Chapter 25
Land Use Planning and Policy Implication: Bridging Between Science, Politics and Decision Making

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Abstract We describe land use planning based on the six main functions and uses of soil and land. Policy input is mainly needed to control the competition between different land uses, avoiding or minimising irreversible impacts. For achieving this, we describe an indicator framework, which allows for planning and controlling complex land use systems.

Keywords Decision making • Land use planning • Policy implication • Politics • Science

25.1 Introduction

Land use planning is a complex issue in view of the six different functions and uses of soil and land, delivering goods and services to humans and the environment. Policy implication is mainly concerned with the control of competition between the main uses in space and time, aiming at specific targets. In this context, indicators can help decision making by explaining the complexity of the many different land use systems.

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S.A. Shahid et al. (eds.), *Developments in Soil Classification, Land Use Planning and Policy Implications: Innovative Thinking of Soil Inventory for Land Use Planning and Management of Land Resources*, DOI 10.1007/978-94-007-5332-7_25,

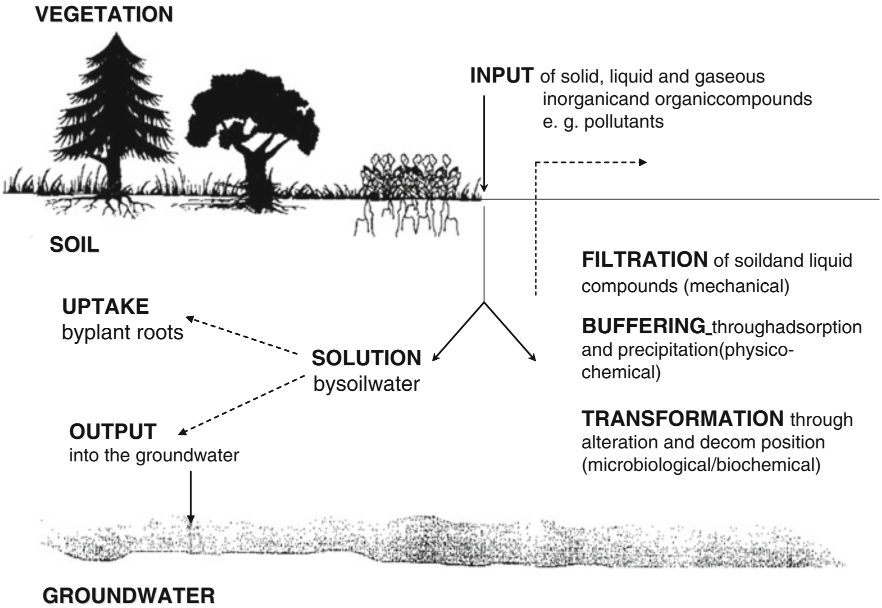

Fig. 25.1 Filtering, buffering and transformation through soil

25.2 Land Use Planning and the Six Main Functions of Soil and Land

Soil has six main functions for the cultural, social and economic development of human societies, which can be distinguished into three more ecological functions and three others, directly linked to human activities in the sense of technical, industrial and socio-economic uses (Blum 2005).

The three ecological functions are:

1. Production of biomass, ensuring food, fodder, renewable energy and raw materials. These well-known functions are the basis of human and animal life.
2. Filtering, buffering and transformation capacity between the atmosphere, the ground water and the plant cover, strongly influencing the water cycle at the land surface as well as the gas exchange between terrestrial and atmospheric systems and protecting the environment, including human beings against the contamination of ground water and the food chain (Fig. 25.1). This function becomes increasingly important because of the many solid, liquid or gaseous, inorganic or organic depositions, due to urban development, industrialisation, transport processes and others. As long as these filtering, buffering and transformation capacities can be maintained, there is no danger to the ground water and to the food chain. However, these capacities of soil and land are limited and vary according to the specific conditions.

3. Biological habitat and gene reserve, with a large variety of organisms. Soils contain three to four times more species in number and quantity than all other above-ground biota together. Therefore, soils are the main basis of biodiversity, on which human life is extremely dependent. Moreover, genes from the soil become increasingly important especially for biotechnological and bioengineering processes.

In addition to these three ecological functions, soil and land have three other functions, linked to technical, industrial and socio-economic uses:

1. They are the physical basis for technical, industrial and socio-economic structures and their development, e.g. industrialisation and urbanisation. One of the main problems in this context is the exponential increase of urban and peri-urban areas, including transport facilities between them. This is also true for the Arabian peninsula.
2. Soils are a source of raw materials, delivering clay, sand, gravel and minerals in general, as well as energy and water. Raw materials from soils are the basis for technical, industrial and socio-economic development.
3. Last but not least, soils are important as a geogonic and cultural heritage, forming an essential part of the landscape in which we live and concealing and protecting palaeontological and archaeological treasures of high importance for the understanding of our own history and that of the earth.

In view of the fact that soil and land are an absolutely limited resource, which cannot be extended or enlarged, the use of these six main functions of soil and land, which are often concomitant in the same area, becomes a key issue of sustainable development, based on land use planning. Land use planning under this aspect can be defined as the spatial harmonisation of a simultaneous use of all these functions in a given area.

25.3 Land Use Planning and Policy Implication

For understanding soil and land use planning under the aspects of a sustainable development, it is necessary to define the interactions and competitions which exist between the different uses of soil and land (Fig. 25.2). In this context, three different categories of interaction and competition can be distinguished as below:

– Exclusive competition between the use of land for infrastructural development, as a source of raw materials and as a geogonic and cultural heritage on the one hand and the use of soil for biomass production, filtering, buffering and transformation activities and as a gene reserve on the other hand.

This becomes evident by the sealing of soil through urban and industrial development, e.g. the construction of roads, industrial premises, houses, sporting facilities and others, well known as the process of urbanisation and industrialisation, thus excluding all other uses of soil and land. The process of sealing is at the moment the most important challenge for land use planning and a great threat to sustainable soil use (Figs. 25.3, 25.4, and 25.4).

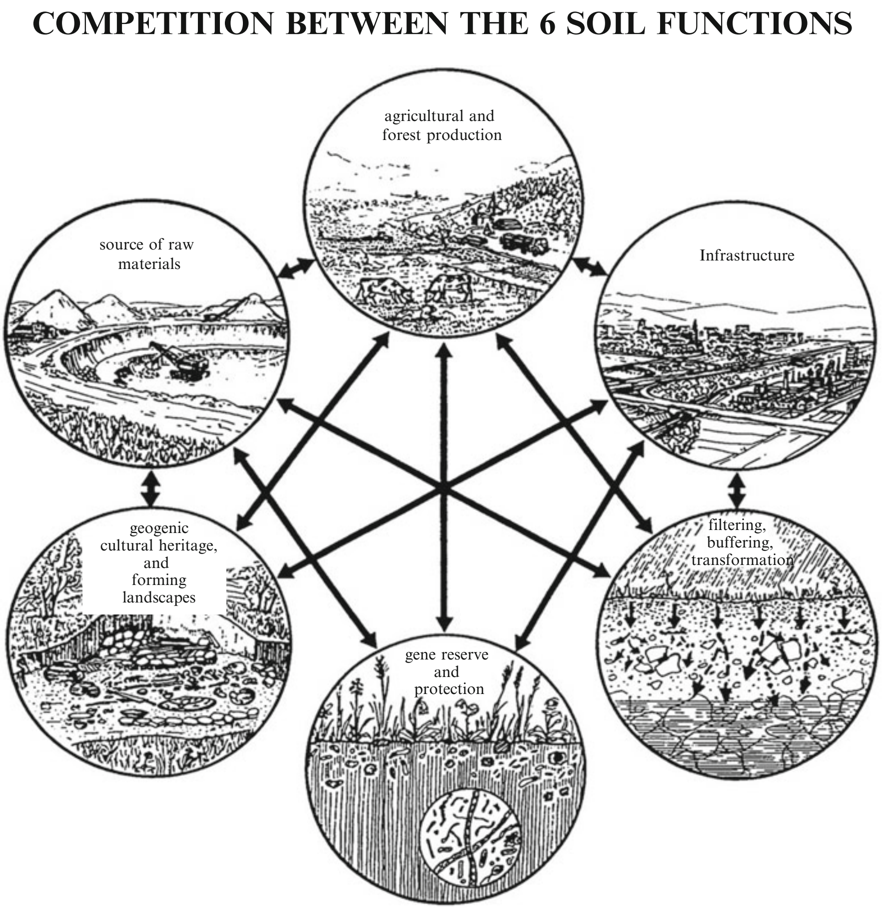

Fig. 25.2 Competition between the six uses of soil and land

- A second category of competition exists through intensive interactions between infrastructural soil and land uses and the use of land for urbanisation and industrialisation, due to the problem of soil contamination and pollution through the atmospheric pathway, the waterway and terrestrial transport (Fig. 25.6).
- A third form of competition also exists among the three ecological soil uses themselves, e.g. when we use waste and sewage sludge on agricultural land, in addition to the deposition of air pollutants, which can have a negative influence on the ground water and the food chain, surpassing the natural capacity of soils for dealing with these adverse contaminants. This is specifically true for high-input agricultural systems (Fig. 25.7), because each drop of rain falling on agricultural land has to pass soil before it becomes ground water underneath. Therefore, the type of soil use is very important for the production of ground water or water filtering for ground water production.

Fig. 25.3 Europe's natural environment at daylight

Fig. 25.4 Europe's built environment at night

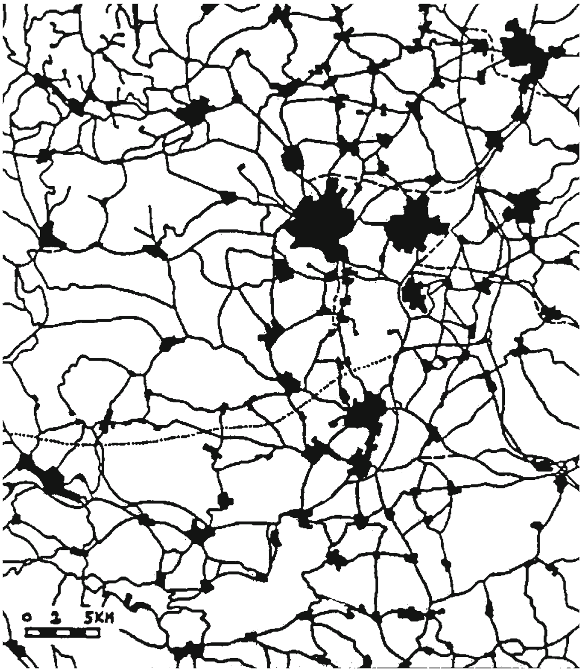

Fig. 25.5 Sealing of soils in southern Germany (observe the scale of 5 km)

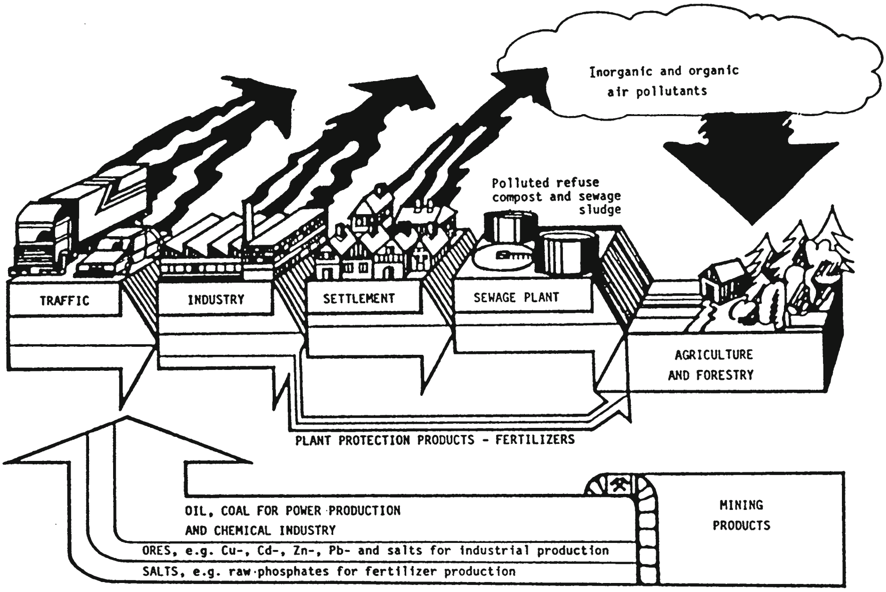

Fig. 25.6 Contamination of soils through different pathways. Pollution through excessive use of fossil energy and raw materials (Blum 1988)

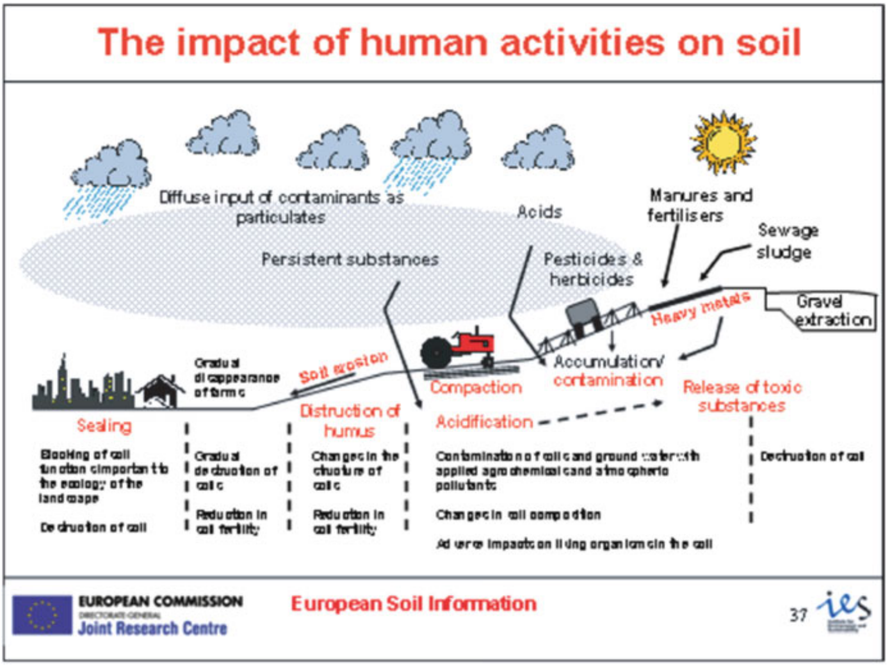

Fig. 25.7 Impact of human activities by urban and rural land use

Summarising, it can be stated that there exist eight main threats to land and soil: sealing through urbanisation and industrialisation, local and diffuse contamination, erosion by water and wind, compaction and further forms of physical degradation, decline in soil organic matter; loss of biodiversity, salinisation and alkalisation and floods and landslides. These main threats were politically defined by the European Strategy of Soil Protection (European Commission 2006).

However, it is not only important to know the threats and damages to land and soil but also to classify them in order of urgency. Under this aspect, we can distinguish between irreversible and reversible damages and threats. The definition of irreversibility is based on a time span of 100 years (about four human generations). Under this definition, irreversible damages and threats are soil loss through sealing; extraction of materials; mining and erosion by water and wind; intensive pollution by heavy metals, xenobiotics and radioactive compounds; advanced acidification and salinisation and deep-reaching compaction. Reversible damages or threats are soil pollution by biodegradable organic compounds, which can be mineralised and metabolised; compaction; glazing and other physical deterioration of the top soil.

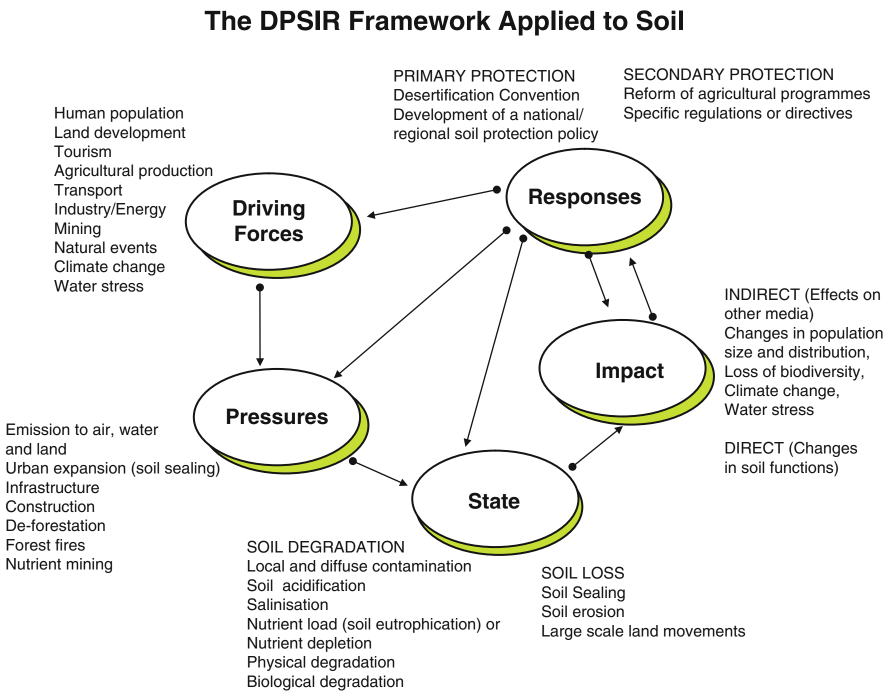

Fig. 25.8 The DPSIR framework approach applied to soil

25.4 Indicators for Land Use Planning: Bridging Between Science, Politics and Decision Making

Land use planning aiming at a sustainable use of land and soil must harmonise the different uses in such a way that irreversible uses are minimised and the six main soil functions are maintained (Blum 2009). However, this is not a scientific question but a political one, which means that people living in a given area or a certain space need to decide which soil functions they may use at a given time or in a given space, using a top-down-bottom-up approach. In this context, scientists only have the possibility to develop scenarios and explain which causes and impacts may occur, when different options are exercised.

For action, politicians and decision makers as well as stakeholders need information. This information can be given by indicators, which are following the cycle of political decision making, e.g. the DPSIR approach (Blum 2004) as shown in Fig. 25.8. Indicators in this sense are information for understanding and managing complex systems. They can be cultural, social, economic, ecological or technical information. Scenarios based on such indicators can help politicians and decision makers as well as land use planners to understand the complexity of the system and to choose the right options.

For this, the criteria for indicators must be policy relevant; focus on real demand and less on the supply of data; are analytically sound, based on science and revealing a clear cause-response relationship; are easy to interpret and understandable for stakeholders at the grass-root level as well as for decision makers and politicians and, finally, are easily measurable and therefore feasible and cost effective in data collection, processing and dissemination.

The most used indicator framework for bridging between science on one side and politics and decision making on the other side is the DPSIR framework approach (Fig. 25.8). From this figure, it becomes clear that a certain state (S) of a soil, e.g. a degraded soil or an eroded soil, is caused by driving forces (D), e.g. agricultural land use, developing pressures (P), such as compaction or erosion. On the other side, the state (S) has an impact (I) which can be direct, e.g. changes in important soil functions, like soil fertility, or indirect, when the changes are affecting the local population which, e.g. cannot produce enough food and therefore cannot live any longer in that area. For mitigating the driving forces or pressures, the state or the impact, responses (R) are needed, which can reach from information, subsidies, until legal regulations at different levels.

In order to make this approach operational, concepts for integrated research, especially on soils, were developed, distinguishing between main research goals, research clusters and sciences involved (Table 25.1) (Blum et al. 2004).

From Table 25.1, it becomes clear that it is necessary (1) to understand the main processes in the soil, induced by threats; (2) to know where these processes occur and how they develop with time; (3) to know the driving forces and pressures behind these processes, as related to cultural, social, economic, ecological or technical, local, regional or global developments; (4) to know the impacts on the ecoservices provided by soils to other environmental compartments and finally (5) to develop operational tools for the mitigation of the threats and impacts.

For this, 5 research clusters were developed, showing the analysis of processes; the analysis of the state and its changes with time (soil monitoring); the relating of the threats to driving forces and pressures, cross-linking with cultural, social and economic drivers, to analyse the impacts on other environment compartments, like air, water, biomass production, human health and culture and finally the development of strategies and operational procedures for the mitigation of the threats (responses) as shown in Fig. 25.9. The relationship between the explained eight threats to driving forces and pressures through cross-linking with policies is shown in Fig. 25.10, where the agricultural policy is made responsible for erosion, losses of organic matter, decline in biodiversity, compaction, salinisation and contamination.

An example of the analysis of impacts by relating those to the soil deliverables into other ecological compartments is shown in Fig. 25.11, where the impact of erosion on the air, the water, the biomass production, human health and biodiversity is shown.

Finally, looking into the necessity to involve different sciences in different operational steps aiming at developing scenarios for politicians and decision makers, Table 25.1 shows that for most of the priority research areas, different sciences are necessary for developing sound results.

Table 25.1 Concept for integrated research in ecology – example soil

	Main research goals	Research clusters	Sciences involved
1	To understand the main processes in the eco-subsystem soil; induced by threats	Analysis of processes related to the 8 threats to soil and their interdependency: erosion, loss of organic matter, contamination, sealing, compaction, decline in biodiversity, salinisation, floods and landslides	Interdisciplinary research through cooperation 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 of methods for the analysis of the state (S) of the 8 threats to soil and their changes with time = *soil monitoring* in Europe	Multidisciplinary research through cooperation 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 cultural, social, economic, ecological or technical, local, regional or global developments	Relating the 8 threats to *driving forces (D)* and *pressures (P)* = cross-linking with EU and other policies (agriculture, transport, energy, environment, etc.)	Multidisciplinary research through cooperation of soil sciences with political sciences, social sciences, economic sciences, historical sciences, philosophical sciences and others
4	To know the impacts on the ecoservices provided by the subsystem soil to other environmental compartments (eco-subsystems)	Analysis of the *impacts (I)* of the 8 threats, relating them to soil ecoservices for other environmental compartments: air, water (open and ground water), biomass production, human health and biodiversity	Multidisciplinary research through cooperation of soil sciences with geological sciences, biological sciences, toxicological sciences, hydrological sciences, physiogeographical sciences, sedimentological sciences and others
5	To have operational tools (technologies) at one's disposal for the mitigation of threats and impacts	Development of operational procedures for the mitigation of the threats = *responses (R)*	Multidisciplinary research through cooperation of natural sciences with engineering sciences, technical sciences, physical sciences, mathematical sciences and others

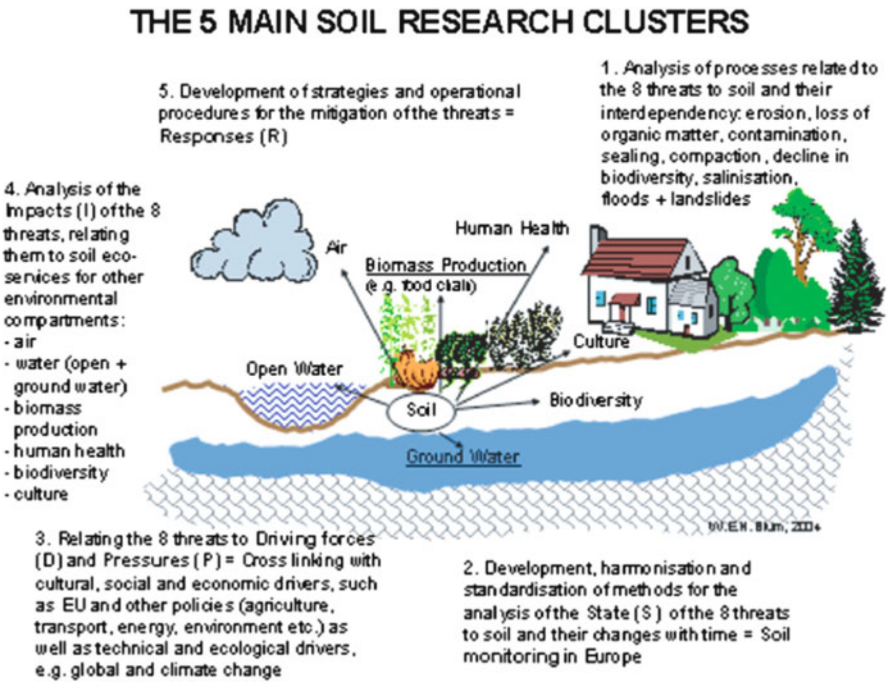

Fig. 25.9 The five main research clusters (Blum 2004)

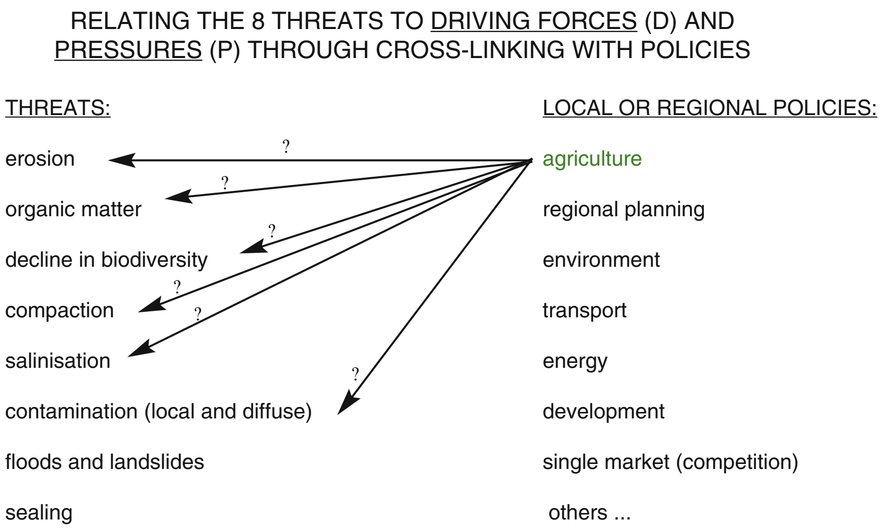

Fig. 25.10 Relating the eight threats to driving forces (D) and pressures (P) through cross-linking with policies

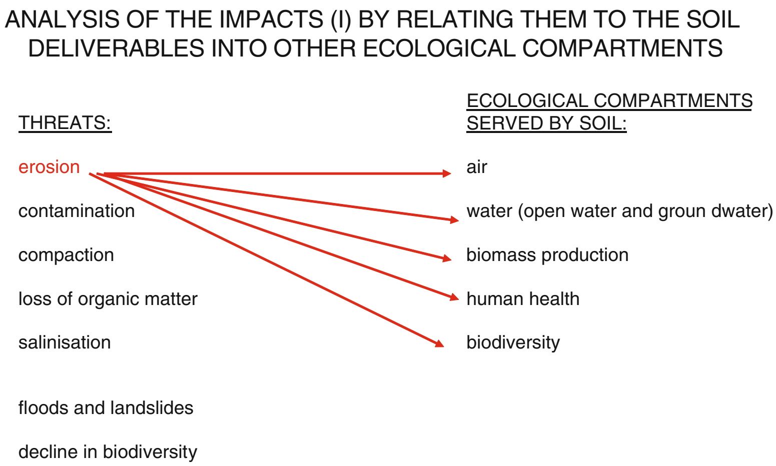

Fig. 25.11 Analysis of the impacts (I) by relating them to the soil deliverables into other ecological compartments

This indicator framework was developed by the European Environment Agency (EEA), on the basis of frameworks developed by the Organisation of Economic Co-operation and Development (OECD).

25.5 Summary and Conclusions

Land use planning should be based on scenarios which are scientifically sound and contain clear criteria, e.g. indicators. The DPSIR approach allows for understanding and managing complex ecological (technical) systems through the development of such scenarios. For the definition of indicators, new concepts are needed, including interdisciplinary and multidisciplinary approaches, bringing together technical, ecological, cultural, social and economic sciences. Indicators based on this approach can bridge between science and technology on one side and stakeholders, decision making and politics on the other side, thus sharing knowledge between those who have it and those who need it.

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