LIAISE

Linking Impact Assessment Instruments to Sustainability Expertise

Discussion Paper

Improvement of the use and contents of tools for policy relevant test cases

Cross policy analysis and tool descriptions, related to the Soil test case, assessing the need for a soil framework directive

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Preamble

One of the key activities of LIAISE is to develop a process through which Impact Assessment (IA) researchers can interact more effectively with IA practitioners by using improved IA tools. In practice this turned out to be a very tedious task, which led to delay of activities in LIAISE and in WP3 in particular.

In March 2013, interaction took place with JRC and DG environment to set up an "EU soil strategy test case", with the aim to revisit the 2006 impact assessment of the soil thematic strategy in view of (i) new paradigms on soil functions/ services rather than soil threats, (ii) the emergence of grand society challenges at European level, (iii) improved understanding of IA methods and potentials, (iv) improved science policy interaction and last but not least (v) availability of new methods and tools and data for assessing the causal relations between soil management, soil threats, soil functions and grand societal challenges. The aim was thus broader than the use of improved IA tools. More specifically, it included: (i) an assessment of the "Need for a European wide soil protection strategy" in view existing policies and (ii) an overview of the development and use of models that allow to assess the linkage between soil management and soil threats/soil functions at a European wide scale. Inversely, the collection of user requirements and translating them in concrete specifications and modifications for from tool improvements, being one of the goals within WP3, was not part of this "EU soil strategy test case".

This deliverable shortly summarizes results of the study that was carried out in 2013 and the beginning of 2014.

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1 Introduction

1.1 Background

In 2002, the Commission presented its approach to soil protection in a Communication “Towards a Thematic Strategy on soil protection”. The main threats to soil were described, including erosion, decline in organic matter and biodiversity, contamination, sealing, compaction, salinization and landslides. In 2006, the European Commission wrote down their “Thematic strategy for soil protection”, including a proposal for a “Soil framework directive” with an accompanying document on an “Impact assessment of the thematic strategy on soil protection”. However, the proposal for a “Soil framework directive” has not been adopted in 2006. Reasons for not doing so included the argument that soil is not a matter for negotiation at European level as there are no transboundary effects, as with e.g. air and water pollution, the administrative burden and *the limited scientific evidence, particularly with respect to the costs of measures to reduce soil degradation as compared to the benefits*. At present, ongoing activities within the EU Soil Thematic Strategy are thus limited to awareness raising, research and policy integration (EC, 2012).

An important reason for a renewed impact assessment of the thematic strategy on soil protection, including an assessment of the possible need for as soil framework directive, is that soil degradation is now much more prominent on the awareness list than it was in 2006. It has been stressed in many policy related documents in the last decade that soils are fundamental pillars of sustainable development. They are essential for food security, support human well-being, and provide further ecosystem services, such as carbon storage. Consequently, LIAISE researchers in Work Package 2 (‘Science for IA tools and procedures’) invited experts from soil sciences to a workshop in JRC, Ispra, which was held on 24-25 April, 2012. The purpose of the workshop was to establish the status quo and to elaborate a research roadmap towards improved uptake on soil evidence in impact assessment. Steps suggested at the workshop were that members of the LIAISE project, in collaboration with the workshop participants, will further process the results of the workshop by:

1. Consolidating the research agenda by identifying items for impact assessment and use the material as a basis for a joint paper on soil research for policy support in e.g. Environmental Science and Policy.
2. Further developing the LIAISE tools box for improved update of scientific evidence for policy making and sharpening of the functionality with regards to different user groups and attach practical examples of tool applications to the tools in the box.
3. Revisiting the 2006 impact assessment of the soil thematic strategy in view of: (i) new tools and knowledge that have come available that could cover questions which had to be left open in the earlier assessment and (ii) progress that has been made since 2006 with regards to the methodology and the conceptual framework of impact assessment, allowing for new insights through different integration of existing knowledge.

In March 2013, interaction took place with JRC and DG environment to set up an “EU soil strategy test case, with the aim to revisit the 2006 impact assessment of the soil thematic strategy in view of (i) new paradigms on soil functions/ services rather than soil threats, (ii) the emergence of grand society challenges at European level, (iii) improved understanding of IA methods and potentials, (iv) improved science policy interaction and last but not least (v) availability of new methods and tools and data for assessing the causal relations between soil management, soil threats, soil functions and grand societal challenges. The study was carried out in 2013 and the beginning of 2014.

1.2 Aim of and approach to the study

The aims and approaches of the study were twofold. The first aim was to assess the "Need for a European wide soil protection strategy" in view existing policies with a focus on soil (ecosystem) functions in relation to Societal Challenges, particularly food, water and energy security, climate change mitigation and increased resource efficiency. Full results are given in Glaesner et al (2014) and a summary is presented in a policy brief and in this report (Chapter 2)

The second aim is to evaluate new models and tools that have been developed since 2006 which may more properly assess impacts of management in relation to policies on soil quality (threats) and soil (ecosystem) functions. The soil threats considered were discussed in interaction with stakeholders, i.e. JRC and DG Environment. Based on the discussion, we included erosion, compaction, changes in organic carbon and nutrient contents, salinization and contamination. For each considered threat, an overview is presented of tools, methods and data to quantify the linkage of soil management options to relevant impact indicators and where possible available results in terms of geographic variation and extend of soil degradation and respective impacts on soil functions and grand societal challenges. The review aims to aid a stronger science base for the proposed soil protection framework directive. There are no new/improved tool developments originating from this analysis. Full results are given in De Vries et al (2014), while a summary with some examples are presented in Chapter 3.

2 Cross policy analysis

2.1 Methodology

To assess the need for a separate soil directive at European level, a policy analysis for soil protection was carried out i) addressing the state of existing directives affecting soils in terms of soil threats and soil functions, and ii) identifying gaps and overlaps for soil protection in existing directives. Below, we summarize the approach and results, while referring to Glaesner et al (2014) for more details on the study.

Inclusion of soil threats and soil functions in the study
The approach is based on the paradigm shift of soil degradation to societal value of soils by using the concept of soil functions in combination with soil threats, both concepts being mentioned in the proposal for a Soil Framework Directive (EC, 2006b). Protection of soil resources plays a vital role to meet the grand societal challenges. Hence, shift of focus from soil degradation (soil threats) to soil functions may serve as a tool to relate soil to grand societal challenges at European level. The grand societal challenges directly linked to soil are food security, energy security, climate action and resource efficiency.

The concept of soil functions connects physical, chemical and biological processes with values of soil to society in environmental, economic and social terms. Similar concepts are the Ecosystem Services that are divided into provisioning, regulating, supporting and cultural services, as well as the concept of Landscape Services, which was introduced as a bridge between landscape ecology and sustainable landscape development. In our study, we have chosen to apply the soil function concept mentioned in the proposal for a Soil Framework Directive in order to address all soils and not only those related to agriculture.

Cross-policy analysis (gap and overlap analysis)
Criteria for policy selection were sectors with direct relation to soil. The main sectors (pressures) to soil degradation can largely be divided into four main categories: i) agricultural management (related to soil organic matter decline, salinization, erosion and compaction in view of biomass production), ii) industry (related to contamination associated with industrial sites), iii) urbanization (related to soil sealing and land take for urban structures and infrastructure as well as tourism) and iv) climate change (related to greenhouse gas emissions and carbon pool changes). Hence, directives within these four sectors as well as nature conservation directives were selected for the analysis. A total of 16 directives and 2 recent EC communications related to soil were analysed. Based on this analysis, gaps and overlaps of soil threats and soil functions covered in existing directives were identified. The criteria for inclusion were that a certain soil threat or soil function was directly addressed. Directives that may have indirect effects (e.g. policies requiring grazing of animals result in more compaction of soil) were not included. A distinction was made between directives that 'prevent acceleration' and those that 'reduce' soil threats and similarly in those that 'prevent reduction' or 'improve' soil functions. The analysis was related to the counterfactual that no policy (directive) was in place The analysis was carried out at EU level. Hence, national directives were not included in this analysis.

2.2. Results

A summary of the results of the cross-policy analysis (Table 1) showed that of the seven soil threats, three are not covered by existing legislation, i.e. compaction, salinization and sealing. Compaction and salinization are even not addressed in the EC communications. Soil organic matter decline is scarcely covered, and this also holds soil biodiversity, since the investigated directives only focus on biodiversity in general. Only soil erosion and specially soil contamination are to a (relatively) high degree addressed in existing legislation. However, the analysis showed that nearly all policies aim to 'prevent acceleration of threats', while only very few existing legislations aim at a reduction of the mentioned soil threats. More details on the study are given in Glaesner et al (2014).

Not covering all soil threats threatens soil functionality. The analysis further showed that all soil functions are covered in existing legislation, but nearly all directives aim to prevent the reduction of a particular soil functions, but very few directives exist to improve soil functionality for the future. Hence, it is questionable whether the existing legislations related to soil are actually protecting the soil from soil threats or improving a soil function. Soil degradation is still progressing in Europe, questioning whether the existing directives related to soil are sufficient for maintaining soil functionality. The problem of soil degradation is present all over EU and only a limited number of Member States have comprehensive national soil legislation. Already existing high national soil protection legislations of some Member States will not be threatened by a common EU legislation, as it is possible for Member States to go beyond the EU level. Transboundary effects of soil degradation occur, even though soil is generally immobile. These effects include erosion, chemicals in soil, food trade, etc. A common legislation could benefit internal market issues when some Member States have high conservation polices on soil and others have none. In addition, a common legislation may provide the basis for better export of know-how and technologies outside EU.

Table 1. Number of existing European legislative policies covering soil threats and soil functions, thus identifying gaps in legislation. Policies are divided based on whether the policy is 'preventing acceleration of threat' or 'reducing threat' as well as 'preventing reduction of function' or 'improve function'. See text for details.

Soil threats	Gap	Prevent acceleration of threat	Reduce threat	Policies involved
1. Erosion		3		• CAP, Renewable energy, Mining waste
			1	• Floods
2. Organic matter decline		2		• CAP, GMO
3. Compaction	X			
4. Biodiversity decline		8		• Plant protection product, Biocide, GMO[a], Environmental liability, Carbon storage, Pesticide use, Mining Waste[a], Renewable energy[a]
			2[a]	• Habitat, CAP
5. Salinization	X			
6. Contamination		12		• Waste, Landfill, Mining waste, Pesticide use, Plant protection products, Biocide, Environmental liability, Carbon storage, Water Framework, Air quality Framework, Sewage sludge, Industrial emissions
			2	• Renewable energy, Environmental liability
7. Sealing	X			
Soil functions	**Gap**	**Prevent reduction of function**	**Improve function**	**Policies involved**
1. Biomass production		2		• CAP, Renewable energy
2. Storing, filtering and transformation		13		• Nitrates[b], Pesticide use[b], Waste, Landfill, Mining waste, Plant protection products, Biocide, GMO, Industrial emissions, Carbon storage, Water Framework, Air quality Framework, Sewage sludge
			(1	• CAP[c])
3. Habitat and gene pool		8		• Plant protection product, Biocide, GMO[a], Environmental liability, Carbon storage, Pesticide use, Mining Waste[a], Renewable energy[a]
			2[a]	• Habitat, CAP
4. Physical and cultural environment for mankind		3		• Landfill[d], Pesticide use, CAP
5. Source of raw materials		2		• Mining waste, Landfill
6. Carbon pool		2		• CAP, Renewable energy
7. Geological and archeological archive		2		• CAP, Floods

[a] None of these policies are directly linked to soil but focus on biodiversity in general

[b] The Nitrates Directive, Pesticide use Directive (and CAP) focus on off-site impacts which improve this function in some areas of farms, but these activities also contribute to reducing the function, by e.g. application of pesticides. Measure to prevent reduction of this function in these directives is related to e.g. buffer strips and not to the soil as a whole.

[c] CAP includes measures for maintaining soil organic matter, soil structure, etc. which indirectly improve soil function 2.

[d] The Landfill Directive prevents reduction of this soil function in one area by not locating landfills close to residential and recreational areas, however reduces the function (establishing residential and recreational areas) in other areas where a landfill is located.

3 Methods, tools and data for assessing causal relations between land management, soil functions and environmental impacts at European scale

To gain insight in the possibility to evaluate impacts of management, as affected by policies, on soil (ecosystem) functions by affecting soil quality, we evaluated available models and tools that allow application at European scale. Below, we summarize the approach and give some examples of results, while referring to De Vries et al (2014) for more details on the study.

Linkage between soil functions, soil quality (indictors) and soil threats
Soil threats affect soil quality (indictors), which in turn affect soil functions and thereby may cause adverse impacts on aspects, such as food and water security (societal challenges) and furthermore it may lead to biodiversity (loss), climate change and environmental (air, soil, water) pollution, all considered (Table 2).

Table 2 Linkage between societal challenges, soil functions, soil quality (indictors) and soil threats

Societal challenge	Soil Function (Service)	Soil quality	Soil Quality indicators	Threats
Food security	Food and other biomass production	Soil fertility	Major nutrient (e.g. N, P, K) contents Minor nutrient (e.g. Cu, Zn, Mo) contents pH, salinity	Soil nutrient depletion Erosion, Compaction Soil acidification/salinization
Water security	Water storage/ retention	Water retention capacity	Hydraulic conductivity, water retention curve Soil structure, Soil texture, soil aeration	Erosion, Compaction Soil organic matter decline
Biodiversity (loss)	Biological habitat pool	Habitat quality	pH, nutrient contents (availability), water availability	Soil acidification/ eutrophication
Climate change)	Carbon (dioxide) sequestration potential	Carbon content	Soil organic carbon content	Soil organic matter decline
Environmental (air, soil, water) quality	Environmental regulation Storage, filtering, transformation	Nutrients	Phosphate adsorption capacity Cation exchange capacity Metal adsorption constant Organic contaminant degradation rate	Soil eutrophication Soil acidification Soil organic matter decline Sol contamination

A threat to soil quality by agricultural management thus affects soil functions, and a full evaluation may require the use of various models as illustrate in Figure 1 for subsoil compaction impacts on crop yield gap .

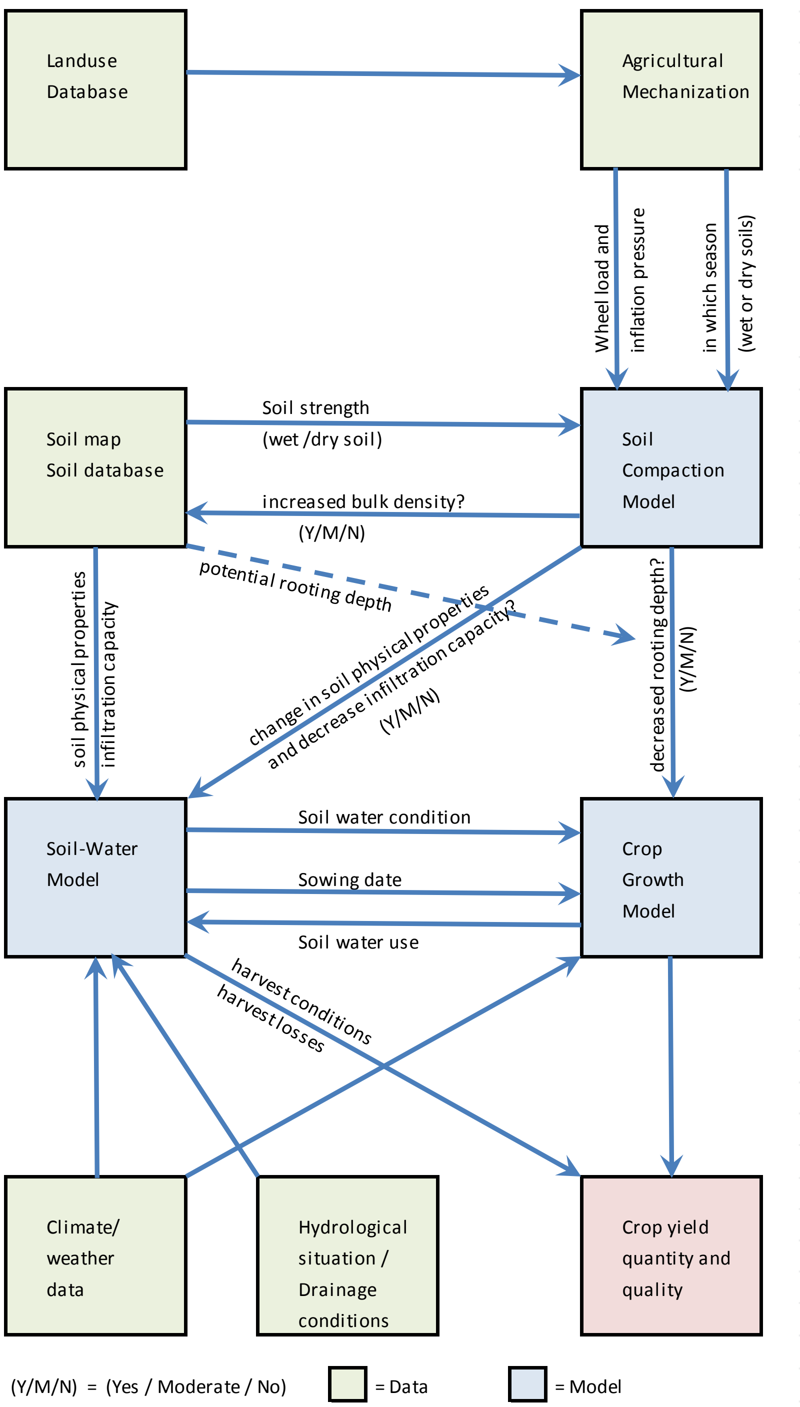


Figure 1. Schematic overview how to determine the impact of subsoil compaction on crop yield. A major part of the economic loss by subsoil compaction can be assessed in this way.

Data and methods to assess management impacts on soil quality indicators
The approach used in the study is that for each considered threat to soil quality, an overview has been made of data and methods/tools for the assessment of

- the geographic variation and trends in soil quality indicators and
- the impact of land management on soil quality indicators and related soil functions/ environmental impacts

This is done according to a common framework, i.e. by a description of:
1. Problem/indicators/critical limits related to each threat, i.e. a state of the art description of the

- Environmental problem related to the threat (current problems). Include short discussion of impacts of the soil threats on soil functions focusing on crop growth/crop quality and environmental regulation (water, carbon, nutrient and pollutant storage) with related impacts on environmental quality (air, soil and water quality)
- (State) Indicators that are available to assess/quantify the specific soil threat in view of the related soil functions (services) (example: for erosion the erosion rate, for metals total metal content, for organic matter the total organic matter content), their relevance (e.g. for metals reactive content or dissolved concentration is more relevant than total content; what about e.g. use of reactive SOM etc.).
- Possible critical limits that exist for those indicators and if so, which values are used or can be calculated with a critical evaluation (e.g. use of 1% or 2% as critical for SOM, but complete risk assessment scheme for metals). If possible, mention which critical limits are currently applied (e.g. total metal content for heavy metals) or are being developed?

As an example, critical limits for air-filled pore volumes is given in Table 3, that are relevant to evaluate effects of soil compaction.

Table 3. Determined minimum and preferred air-filled pore volumes to avoid (severe) anaerobic conditions for plant root growth.

Soil structure	Airfilled pore volume ng should be:	
	At least	Preferably
Excellent	> 2 %	> 14 %
Good	> 5 %	> 15 %
Moderate	> 8 %	> 17 %
No, Bad	> 12 %	> 21 %

2. Factors affecting the development of state indicators (what causes changes in the state of the environment), distinguishing between (i) land management/land use (focus) and (ii) 'external' drivers, such as climate and site conditions, i.e. soil type, slope etc.

3. Methods/models that are available to describe changes in the state of the environment and data that are available (or lacking) to use such models. Relevant aspects for the models used are the:

- Factors that can be evaluated with the model when predicting the dynamics of the state of the environment, dividing between land management options and 'external' drivers, such as like climate and site conditions, as described under point 2
- Spatial and temporal extent (e.g. EU 27 for the period 1980-2050)

- Spatial and temporal resolution (e.g. 10km x 10km grid cells at daily resolution or certain polygon approaches at yearly resolution)

As an example, in Table 4 an overview is given of water and wind erosion methods that have been developed and applied at European (or part of Europe) scale.

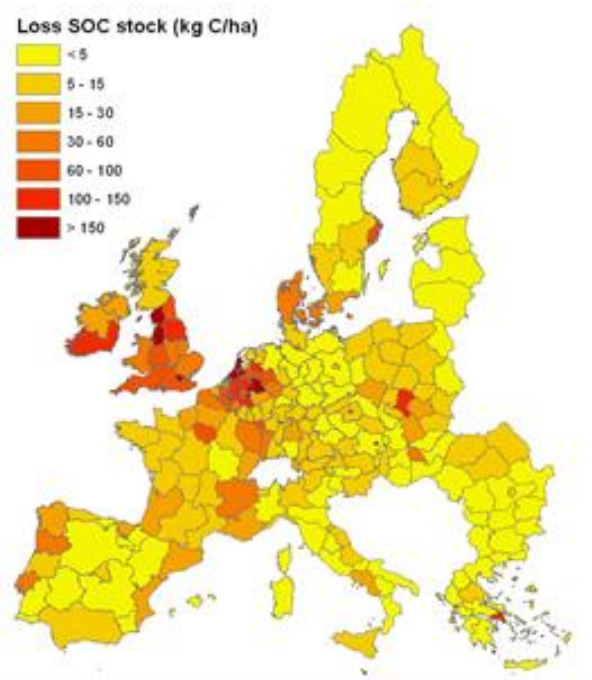
Table 4 Methods used to assess soil erosion at European scale.

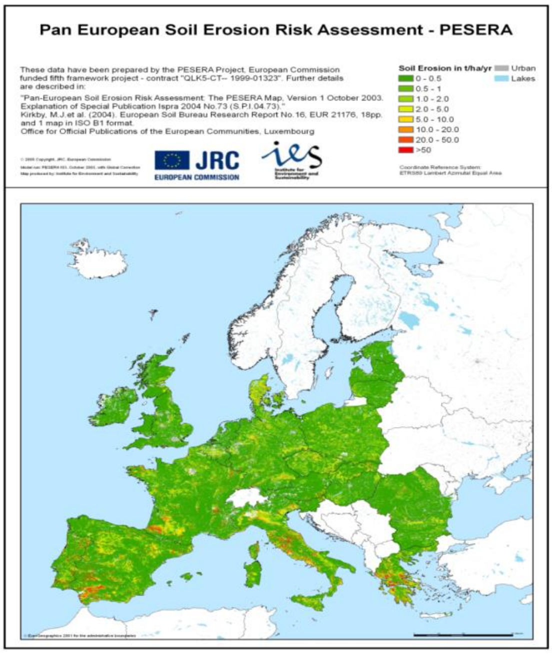
Method	**Type of method**	**Output**	**Scale of application**	**Spatial unit**
Water erosion methods				
CORINE	Decision tree model	Erosion risk in 3 classes	Southern EU	180000 units
GLASOD	Expert opinion	Degradation severity in 4 classes	World	Polygons, scale 1:10M
USLE	Empirical model based on results of erosion plots in USA	Erosion rate (t/ha/yr)	EU	1km pixels
RUSLE	Revised USLE	Erosion rate (t/ha/yr)	EU	1km pixels
MESALES	Decision tree model, developed first for France, then applied to Europe	Sensitivity or risk, in 5 classes	EU	1km pixels
PESERA	Process based model, developed for Europe	Erosion rate (t/ha/yr)	EU	1km pixels
EIONET	Information provided by member states	Erosion rate (t/ha/yr)	11 countries in Europe	1km pixels
Empiric	Statistical analysis of erosion plot data	Erosion rate (t/ha/yr)	Area covered by CORINE land use	100m pixels
Wind erosion methods	Type of method	Output	Scale of application	Spatial unit
WEELS	Process based model	Erosion risk	4 sites in north western Europe	Polygons (fields)
JRC	Susceptibility wind erosion	Erodible fraction (%)	Europe	500m pixels

4. Spatial patterns and if possible trends in relevant soil quality (threat) indicators at EU scale (EU 27 or Pan European level) based on either or model results, i.e. examples of:

- Data (monitoring systems):
  1. Current geographic variation of soil quality (threat) indicators (e.g. maps of data on organic matter contents or total metal contents).
  2. Possible trend data at regional scale (e.g. organic matter trend data).
- Model results
  1. Current geographic variation, e.g. of simulated erosion rate in response to ‘external’ drivers, such climate, and site conditions
  2. Possible trends, e.g. maps of (results from) model studies on dynamics of state indicators for metal (metal accumulation) in response to management measures.

Below two examples are given of European wide applications of models that have been developed to assess impacts of management on soil threats, i.e. MITERRA for changes in soil organic matter content and PESEREA for erosion. More details on approaches and results are given in De Vries et al (2014)





Assessments of loss of SOC with the MITERRA model (left) and erosion with the PESERA model (right) at EU 27 level.

The above examples show that the developed models are helpful to improve the state of knowledge in terms of present extent of the problem (as for example the geographic variation in soil erosion as given above) partly modelled) but also (and more relevant) to evaluate the cost-effectiveness of policies and related (management) measures (as illustrated for the MITERRA model result for a policy scenario).

4. Conclusions

To ensure that all soil functions are maintained, policy legislation and planning is necessary. This study highlights that a Soil Framework Directive would give an EU added value by directly addressing soil threats and functions in policies, as this is only partly occurring at present in existing legislation.

Based on the availability of new methods and tools and data for assessing the causal relations between soil management, soil threats and soil functions, a better evaluation of measures is possible in case such a directive would come into force.

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