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UNDERSTANDING CAUSAL RELATIONSHIPS: FROM DRIVERS, CAUSAL CHAINS AND SYSTEM MODELS TO SCENARIOS AND NARRATIVES

1. Introduction: different modelization approaches

The understanding of causal relationships implies that we are able to predict future. Big works, very time-consuming, such as the US Millennium Ecosystem Assessment, have been done in order to translate scientific understandings to policy makers. To improve our understandings, we have to identify what is cause and what is effect, and we need for an integrative transdisciplinary research, particularly between social and natural sciences.

There are two major types of global change: systemic and cumulative global change. To understand them, i.e. answer to the questions what? where? how? why?, we have to (i) understand causes, processes and impacts, (ii) understand policy needs and (iii) develop non-implausible futures for human development.

2. The DPSIR concept

To understand causal relationships, different kinds of approach exist. The DPSIR concept is one of them. The DPSIR concept is a linear chain linking drivers, pressures, state, impact and the respond. This scheme exists in many study (the IHOPE paper was one of the first to introduce this kind of concept), but it's difficult to assess it, to really look at the all picture. However, linear models are needed for communication, and particularly to interact with policy.

• **Components of the DPSIR concept:**

A **driver** is “any natural or human-induced factor that causes a change in a system”. The understanding of drivers is important for the dynamic of the system. There are direct drivers, that undeniably influence the system, and indirect drivers, that operate more diffusely. Drivers can be classified according to different characteristics: direct/indirect, anthropogenic/biophysical, dependent/independent, exogenous/endogenous, primary/secondary, immediate/proximate, external/controllable.

A **pressure** is “the actual consequences of a driver on a system to which the system reacts”.

The **state** is “the condition of the system after the influence (i.e. pressure) of the driver(s)”.

The **impact** is “the effect that change in state has on the output of a system, after it is influenced”.

The **responses** are “the measurements taken to mitigate the drivers, reduce the pressure, alter the system and/or cope with the impacts”.

• **Examples (LUC dynamics)**

Several models of land-use changes don't really integrate socio-economic aspects. They are often only considered as inputs in the system. However, the development changes the way how we use

nature. There can be completely different sets of LU because of the different opportunities that exist such as globalization or the technological development in the far-west.

Land-use changes dynamics are also often explained by a limited number of drivers. The GLOBIO project, which studied the human impacts on the tundra and arctic environment, took only one driver (the roads) into account. However, there are complex interactions between drivers that come from different disciplines, as shown by Geist and Lambin (2001) in the case of deforestation.

- **Advantages and disadvantages**

Among the advantages of the DPSIR concept, we can mention that (i) it is a wonderful tool to communicate, (ii) it allows to identify and list relevant drivers, (iii) it is simple to implement. However, the fact that the classification of factors in different boxes is depending on our own view, the difficulty to classify variables and the fact that feedbacks mechanisms are not taken into account are important disadvantages. These disadvantages highlight the need to use a more comprehensive modelling approach. Causal chains are useful to communicate but not to understand!

Here are some other approaches that can be useful:

- the IPAT identity, which is based on a series of elements whose combined value capture the outcome. The IPAT identity is useful but was strongly criticized.
- the KAYA identity is the hart of many climatic studies, in the scenarios of CO₂ emissions. This approach make communication easy, but neglect feedbacks that accelerate or slow down processes.
- more complex models specify all drivers from different domains (nature/environment, human, economic, and institutional) and all interactions.
- the IMAGE-2 model uses linear model and include feedbacks. Once more, it make the communication easier but don't specify components and interactions.

- **The challenge of spatial scales**

Another challenge is the different scale levels. Different drivers and incentives are linked to different spatial scales. For instance, interactions between individuals and land happen at the local scale while the modelling of global change is done at the highest levels. These different levels are strongly interconnected.

3. Scenarios and narratives

Many scenarios come from industries, which need appropriate forecasting in order to adapt their management strategies. For example, Shell Oil industry developed different plausible scenarios and in particular a possible coalition of oil exporting countries. In consequence, after the OPEC cartel formation, Shell adapted more easily to oil price rising than its competitors.

Scenarios are characterized by a high uncertainty (which is function of the quantity of data) and a high knowledge on causality. These characteristics allow to distinguish the scenarios from the

predictions, the projections and the exploration. There are different possibilities for scenarios whereas there is only one prediction (characterized by a high knowledge on causality and a low uncertainty).

Scenarios are defined as (i) hypothetical, (ii) describing dynamic processes, (iii) consisting of states, driving forces, events, consequences and actions, which are causally related, and (iv) starting from an initial or desired state, depicting a final state or path at a fixed time horizon.

There are different ways of doing scenarios (judgmental methods, extrapolative methods and causal and mathematical models) and also different types of scenario (qualitative or quantitative, exploratory or anticipatory, baseline or policy and expert-based or participatory). These last years, the trend in the development of scenarios is to combine different methods, to develop multi-disciplinary integrated approaches (IPCC, MA, ...), and to involve stakeholders in this process. Scenarios are developed by experts and scientists and results are communicated to policy makers and the public. However, the scientific discussion on the domain, value and likelihood of scenarios continues.

4. Final message

The DPSIR concept is useful to communicate to policy makers and other illiterate audiences, but we have to be careful to use it to understand factors and relationships and to develop comprehensive scenarios. The challenge is to find a way to respond to the changes given the high uncertainty and to create a dialogue between science and policy.

5. Discussion

- There are a lot of confusions of terms in literature. Scenarios are caricatures, their probability of occurrence is null. They are not realistic, it is a simplification of reality, but we learn about the system by doing that. Assumptions are very specific.
- Linear models are used to communicate even if dynamic models exist.
- The DPSIR concept can be a way to organize things. It has to be used as first step, to identify drivers, pressure, states, impact and responses, but some parts of the system are more important than others according to objectives. On the basis of the global linear model, different models can be created.
- Emergent macro properties are essential. When drivers and interactions are identified, systemic properties start to emerge. All components together, at different scales, define the behaviour of the system.

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