the ELME project, are described below.

Discussion of the DPSIR information categories is structured around the definitions of the European Environment Agency (EEA, 1999) and subsequently modified in its glossary (EEA, 2010), as shown in Table 1. The EEA is considered an authoritative source since the Agency or the European Commission have been cited as the source for the framework (e.g. Bowen and Riley, 2003) and these definitions have been widely applied by the EEA (e.g. EEA, 2007) and in projects for the Commission (e.g. Eurostat, 1999).

Table 1. Summary of DPSIR information categories per EEA

Driver	Pressure	State	Impact	Response
Driving force** *social, demographic and economic developments in societies and the corresponding changes in life styles, overall levels of consumption and production patterns*	Pressure** *developments in (the) release of substances (emissions), physical and biological agents, the use of resources and the use of land*	State (indicator)* *condition of different environmental compartments and systems in physical, chemical or biological variables*	(Environmental) impact* *impacts on human beings, ecosystems and man-made capital resulting from changes in environmental quality*	Response** *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*

Sources: *(EEA, 2010), **(EEA, 1999)

The following critique of the definitions in Table 1 is outlined under the two broad headings described above, definitional uncertainty and limited conceptual underpinning. To illustrate key points, the issue of eutrophication resulting from the use of man-made fertilisers in agriculture is employed.

Definitional uncertainty

1. Both the Driver and Pressure definitions refer to "developments", suggesting that they necessarily reflect changes in level. It is then unclear how they can encapsulate steady-state activities that nevertheless result in ecosystem change.

   In the example of eutrophication, the definitions as they stand correspond to social-economic factors, such as growing demand for animal protein, leading to increased demands on agricultural output of fodder crops (Driver) and the consequent changes in the release of eutrophying agents (N, P, K) into watercourses (Pressure). This is a valid construct but limited in that it does not capture information on the inter-relation between these factors and eutrophication where there is no change – even without growth in the demand for agricultural output, the continuing use of man-made fertilisers contributes to eutrophication.

2. The definition of State refers to indicators of "different" aspects of environmental systems. Thus, it is distinct from the definitions of other categories in that it refers to measurement (indicators) rather than the nature of the category which is the subject of measurement. Furthermore, it is unclear whether "different" refers to alternative measures relevant to a given environmental issue or that a range of issues needs to be encompassed in any analysis of a system. The former interpretation appears more consistent with definition by reference to measurement but highlights the need for a definition of what is to be measured.

3. Since Impact is defined to include effects on ecosystems, it is unclear where the boundary lies between State and Impact.

   Referring to the eutrophication example, the envisaged distinction in DPSIR could be between eutrophication as the relevant State and its consequences, such as the effects of hypoxia on particular species, as the Impact. However, this division would introduce an artificial distinction since ecosystem changes attributable to eutrophication would also fall in the State category since they reflect the "condition of different environmental compartments and systems". Thus, ecosystem changes attributable to eutrophication could be treated as a manifestation of Impact or an aspect of State.

   Alternatively, if State is taken to represent the availability of eutrophying agents, then Impact would embrace both the extent of eutrophication and its consequences. In this case, the Impact category would be seeking to encapsulate too wide a range of information, particularly given its inclusion of consequences for human systems (see further below).

4. The information categories are defined independently rather than by reference to one another. This may be just a matter of wording, but linked definitions would emphasise their inter-relatedness and enhance the user's ability to adopt the framework in their analysis.

Conceptual underpinning

1. Aside from the issue of restricting attention to "developments" in the Driver-Pressure relationship, the definitions of Driver, Pressure and State compress the representation of several potentially independent variables and may thus disguise decoupling.

   In the eutrophication example, there are three relevant relationships which might be captured by the Driver, Pressure and State categories:
   - demand for agricultural output and use of fertilisers
   - use of fertilisers and the amount of eutrophying agents available to cause eutrophication
   - the amount of eutrophying agents and the extent of eutrophication.

   Thus, there are four variables but only three categories to capture them. The first variable (demand) may be aligned with the Driver category, the second (use of fertilisers being a "release") with the Pressure category and the fourth (eutrophication) with the State category. This analysis allows scope to assess decoupling between demand and fertiliser use (categorised as Driver and Pressure respectively), and between this use and eutrophication (Pressure and State respectively). However, this approach to analysis compresses information on the complex scientific processes intermediating fertiliser use over some area and eutrophication at another, by leaving out the third variable, the amount of available eutrophying agents.

   Alternative approaches would be either to include the availability of eutrophying agents in the State category or combine demand and fertiliser use in the Driver category. These approaches are both unsatisfactory in their own ways. In the first case, putting two environmental issues in the same category obscures the focal issue (eutrophication) and, again, the possibility of changes in the relationship between them. In the latter case, the potential decoupling of agricultural output and fertiliser use is obscured. Transparency in such relationships is particularly important as they manifest different aspects of human systems that constitute alternative targets for Response actions.

2. Defining Impact to include effects on human and ecological systems conflates highly distinct concepts, with their own systems of measurement, and disguises the link between them. Furthermore, defining the ultimate consequences of anthropogenic ecosystem change in this way complicates comparison with the human activities that gave rise to them and thus hampers decision-making as to Response. Separating these two forms of Impact would isolate the effects on human systems commensurate with Driver measures.

To illustrate with the eutrophication example, say that the ecosystem Impact measure is X, representing chemical or biological change due to agents derived from fertiliser use, and a separate measure of human impact is necessary, say Y, representing the external costs of this ecosystem change, e.g. loss of consumer surplus due to the diminution of commercial fishery stock. It is Y that is comparable to Driver measures. For example, if this measure is the consumer surplus derived from agricultural output, Z, then there is direct commensurability, i.e. it is possible to compare cost, Y, with benefit, Z.

Modifying DPSIR – Definition of DPSWR

Although the above critique of the DPSIR framework is fairly extensive, the core ideas of DPSIR remain useful, and a modification, rather than the introduction of a wholly new framework, is adequate to deal with the identified limitations. This avoids a radical reform that might be problematical in other ways and is in the spirit of the evolution of social-ecological accounting frameworks to date.

In modifying DPSIR to address the definitional and conceptual limitations discussed in the previous section, two guiding principles are adopted:

- aligning categories with either human systems or ecological systems as far as possible so as to support commensurability between categories of information relating to human systems, and
- avoiding the introduction of new categories so as to keep the overall number to the minimum possible.

The specific modifications follow from the above critique and may be summarised as follows:

Segregating Impacts and Renaming

In mDPSIR, the Impact category was reserved to impacts on human systems in order to support comparison with the value of Driver activities, with ecosystem changes treated as part of the State category. Although this modification was successfully adopted in the analyses of the ELME project, natural scientists found it difficult to employ the word "impact" exclusively in this context and instinctively used it to encompass ecosystem change.[2] Consequently, in the KnowSeas project the category was renamed as Welfare to connote the restriction of the former Impact category to human system effects, while the term Impact encompasses State and Welfare as alternative forms of impact.

Expanding the Scope of State

Moving ecosystem change from the Impacts category to the State category makes it unnecessary to draw a distinction between the two categories. In the modified framework, the State category thus encapsulates the environmental or ecosystem change(s) relevant to the analysis in hand. Related changes that are not captured by the modified Pressure category (see below) are also included in the State category.

[2] I am grateful to Laurence Mee for this insight.

Pressure as a Linking Mechanism

This category in DPSIR implies human agency but in the modified framework it takes on a broader meaning as representing the mechanism or process that intermediates between human action and the State that is of interest. As such, it becomes more conceptual and open to various uses dependent on the relevant analysis.

Distinguishing Levels of Driver

The key modification here is to focus the category on human activities that give rise to Pressure on natural systems so that the relation between the two is more explicit; DPSIR refers to large scale and potentially long-term changes in human systems which are at some remove from specific activities that precipitate ecosystem change. Nevertheless, some scope needs to be offered for recognising these broader changes as well as the immediate activities associated with Pressure(s). Consequently, the definition of Driver in the modified framework highlights an activity or process within the human system but allows separation between immediate Drivers (those proximate to Pressures) and underlying Drivers (corresponding to the Driver category in DPSIR).

These modifications are embodied in the definitions of information categories in the modified framework shown in Table 2. To distinguish this framework from mDPSIR, it is referred to as the DPSWR framework, reflecting the renaming of the Impact category.

Table 2. Definition of DPSWR information categories

Information Category	Definition	Commentary
Driver	An activity or process intended to enhance human welfare.	▪ Human welfare has a broad economic meaning so that the category covers anything done that is intended to be for the benefit of at least one person. ▪ Activities may be organised according to economic sectors.[a] ▪ Where necessary the category can be split between: - Immediate Drivers: activities proximal to at least one Pressure. - Underlying Driver: population, economic, social and technological factors that influence the level/nature of Immediate Drivers.
Pressure	A means by which at least one Driver causes or contributes to a change in State.	Thus a pressure is a link between a Driver and a change in environmental State, effectively therefore the agent of change. Generally, it is a by-product or an unintended consequence of the Driver activity/process. It may be a human activity, although one not intended of itself to enhance welfare, e.g. the type of gear used in fishing, but may more often be a change in natural systems, e.g. the concentration of chemical pollutants .
State (change)	An attribute or set of attributes of the natural environment that reflect its integrity as regards a specified issue (or change therein).	This definition allows flexibility so that the information or measure used can be tailored to the precise circumstances that are relevant. However, often the most useful information will: ▪ relate to the extent to which a system has been subject to disturbance, particularly in terms of ecosystem functionality, and ▪ reflect changes in State over time. Natural (i.e. non-anthropogenic) variability may influence the effect of Pressures on State or change in State.
Welfare	A change in human welfare attributable to a change in State.	▪ "Change" allows for enhancement but generally we are concerned with diminution in welfare. ▪ Welfare is not only affected by changes in use values; it can be affected by changes in nonuse values that people hold (e.g. in respect of general ecosystem functionality or the viability of particular species).
Response	An initiative intended to reduce at least one Impact (State or Welfare change).	In this sense "initiative" is an action that would not have been taken in the absence of an Impact or set of Impacts. It may operate through influencing any of the above but with the intention to ultimately reduce Impact.

[a] The following sectors were used in ELME: Agriculture, Energy, Fisheries (including aquaculture), Household (including individual consumption), Industry, Tourism & Recreation, Transport, Urban Development (including development of tourism infrastructure).

Figure 1 provides a graphical summary of the DPSWR framework in Table 2, and Table 3 provides an illustration of the differences between this and the DPSIR framework using the eutrophication example employed above. Since the intended content of the Response category is unchanged, it is simply expressed differently (see further below), it is omitted from the table.

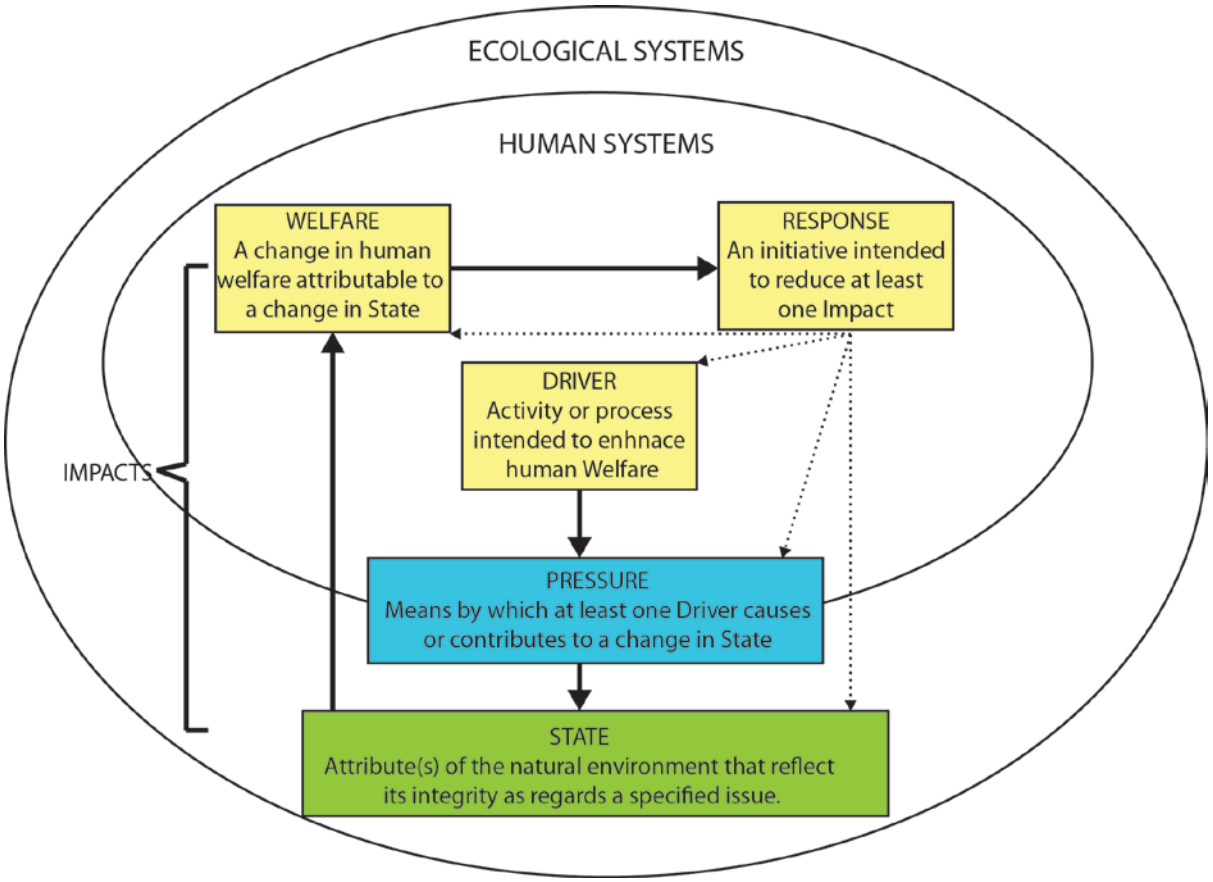

Figure 1. Outline of the DPSWR Framework

Table 3. Comparison of the DPSIR and DPSWR frameworks

DPSIR		DPSWR	
Driver	Demand for agricultural output	Underlying driver	Demand for agricultural output
		Driver activity	Use of man-made fertilisers
Pressure	"Release" of eutrophying agents	Pressure	Eutrophying agent load in water-bodies
State (indicator)	Indicators of eutrophication	State (change)	Eutrophication and it wider ecological consequences
Impact	Consequences of eutrophication for human and ecological systems	Welfare	Consequences of State for human welfare

Application of DPSWR

In addition to the substantive modifications of the category contents, the definitions in DPSWR (Table 2) are expressed in an inter-related form, turning on State as the core category. Thus, ecosystem change acts as the motivating issue for the framework definitions, but they are designed to enable the user to identify information categories relative to their category of interest. For example, the user may be interested in a particular Driver activity, in which case the definitions lead on to identifying relevant Pressures and States. However, they may be concerned with a particular ecosystem change and reversal of the definitions will enable them to identify relevant Pressures and consequently Drivers.

This flexibility in the use of the framework is intended to be reflected in the definitions given in Table 2. They are designed to overcome the uncertainties of the DPSIR framework by clarifying the nature of the information covered by each category, but they allow for some flexibility in interpretation dependent on the user's needs. Furthermore, in this context, they do not prescribe the measures to be used to represent each category, allowing the user to decide what measure is appropriate to their analysis.

Flexibility in timeframe is also afforded by the DPSWR framework. As discussed above, DPSIR's Driver and Pressure category definitions refer to "developments", i.e. changes over time. This scale of measurement is encompassed in the DPSWR framework in that Driver and State, for example, may be measured over an extended period to address questions such as: How much has State changed over the last 20 years, given the change in Driver over that period? However, DPSWR's definitions also support analysis by period rather than change over time – for example, in addressing how much State changes given a rate of Driver activity.

Concluding Remarks

The DPSIR framework has been widely used, but its definitional uncertainties have engendered variations in the application of its component information categories, limiting comparability among studies and thus the accumulation of knowledge about the interactions between human and ecological systems. While seeking to address these uncertainties and thus enhance comparability, the DPSWR framework also introduces changes that enhance the conceptual underpinnings of social-ecological accounting.

Most notably, the DPSWR framework isolates human system aspects of the interaction with ecological systems, enabling a direct comparison of the sort required by cost-benefit analysis. This reconfiguration also supports accountability within human systems. By isolating human from environmental impacts it is possible to describe which of these and to what extent they are attributable to those who perform Driver activities.

Although DPSWR has advantages over DPSIR that can support multidisciplinary research and comparability both within and among environmental studies, there is scope for further evolution. DPSWR, like its predecessors, abstracts from the spatial and temporal

aspects of the relations between information categories. Conceptualising these aspects within social-ecological accounting frameworks would advance their usefulness.

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