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## **Frameworks for Environment Statistics – A Common Denominator?**

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## 1. Introduction

There exist a lot of suggested frameworks and/or environmental information systems concerning development of environmental statistics. Examples are DPSIR (driving forces, pressure, state, impact, response), the Ecosystem approach (focusing on terrestrial, marine water, freshwater and atmosphere components of ecosystems), SEEA (system of environmental economic accounts), NAMEA (National Account Matrix including Environmental Accounts) and the capital approach (produced/physical and financial capital, human capital, environmental and social capital). In addition a lot of information initiatives have come up like the beyond GDP initiative, the Stiglitz commission, Europe 2020, Environmental indicators and Sustainable development indicators etc. We also have the MDI (millennium development indicators), the CSD (Commission development indicators) and the recent OECD initiative, the indicators for the green growth strategy.

Although all these frameworks and/or initiatives may seem different, because the point of departure for developing them is different, there possibly exist some common denominators that unite them. This is very important because of potential simplifications of the data requirements and potential data quality improvements within the statistical system that is going to support all these frameworks and form most of their information basis. The statistical system should serve these frameworks in a consistent, systematic and efficient way, i.e. having a multipurpose flexible statistical system is very important to avoid double work, double counting, confusion and resignation.

In this paper the focus is on the common features among the systems rather than on the differences in approaches, and our intention is to show that there principally exists a “general framework” that can reduce all the suggested frameworks to variants or dimensions of this general framework. This “general framework” then helps us to unite rather than disperse our thoughts about the frameworks and then to simplify the practical work of compiling environmental statistics. The discussion of choice of framework may then be reduced to a discussion of the particular focus of a separate block of such frameworks rather than of the differences between the frameworks.

To address the question of sustainability, which is an important question in environmental statistics, we need a conceptual framework: *It is necessary to have a tight, analytical sound framework from which to approach to practical decisions. Along the way corners have to be cut and qualitative judgements have to be made. But having a correct framework at the back of one's practical mind is good practise and enables us to recognize when a corner has to be cut and it forces him to search for good way to do this (Dasgupta (2001)).* This statement addresses the important question of accuracy, quality and reliability and accepts that due to measuring problems this puts the statistical community into tough methodological and practical challenges. At the same time it indirectly addresses the consistency question, i.e. consistency across different frameworks, which the statistical community should highlight in their production process of statistics.

First we start by giving a brief explanation of the main elements in the DPSIR approach, and then we continue with the SEEA/NAMEA approach, the capital approach and the Ecosystem approach.

Then we make some remarks about other initiatives and finally we try to sum up and try to set up a formal link between all these frameworks – illustrated in figures - and finally ask whether it could suffice with just one framework when working with production of the statistics. If so, the statistical system could be kind of a multipurpose system that serves all the

frameworks/initiatives in a consistent, systematic and efficient way which also eases the statistical discussions, the analyses and the environmental policy formation.

Another but related question is the role of national statistical offices vs. the role of other public agencies and environmental research institutes in the contribution of relevant statistics to fill in the frameworks with facts. A Norwegian example is presented at the end of the paper, just to show the complexity in environmental data gathering.

## 2. DPSIR or SDPI-R?

**DPSIR** (Driving forces, Pressure, State, Impact and Responses) is a causal framework for describing the interactions between society and the environment. The framework has been adopted by the European Environment Agency, forms the basis of the present framework for environmental statistics in UN and is an extension of the pressure-state-response model developed by OECD.

When we discussed this framework in Norway in the 1980s our ranking of the letters DPSIR where kind of different. We, see Alfsen, Bye and Lorentsen (1987), applied the SDPI-R ranking. This may seem to be a semantic question, but in the discussions below, especially when it comes to the ecosystem approach, this ranking may be important for the understanding of the framework and in particular for the importance of focusing on the role of policy response – as rationale for environmental statistics.

In the **State** part of the model we find information on the amount of non-renewable and renewable resources (oil, gas, minerals, land, fish, water, etc), and information on different aspects of the state of the environment (atmosphere, land, marine). The Driving forces are economic activities having effects on resources and environment, and in our context, this implies a connection between the economic accounting in the national accounts and the resulting pressure on the environment. From this driving forces elements, we derive a set of Pressure measures. The **Pressure** follows from some kind of activity that generates changes in the State, like for instance pollution that affects water quality, emissions that affect climate etc. The **Impact** part is then equivalent to the change in the State variables (for example increased CO<sub>2</sub> concentration). The State variables could be influenced by the pressure variables but also by the **Response**, which include environmental policy variables like taxes, tradable emission permit markets, regulations, investments in environmental projects etc. Note that in our interpretation the Response element of the framework only contains policy response, i.e. human response to environmental change, whereas other interpretations have suggested that it also encompasses self-remedying responses of the environment. The links between all dimensions of the SDPI-R framework may be linear, non-linear or more complex depending upon the activity.

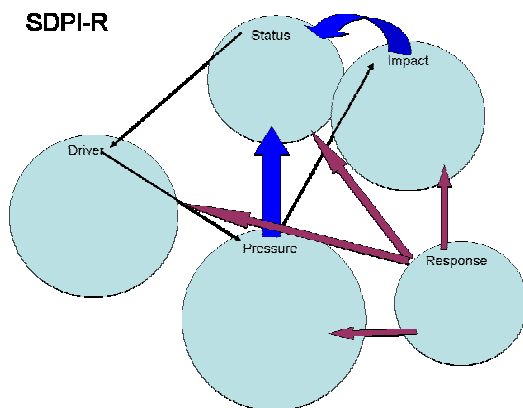
As a first step, data and information on all the different elements in the SDPI-R chain is collected. Then possible connections between these different aspects are postulated. Through the use of the SDPI-R modelling framework, it is possible then to gauge the effectiveness of environmental policy responses put into place

In Alfsen, Bye and Lorentsen (1987) we formulated the following model for generation of the necessary statistics in our SDPI-R framework.

*Table 1. The SDPI framework in Alfsen, Bye and Lorentsen (1987)*

1. Resource base (or Environment status) at date t-1
2. Adjustments of resource base in t (new discoveries, reappraisal of old discoveries)
3. Resource base at date t
  
4. Reserves – i.e. profitable resources to develop, (developed and non-developed) at date t
5. Adjustments of reserve base (new technology, new cost of extraction, new information on prices, new regulations)
6. Total gross extraction in period t
7. Use of reserves in extraction process
8. Net extraction
9. Reserves base at t+1
  
10. Import
11. Export
  
12. Total domestic use
13. Domestic use by source

Item 1-9 deal with the State part of the framework, while item 10, 11, 12 and 13 cover the Driving forces part. Item 6 says something about the *direct* changes in the past on the resource/ecosystem base (Pressure and Impact in the extraction process) and item 12 and 13 linked with other information (for instance emission coefficients, water use coefficients, land use coefficients etc), say something about the *indirect* effect on the environment (pressure and impact). The pressure and impact parts affects item 2 and 4 and thereby item 3 and 8.



In the figure we see the link between the SDPI part and the Response part. In Bye, Bye and Lorentsen (1988) this was included through a formal policy analysis based on a model.

We will come back to this table as a reference for discussion when commenting on the other frameworks below. In the following we are consciously referring to the SDPI-R instead of the DPSIR approach since this fits best in our reasoning, with particular emphasis on the crucial role of environmental statistics in the process of evaluating environmental policy.

### 3. SEEA approach

SEEA (System of integrated economic environmental accounting) is a framework for organising statistics (natural resources and environment) where we combine accounting in physical and

economic units (UN 2003)<sup>1</sup>. The link to the national accounts is essential in the framework, as parts of the SDPI-R approach commented on above.

The main elements in the SEEA approach are the following, the Asset accounts and the Physical flow accounts:

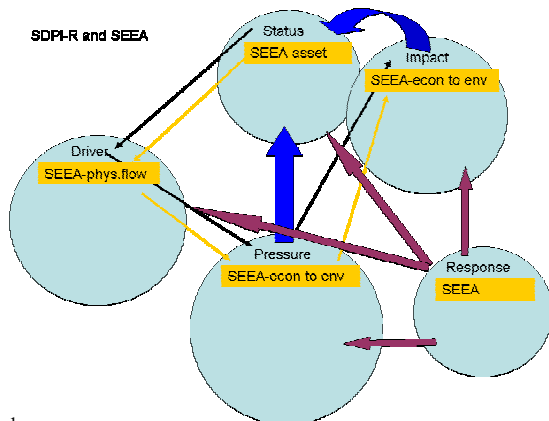
**Asset accounts** (following the definitions and valuation principles in the SNA)

- i) Stock levels at t
- ii) Extraction
- ii) New developments
- iii) Revaluation (due to technology improvements and information on cost and prices)
- iv) Depletion and degradation
- v) Stock levels at t+1

The stock levels may in principle capture traditional resources like fossil energy, renewables, marine resources, land, freshwater, atmosphere etc, however just a few of them are so far covered in the first proposal of the SEEA framework. This asset part of the SEEA approach is almost in principle identical to the State part of the SDPI-R approach described above, with Stock levels corresponding to the State, and Extraction representing the Driving forces. In the SDPI-R approach we only focus on physical measures while the asset accounts in the SEEA also focus on the valuation of the assets – following the principles of evaluation in the national accounts. This, however, should not influence on the physical part of the measures, cf. the difference between resources and reserves in the SDPI-R approach.

**Physical flow accounts**

- Flows from the environment to the economy
  - Resources
    - Materials
    - Energy
    - Water
- Flows from the Economy to the environment (these are Impacts that represent the change in the state?)
  - Waste
  - Disposals
  - Residuals
  - Emissions



In the physical accounts we may distinguish between the flows from the environment to the economy and flows from the economy to the environment. Flows from the environment to the economy are obviously comparable to item 6 in the SDPI-R approach in chapter 2, i.e. the extraction of resources and thereby change in the state of the resource/environment base. But the main focus in SEEA is on the driving forces aspect since this element combines the use of

<sup>1</sup> An editorial board is now working with outcome papers from the London Group to develop a new revised manual for SEEA which is supposed to be submitted to the 43<sup>rd</sup> session of the UNSC for adoption in February 2012.

resources with the driving forces in the national account activities.

Flows from the economy to the environment are obviously part of the chain from Driving forces to Pressure and Impact, of the mentioned activities above. In statistical sense it is hard to see that this is really different from how this is treated in the SDPI-R approach, hence there is clearly a common denominator between the SDPI-R and the SEEA frameworks in how the interactions between the economy and the environment can be represented in statistical terms.

Schenau (2010) also discusses the relation between the SEEA and the DPSIR frameworks.

#### **4. NAMEA**

The acronym NAMEA stands for National accounting matrix with environmental accounts. A good description of the NAMEA approach is given in Haan and Kee (xx). From their work we find the following explanation:

*The environmental accounts show the interactions between producer and consumer (household) activities and the natural environment. These interrelationships occur as a consequence of the environmental requirements of these activities: natural resource inputs and residual outputs. These requirements are appointed to these activities when and where they actually take place. This direct recording is consistent with prevailing national accounting practices. By providing economic and environmental data in a consistent Leontief-type framework, the NAMEA is particularly suited for analytical purposes.*

This is exactly the same intention as in the SEEA approach and detailing the analyses of the approaches shows that there are no major differences between them when it comes to the relationships between the economic driving forces and the environmental pressures and impacts ; i.e what is said about the principles of SEEA above also is relevant for the NAMEA approach, however, the State of the environment is not included in the NAMEA framework (?).

#### **5. Capital approach**

The point of departure for the capital approach is the need to address the question of sustainable development accepting the importance of capital and investments to foster such a development in terms of securing the long-term “wealth of nations” (see Smith (1776)). This does not concern just capital in a traditional economic sense , but all kinds of capital –physical capital (buildings, machineries etc), financial capital (serving the investment in new capital), human capital, natural resource capital (the market part of environmental capital), environmental capital (the non-market part) and social capital.<sup>2</sup>

The relevance of the capital approach in this context is along two dimensions: i) the environment as a separate capital category (with all the challenges on measuring and valuing) and ii) the substitutability between environmental capital and other forms of capital, see UN (2008).

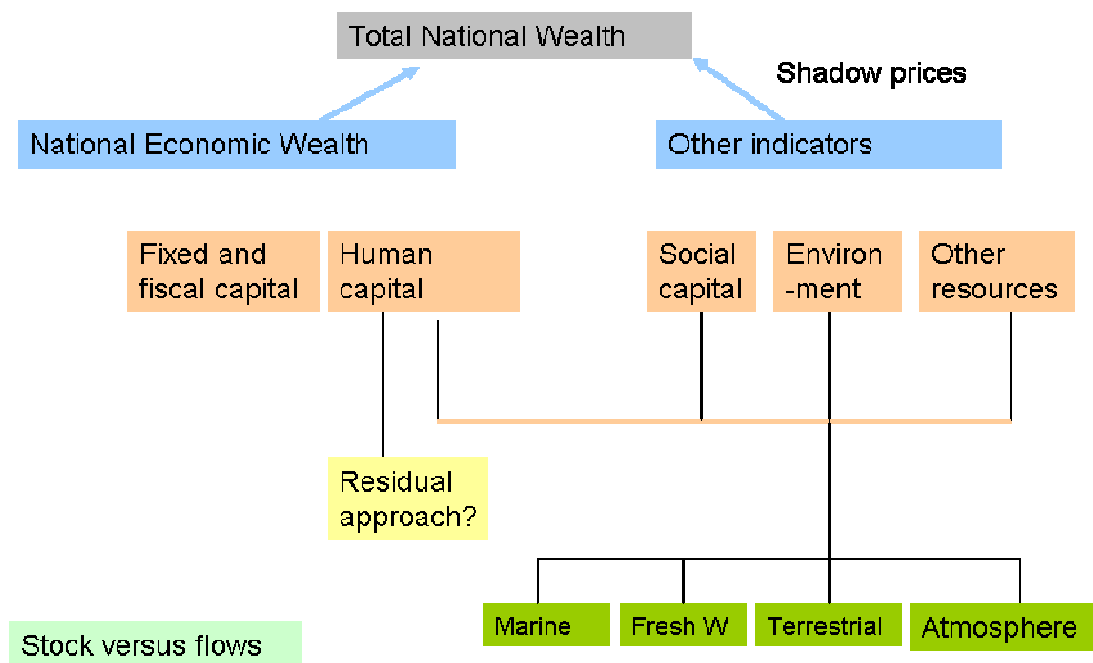
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<sup>2</sup> In the preliminary draft of the SEEA in 2003, accepting that SEEA was not developed to directly serve the measuring of sustainable development, this may still be one of the applications. Three conceptions of sustainable development are described in the SEEA handbook, with the capital approach noted as the one to which SEEA is best suited, i.e there are clear links between the SEEA approach and the capital approach.

- The environment as a separate capital
  - This may be physical measures of state variables for marine resources, fresh water resources, terrestrial resources or atmosphere, see figure x below.
  - The market based capital (natural resources). This has a clear link to the asset account in the SEEA and the State in the SDPI-R framework.
  - There is also a link between the Driving forces (that extracts the resources), the pressure and impact elements that changes the environmental values (both physically and in monetary terms)
  - In practice we cannot aggregate environmental capital into one measure like for instance real capital (where we use prices as weights), because we do not have any reasonable weighing mechanism. The environment is very heterogeneous, i.e. we need a set of heterogeneous indicators for describing the environmental capital. To exemplify the problem: If you are willing to pay 10USD for a kilogram of salmon how much are you willing to pay extra for the marine resource that fed the salmon and the environmental quality that sustained it?
- The substitutability
  - We often see this as a theoretical concept – cf Hamilton – to challenge the basis for calculating the value of the environment (through substitution elasticities and shadow prices), but in our context we do not dwell with this.

In our context it is more important that the Capital Approach is consistent framework comprising the different kinds of capital, so that we may have a multidimensional representation of the State in the SDPI-R and the Asset accounts in the SEEA framework. By combining the capital approach with the interactions between the economy and the environment, there is clear link between the State element and the responses element as in the SDPI-R framework, although the capital approach in its original version does not directly address the driving forces.

## The Capital approach







best understanding of the ecological interactions and processes necessary to sustain ecosystem composition, structure, and function. In recent years, sustainability has become an explicitly stated, even legislatively mandated, goal of natural resource management agencies. In practice, however, management approaches have often focused on maximizing short-term yield and economic gain rather than long-term sustainability. A prevailing public perception is that the immediate economic and social value of supposedly renewable resources outweighs the risk of future ecosystem damage or the benefits of alternative management approaches. This may be a misconception but do we have the proper information to convince otherwise?

The ecosystem management is driven by explicit goals, executed by policies, protocols, and practices, and made adaptable by monitoring and research based on our best understanding of the ecological interactions and processes necessary to sustain ecosystem composition, structure, and function. The central goal of ecosystem management is sustainability, where the emphasis is on delivering ecosystems services for current use without compromising the ability to provide them in the future. A fundamental aspect is the need to protect sources of resources; that is, ecosystems require appropriate protection to ensure the provision of ecosystem services. It is biodiversity that is the key to supporting resilient, productive and healthy functioning ecosystems and therefore underpins the provision of ecosystems services.

Ecosystems are normally divided into four main components

- Marine water (open ocean, coastal)
- Fresh Water (Wetlands, Lakes, Rivers)
- Terrestrial (Forest, Gras/rangeland, Desert, Tundra, Cropland, Urban)
- Atmosphere (climate)

The ecosystems deliver services beyond extraction of natural resources (forest, minerals, energy, fish, freshwater, clean air)

- Some services are
  - sink for sequestration (marine, soil, forest) of greenhouse gases,
  - a recipient for polluting items,
  - services for leisure time activities, etc.
  - biodiversity

Several other aspects are important

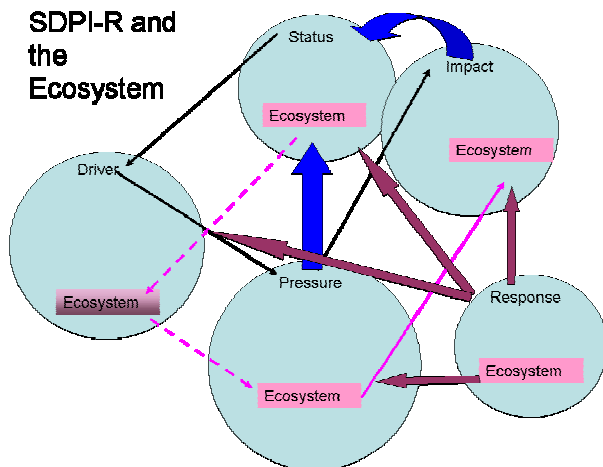
- Stochastic capacity, resilience and threshold levels
- Restoring capability, adaptation and substitution possibilities.
- Ecosystem degradation and decline in service capacity

In Statistics Canada (2010) the following statements are made:

- *..... each framework attempts to organize and link human activities to their impact on the environment. Each one also includes the state of the environment at a particular point in time and society's response to its negative impact on the environment.*
- *In a multi-component system framework, it may be impossible to establish cause and effect. In the natural world, each process and state influences and is influenced, making it difficult to separate out the pressure, the state and the response. Public policy and decision makers may also have difficulty interpreting the results from a multi-component framework that can result in misclassifications and improper conclusions being drawn from the results*

In the first bullet point we are close to the SDPI-R approach, the second doubts the possibility to establish reliable driving forces within the ecosystem management approach. (The nature response to response is included?) This raises two issues

- With no driving forces included in the ecosystem management approach, the policy makers are not able to implement an effective policy to stop or weaken these driving forces, i.e. you will have an ever lasting driving pressure against deterioration of important ecosystems.
- The policy measure should then be directed towards the ecosystem itself. For situations of reaching ecosystem threshold values (corner solutions) this seems reasonable, for non-corner solution a regulation implies shadow prices that affect the driving forces. But, within the original version of the ecosystem management approach we are not able to calculate the effects of the regulation on economic activity.



The bottom line is that many parts of the ecosystem management approach still fits into the SDPI-R framework, see the figure. An open question is then the link between the Drivers and the State and the Pressures.

The ecosystem management approach is unique among the considered frameworks in its detailed representation of ecosystem knowledge, essential for conceptualization and/or measurement of environmental capital. In order to enhance the framework for development of environmental statistics, it is a crucial challenge to further research and statistical efforts to combine the

biological knowledge inherent in the ecosystem management approach, representing the State in the SDPI-R model, with relationships representing the interactions between the economy and the environment, in order to directly address the driving forces and the policy responses.

## 7. Other initiatives

Below we comment briefly on the connection to other initiatives like the "GDP and beyond, the Stiglitz commission, the Commission Development Indicators and the OECD "the indicators for the green growth strategy".

### GDP and beyond

- With the Communication "GDP and Beyond: Measuring progress in a changing world", Commission of the European communities, Brussels 20.8.2009 COM (2009) 433 final <http://eur-lex.europa.eu/Notice.do?checktexts=checkbox&val=499855> the European Commission committed itself to work in several areas to improve existing measures and to report on the implementation and outcomes of the actions put forward in the Communication by 2012
- The commission bases several policy decisions on GDP measures, and focuses on the complementation of GDP with environmental and social aggregated indicators to be relevant in the policy making. They focus on aggregated measures that encompasses climate change, nature biodiversity, pollution and health aspects, water use and pollution and waste generation and use of resources.
- Aggregated indicators (harm and pressure on the environment) raise several methodological questions not yet solved (cf the weighing of heterogeneous measures)
- Environmental quality which is another term for the environmental status or in economists' term, environmental capital.
- Timeliness in the information process which calls for methodological advances
- To be relevant for policy making the commission advocates link between the economic development, resource extraction and environmental change (pressure and status) which makes a clear link to the both the DPSIR and the SEEA framework, and also a clear link to the capital approach since they want a link to natural capital and change in stocks (crude oil, fish, forest).
- A clear link between the supplement of physical measures with monetary figures

- They even seem to support the development of valuation methods for valuing environmental services.

### **The Stiglitz commission**

The Stiglitz commission focuses on a lot of variables and distributional aspects, of which some is also relevant for the FDES. Especially they focus on the measuring of all sorts of capital, including environmental capital, in addition to all kinds of flow variables also relevant to the environment. On the environment the Stiglitz commission suggestions look pretty much like the suggestions in the capital approach.

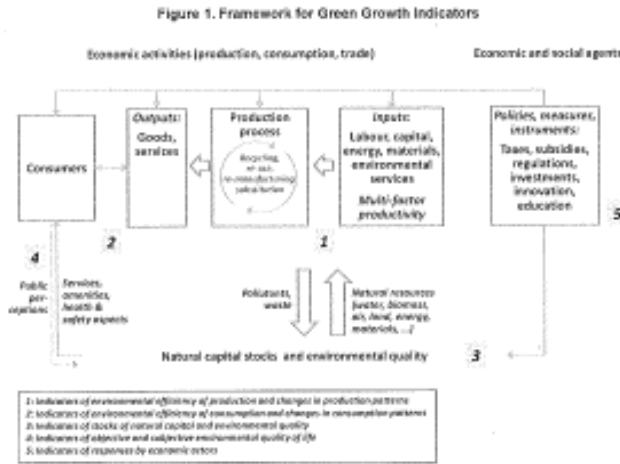
### **CSD Indicators**

The United Nations Commission on Sustainable Development (CSD) was established by the UN General Assembly in December 1992 to ensure effective follow-up of United Nations Conference on Environment and Development.

The indicator set covers poverty, governance, health, education, natural hazards, atmosphere, land, Oceans seas and coasts, biodiversity, economic development, global economic partnership, consumption and production patterns (which also includes pressure and impact on the environment – like for instance generation of waste).

Again, several of the indicators are closely linked to information we want to gather in the other approaches presented here which again addresses the multipurpose aspect of the statistical framework.

## The indicators for the green growth strategy

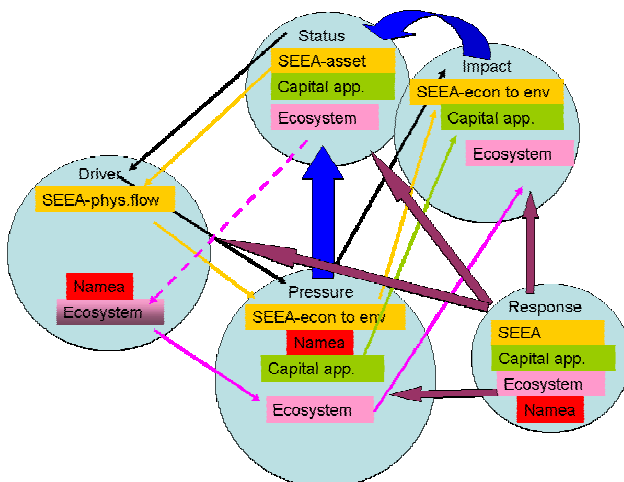


In OECD (2010) examples of indicators for the green growth strategy are presented. The indicator set will support policy analysis in the OECD. The focus is on market failures and externalities. The intention is that the indicators will help identifying instruments to foster environmentally friendly economic growth. Policy relevance, analytical soundness and measurability are highlighted.

The figure is a copy of the figure in OECD (2010) illustrating framework. The four left block in the figure coincide with the Driving force block in the frameworks presented earlier in this paper. The arrows at the bottom show links back and forth to/from the environment, while the right hand block is the instrument part, i.e. the response part in the other frameworks presented here. The resemblance is obvious, in particular since the focus on market failures and externalities emphasizes important economic mechanisms underlying the driving forces from the economy to the environment.

## 8. A common denominator FRAMEWORK for environment statistics

In the introduction we asked the question whether there is possible to find a common denominator framework for all the frameworks presented. The review has shown that the common features between all the frameworks are more obvious than the differences among approaches.



The point of departure for the frameworks are different, obviously, and there is also a difference with respect to which element is most in focus. For instance, the capital approach framework and the ecosystem management approach focus most on the state or capital part, while the SEEA focus very much on the capital and the driver part. The description of the response and impacts parts is also slightly different in the semantics, but not really in principle. All frameworks consider the response part.

In our context the important question is whether these frameworks are very different with respect to the statistical challenges. Our view is that important ecosystem and resource questions are the same. Although the capital and ecosystem approach seem to be less concerned about the driving forces, deriving such relations does not harm the content in these approaches, on the contrary it deepens the approaches. Some

approaches may be diving deep down in the details while other framework just scratch the surface, but again, this is a question of aggregation (which of course may be hard to overcome because of weighing problems over heterogeneous characteristics).

When the approaches seem to have so common features the statistical challenge is to provide them all with data in a consistent and efficient way within the same statistical system (including the initiatives described in chapter 7).

## 9. The role of statistical offices

- KLIF – Norwegian Climate and Pollution Agency – [www.klif.no](http://www.klif.no)
- DN – Directorate for Nature Management – [www.dirnat.no](http://www.dirnat.no)
- NVE - Norwegian Water and Energy Directorate – [www.nve.no](http://www.nve.no)
- NINA – Norwegian Institute for Nature Research – [www.nina.no](http://www.nina.no)
- NGU – Geology for Society – [www.ngu.no](http://www.ngu.no)
- NILU – Norwegian Institute for Air Research – [www.nilu.no](http://www.nilu.no)
- NIVA – Norwegian Institute for Water Research – [www.niva.no](http://www.niva.no)
- IMR – Institute of Marine Research – [www.imr.no](http://www.imr.no)
- NILF – The Norwegian Forest and Landscape Institute – [www.skogoglandskap.no](http://www.skogoglandskap.no)
- Bjerknes – Bjerknes Center for Climate Research – [www.bjerknes.uio.no](http://www.bjerknes.uio.no)
- NPD – Norwegian Petroleum Directorate – [www.npd.no](http://www.npd.no)
- NPRA – Norwegian Public Roads Administration – [www.vegvesen.no](http://www.vegvesen.no)

The devil is always in the details, which we have not discussed very much in this paper. Along all these dimensions a lot of institutions are producing statistics, which follows from responsibilities and competence. It is inefficient that statistical offices produce all the statistics necessary to follow up environmental considerations. The table shows a selection of other institutions in Norway - public agencies and environmental research institutes - that produce relevant statistics for several parts of the earlier discussed frameworks, and so it has to be. Still, it is important that all these institutions have a common understanding of the necessity of a

framework to be able to communicate about the development of environmental statistics, and in this context the link between frameworks is also important to understand. We do not think that it is possible for all institutions to work along the same framework, but if we know about the links the communication process is much easier, also the communication with policy formation bodies.

## 10. Conclusions

The environmental statistics framework cannot exist in a vacuum. The real value of a framework is that we focus on the relationship between the different elements in the framework – in the saying “all depends on all”. The framework is a systematic way of organising the information flow to obtain relevance, accuracy, accessibility, interpretability, quality, coherence and consistency and at last but not at least; efficiency in the production of statistics.

It is not the number of frameworks, the name of the framework or the point of departure of the framework that matters – it is the content that is important – the rest is a matter of organizing the statistical information in a rational way.

It is obviously important to describe status (this is the main elements in the ecosystem approach, the status in the SDPI-R framework, the Asset element in the SEEA framework, the capital approach and most of the other initiatives). It is also important to describe what kind of driving forces that changes (pressure, impact) the status – it may be difficult but efforts should be made to make statistics relevant for policy formation. This seems to be most clearly stated in the SDPI-R framework and the SEEA framework.

I.e. – whether we choose one or another point of departure should not be that big a deal – therefore two other elements may be very important:

- We should try to unite on one framework – what are the arguments?

- The DPSIR is a long proven success –
- The SEEA is a highly emphasized framework from UN
- Although the ecosystem approach has also existed a couple of decades it is not implemented in a large scale?
- The ecosystem approach lacks the driving force aspect that seems to be important in most other initiatives? The other approaches lack the understanding of the ecosystems. A crucial challenge for development of the framework for environmental statistics is to combine the insights from the various approaches.
- The rest is just analytical variants?
- The statistical system should serve the frameworks in a consistent way – i.e. be multipurpose
  - The same figures should be applicable in all frameworks and recognisable from framework to framework
  - The statistics has just one language- or so it seems – but the selection and interpretation of data and numbers are highly dependent on what is sometimes called the “statistical narrative” (Giampietro and Sorman 2009), that is, how the purpose of the statistical production process is defined, and the choice of statistical framework is crucial for clarifying this purpose – enhancing the understanding of the interactions between the economy and the environment in statistical terms.
  - Regardless of choice of conceptual and statistical framework, an important common denominator is to recognize the need for a disaggregated and comprehensive information basis for environmental data in physical units, in order to represent the complex interactions between the economy and the environment.

And to repeat the bottom line: *The environmental statistics framework is a systematic way of organising the information flow to obtain relevance, accuracy, accessibility, interpretability, quality, coherence and consistency and at last but not at least; efficiency in the production of statistics.*

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