SOIL INDICATORS FOR DECISION MAKING – SHARING KNOWLEDGE BETWEEN SCIENCE, STAKE HOLDERS AND POLITICS

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Abstract
It is shown how stakeholders, politicians, decision makers and the broad public can be provided with comprehensive information on soil and water conservation, based on scientific knowledge, in the form of DPSIR-indicators, allowing them to understand complex systems and processes and to react by developing responses and solutions. The dimensions of space and time within this indicator system, as well as a research concept for the identification of indicators on the basis of the DPSIR approach is discussed.

Additional Keywords: soil and water conservation, soil indicators, DPSIR approach, dimensions of space and time, research concepts

Introduction
Conserving soil and water for society is a complex issue, which must be based on scientific knowledge. But complex issues are difficult to understand, specifically for those at grass root level, e.g. stakeholders, as well as for those who provide solutions such as politicians and decision makers. The question is therefore how to bridge between the available scientific knowledge on one side and those who need it for defining policies, and operational procedures, such as stakeholders, and politicians and decision makers on the other side (Blum 2001).

Therefore, in the following, a soil indicator framework is described which allows to share information and solutions between both sides.

Soil indicators – the DPSIR approach
Indicators can only be used within a clearly defined framework: first we have to analyse a problem, then the reasons behind it and the impacts it causes, before we come to responses or solutions.

The DPSIR approach, distinguishing between Driving forces, Pressures, State, Impacts and Responses is such a framework (European Environment Agency, 1999).

It was developed on the basis of the DSR framework approach of the OECD (1997), aiming at harmonising agricultural practices with environmental conditions (Blum 1998 a,b; 2002 a,b).

The DPSIR framework applied to soil is shown in Fig. 1. Indicators within this framework must be:
- policy relevant, focussing on real demand and less on the supply of data;
- analytically sound, based on science and revealing a clear cause-response relationship;
- easy to interpret and understandable for farmers at the grass-root level (stakeholders), as well as for decision makers and politicians;
- easily measurable and therefore feasible and cost effective in data collection, processing and dissemination.

On this basis, indicators were developed for 5 different targets:
1. driving forces, indicating what is causing a certain state of soil. These can be cultural, economic, social, technical and ecological driving forces, ranging from market conditions to climate change;
2. pressures, which are the mental and physical expression of driving forces, such as emission to air, water and land, infrastructural changes, e.g. urban expansion; deforestation; intensive rainfall; storms; forest fires; nutrient mining and others;
3. the state which is caused directly by the pressures inducing soil degradation, e.g. by contamination, acidification, salinisation, eutrophication, nutrient depletion, loss of organic matter, compaction, loss of biodiversity, or total loss of soil through sealing, erosion, landslides and others;
4. the impacts which are directly caused by the state are changes in soil functions, e.g. loss of soil fertility, or indirectly, like changes in population size and distribution, loss of biodiversity, local climatic change, water stress and others;

5. the responses which are given to alleviate the impacts, the state, the pressures, or the driving forces can be legal or administrative instruments, economic instruments such as market regulations, incentives, technical interventions, and others.

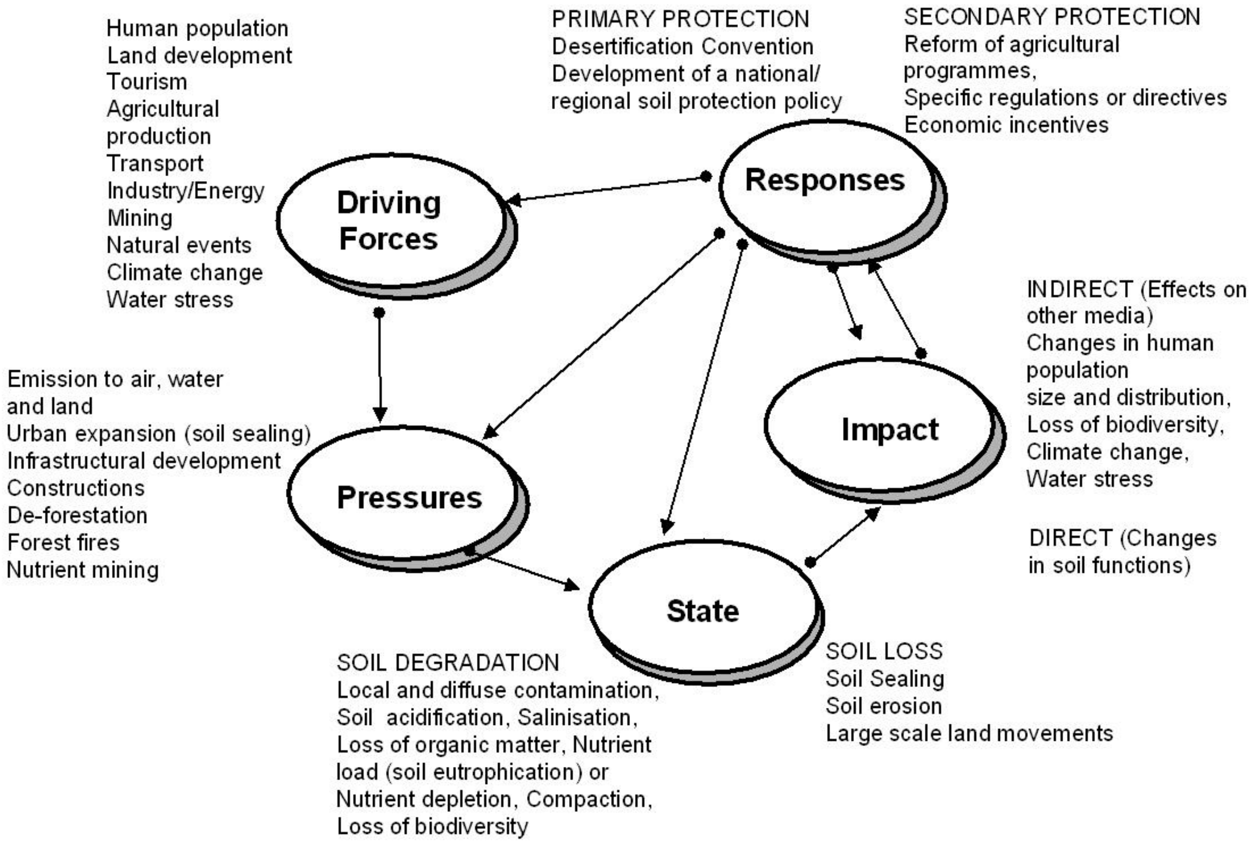

Figure 1. The DPSIR Framework applied to soil

This framework allows for answering key questions in the understanding of complex soil systems, such as: What is the driving force behind a problem? What are the pressures, deriving from the driving forces? What is the state that the pressure creates? What are the impacts that result from the state?

It also allows for responding so as to change the driving forces, in order to alleviate or to reverse a problem, developing solutions through the implementation of operational measures, see Fig. 1.

For example a driving force can be the lowering of prices for agricultural commodities on local markets, thus decreasing the income of farmers. Reduced income and the inability to replace nutrients by fertilisers results in the pressure of nutrient mining. This leads to soil degradation by nutrient depletion and on arable land on sloping terrain also to soil erosion, as there are no anti-erosion measures taken, because of lack of funds. The resulting change in soil function and decrease in soil fertility cause the direct impact of reduced biomass and subsequently food production. Indirect impacts may be changes in population size and distribution in rural areas, as a result of low income. The response should, whenever possible, be directed at the driving force, e.g. towards improving market conditions and maintaining reasonable market prices for agricultural commodities rather than remedying the state of the soil or alleviating the pressure itself by supplying fertilisers to farmers. In this example, the ideal response might be an economic or social instrument rather than a technical one.

Driving forces of land and soil degradation – the dimensions of space and time

However, problems cannot always be solved on a local level, because different dimensions in space and time must be considered in the analysis and understanding of the systems, as well as for the development of remediation strategies and solutions.

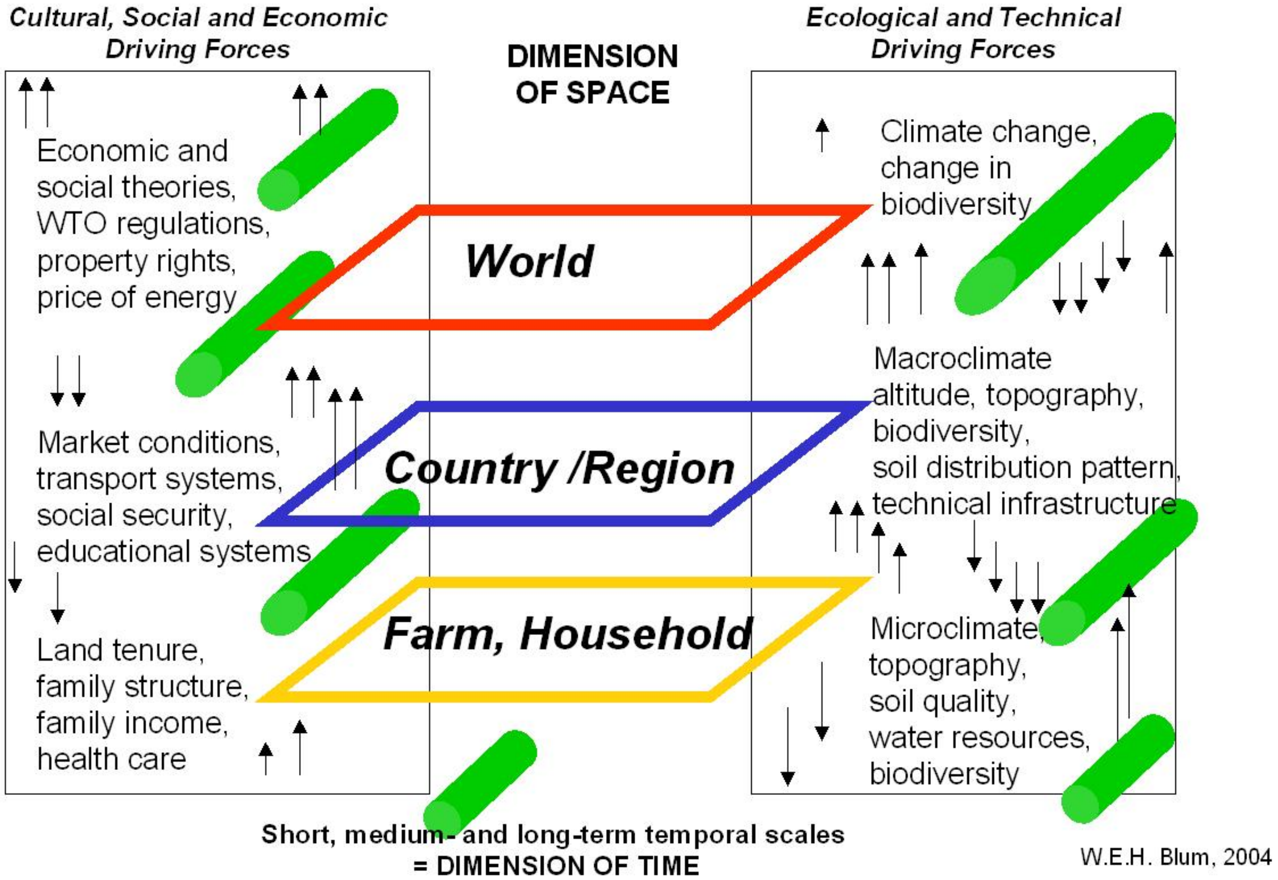

Figure 2. Driving Forces of Land and Soil Degradation – Dimensions of Space and Time

Fig. 2 indicates how driving forces might be linked together in the dimension of space and time. In this figure, three spatial levels can be distinguished: the world level, the country or regional level and the farm/household level. All three levels are inter-connected by cultural, social and economic driving forces, ranging from economic and social theories or WTO regulations, to the question of property rights or prices for energy and other goods, thus connecting the world level with the farm and household level. The same is true for technical and ecological driving forces, such as climate change and others. - For example, the impact of WTO regulations occurs on all three levels. Whenever a farmer is participating on a world market with his agricultural commodities, he is subject to the economic and social conditions created by these regulations, which means that in case of critical ecological conditions, a farmer might be tempted to make use of all kinds of technical measures in order to participate in the market, which often means that ecological damage occurs. - Also global and climate change might be an important driving force in some world regions. But climate change is the result of numerous locally based processes, which altogether lead to global change. Therefore relationships exist in both directions.

On each level, processes are occurring at different temporal scales, such as short-, medium- and long-term scale, which are indicated in green colour, in Fig. 2.

Research concepts for defining indicators

In Table 1, a concept for integrated soil research is shown, using the DPSIR Framework approach, sub-divided into research goals, research clusters and sciences involved.

Fig. 3 shows the operational approach through 5 main research clusters, starting with research cluster 1, dedicated to the analysis of processes related to the main threats to soils and their inter-dependency: erosion, loss of organic matter, contamination, sealing, compaction, decline in biodiversity, salinisation floods and landslides. The second cluster indicates the development, the harmonisation and standardisation of methods for the analysis of the State (S) caused by the threats and its changes with time = Soil Monitoring.

Table 1. Concept for Integrated Research In Ecology– Example soil

	MAIN RESEARCH GOALS	RESEARCH CLUSTERS (see Fig. 3)	SCIENCES INVOLVED
1	To understand the main processes in the eco-subsystem soil; induced by threats	Analysis of processes related to the threats to soil and their interdependency: erosion, loss of organic matter, contamination, sealing, compaction, decline in biodiversity, salinisation, floods and landslides	Inter-disciplinary research through co-operation of soil physics, soil chemistry, soil mineralogy and soil biology
2	To know where these processes occur and how they develop with time	Development and harmonisation and standardisation of methods for the analysis of the **State (S)** of the threats to soil and their changes with time = **soil monitoring**	Multi-disciplinary research through co-operation of soil sciences with - geographical sciences, - geo-statistics, - geo-information sciences (e.g. GIS)
3	To know the driving forces and pressures behind these processes, as related to policy and decision making on a local and regional basis	Relating the threats to **Driving forces (D)** and **Pressures (P)** = cross linking with cultural, social and economic drivers, such as policies (agriculture, transport, energy, environment etc.) as well as with technical, and ecological drivers, e.g. global and climate change.	Multi-disciplinary research through co-operation of soil sciences with political sciences, social sciences, economic sciences, historical sciences, philosophical sciences and others
4	To know the impacts on the eco-services provided by the sub-system soil to other environmental compartments (eco-subsystems)	Analysis of the **Impacts (I)** of the threats, relating them to soil eco-services for other environmental compartments: air, water (open and ground water), biomass production, human health, biodiversity and culture	Multi-disciplinary research through co-operation of soil sciences with geological sciences, biological sciences, toxicological sciences, hydrological sciences, physio-geographical sciences, sedimentological sciences and others
5	To have strategies and operational tools (technologies) at one's disposal for the mitigation of threats and impacts	Development of strategies and operational procedures for the mitigation of the threats = **Responses (R)**	Multi-disciplinary research through co-operation of natural sciences with engineering sciences, technical sciences, physical sciences, mathematical sciences and others

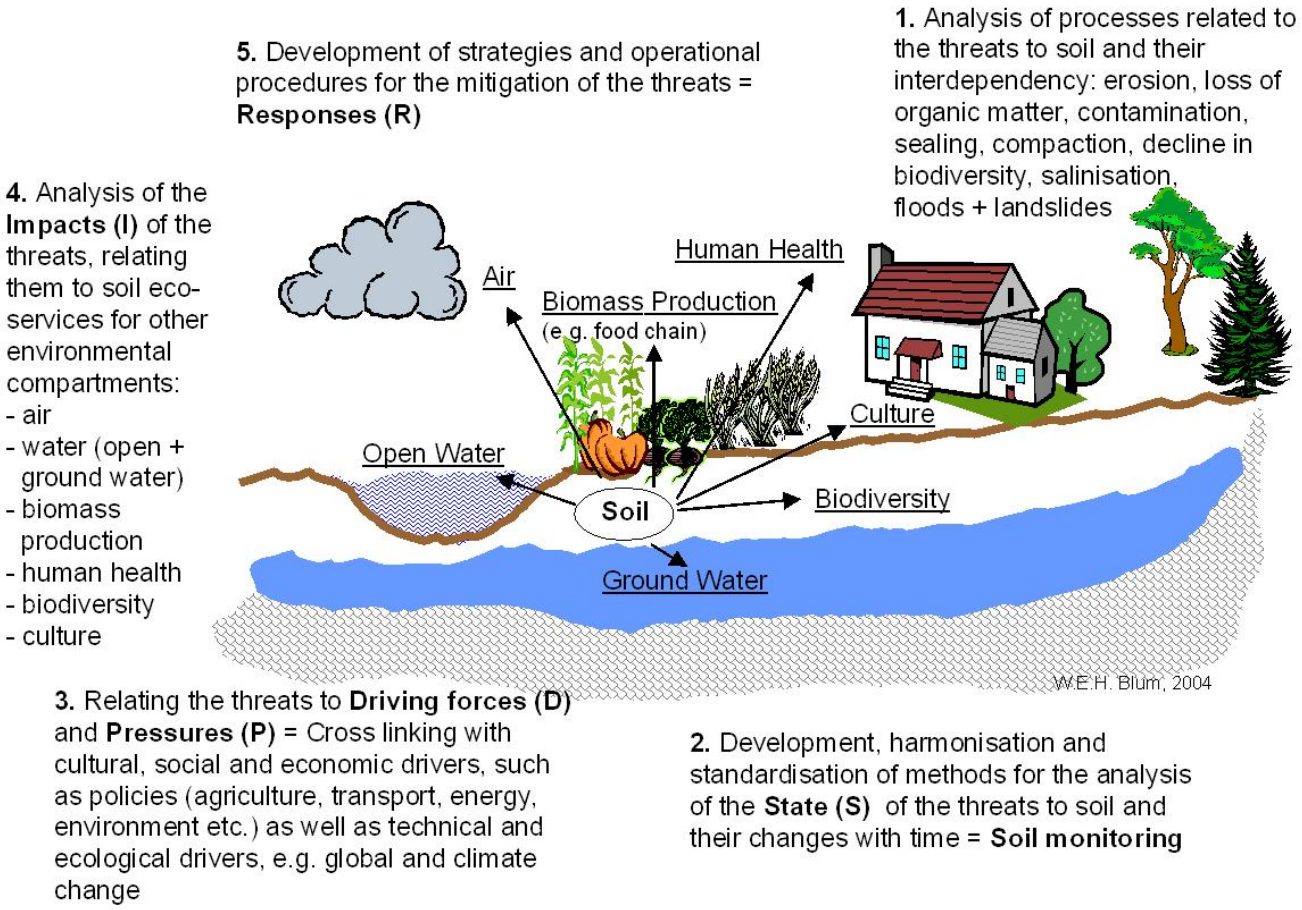

Figure 3. The Five Main Soil Research Clusters

The third research cluster relates the main threats to Driving Forces (D) and Pressures (P), cross-linking those to cultural, social and economic driving forces, such as policies in agriculture, transport, energy, environment etc. as well as to technical and ecological driving forces, such as global and climate change.

The fourth research cluster deals with the analysis of the Impacts (I) of these threats, relating them to soil ecoservices for other environmental compartments, such as air, water (open and ground water), biomass production (food chain), human health, biodiversity and culture.

Finally, on the basis of 1-4, policies and operational procedures for the mitigation of the threats can be developed = Responses (R).

Conclusions

From this, the conclusion can be drawn that stakeholders as well as politicians and decision makers can be provided with comprehensive information based on scientific knowledge in the form of indicators, allowing them to understand complex systems and processes and to react accordingly. This is exactly what we mean by sharing solutions in conserving soil and water for society.

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