REPORTS OF THE TECHNICAL WORKING GROUPS

ESTABLISHED UNDER THE THEMATIC STRATEGY FOR SOIL PROTECTION

VOLUME - VI

RESEARCH, SEALING & CROSS-CUTTING ISSUES

Editors

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Anna Rita Gentile, Robert J A Jones
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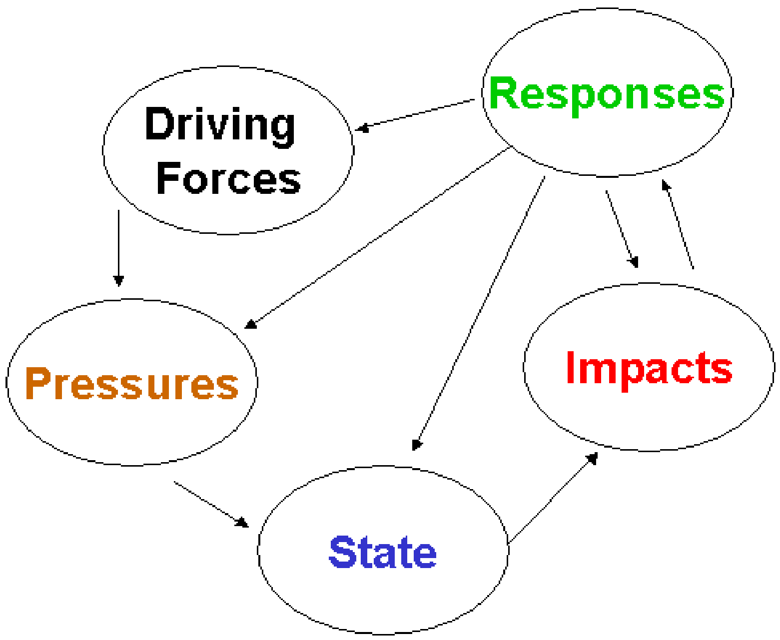

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European Environment Agency

2004

EUR 21319 EN/6

This document may be cited as follows:

Van-Camp. L., Bujarrabal, B., Gentile, A-R., Jones, R.J.A., Montanarella, L., Olazabal, C. and Selvaradjou, S-K. (2004). Reports of the Technical Working Groups Established under the Thematic Strategy for Soil Protection. EUR 21319 EN/6, 872 pp. Office for Official Publications of the European Communities, Luxembourg.

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EUR 21319 EN/6

Printed in Italy

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RESEARCH, SEALING AND CROSS-CUTTING ISSUES

Task Group 1 on
RESEARCH FOR EROSION, COMPACTION, FLOODS AND LANDSLIDES

Anton Imeson, Coen Ritsema, Rudi Hessel

Introduction

This report considers the research needed to address threats posed by soil erosion, flooding, compaction and landslides. These threats are related by common pressures, drivers and impacts and they could be addressed in some cases by similar policies and actions. They are threats that in many cases have increased as a result of the impact of land use changes and development since the 1960's. The report was obtained mainly through expert consultation of both individuals and leading research groups. Ideas and recommendations from the Working Group on erosion have also been incorporated and synthesised.

This report is not intended to provide a complete analysis of the research needs in the four areas that it covers. Within the framework of the overall mandate it has attempted to synthesise a vast amount of information and reduce this to a small number of key actions. In accordance with the mandate, emphasis has been given to a) identifying and structuring existing information in order to make it more easily available, b) analysing barriers that prevent full use of scientific results for policy, and c) formulating recommendations to improve the transfer of information.

The threats posed by soil erosion, flooding, compaction and landslides have much in common. These threats are related by common pressures, drivers and impacts and would benefit from similar responses. Throughout this report, the 5 cluster adaptation of DPSIR is used.

The analysis of the information provided by the contributors repeatedly stressed a few recurrent points. Firstly there was a need for an integrated methodology that tackled all of the drivers and impacts. Although there have been recent scientific advances in developing integrated methodologies, it will be a major challenge do develop the tools that are needed. Another many faceted issue is the data and information base that presently exists. A major rethinking of data and monitoring requirements could be considered. Climate change and/or land use change are important drivers in many cases, and should receive due attention.

Finally, there is the need to communicate scientific research and to motivate implementation.

Summary and Recommendations

1. Soil erosion

Processes and modelling

Knowledge on soil erosion is scattered across disciplines, very diverse of character, and not yet established and employed to full extent. In order to develop an integrated strategy for addressing soil erosion at different spatial and temporal scales, knowledge on regulating soil erosion processes should be expanded and enlarged to understand in more detail than currently possible why, where, when, and at what rate erosion occurs under given conditions of land use and climate. Advanced multi-scale simulation models should be developed, tested and applied for different agro-environmental zones within Europe, preferably using state-of-the-art GIS approaches and remote sensing data gathering techniques.

Data and monitoring

The situation regarding available data and information systems is critical for although observations have been made for a long time, measurements are sorely lacking. Data, indicators and monitoring are needed at different spatial and temporal scales for evaluating the performance of policy and compliance, to provide early warning, and to help understand how land use and climate changes are impacting on the capacity of the system to handle the pressures that lead to erosion. Sites should be selected for long term measurements of erosion.

Driving forces and pressures

The driving forces for soil erosion are climate (energy of rainfall and wind), and its major pressures are climate change and land use change. Land use change is motivated by economic, political and financial incentives, as well as by social and psychological ones.

Impacts

An integrated strategy for combating erosion that cuts across disciplines, scales and sectors is necessary. This requires an improved conceptual framework that integrates the different drivers and impacts, and which can be used to develop advanced assessment, monitoring, modelling, conservation and remediation approaches for managing and preventing erosion and also for supporting policies and local action groups.

Responses

Tools are needed that help policy makers identify when an emergent erosion problem is likely to occur. Tailor-made conservation and remediation strategies need to be developed for preserving the soil (and water) resources. These strategies should be technically feasible, economically viable and socially acceptable for related stakeholders, and effective in reducing and/or preventing runoff and erosion. These actions should increase the capacity of the soil or landscape in its ability to adapt and adjust to changing external pressures without erosion being the result.
Knowledge about erosion should be made generally available and communicated to all relevant disciplines, sectors and actors. Considering soil functions as capital, could stimulate adoption of measures to combat erosion. Research should be executed in close interaction with end-users, and address the problems actually encountered in stopping erosion using multidisciplinary approaches.

2. Floods

Processes and modelling

Actions to prevent erosion on slopes may reduce flood risk but they can have counter-intuitive impacts downstream in channels that should be considered. It is necessary to understand the impact and complex interactions between processes that operate at different rates and which influence the capacity of soils and channels to regulate water both during individual storms and over many decades or centuries. Topics of relevance are i) Identification of natural, long-term tendencies, including delayed response ii) Systematic analysis of channel responses, and iii) Modelling of channel response and feedback.

Data and monitoring

Important issues are i) Identification of flood zones, ii) Monitoring of channel form and channel changes – cross sections and detailed mapping iii) river channel capacity monitoring, e.g. by remote sensing.

Driving forces and pressures

The main pressures are land use change and climate change. Land use change can result in reduced storage capacity of the soil and in expansion of sealed surfaces. Storage capacity of rivers has likewise decreased.

Impacts

The risk of flooding is increasing because more property is located in flooding prone areas, while flooding frequency might increase.

Responses

Topics which need attention are a.o. i) Work with nature, ii) Functional floodplains and channel adjustment, ii) Retaining flood storage, iv) Increasing flood attenuation, v) River restoration, and vi) Use of vegetation.

The actions proposed to reduce erosion on slopes will also decrease flood risk by increasing the water storage capacity of the soil. Sinks and source areas of water on slopes should be managed in ways that promote the water regulation function of slopes and catchments. This management requires local support and tools.

3. Compaction

Processes and modelling

More process knowledge is needed about relationships between compaction and plant growth (production) as well as with functions related to the environment and water management.

Effects of subsoil compaction should be better incorporated in models to predict processes such as soil water flow, transport of solutes and crop growth. This requires the development of models that quantify the link between soil porosity, water infiltration and root development.

Data and monitoring

Problems of compaction are widely distributed throughout the world but tend to be most prevalent where heavy machinery is used in agriculture or forestry. An assessment of the existence and seriousness of subsoil compaction throughout Europe should be initiated. The assessment should be a real examination of the subsoil of common and representative agricultural soils in all European countries. This research area is crucial in order to increase our understanding of the soil compaction process and hence our possibility of developing tools to predict and thus avoid subsoil compaction.

Driving forces and pressures

Continuing mechanisation of agriculture and forestry has led to ever increasing wheel loads, which have led to soil compaction.

Impacts

Soil compaction can decrease infiltration, increase erosion rates, increase flooding and hinder plant growth.

Responses

Responses are likely to be technical, such as reducing tyre inflation pressure, ploughing on-land, different wheel arrangements, tracks instead of wheels or automated low-weight machinery. Other options are drainage (increases soil strength) and minimum tillage systems. User friendly decision support systems are needed to assist the farmer in selecting the best equipment and methods to prevent overcompaction.

4. Landslides

Processes and modelling

An analyses of relationships between precipitation regimes and slope stability in well-instrumented landslide sites, with the support of hydrodynamic numerical models is needed to reach an in-depth understanding of the different hydrological systems working in different types of mass movements. The climatic signals of dated landslides and the completion of mass-movements series should be ascertained. Further effort must be put on downscaling General Circulation Models, particularly in the difficult Mediterranean area. At the catchment (regional) scale we must validate the numerous current hazard and risk mapping experiments and analyse the role of mass-movements as a major sediment source to torrent loads. Since many different types of landslide exist, no single model can be used for all types, but instead different models are needed. Better models are especially needed for fast landslides. Measurement techniques should also be adapted to each type.

Data and monitoring

The risk from landslides activity should be reduced by appropriate monitoring, short-term behaviour prediction and action to minimise the risk when hazardous movements are indicated.

Driving forces and pressures

The driving force of landslides is gravity, but hydrological conditions and vegetation are very important factors that can trigger or prevent landslides. Climate change can influence the activity of landslides.

Impacts

Landslides are a major threat in mountainous and coastal regions because each year they claim lives, and result in large damage to property.

Responses

With an accurate prediction of short-term behaviour of mass movements, early warning systems can be built without false alarms and giving the community at risk sufficient warning in order to take appropriate action.
Multidisciplinary investigations could provide clues on how to meet mass movements risks, plan practical mitigation measures and integrate hazard assessment studies into community development plans. New techniques should be developed to make human activity compatible with the existing and potential mass movements, not only by alert systems but using engineering solutions to reduce the vulnerability of settlements.

Summary table

The table below gives a summary of the research needs presented above, with information about urgency added. The sequence used in the table follows the sequence of the report and of the summary. Urgencies are rated here using asterikses, where 1 asteriks signifies relatively low priority (long term) and 3 asterikses signifies high priority (short term). This division in priorities does not mean that research priorities with low priority are not important; it rather indicates that these priorities are indeed important, but can receive attention somewhat later than the other priorities.

Processes and modelling (cluster 1)

The state-of-the-art in soil erosion, soil conservation and protection research is currently being assessed in a EU concerted action (www.Scape.org). As part of this action, in June 2003, several experts were requested to present briefing papers that covered amongst other things, the state of the art regarding erosion processes, models, data, soil quality and the economic and financial costs of erosion, and to describe case studies that illustrated best practices. These and other papers can be found in the appendix.

Since 1960, European scientists have developed a sound understanding of the mechanical processes of erosion and of the mechanisms of rill erosion, tunnel erosion wind erosion, gullying and tillage erosion and of the influence of biological processes in erosion and of the influence of the soil water chemistry on infiltration runoff and sediment transport. They have also investigated how key processes (e.g. surface sealing, infiltration and runoff) can be managed, and developed successful strategies for reducing runoff and erosion. They have also examined how erosion processes are influenced by weather and climate. What these and other studies have shown is the need to consider processes at different scales and to consider feedback mechanisms between the soil and erosion, including links between bio-physical drivers and socio-economy. Although the mechanism and basic principles are understood, the importance of the temporal scale and spatial characteristics have to be largely guessed.

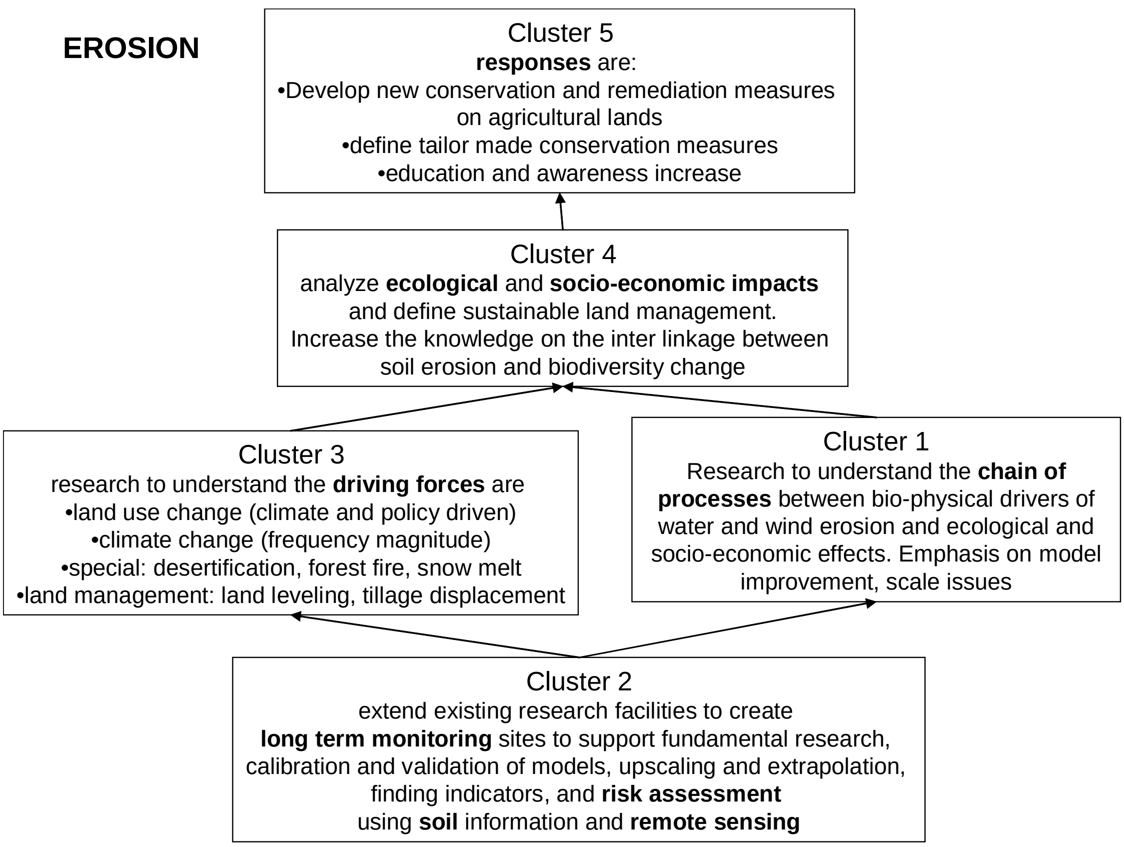
The problem is the environment in which we study erosion is changeable and unstable. Most research data was obtained under totally different hydrometeorological background conditions. Over the past decades the USA has invested large sums in developing soil erosion models. The models usually perform very badly outside of the catchments in which they were developed and are almost impossible to validate.
Europe has made some attempts to develop its own models (e.g. Eurosem, LISEM) but erosion remains difficult to forecast because of its sensitivity to initial soil moisture and other conditions and because of feedbacks that are not included in the model. Different approaches to modelling are being developed and particularly at the coarser scales (e.g. PESERA) some strategic advances have been made. Most large scale models usually model a hypothetical erosion risk or hazard. In the near future it might be possible to validate models and monitor erosion using airborne laser elevation data and cadastral information about land use.

Research priorities	**cluster**	**priority**
Erosion		
Expanding the knowledge on soil erosion processes and modelling, especially regarding different spatial and temporal scales	1	**
Soil erosion assessment and monitoring should be standardised and structured to overcome problems of widely scattered and diverse information	2	***
The effect of changes in climate and land use on erosion	3	**
Development of integrated strategies for addressing erosion, including ecology and socio-economics	5	***
Development of tailor made conservation strategies that are technically feasible, economically viable and socially acceptable	5	*
Floods		
Understanding the complex process interactions that determine flooding risks at different time scales	1	**
Assessment of flooding risk in Europe	2	***
The effect of changes in climate and land use on flooding	3	**
Development of flood management strategies that work with nature instead of against it	5	***
Increasing storage capacity in catchments and channels	5	*
Reduce quickflow area and quickflow connectivity	5	*

Continued….

Research priorities	cluster	priority
Compaction		
New models for stress transmission and soil deformation	1	**
Better models for predicting effects of compaction on soil processes such as water flow, transport of solutes and crop growth	1	**
Assessment of existing compaction level in Europe to give new data for better models	2	***
Development of strategies to reduce compaction, including technical measures and decision support systems	5	*
Landslides		
Understanding the relationship between climate and landslides and development of better models for fast landslides	1	**
Short-term prediction of landslide activity, including the use of models and GIS	1	***
Predicting future behaviour of landslides under different climate and land use	3	*
Design of reliable early-warning systems	5	***
Living with landslides and sustainable development in landslide prone regions, using both land use changes and technical measures	5	***

1. Soil erosion



A clear missing factor is how at a European level the different erosion situations are related to the agro-ecological systems and to socio-economic situation. In Northern Europe erosion is a nutrient and water quality problem – in Southern Europe erosion is a soil loss problem. How can we relate the different agro-ecological zones in Europe with the type erosion and the risk on erosion, and which sustainable measurements are needed to prevent erosion in each agro-ecological zone? CAP should amongst others be directed to that, and a link with the soil and geology situation should be included.

Erosion takes on a variety of forms and each has its own specific characteristics. A proper consideration should be given to research questions specific to the different processes In the next version of this document attention will be given to a) erosion in the different geo-ecological zones of Europe, b) to the relationship of erosion to management, and c) to thresholds and resilience and how these can be managed to limit the scale of erosion. Most of the literature inadequately considers chemical and biological factors and processes.

Data and monitoring (cluster 2)

When attempts are made to actually structure, evaluate and analyse the data and information available, as the mandate requests, it is clear that real hard data and validated models are very scarce. Conclusions are drawn mainly on the basis of memory, experience and indirect evidence, not from dedicatedly collected data. Many observations have been made, but few measurements. Most data and models are site and context specific and collected or developed using concepts and frameworks that have been superseded. Lack of data and models does not mean that nothing is known about erosion. Europe has an excellent active soil erosion community who have developed a deep and valuable understanding of the problem and who are actively networking (e.g through the European Society for Soil Conservation) and in most cases could recommend actions that would stop erosion directly. All of the links, organisations and programmes dealing with erosion in Europe can be found at the soil erosion site: http://soilerosion.net/ that the reader of this report is urged to visit.

The diversity of objectives amongst soil erosion researchers has been a barrier to outsiders trying to understand sometimes contradictory conclusions. Most studies of erosion have been executed by geomorphologists or agricultural scientists so it reflects the research agendas and paradigms from these disciplines. In the 1960's the first measurements of erosion started to be made, notably in Sweden, Poland, France and then later in Belgium, Germany England, Portugal and Italy and it is in these countries that the longest records of soil erosion measurements and traditions of modelling are found. European research was greatly influenced by ideas from the US soil conservation service but in fact there was relatively little joint research with the Americans.

The literature on soil erosion is scattered across different disciplines and it is very diverse, for the non-expert difficult to synthesize. Most treatments of the problem are limited in scope and deal with either specific research questions or management related goals. The first measurements and experiments used statistically designed experiments to try to establish the relative importance of different factors and this was also the approach of the Universal Soil Loss Equation developed from data collected between 1935 and say 1970 in the USA for gently sloping agricultural fields. The purpose of the measurements was mainly demonstration and testing the relative benefit of different soil conservation methods. Unfortunately, these findings have, for lack of European data, also been widely applied in Europe, in some cases even in policies.

Stimulated by the fifth Framework programme, many soil erosion scientists have become accustomed to undertaking soil erosion research as parts of consortia that involve stakeholders, end-users and small and medium enterprises. There has also been much research aimed at developing different types of indicator systems that can be used to identify different sensitivities to erosion (see for example Brandt et al 2003)

The integrated and interdisciplinary nature of much soil erosion research in Europe is far ahead of the United States. Soil erosion research in the USA tends to be data driven and there is infinitely more data available than in Europe The huge investments that the USA makes in collecting environmental data is on the other hand a constraint to the adoption of new frameworks and concepts so that much US work is conceptually less advanced than in Europe.

There are two main aspects for erosion: runoff and sediment **generation** and **connectivity** between sources and sinks. The spatial configuration and changes in spatial patterns of soils and land use are as important as the temporal changes between land use types. It is necessary to establish long term research catchments for monitoring to investigate such spatial patterns and connectivity.
These catchments can be based on the existing research catchments that exist in almost every country (using the main agro-ecological zones that are based on land use, climate and soil type). **EU Support** is needed to build these into key-areas that will help to solve the problems outlined in this report. The downstream areas of these catchments are included as an integrated part so that the complete chain of events processes can be studied (up-scaling of processes and connectivity) as well as the socio-economic impact. Monitoring and harmonized datasets can be generated for these areas. These datasets should serve to:

1. Analyse on a short timescale the effects of tailor-made conservation and mitigation measures
2. Analyse magnitude and frequency of rainfall events
3. Provide data for calibration and validation of models, and to develop existing models further to fill certain gaps in current models.

Driving forces and pressures (cluster 3)

The driving forces and pressures of soil erosion are social, economic, ecological and physical but they act in an integrated way and require an indicated research approach. Soil erosion is directly driven by the forces of climate (energy of wind and rainfall), but it occurs when the vegetation and upper soil horizons have their storage and regulation functions impaired or diminished mainly under the influence of human actions. All kinds of pressures (e.g. pollution, cultivation and land levelling) can lead to the gradual or sudden loss of the (adaptive) capacity of the soil and its ecosystem to retain water and sediment on a slope.

Human induced soil erosion occurs at specific vulnerable locations for specific periods of time, following activities that involve removing or disturbing the vegetation and organism rich layer of surface soil that prevents soil erosion from occurring. Stones and vegetable litter protect the soil from erosion. Rain, hail and flowing water, supply the energy that causes erosion but from a policy perspective it is the vegetation and protective soil cover that is the main factor.

There are four main driving forces or pressures for erosion:

1. Land use changes such as change in scale and intensity, abandonment, and desertification. Such changes are caused by economics, politics or climate changes and are likely to be different for northern Europe and southern Europe.
2. Specific cases such as forest fires and snowmelt
3. Human activities such as land levelling and soil displacement by tillage
4. Climate change: change in frequency and magnitude of events

The main tool to investigate the effects of such pressures is modelling.

Impacts (cluster 4)

Soil erosion can on site result in loss of soil and nutrients, as well as in damage to crops. Severe soil erosion can hinder agricultural practices. Of site in can cause problems because of flooding and pollution. In northern Europe, flooding and pollution are the most important impacts, while in southern Europe soil loss is more important.

Impacts of erosion is an area that is rarely studied and currently is in the focus of the erosion community (COST 634). The socio-economic **cost of erosion** needs to be **researched** and **modelled**, and cost benefit analyses of mitigation measures need to be performed. This is a relatively new area and links with social and economic scientists, even legislation should be sought. Beneficiaries are clear: people affected, local government, insurance companies etc.

Responses (cluster 5)

A major weakness in Europe compared to some other regions concerns the involvement of local action groups (e.g. Landcare) in programmes to combat erosion. Nevertheless, several research groups have begun to establish and involve various focus and other groups in the context of combating desertification (see Medaction 2003).

Combating erosion involves selecting actions that are specific to environmental and socio-economic contexts. Actors need to understand the causes and contexts of local problems at a hierarchy of relevant spatial and temporal levels. Combating erosion therefore must take place at the levels of the soil, field, slope, and landscape. At the level of action where support is needed, there is unfortunately a lack of both information and trained personnel. Erosion is too frequently treated as an isolated problem.

Concerning research in erosion the challenge is also to translate existing and new scientific knowledge in practical measures for land users. To solve the erosion problem we should clearly look at the driving factors causing it – these factors are often hidden in society and the farmers are often pressed to do things that they know to be harmful to the environment. It is important that the economical effects of a reduction in erosion at the farm, regional and national level is made visible. Today the costs of reducing erosion are met by the farmer, but the long term profits are always hidden. Make them visible.

Responses must focus on the one hand on erosion prevention and mitigation, testing new methods that are feasible and economically acceptable by the farming community, and if necessary the cost may be carried by all who benefit. A cost benefit analysis in cluster 4 helps to show who has a relation to the erosion chain of events and profits from mitigation. A second focus here must be in education and awareness raising.

Priority areas where research is needed

The working group on soil erosion presented a long list of research needs, which can, however, be summarised in several research priorities.

Priority 1 Expanding the knowledge on soil erosion processes and modelling (cluster 1)

Knowledge on soil erosion is scattered across disciplines, very diverse of character, and not yet established and employed to full extent. In order to develop an integrated strategy for addressing soil erosion at different spatial and temporal scales, knowledge on regulating soil erosion processes should be expanded and enlarged to understand in more detail than currently possible why, where, when, and at what rate erosion occurs under given conditions of land use and climate. Advanced multi-scale simulation models should be developed, tested and applied for different agro-environmental zones within Europe, preferably using state-of-the-art GIS approaches and remote sensing data gathering techniques.

Priority 2 Advanced soil erosion assessment and monitoring (cluster 2)

The situation regarding available data and information systems is critically desperate and there are good reasons for radically modernising the approach towards soil erosion data, indicators, and monitoring. Data, indicators and monitoring are needed at different spatial and temporal scales for evaluating the performance of policy and compliance, to provide early warning, and to help understand how land use and climate changes are impacting on the capacity of the system to handle the pressures that lead to erosion. In this, Europa lags behind the USA by a long way. The problem was described in Poland: "There is a need to develop small-scale information systems. The most frequent floods take place in small mountainous catchments and bring huge economic losses. National and European projects are developed for bigger areas, when the real problems and potential solutions lay much lower. The same regards erosion. There is no common database of erosion control system **applied all over Europe, which can be a useful analysis tool.**" Several new (nano) technologies are potentially available for monitoring soil movement and remote sensing with airborne radar is already revolutionising monitoring. detailed radar derived surface elevation data with 5 cm resolution and link this to actual land use data and information. This could be used for site-specific compliance or for long-term monitoring.

Research catchments for long term monitoring should be established. In fact there are already many research sites where long term **observations** have been done in Europe, but the **measurements** are often not continuous and not done with a common methodology. Consequently, the conceptual knowledge and ideas are good but the data is lacking for long term analysis, e.g. in relation to climate changes and land use changes. To overcome this data scarcity it is necessary to assign a few research catchments (e.g. one per agro-climatic zone) to do long term measurements. For selection of sites use can be made of catchments for which long term data of some sort already exists, such as: Medalus catchments, Leuven, South Downs, Nord Pas de Calais, Roujan, Vicarello etc etc. In these selected catchments data must be gathered to investigate:

1. Land use change

2. Climate change: frequency-magnitude analyses of erosive events is one of the important possible outcomes of monitoring, since it might be changing as a result of climate change.

3. Calibrating and validating of soil erosion models at European, national and sub-national scales using data from fully instrumented erosion monitoring sites. This is linked with the establishment of monitoring programmes and requires standardisation of procedures/methodologies for data collection (for details see working group on monitoring).

4. Specific cases. Currently available models at a European scale (of which PESERA is the most advanced) simulate sheet and rill erosion, and do not account for soil loss by other processes such as gullying, landslides, snowmelt erosion, wind erosion, tillage erosion, sub-surface erosion, etc. In order to cope with the assessment of soil loss by different processes in different regions, several options exist:

   4.1 combining different soil erosion processes in one model and elaborating a single soil loss map at a European scale (most ambitous);

   4.2 developing individual models and maps at a European scale for the most relevant soil erosion processes;

   4.3 carrying out a 'qualitative expert assessment' of the currently available European soil erosion map (PESERA), allowing to identify areas where predictions of the model at a European scale over- or underestimate soil losses due to the fact that specific erosion processes are not taken into account or for any other reasons. This type of 'practical validation' can be based on a comparison with national and sub-national maps and on local expert knowledge of the terrain, which should be obtained in research catchments. This option may be of significant importance to create a broader support of member states for the European soil policy in general, and for adopting measures in particular, as they have the chance to be involved in and to have a grip on the process of assessment, including aspect specific for the particular member state.

Priority 3 Changes in climate and land use (cluster 3)

The main driving forces behind erosion are changes in climate and land use. Therefore specifically the effects of climate change should be a research priority, as well as changes in land use scale and intensity, politically driven land use changes, effects of forest fires, land abandonment and desertification.

Priority 4 An integrated strategy for addressing erosion (cluster 5)

We should have both the conceptual framework and tools in place that allow the EU to develop an integrated strategy for soil conservation and protection. This strategy should be able to handle the complexity and diversity of scales and integrate across sectors and disciplines. It should link the whole chain of DPSIR in problem defined actions. Part of this will involve new research needed on such things as the integration of erosion with social and economical factors, effect of soil compaction on erosion, production level and water management situation, the effect of land management (specifically time-variance of soil properties and infiltration processes), and soil type in relation to the risk of erosion and flooding. The tools will incorporate integrated system (IT) technologies for catchment management, which will provide erosion control, water management, etc. More research on economic and social aspect of soil degradation is needed. Strategies for easy-to-use knowledge transfer from academic and SME to decision- makers and end-users should be developed.

The emphasis in this priority should be on the socio/economic effects of erosion, while still including the chain of events that links the bio-physical aspects to the socio/economic impact erosion has. The following points specifically need attention:

1. The socio-economic factors, including agricultural policies at regional, national or European level, that drive land-use changes and promote soil erosion should be identified and incorporated in agro-ecosystem dynamics modelling.

2. Testing and monitoring the effectiveness of both preventive and mitigation measures against soil erosion is necessary, along with cost-benefit analyses.

3. Identify acceptable soil erosion risk levels and soil loss tolerance for each agro-ecological zone.

4. Develop for each agro-ecological zone an advice system on alternative forestry practices and agricultural production systems reducing the risk of soil erosion. Investigate the potential of different soil management techniques (ranging between conventional tillage and no-tillage) in the different agro-ecological zones.

Priority 5 Development of tailor-made conservation and remediation strategies (cluster 5)

At a European level, erosion is mainly a nutrient and water quality problem in the north, while in the south it is generally a soil loss problem. Tailor-made conservation and remediation strategies need to be developed for preserving the soil (and water) resource, resulting in more water retention, soil cover, very fine-roots, and for example soil binding substances. These strategies should be technically feasible, economically viable and socially acceptable for related stakeholders, and effective in reducing and/or preventing runoff and erosion. These actions should increase the capacity of the soil or landscape in its ability to adapt and adjust to changing external pressures without erosion being the result. Specific actions should be:

1. Investigating all environmental effects of conservation tillage, including the contamination risk by herbicide use and the net greenhouse gas effect (carbon sequestration versus N2O and CH4 production). This may be different in different agro-ecological zones.

2. More research is needed on the development and implementation of land-use planning methodologies or decision support systems to formulate systainable soil use, taking into account both socio-economic factors and inherent soil erosion risks.

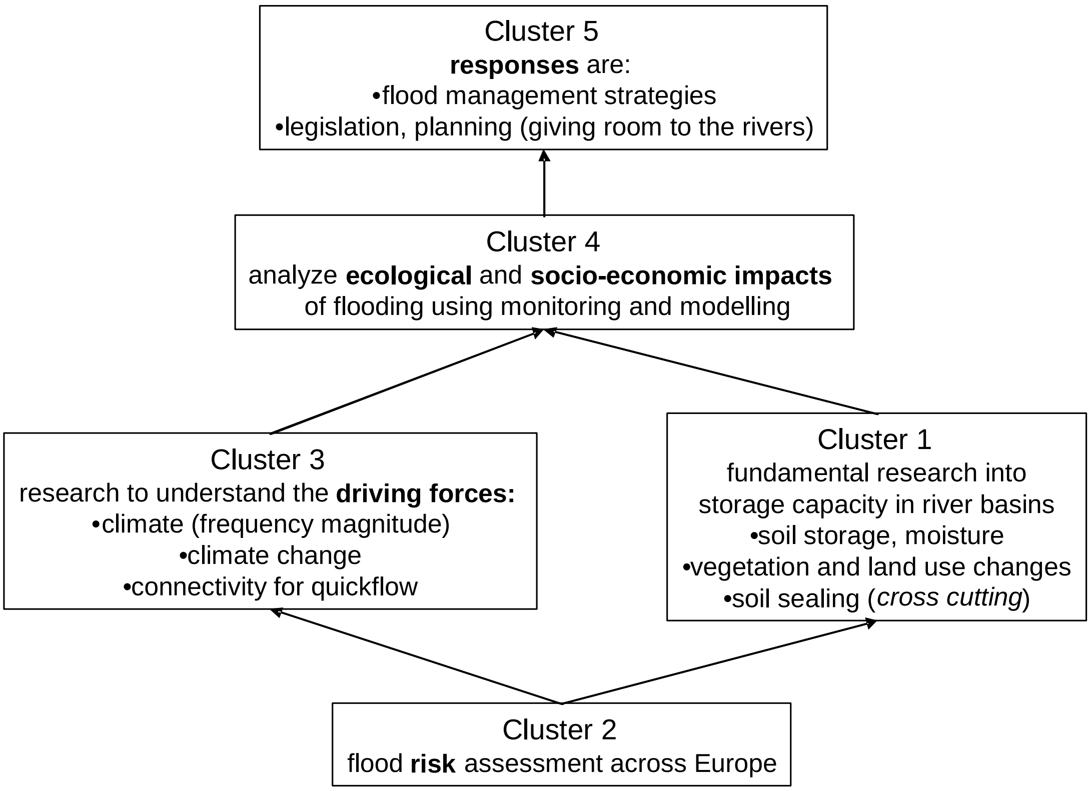
3. Develop methodologies to assess temporal trends and spatial variation of defined soil erosion indicators, helping to assess the effectiveness of proposed policies and measures.

4. It is probably worthwile to look also at soil resilience: what is the ability of soils to recover from land degradation? Hence, how big is the problem actually?

Priority 6 Awareness raising, promotion of local actions, and communications (cluster 5)

Knowledge about erosion should be made generally available and communicated to all relevant disciplines, sectors and actors. To motivate action on the local, regional, national and/or European scale the economics of soil erosion needs to be fully treated and explained. Soil erosion can mean an irreversible loss of capital. Considering soil functions as capital, could stimulate adoption of measures to combat erosion. Research should be demand driven and executed in close consultation and interaction with end-users, and address the problems actually encountered in stopping erosion using multidisciplinary approaches, and assessment, monitoring, modelling, conservation and remediation techniques as outlined in priorities 1 to 5.

FLOODING



Research for Erosion, compaction, Floods and Landslides

2. Flooding

Processes and modelling (cluster 1)

Flooding has been observed to be on the increase in Europe, which can be explained by: i) the reduced capacity of soil to accept (infiltration) and store water, as a result of land management and land use change, ii) the expansion of sealed areas and reductions in the infiltrating area, iii) changing climatic conditions, iv) due to the risk taken by people who chose to develop and live in flood prone areas, and v) complex and delayed responses of river channels to the input and storage of sediments.

Increased flood risk can be seen as the interaction of sets of fast and slow processes. The fast processes are the hydrological ones that lead to a storm generating runoff on runoff contributing areas that comprise usually no more than 5 to 25 per cent of a drainage basin. Slower processes such as the gradual thinning of the soil, or subsoil compaction over several years or decades gradually reduce the critical rainfall intensities needed to generate overland flow or subsurface flow. Other slower processes are the extension of built up areas or the gradual accumulation/removal of sediments in rivers that dramatically influence the amount of water a channel can store before it becomes bank-full. During the last fifty years the water storage capacity of soils, river channels and ecosystems has in many areas been lowered by an order of magnitude as a result of these relatively slow processes. There are other locations, however, where storage has been increased.

State-of-the-art experience in managing catchments and rivers has a long tradition in Europe.(e.g. Bravard et al 1999). The complex links that exist between soil-erosion-mass-movements and river channel behaviour over a period of more than 150 years are clearly explained in this keynote study. The main challenge then for flood prediction is to integrate the effects of slow but dynamic processes into their predictions. The Ribamond Concerted Action (Balabanis et al 1998) dealt with river basin modelling, management and flood mitigation. This contains interesting examples of river channel management in Europe.

Mass movements are a major natural source of coarse sediments to rivers. These also inject plugs of sediment into rivers that would under natural conditions end up as floodplain deposits further downstream. In many river channels, material accumulates and reduces channel capacity because the magnitude of for example annual peak flows has been reduced and it can not remove material deposited by channel collapse and mass movement. This means that when a really extreme event occurs, the lowered capacity of the channel causes flooding. However, the main problem in some rivers is the lack of coarse sediment being input into the channel. Channel erosion and mass movements are necessary sources of the coarse sediment in rivers. If this is not allowed into the channel, the channel might erode its bed.

It is well known that soil conservation works on slopes in the United States had a positive effect on the slope but that that this caused the erosion of the river channels several decades later (Trimble ref). Grass strips that trap sediment do not keep back water so that when sediment free water reaches the channel it has the capacity to erode and entrain sediment. The transport capacity of water is a key indicator in determining whether particular size-classes of sediment will be deposited or eroded along river channels. It makes the response of river channel capacity to sediment inputs persistent and complex. A few key studies have been done in Europe, mainly in France and Poland that demonstrate the interactions between sediments and floods over periods ranging from days to several centuries. For example, principles of engineering geomorphology applied to manage channels in France are demonstrated by Bravard et al (1999).

River channel capacity and morphology can be easily be monitored (by remote sensing) and they provide a valuable link between the soil, land use change and the landscape. This link is reflected from data and information on “sediment budgets” which look at the fate of sediment eroded on slopes and investigate the residence time of sediment stored as colluvium and alluvium. Depending on the catchment, up to 60 to 70 per cent of eroded sediment is stored in colluvial sinks and a large amount of sediment is stored in channels. The bedload sediment supplied to a river by erosion, (for example following the erosion that took place following the wheat campaign in 1950 in the Alentejo. Portugal) is slowly being transmited as a slug down the river so that the sediment from the Alentejo is now just reaching Lisbon, say a hundred km away only 50 years later. As this sediment wave slowly moves through the system it creates a temporary flood risk by dramatically lowering the channel capacity. In other words there is a delayed response and persistence effect of “erosion events” that affect and explain the changing risk of flooding.

Data and monitoring (cluster 2)

Important issues are i) Identification of flood zones, and determination of flooding risk throughout Europe, ii) Monitoring of channel form and channel changes – cross sections and detailed mapping iii) river channel capacity monitoring, e.g. by remote sensing.

Driving forces and pressures (cluster 3)

The drivers for flooding are partly the same as for soil erosion, and some of the recommendations made for soil erosion are therefore also beneficial to mitigate flooding:

- Nature of rainfall events and weather changing, which might be changing because of changes in climate. Is there an increase flood risk because of climate change? Probably yes but this risk can be reduced by managing and improving the water regulation function of the soils and landscape.

- Effects of changes in land use. A study by Dorren and Imeson (2003), for example, found that the most severe flooding in The Netherlands was the result of land reallocation schemes that dramatically reduced infiltration and increased the erodibility of the top soil. The ability of soils to accept and retain water has been extensively investigated and reported in Europe. It is apparent that the impact of land use changes on the storage capacity of soils is an order of magnitude higher than the influence of any change in climate. This is a cross-cutting issue with erosion and sealing. However, climate can also influence land use and vegetation growth.

- Effects of river management and flood defence schemes. There has been a dramatic decrease in the capacity of rivers to store and transmit water. Gregory (ref.) and others have conducted and published surveys of changes in river channel capacity in Europe.

Impacts (cluster 4)

The risk of flooding is increasing because more property is located in flooding prone areas, while flooding frequency might increase. The following aspects of flood impacts should be investigated:

a. Morphological impacts, including the role of different size floods and sequences

b. Systematic analysis of channel responses to floods and hydrological changes

c. Spatial variability and effects of morphology and its effects on conveyance and capacity

d. Role of sediment in flood impacts – recognition of sources, supply and connectivity and changes over time and with flood events.

e. Effects of vegetation on conveyance and capacity

f. Effects on habitats and ecosystems

An excellent analysis of projected flood impacts in the UK has recently been prepared as part of the DRAFT project, and can be found in the Appendix. It also includes an economic analyses of the costs and benefits of different flood protection works.

Responses (cluster 5)

Topics which need attention are a.o. i) Work with nature, ii) Functional floodplains and channel adjustment, ii) Retaining flood storage, iv) Increasing flood attenuation, v) River restoration, and vi) Use of vegetation.
The actions proposed to reduce erosion on slopes will also decrease flood risk by increasing the water storage capacity of the soil. Sinks and source areas of water on slopes should be managed in ways that promote the water regulation function of slopes and catchments. This management requires local support and tools.

Priority areas where research is needed

Priority 1 Assessment of flooding risks in Europe (cluster 2)

Topics of relevance are i) Identification of natural, long-term tendencies, ii) Identification of flood zones, iii) Monitoring of channel form and channel changes – cross sections and detailed mapping, iv) Systematic analysis of channel responses, and v) Modelling of channel response and feedback

Priority 2 Development of flood management strategies (cluster 5)

Topics which need attention are a.o. i) Work with nature, ii) Functional floodplains and channel adjustment, ii) Retaining flood storage, iv) Increasing flood attenuation, v) River restoration, and vi) Use of vegetation.

Priority 3 Increase storage capacity of soil and vegetation (cluster 5)

The actions proposed to reduce erosion on slopes will also decrease flood risk by increasing the water storage capacity of the soil.

Priority 4 Reduce area and connectivity of areas producing quickflow (cluster 5)

Sinks and source areas of water on slopes should be managed in ways that promote the water regulation function of slopes and catchments.

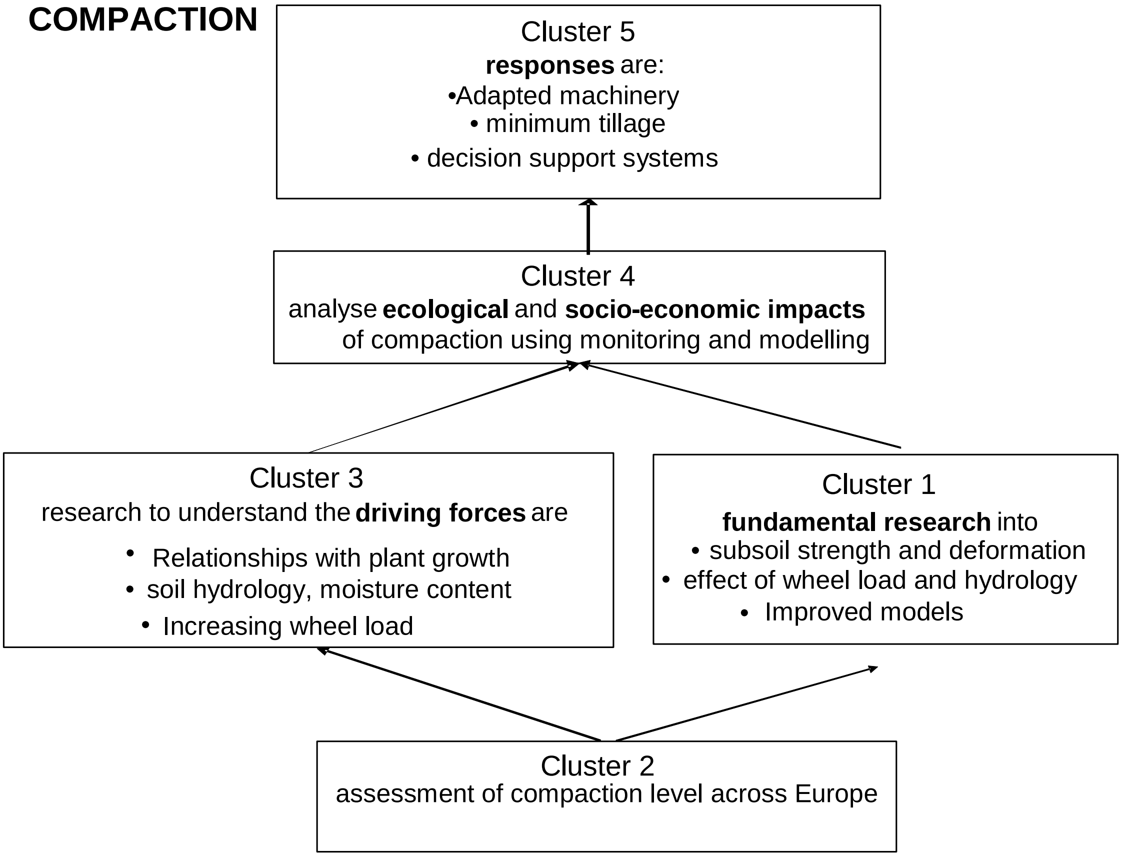
3. Soil compaction

Processes and modelling (cluster 1)

Compaction is a process of densification and distortion in which total and air-filled porosity and permeability are reduced, strength is increased, soil structure partly destroyed and many changes are induced in the soil fabric and in various behaviour characteristics. The compaction process can be initiated by wheels, tracks or rollers, and from the passage of draft or grazing animals. In arable land with annual ploughing, both topsoil and subsoil compaction should be considered. The subsoil can be defined as the soil below the ploughed layer (about 20 - 35 cm thick). This definition of the subsoil includes the panlayer as the upper part of the subsoil. The panlayer is caused by the tractor tires driving on the subsoil during ploughing and by very high wheel loads. Contrary to the topsoil the subsoil is not loosened annually and compaction is cumulative and in the long run a more or less homogeneous compacted layer is created. The resilience of the subsoil for compaction is low and subsoil compaction is at least partly persistent.

Problems of compaction are widely distributed throughout the world but tend to be most prevalent where heavy machinery is used in agriculture or forestry. Preliminary estimates in 1991 suggest that the area of degradation attributable to soil compaction may equal or exceed 33 Mha in Europe (Oldeman et al., 1991). Recent research showed that compaction is the most widespread kind of soil physical soil degradation in Central and Eastern Europe (Batjes, 2001). About 25 Mha proved to be lightly and about 36 Mha moderately compacted. All agricultural soils in developed countries display compacted subsoils. Some soils are naturally compacted, strongly cemented or have a thin topsoil layer on rock subsoil. Soils can vary from being sufficiently strong to resist all likely applied loads (low compactibility) to being so weak that they are compacted by even low loads (high compactibility). Well-structured soils combine good physical soil properties with high strength. Sandy soils with a single grain structure and compacted massive soils can be very strong, however, rootability and soil physical properties are then often bad. Roots have a

COMPACTION



binding action and increase the elasticity and resistance of a soil to compaction. Soil moisture has a dominant influence on soil compactibility.

Dry structured soils are strong with a low compactibilty. As the moisture content increases, soil compactibility increases until the moisture content is approximately at the field capacity point, when a condition known as the optimum moisture content for compaction is reached. At still higher moisture contents the soil becomes increasingly incompactible as the incompressible water fills ever more the total porosity and further loss of air-filled porosity becomes impossible. However, although the compaction may be minimal the plastic flow of an overloaded wet soil results in a complete destruction of soil structure and macropores with accompanying diminishing of soil physical qualities. Increases in organic matter content tend to reduce soil compactibility and to increase its elasticity.

The area degraded by soil compaction is increasing because wheel loads in agriculture are still increasing. Even on moderate strong soils compactions up to 80 cm below surface were measured under wheels of sugarbeet harvesters (Ehlers et al., 2003). The result is that subsoils are increasingly compacted to ever-greater depth. The conclusion is that European subsoils are more threatened than ever in history.

Progress in subsoil compaction research is slow and concentrated in just some institutes and universities. A large international research project to combine different skills and resources is needed to make a decisive forward step in subsoil compaction research.
The conclusions of Håkansson and Reeder (1994) and Soane and Van Ouwerkerk (1994) are still sound: Subsoil deserves special attention because it is very persistent and the possibilities of natural or artificial loosening are disappointing. Although the conclusions of many researchers on subsoil compaction and guidelines on soil stress limits have been known for many years now, this knowledge seems to be neglected by manufactures and users of heavy agricultural equipment. The impressive technical skills are mainly used for improving the machinery, increasing the comfort of the driver, handling of the harvest and trafficability, while protection of the subsoil seems to be considered as a second order problem. However, in the long-term the disadvantages of the reduced fertility and profitability of the soil, problems with too wet soils and environmental problems will become apparent at the expense of the farmer and the whole society.

Data and monitoring (cluster 2)

The soil compaction database SOCODB, erected by two European Concerted Actions on Subsoil Compaction (Trautner et al., 2003), should be extended with more measurements on strength of subsoils. Also results of wheel load traffic experiments should be added to this database because these results can be used for validation and calibration of this decision support system. The dynamic aspects of the wheel loading and the reaction of unsaturated soil on dynamic loads are still badly understood and mainly qualitative. In many compaction studies static or semi-static tests as used in civil engineering are the basis of the determination of strength and deformation properties of agricultural soils, while the dynamic strength of soils can be higher or lower than the static strength.

Driving forces and pressures (cluster 3)

Since World War II and even before agriculture is increasingly mechanised. Main drivers for this development are economical reasons like the lack of cheap labour and intensification of agriculture. Another trend is that in the sixties the area cropped with grains decreased and the area cropped with potato and sugar beet increased, because the profitability of potato and sugar beet is much higher than of grains. Also the area with silage maize increased from zero to in some countries the largest arable crop. In most cases the area silage maize replaced grassland. The total weight of these crops, the traffic intensity and so the compaction risk are much higher than for a grain crop. Moreover, silage maize, potatoes and especially sugar beet are harvested later in the season than grain crops. This results in a higher risk for wet soil conditions during harvest, which makes the soil vulnerable for compaction. Wheel loads in agriculture are still increasing. Twenty years ago wheel loads of 50 kN were considered very high. Nowadays wheel loads of up to 130 kN are used during harvesting of sugar beet (Poodt et al., 2003). During the last 10 years the mass of the sugar beet harvesters increased as an average by 5 Mg per year resulting nowadays in machine with more than 50 Mg if the bunker is fully loaded.

Nowadays self-propelled slurry tankers with injection equipment with wheel loads of 90 – 120 kN are used in early spring on wet soils. The largest tires available with an inflation pressure of about 200 kPa are needed to carry such high wheel loads. Suggested maximum values of tire inflation pressure range from 40 kPa for wet soils in spring to 200 kPa for dry soils in summer and autumn. However, sugar beet are harvested until late autumn when soils are moist or even wet.

Impacts (cluster 4)

Soil compaction is a form of physical degradation in which soil biological activity and soil productivity for agricultural and forest cropping is reduced and which results in a decreased water infiltration capacity and increased erosion risk. The panlayer is in many cases less permeable for roots, water and oxygen than the soil below it and is the bottleneck for the function of the subsoil.

Soil macropores have a diameter larger than 50 micrometer and are created by soil biological processes as rooting of plants and digging by soil fauna and soil physical processes as shrinkage during drying. In most cases the macropores are continuous and form the “highways” for air and water deep into the soil. Also roots and soil fauna make use of the macropores to overcome dense soil layers. Continuous macropores determine to a high extent the soil physical and soil biological quality of a soil. Macropores are the most vulnerable pores to soil compaction and pore volume reduction by compaction will be mainly at cost of the macropores (Kooistra and Tovey, 1994). Shearing and plastic flow of the soil during the compaction process has a very detrimental effect on pore continuity. The loss of macro porosity and pore continuity reduces strongly the ability of the soil to conduct water and air. Poor saturated hydraulic conductivity and reduced infiltration capacity result in surface run-off and eventually flooding and erosion and transport of nutrient and agrochemicals to open water.

A poor aeration of soil, yields non-optimal plant growth and induces loss of soil nitrogen and production of greenhouse gases through denitrification in anaerobic sites. Plastic deformation of soil aggregates and higher bulk density resulting from compaction and soil shearing increase the penetration strength of the soil. This limits root growth and crop exploitation of soil water and nutrients. The limited rooting depth and the deteriorated circumstances for soil fauna reduce the depth of the soil biosphere and hinder biological recovery of the compacted soil. The reduced plant growing conditions result in a higher vulnerability of the crop to diseases and plagues. Subsoil compaction is a hidden form of soil degradation that affects all the agricultural area and results in gradually decreasing yields and yield security and gradually increasing problems with waterlogging. The impact of subsoil compaction is primarily prominent in years with extreme dry or wet periods and crop yield reductions of more than 35 % and even crop loss are measured (Håkansson et al., 1987, Håkansson and Reeder, 1994). Subsoil compaction proves to be very persistent, even in subsoils with shrinkage and swelling and annual deep freezing (Håkansson and Reeder, 1994). Reduced crop yields and reduced nitrogen contents in the crop were measured 17 years after a single compaction event with wheel loads of 50 kN (Alakukku, 2000).

Contrary to erosion, subsoil compaction is a hidden form of soil degradation without any visible exposure. The reduced infiltration capacity results in flooding during high rainstorm events and results also in an increased harvesting risk in wet years. However, people blame the problems on global change effects and the increased area covered with roads and buildings and forget the much greater agricultural and forest areas with reduced infiltration capacity. Only if the crop suffers from subsoil compaction and can be compared with a crop on a non-compacted neighbouring field, then the detrimental effect of subsoil compaction can be seen. Normally all fields in a region are treated more or less in the same way, so in reality this comparison is not possible. Moreover, on many soils marked effects of subsoil compaction are only visible in dry or wet years. The map presenting the vulnerability to subsoil compaction presented by Jones et al. (2003) is just a preliminary analysis, however, it has already proved to be very useful in convincing policy makers that subsoil compaction is a serious threat.

Responses (cluster 5)

It is almost impossible to avoid topsoil compaction. On the other hand, conditions are optimal for reloosing by tillage and natural processes as freezing, drying and swelling and biological processes. Nevertheless, on clayey soils dense clods can be found years after a compaction action. Subsoil compaction is much more persistent. Biological recuperation of the subsoil is slow, not complete, and sometimes absent. Also artificial loosening of the subsoil proves to be disappointing. The loosened subsoil is recompacted very easily, and important soil physical properties such as saturated water conductivity and gas diffusivity are strongly reduced to less than a tenth or a hundredth of the original values.

The detrimental effects of subsoil compaction on crop production are often compensated by improved and deeper drainage and by increased supply of nutrients and water (irrigation). These pseudo solutions to the compaction problem lead to excessive use of water and nutrients and environmental pollution, and are not longer socially and politically accepted.

Subsoil compaction should be prevented instead of repaired or compensated. This is possible by taking care that wheel loads and tyre inflation pressures are limited and do not create stresses in the subsoil that exceed the actual strength of that soil (Van den Akker and Schjønning, 2003). Even on weak soils relatively high wheel loads are possible by using large tyres with low inflation pressures or well-designed tracks. Research on light unmanned mini-tractors is going on. Structure and natural strength of the soil can be increased by improved drainage and by adoption of conservation tillage systems with minimum soil disturbance. Subsoil compaction during ploughing can be prevented by using improved steering systems and adapted ploughs allowing the tractor to drive with all wheels on the untilled land (on-land ploughing). It is also possible to concentrate wheel loads on permanent traffic lanes and limit the compaction to these sacrificed wheel ways. By using wide span vehicles (gantries), the sacrificed area can be limited.

However, altogether these solutions are hardly used because of short-term economical reasons, unawareness, and negligence because the damage to the subsoil is not as readily visible as e.g. erosion. Also the limited knowledge and data on soil strength under dynamic loading makes prevention of subsoil compaction difficult.

By using low tire inflation pressures it is possible to reduce the soil stresses, at least in the upper subsoil (Arvidsson et al. 2002), enough to take care that the actual strength of the subsoil is not exceeded. A tire with an inflation pressure of 200 kPa and a wheel load of 30 kN will cause more damage to the upper subsoil than a low pressure tire with an inflation pressure of 80 kPa and a wheel load of 50 kN. Therefore, simple guidelines in the form of axle or wheel load limits can lead to unnecessary and uneconomically low wheel loads. An improvement is the use of limits for inflation pressure, average ground pressure and vertical soil stress at 0.5 m depth (www.subsoil-compaction.alterra.nl). However, the subsoil-related limit for vertical stress at a depth of 0.5 m is difficult to use because the stresses exerted at this depth by wheel loads is unknown. A next improvement is now started in several states in Germany, where guidelines are introduced to prevent soil compaction by comparison of the actual stress distribution with the strength of the soil expressed as precompression stress (Horn and Fleige, 2003). The development of user-friendly decision support systems is encouraged to make use of the increasing possibilities to simulate stress distributions in the soil and to compare these stresses with the strength of soils.

Without doubt technical solutions are possible and, even in the short-term, may be profitable or costs-even (Vermeulen et al. 1994). Manufactures, agricultural engineers and soil scientists should collaborate and research should be initiated to solve this problem and find solutions. This requires acknowledgement of the subsoil as a vital and vulnerable non-renewable resource increasingly under threat and a pragmatic recognition by soil scientists that a 100 % protection of the subsoil is not realistic.

Similar problems arise with the practice of conventional ploughing in which two tractor wheels run in the open furrow on the subsoil. This can be solved by ploughing on-land, and today there are technical solutions to facilitate this, for example automated steering equipment. Maybe a collaborative information campaign by manufactures, advisers, agricultural engineers and soil scientists can promote on-land ploughing.

Priority areas where research is needed

Future work in subsoil compaction research in Europe should concentrate in the following areas:

Priority 1 Implementation of new models for prediction of stress transmission and soil deformation (cluster 1)

Development of soil compaction models that reflects soil behaviour in the field is needed. Therefore methods to measure stresses and deformations in soil should be further improved and validated. In recent FEM models undrained load - deformation - failure processes are coupled with interactive water flow processes (Richards et al., 2000). More research is needed to improve these models and to include also dynamic loading in the model. Recent research (Trautner, 2003) indicates that existing models oversimplify soil behaviour and stress distribution in a number of situations. This is not only academic as the key question of the possibility of solving the high axle load problem through improved, low-pressure tyres is highly related to the stress transmission in the soil. A rigid, dry soil in some occasions apparently may transmit the stress nearly undamped to lower soil layers that may be more wet and hence vulnerable to compaction. Especially in these specific cases model computations should be accompanied with measurements in traffic experiments.

Priority 2 Improvement of models predicting and describing effects on soil functions (cluster 1)

Effects of subsoil compaction should be better incorporated in models to predict processes such as soil water flow, transport of solutes and crop growth. In most models the effects of compaction are totally neglected or only included by reducing the estimated rooting depth. This leads to underestimation of the effect of compaction in scenario and model studies (Lipiec et al., 2003). The effects of soil compaction on water flow, root development and soil physical functioning are not clearly analysed and quantified. This requires the development of models that quantify the link between soil porosity, water infiltration and root development.

Priority 3 Assessment of existing compaction level in European soils (cluster 2)

An assessment of the existence and seriousness of subsoil compaction throughout Europe should be initiated. The assessment should be a real examination of the subsoil of common and representative agricultural soils in all European countries. It should include digging of soil pits and examination of rooting and structure and determination of at least bulk densities and saturated hydraulic conductivities. Pedogenic and management induced causes of dense (poor functioning) soil horizons should be identified. It should also include assessment of the vulnerability of the soils to compaction, to continue the work by Jones et al. (2003).

Priority 4 Quantification of compaction effects on soil functions (cluster 2)

This should include plant growth (production) related functions as well as functions related to the environment and water management. These groups of functions can not be discussed separately. A reduced rooting depth may reduce crop growth but also increase leaching of nutrients (incl. N) to deeper soil layers (eventually to the groundwater or the aquatic environment via surface flow). Nitrogen may also be lost to the atmosphere (greenhouse gas N_2O). Especially environmental effects of subsoil compaction should be more intensively studied. This can be subdivided in studies on the effects on (a) erosion and flooding, (b) biodiversity, fertility and organic matter development, (c) emission of green house gasses and (d) leaching of nutrients, agro-chemical and chemical pollution. In these studies, the effect of compaction on the interaction of physical, chemical and biological soil processes deserves special attention.

Priority 5 Quantification of strength, deformation and compaction of soils and stress transmission in soils (cluster 2)

This research area is crucial in order to increase our understanding of the soil compaction process and hence our possibility of developing tools (such as models) to predict and thus avoid subsoil compaction. The existing expressions of soil strength (especially the precompression stress), soil deformation and soil compaction are problematic in several ways. The soil is assumed to be elastic to some point at which it turns to a plastic medium. However, in reality soil is elasto-plastic. This means that some deformation will occur also at lower levels of stress. In agricultural soils, (accumulated) small deformation events may significantly influence soil functions (especially if the deformation is induced by shear). Soil compaction models and determination methods of soil strength do not or only empirically take into account the dynamics of loading taking place when wheels of agricultural implements traffic the soil. The dynamic strength and behaviour of unsaturated soil is still not well understood. This leads to under- and overestimation of the risk of soil compaction. More qualitative and especially quantitative results about dynamic soil strength in relation to dynamic wheel loads are urgently needed. Needed are studies based on the actual loading situation, especially taking into account topsoil characteristics, distribution of stresses in the soil - tire interface and rut depth formation as these may be decisive for the stress transferred to deeper layers.

Priority 6 Evaluation and development of management tools to reduce subsoil compaction (cluster 5)

These could be technical, such as reducing tyre inflation pressure, ploughing on-land, different wheel arrangements, tracks instead of wheels or automated low-weight machinery (Alakukku et al., 2003, Chamen et al., 2003). They could also be management measures, such as choice of crop rotation or adjusting traffic to soil water content. An increased awareness among farmers is also necessary alongside with the continuous rationalisation in agriculture. This can be promoted by the development of user-friendly decision support systems to show the effects of compaction and to assist the farmer and his advisors in the selection of ways and equipment to prevent overcompaction.

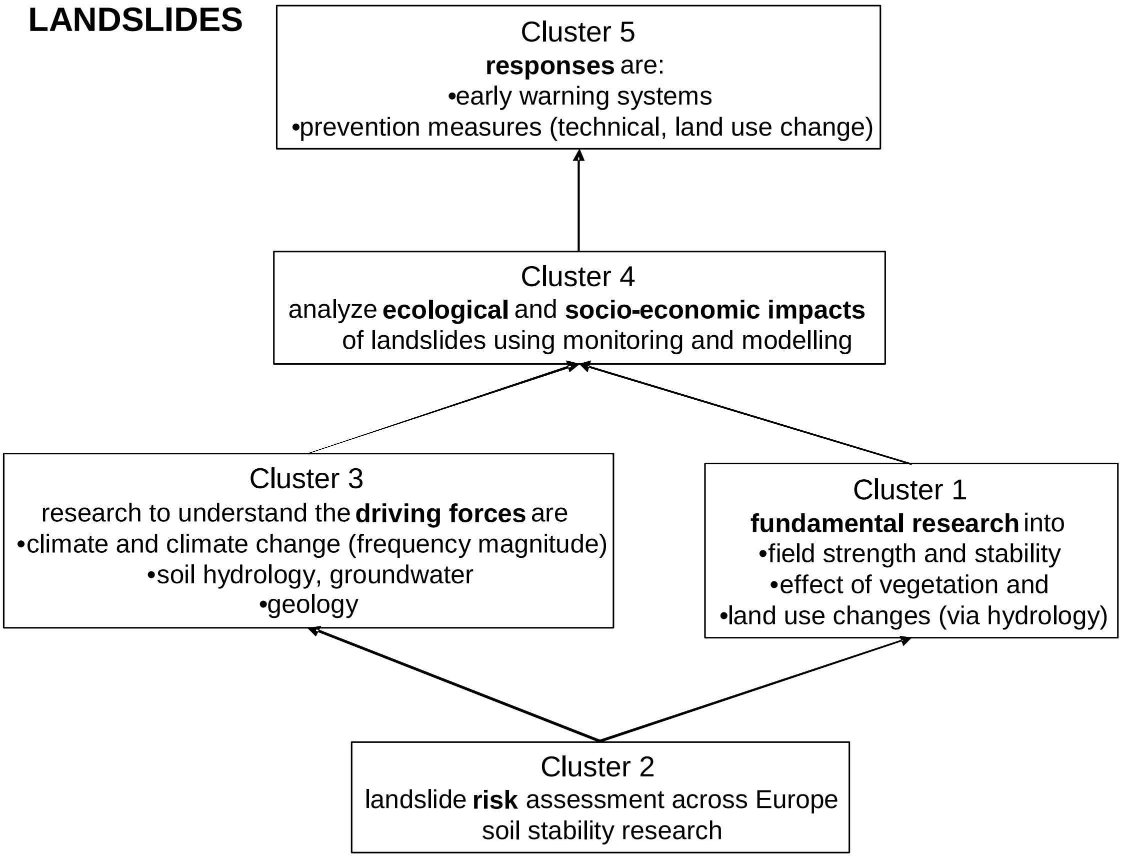
4. Landslides

processes and modelling (cluster 1)

The form and scope of landslides, - which is a generic term for all slope movements, including slides, falls and debris flows-, are very diverse because of the multiplicity of initiating mechanisms (erosion, deformation, dissolution and rupture under static or dynamic load), combined with topography (height and gradient of the slope etc.), lithology (characteristics and susceptibility of materials – solid, plastic, viscous, liquid), structure (overhang, fracturing, superimposed layers), characteristics of the water table and relative proportion of water and solid materials.

Causes are generally multiple, a conjunction or superimposition of several factors, including predisposition and triggering factors (i.e. rainfall, earthquake). The diversity and the complexity of these various phenomena require i) the expertise of engineering geo(morpho)logists, geophysicists, hydrologists, and geotechnical and civil engineers, and ii) the use of different investigation and measurement techniques adapted to each type of phenomena (characterized by very different displacement rates). There is not one general landslide model, but several models, each one being more or less adapted to a type of landslide. Deterministic models can help to define the intensity and temporal occurrence. They can also help to build hazard scenarios based on environmental change, or help checking the effectiveness of countermeasures. Model results are very diverse and not always pertinent because of the variety of the movements: research has made greater progress in the case of rigid and muddy landslides as well as rock block trajectories; on the other hand, better models have to be developed for fast gravitational movements (mass rockfall, granular debris flow).

LANDSLIDES



It is still not possible to forecast the occurrence of a landslide or the reactivation or speed-up of an existing dormant or slow-moving landslide with a degree of accuracy useful for prediction. Better monitoring techniques are needed, including a better understanding of hydrological systems and of the movement mechanisms during the failure and post-failure stages in order to make more accurate predictions.

Shallow landslides can be a significant source of sediment in upland watersheds. Modelling delivery of landslide materials to streams requires determining where and when shallow landslides will occur, which volume will be mobilized, whether they are rainfall-induced or human-induced or whether they will reach the stream or will be stored as colluvium at the footslopes. Few physically based models have been developed to simulate such processes.

Europe comprises a wide range of climatic regions and of mass movements types, which may conveniently be subdivided in slow-moving and fast-moving landslides:

- Slow-moving landslides *(rotational*, *translational*) corresponding to mass displacements of more or less coherent soil, with limited internal deformation. The displacement is progressive and may be accompanied by rupture, but in general with no sudden important acceleration. These movements can be monitored and controlled and are not a direct threat to personal safety (except in specific cases like Goldau Slide, Switzerland, in 1806) but an important threat to human infrastructures;

- Fast-moving landslides that may accelerate suddenly. They can be subdivided into two groups, depending on whether the material is propagated as more or less individual particles (*rockfall, rock avalanche*) or as reworked mass (*mudslides, earthflows, debris flows).* Some of these landslides can show episodic behaviour, but others only experience one phase of rapid long run-out activity (e.g. rockfalls). The latter type might be used for analysis of the impact of different climatic situations on mass movements behaviour, provided that the slide can be dated.

Determination of landslide evaluation under future climatic scenarios and land-use change is a basic social and economical necessity. However, our knowledge of the effects of past climates and changing land use is incomplete because there are not enough reliable and long-term series of dated mass movements for all the mountain and coastal regions of Europe. In the absence of this knowledge we cannot forecast the behaviour of mass movements in the future by empirical or deterministic models.

We need to know what will happen to both active and dormant mass movements, to what extent debris flow may increase in the case of melting permafrost in Alpine areas, how changes of vegetation cover due to changes in climate or land use may effect the occurrence of new slope failures in the fragile environments of Mediterranean regions and how these changes may affect the efficiency of protective forests against rock fall and other mass movements in European mountainous regions, or how sea level rise may affect the activity of coastal landslides.

The mechanisms of landslides, including the link to land-use and climatic change should be further investigated to allow short-term and long-term forecasting of landslide hazard, at both site and catchment scale.

Main research topics are:

- extending our knowledge of relationships between climate change and the activity of different types of landslides over Europe, in the past and presently, to understand their mechanisms and triggering conditions;

- testing the performance of numerical geomechanical models (hydro-mechanical coupling) under different climatic, environmental, hydrological and land use scenarios and validating them against frequent, high-quality real-time monitored data captured by the most advanced techniques;

- validating the vast amount of GIS-related statistical and deterministic techniques to improve landslide susceptibility and hazard assessment at both site and catchment scale. This is of major importance for landslides research with measurements ranging from local, single landslides to regional, or even national landslide distributions. Dependent on the investigation scales, models have to be chosen respectively.

- coupling landslide delivery models to soil erosion models;

- to evaluate changing societal vulnerability in the face of socio-economic development and changing climatic conditions, including relations between hazard, vulnerability and risk.

Data and monitoring (cluster 2)

In several European countries, the landslide problem is being increasingly recognised and landslides are one of the primary hazards being mapped by the different civil authorities, although not always in an appropriate way because of their diversity, frequency and wide geographic distribution, as well as because they are often not well understood. Furthermore, hazards posed by landslides are dynamic. We can therefore state that there is not much accurate data on landslides in Europe at a sufficient spatial and temporal scale, mainly because of the variety of landslides types which behaviour is drastically different. Landslides management relies heavily on using the information available and on previous experience. Current knowledge must be extended by analysing, interpreting and treating well-documented case histories and databases. Such inventories are essential in order to test new models and hazard mapping procedures, which require a great deal of good quality data. At present there is a large amount of widely-scattered landslide data in Europe. In addition, information from historical archives must be assessed by extracting relevant information from historical sources. In such a database, special emphasis must be placed on well-instrumented landslides at the site and at the catchment (regional) scale.

In addition, new monitoring and mapping techniques at different scales must be explored and tested in order to improve prediction and forecasting capabilities and these methods should be incorporated into landslide hazard management strategies.

Driving forces and pressures (cluster 3)

In Europe, landslides form an increasing threat due to population growth, increasing summer and winter tourism, and to intensive land use change and climatic change.

In addition, development increases the incidence of landslides by changing their topographic, soil, and vegetation controls. Consequently, there is an increasing concern because the spread of roads, development of leisure and recreational areas, changes in agricultural practices and forest management, are having an adverse effect. Additionally, climate changes can similarly increase the incidence of landslides.

Impacts (cluster 4)

Landslides are a major natural hazard, claiming thousands of lives and millions of Euros in lost property each year in almost all mountain and coastal areas on the Earth.

Recent events show that landslides may have very destructive effects (Sarno, Italy, May 1998, 160 people killed; Gondo, Switzerland, October 2000, 13 died, etc).These hazards pose the biggest challenge to developing and maintaining a sustainable infrastructure.

Data on the social and economic effects of landslides are now available from numerous countries. As European mountain and coastal areas are increasingly developed, the potential costs of landslides also increase. Insurance claims as a result of this threat are steadily rising.

Responses (cluster 5)

It is now increasingly recognized that landslide hazard assessment forms an important part of land use planning in mountain and coastal environments. Authorities with the responsibility for protecting livelihood and infrastructure from the threat of landslides are particularly concerned with four critical aspects: (1) spatial distribution of landslides, (2) understanding of their mechanisms, (3) predicting (short- and long-term) occurrence and impact, and (4) mitigating impacts.

The development, management and implementation of alert systems for a variety of mass movements types and adapted to specific hazard exposure should be emphasized. This should be based on devising a reliable and affordable method of alerting authorities to landslides hazards and transmitting the information necessary to implement protective measures.

Historically, landslide hazard and risk management have mostly concentrated on the avoidance of dangerous areas. However, the situation in European mountains and coastal areas, where hundreds of villages are located either on active or dormant landslides, requires positive action to ensure that human activity is compatible with the presence of landslides. This is the so-called concept of 'living with landslides' which means learning how to make mass movement hazard compatible with human activities by developing hazard management procedures and lowering vulnerability by new landslide mitigation techniques, including both protective and reinforcement actions for different types of man-made structures and networks.

Areas where research is needed

Priority 1: Understanding Climate and Mass Movement Relationship (cluster 1)

A sound analyses of relationships between precipitation regimes and slope stability in well-instrumented landslide sites is needed, with the support of hydrodynamic numerical models if we are to reach an in-depth understanding of the different hydrological systems working in different types of mass movements. The climatic signals of dated landslides and the completion of mass-movements series need to be ascertained. Further effort must be made in downscaling General Circulation Models, particularly in the difficult Mediterranean area. The following specific topics must be addressed:

- Improvement of ground based and remote sensing techniques for mass movement mapping and monitoring;
- Assessment of the relationships between rainfall, temperature, radiation, vegetation and landslide movement by means of coupled hydrological-mechanical models validated with monitoring results of well-instrumented landslide sites;
- Reconstruction of historical and pre-historical landslide activity in Europe and its relation to past climates.

Priority 2: Short-term prediction of landslide activity (cluster 1)

The risk from landslides activity should be reduced by appropriate monitoring, short-term behaviour prediction and action to minimise the risk when hazardous movements are indicated. For short-term prediction, the following action must be undertaken:

- Testing and combining new investigation methods and monitoring techniques in geophysics, hydro-chemistry, geodesy, remote-sensing and mapping for different landslide sites and different spatial and temporal scales;
- Testing, developing and adapting hydrological and mechanical models which describe the times and mechanism of first-time failures;
- Testing models for post-failure mechanisms, which describe the transition of solid-like material into fluid-like material, in order to improve the prediction of dangerous accelerations and the run-out distances;
- Incorporate landslide stability and runout models in soil erosion models to estimate the percentage (often important) of landslide material delivered to torrential and river streams (debris flows, hyperconcentrated flows, sediment load);
- Using these deterministic models to assess the impact on infrastructures, to improve our prediction of damage and to carry out a proper risk assessment.
- On the catchment (regional) scale, the numerous current hazard and risk mapping experiments need to be validated and the role of mass-movements as a major sediment source to torrent loads analysed. Surprisingly most of these procedures or models have never been validated. Establishment of procedures for validating existing maps on the basis of mass movement data is needed.
- Improvement of both hazard and risk maps methodology, particularly by assessing the probability of slope failure, the temporal frequency of landslide occurrence and the determination of run-out distances, using deterministic dynamic hydrological and geotechnical models integrated into GIS;

Priority 3: Prediction of future landslide behaviour under different land use changes and climate scenarios (cluster 3)

Analysis of future GCM scenarios, in combination with expected trends in land use to derive scenarios that are likely with respect to both weather conditions (mainly precipitation) and land use. Simulate the effects of such scenarios on the stability of slopes by means of coupled hydrological and mechanical numerical models.

Priority 4: The design of early warning systems (cluster 5)

With an accurate prediction of short-term behaviour of mass movements early warning systems can be built without false alarms and giving the community at risk sufficient warning to take appropriate action. This includes the following steps:

- The design of an effective approach to establish alert systems for a variety of mass movements types and adapted to specific hazard exposure;
- Testing the approach on several European landslide test sites which already have substantial instrumentation and previous records;

- Defining strategies for various levels of risk for social organisations, in collaboration with decision-makers at local, regional and international level;

- Ascertain the reliability of data acquisition and transmission systems, as well as the limitations of both hydrological and geotechnical models;

- Define alert thresholds and analyse the incidence of false alarms;

- Determine prevention actions compatible with short-term prediction information.

Priority 5: Living with landslides and sustainable development (cluster 5)

Multidisciplinary discussions could:

- Give clues on how to meet mass movements risks, plan practical mitigation measures and integrate hazard assessment studies into community development plans, taking account of procedures and the end-users' need for sustainable development;

- Develop new techniques to make human activity compatible with the existing and potential mass movements, not only by alert systems but using engineering solutions to reduce the vulnerability of urban settlements and to minimise the social, environmental and economic effects of mass movements;

- Evaluate vulnerability reduction actions designed jointly with buildings and networks designers and developers.

5. Issues that cut across work groups

1. Salinity. Soil behaviour is greatly influenced by salt. It influences swelling and dispersion and these influence rill and gully erosion.

2. Organic matter: Soil behaviour (including erodibility) is greatly influenced by organisms and organic matter.

3. Data and monitoring. Recommendations for monitoring of erosion and sediment transport.

4. Contamination: can greatly influence erosion through inhibiting growth of organisms. Soil not protected from rainfall.

5. Land use. Land use and land use change are very important in soil erosion, flooding and landslides, while land use management is very important for compaction.

6. Climate. Climate change is like land use change of major importance for soil erosion, flooding and landslides

RESEARCH, SEALING AND CROSS-CUTTING ISSUES

Task Group 2 on
RESEARCH FOR SOIL CONTAMINATION

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Summary

The working group on research has derived three specific questions from the mandate of DG Environment:

A. What is the state of the art of the available knowledge?
B. What are the barriers in the implementation of the knowledge?
C. What are the gaps in scientific knowledge?

In the first meeting of the working group on research it has been agreed that the various task groups will work according the DPSIR scheme. With respect to the task group contamination this has been translated in the following key questions:

A. DPSIR - Knowledge

What are the driving forces behind research on soil contamination?

- The current management of contaminated soil is too expensive and not efficient;
- The ongoing soil pollution by diffuse sources;
- The need to balance the care for the soil/groundwater/sediment/water system (subsurface) and the wish to use the subsurface in a proper and sustainable management.

What are the pressures to research on soil contamination?

- The reduction of costs and improvement of efficiency of contaminated land;
- The research driven by the wish for sustainable land management is focused at the protection of the soil in balance with the different functions of the soil.

What is the state of research on soil contamination? What is the quality of the national/European infrastructure?

- Risk assessment, however there is still a lot of uncertainty in the assessment;
- A lot of research has been done to optimise the performance and to reduce the costs of the treatment of excavated soil;
- A lot is known about the impact of single contaminants under specific conditions;
- In-situ soil and groundwater treatment is improving due to a large research effort in some EU countries.
- A lot of research has been executed on Natural Attenuation, now accepted as a "remediation" tool.
- A better understanding of contaminant behaviour/pathways has broadened the range of risk based remediation techniques;
- To little research has been done on diffuse soil pollution.

With respect to the European knowledge infrastructure it is concluded that an annual budget of € 30 million is available in EU and national programmes, however the research is scattered, there is overlap and the dissemination is poor.

What are the impacts of the state of the research on soil contamination?

The impacts of research could be divided in two groups: policy and technology.

- Policy impacts: Recognition of soil contamination has resulted in too rigid policies, often over-reacting but also sometimes under-reacting. Research has led to a better understanding of the problem and to more realistic solutions;
- Technology impact: The first applied technology for soil remediation was the excavation and ex-situ treatment of soil. Due to applied research the costs of this technology have been reduced by 50 to 80 %. Next to excavation in-situ techniques are developed and applied. Research has also led to a better understanding of the natural "cleaning" capacity of the subsurface.

What are possible responses of research?

A better knowledge of the background of the problem of contamination by the experts and the authorities is leading to lower costs and a more effective management of the problem. More specific responses of research are:

- EU risk assessment methodology for chemicals (793/93/EC);
- The setting up of risk based soil criteria; these are based on impact assessment studies;
- The acceptance of the use of crop protection;
- EU directive on groundwater is based on the knowledge of the groundwater quality;
- National policies in Germany and The Netherlands have been adjusted based on the results of research programmes.

B. Bottlenecks in use of knowledge

There are some severe bottlenecks in the use of research results. These bottlenecks are:

- The dissemination of knowledge is poor; especially the knowledge of local authorities in Europe is not up to date;
- The EU action plan for Environmental technologies has identified a number of "key barriers" in the application of new developments;
- The short-term research is not enough demand driven. The result is that there is a mismatch between the knowledge supply and knowledge demand;
- There is a gap between the researchers and users of research results, as well as in the language as in the problem definition.

C. Research needs (Grouped in clusters as defined by W. Blum)

Cluster 1

- Identify and quantify contamination sources (both geogenic and anthropogenic), especially diffuse, the route of entry and fate of contaminants into/in the environment and assess the spatial and temporal variations.
- Understand the capacity controlling factors in soil influencing long-term behaviour of contaminants in soil.
- Understand the impact of contamination on the soil/water/sediment system (the subsurface)

Cluster 2

Produce, validate, optimize, and harmonize in view of normalization, exhaustive, reliable, and economical measurement methods for all steps of the characterization of soil contamination (sampling, analysis, background levels, etc), specifically addressing:

- Sampling, identification and quantification of "non standard" substances (e.g. VOCs, known and emerging pollutants) in soils;
- Early warning systems (ex. sensors) of pollution in soils;
- Characterization of speciation and long and short term fate of pollutants in soils;
- Passive sampling technologies related to soil pollution;
- Indicators/tracers for the assessment of soil quality and functioning;
- Interdependencies of effects and behaviour of substances in soil under different conditions, in order to better organize the site characterization.

Cluster 3

- Define criteria and harmonize methodologies to allow the identification of chemicals which may pose potential danger in the future (priority substances for the terrestrial environment).
- Identify the socio-economic driving forces (money, education, regulation, administration) and influencing management actions (e.g. change to different chemicals, system of crop rotation, cattle unit allowed per acre, no-till, soil–protection as a trade-off) influencing soil pollution and quantify their effects on soil pollution;
- Identify the measures for the control of non-point pollution from diffuse sources.

Cluster 4

- To improve and harmonize the conceptualization and the modelling of the transfers of contaminants from and within the soil and of the subsequent risks, specifically addressing:
    - Bioavailability for humans (soil ingestion, inhalation, dermal uptake);
    - Bioavailability to plant and soil organisms;
    - Vapour transfer from soil into outdoor and indoor air;
    - Integration of the background exposure;
    - (Eco)Toxicological reference values and their uncertainty/reliability.
- To improve risk assessment methodologies for:
    - Remediation activities on a contaminated site;
    - Re-use of waste as a soil (ashes from incinerator, foundry sands,…);
    - Impact of agriculture practices on soils (sewage sludge, fertilizers,…);
    - Fate and impact of diffuse pollution and eutrophication by deposition in near-natural ecosystems of Europe.
- To construct a” fit-for-use” tool box for risk modelling for use in (parts of) Europe, including:
    - Documentation on the sensitivity of calculated exposures to the input parameters and guidelines on when and how to measure concentrations in contact media.
    - Information on the uncertainty/ reliability of the calculated human and ecological exposure.-To Develop flexible but harmonized methods for establishing “tolerable loading” in soil.
- To develop a conceptual basis for combining different sources of spatiotemporal variability (physical, chemical, biological) for complex soil and ground water systems

Cluster 5

- Identification of natural attenuation capacities of soil and its preservation (link with cluster 1)
- Improve the quantification, and the consistency with impact assessment, of natural soil rehabilitation processes.
- To develop a method for the comparison of alternative management options (evaluation of risk based approaches in decision support systems)

D. Recommendations

The following recommendations are given by the task-group contamination:

- Policy:

- Various policies on the environment such as the soil and groundwater policies and the New Chemicals Policy should be linked and be compatible;
- Standards limit values etc in soil, water, groundwater, sediment and air should be based on common principles.

- Organization of research:

- To have one European RTD agenda, that is compatible with the 25 national RTD agendas;
- To improve the cooperation of national and European RTD programmes for example the ERANET project SNOWMAN

- Dissemination and use of research results by RTD-funders by eg:

- Stakeholder involvement in RTD projects,
- The use EUGRIS as European portal (www.eugris.org)
- To make public available databases for relevant substances (chemical, toxicological and eco-toxicological data)
- Consequent use of topic related communication processes as it was initiated with e.g. ETAP
- To digest research results into information that can be used for practical applications

- To continue the working research as a network of excellence to consolidate and update the soil RTD agenda;
- To make soil science more appealing for young scientists

1. Introduction

The general mandate of the working group on research and its task groups is based on the following statement: *"Knowledge-based approach is a fundamental requirement for policy making, highlighted in the 6th EAP. Research as an information and knowledge base to policy fulfils a key role in the soil thematic strategy. Therefore a working group on research has been established with the main purpose of facilitating transfer of information between researchers and policy makers, and identifying short term, medium term and long term research needs for soil".*

It has to be stressed that according to the mandate of the working group this document deals only with soil contamination that is defined as a result of a human activity. The analysis and recommendations do not cover risks coming from soils with naturally high contents of some elements and substances.

The working group has derived three specific questions from this mandate:

- What is the state of the art of the available knowledge?
- What are the barriers in the implementation of the knowledge?
- What are the gaps in scientific knowledge?

The task group contamination of the working group research has reformulated these questions into the task for this task group:

- Identifying and structuring existing information on soil contamination in order to make it more easily available;
- Analysing barriers that prevent full use of scientific results with respect to soil contamination for policy;
- Identifying additional short, medium and long term research needs on soil contamination;
- Formulating recommendations to improve the transfer of information on soil contamination;

In the first meeting of the working group on research it has been agreed that the various task groups will work according the DPSIR scheme. With respect to the task group contamination this has been translated in the following key questions:

- What are the driving forces behind research on soil contamination? Why is research needed, what goes wrong when there is no research?
- What are the pressures to research on soil contamination? Who is funding research; who is asking for the knowledge?
- What is the state of research on soil contamination? What is known what is unknown? What are the research needs, at short, medium and long term? What is the quality of the national/European infrastructure?
- What are the impacts of the state of the research on soil contamination? What kind of mistakes is made due to the lack of knowledge? What kind of things are going well due to research results?
- What are possible responses of research? Do the results of research have any influence on policy or practice, if so what kind of response if not why not?

2. The DPSIR analysis

The annexes to this report present a detailed description of the DPSIR; this chapter summarizes the opinions of the different task group members, who have contributed by letter.

What are the driving forces behind research on soil contamination? Why is research needed, what goes wrong when there is no research?

Research is necessary to improve decision making because the issues of contaminant exposure and effects in soils are very complex. Additionally, the costs of making decisions based on poor information is too great to ask of society, especially when we can realistically develop scientific tools that will allow for meaningful decision making.

The most relevant driving forces for research are:

- The current management of contaminated soil is too expensive and not efficient. Soil contamination is a complex problem, not only complex from a physical and scientific point of view but also from a societal point of view. Soil contamination is often a cocktail of substances with different behaviour and fate and a different impact. Often the state of the contamination is measured in a static way by measuring the concentration of pollutants, however far more interesting is to know what the future trend is in the risk of the pollutants. Answers to these questions are complex. From a societal point of view contamination is a black and white issue due to the public risk perception, which unequivocally equates “contamination” with “poison” and “health problems”, even in circumstances where the weight of scientific evidence shows a low probability of risk. Due to this complexity and due to some historical and recent scandals with soil contamination, authorities often choose the way of certainty, which results in overestimating risks, unnecessary costs of remediation, and no benefit to the environment.

- The ongoing soil pollution by diffuse soil pollutants at regional to national scales, such as traffic, diffuse water pollution, atmospheric deposition, consumer products, fertilizers, animal manure, and plant protection products (pesticides). These sources enrich the soils and sediments slowly but steadily either with unwanted substances or with wanted substances in too large amounts. To obtain a sustainable development, inputs of unwanted substances have to be decreased further. This is especially true for Cd, N and P in inorganic fertilizers, as well as for Cu, Zn, N and P in animal manure, various pesticides, and atmospheric depositions of N.

- The need to balance the care for the soil/groundwater/sediment/water system (subsurface) and the wish to use the subsurface in a proper and sustainable management. Soil has been recognised by the EU and national authorities as an important part of the environment that has to be protected. Soil is, together with water and air, an important compartment through which contamination can reach humans/animals and ecosystems, and cause adverse effects:

    - In a direct way because soil is what is on earth’s surface and the first compartment to be in contact with humans and living organisms
    - In an indirect way because soil is used to produce food
    - Soil is the habitat of organisms at the beginning of the food-chain
    - Soil is an integral component of the hydrological cycle on earth. It serves as a receiving media for waste disposal and a recharge area for the replenishment of surface and groundwater.

Historical pollution and possible new pollution is a threat for this sustainable use.
Due to the lack of knowledge about diffuse contaminants of soils, especially on degradation/accumulation processes or inorganic and organic pollutants in relation with the spatial variation of soils properties and characteristics, there is no proper management of diffuse contamination.

What are the pressures to research on soil contamination? Who is funding research; who is asking for the knowledge?

Pressures could be divided into groups related to the two drivers, mentioned before:

- The reduction of costs and improvement of efficiency:

    - The need to reduce the costs of soil characterisation and remediation;
    - The need to develop accurate policy and regulations;
    - The need to manage contaminated soil in an environmentally efficient way;

    These needs are asking for short-term applied research. Private and public "problem owners" are the main funding actors of the research.

- The research driven by the wish for sustainable land management is focused at the protection of the soil in balance with the different functions of the soil:

    - Reservoir for space and energy storage;
    - Resource for drinking water and raw materials;
    - Substrate for food and biomass production;
    - Basement for buildings;
    - Space reservoir for infrastructure;
    - Filtering, buffering degrading, immobilising and detoxifying organic and inorganic materials;
    - Habitat and gene pool.

This type of research is mainly a societal responsibility that has to be founded by national and EU resources.

What is the state of research on soil contamination? What is known what is unknown? What are the research needs, at short and long term? What is the quality of the national/European infrastructure?

In general terms a lot is known about the management of point sources. However there is a lack of effective procedures from diffuse sources. The sources of contamination are well described and identified. Some is known of the diffuse transportation and deposition, whereas direct deposition and volumes (applications in agriculture) are well known. Our understanding of geographical distribution of soil contamination is relatively well understood. Relatively little is known of downward transportation, more specific the quantification of contaminant fluxes and how this relates to degradation in soil. For many compounds the degradation and sorption kinetics are well described.

More specific to the state of the knowledge contaminated land it may be concluded that:

- A lot of research has been made on human risk assessment, with several tools having been developed and compared:

- Their relative consistencies and inconsistencies, depending on the pathways and scenarios to be calculated, are now quite well known. When differences arise, they are mostly explainable and manageable. But some differences are very big and not explainable, especially with risks related to dermal contact, transfer to plants, indoor air calculations, and diffuse pollutant deposition at the soil surface. It showed that the results of the risk models depend on many factors and mistakes are easily made. The safety factors and algorithms embedded in each model are partly responsible for the differences.

- Experimental validation currently remains quite poor.

- To come to a more harmonized European approach and to tackle the soil remediation in a more cost efficient way, it is recommended to build a toolbox of European risk models in order to standardize elements where it is possible in combination with flexible elements to accommodate the different national approaches. A first step is to validate the risk models, conceptually for some of them (indoor air calculations), and with monitoring data as far as possible, to avoid excessive conservatism (but also sometimes laxness). This is necessary to increase the support for a practical and realistic improvement of soil quality.

    - Excavated soil cleaning: a lot of research has been done to optimise the cleaning and to reduce the costs.
    - Although a lot is known about the impact of single contaminants under specific conditions the knowledge on cocktails is poor and fragmented.
    - In-situ soil and groundwater treatment is improving due to a large research effort in some EU countries.
    - A lot of research is spent on the understanding of the natural processes in the soil and groundwater the degradation, sorption, immobilisation etc of contaminants by nature is, all together called Natural Attenuation, is now accepted as a "remediation" tool.

- A better understanding of contaminant behaviour/pathways has broadened the scala of risk based remediation techniques (ex. Pb-polluted soils in old urban centres in NL is not excavated or treated because research revealed that the Pb was very little bio-accessible (PBET-test)).

With respect to the state of knowledge there is an urgent need for review-papers and a overview of "chemical abstracts" on soil contamination, in order to provide a better understanding of the state of knowledge and to make the knowledge more available for the "users".

The future New Chemical Policy (NCP) will be a huge trigger for new data. This data will be made available and a link should be established between the NCP and the future soil legislation.

The gaps in knowledge are presented in chapter 3.

With respect to the European infrastructure, reference is made to the conclusions of the Clarinet working group (Annex I).

What are the impacts of the state of the research on soil contamination? What kind of mistakes is made due to the lack of knowledge? What kind of things are going well due to research results?

The impacts of research could be divided in two groups: policy and technology.

- Policy impacts: Due to a lack of knowledge regarding dangerous substances and the missing regulation of waste dump soil and groundwater has been severely polluted up to the eighties of the previous century. Recognition of the problem has resulted in too rigid policies, often over-reacting but also sometimes under-reacting. Research has led to a better understanding of the problem and to more realistic solutions such as:

- The acceptance of a risk based approach instead of a “concentration” approach;

- The use of a pragmatic stepwise approach for compliance checking (from using limited information with a high level of uncertainty to using detailed up to date information with a high level of certainty in the assessment). This resulted in a prevention of costly emission reduction measures.

- The application of in-situ treatment and natural attenuation as tools to reduce risks.

- Technology impact: The first applied technology for soil remediation was the excavation and ex-situ treatment of soil. This technology is now a commercial market driven activity. Due to applied research the costs of this technology have been reduced by 50 to 80 %. Next to excavation in-situ techniques are developed and applied; in-situ immobilisation and remediation. Research has also led to a better understanding of the processes in the soil and groundwater and the natural “cleaning” capacity of the system. This has resulted to the acceptance of natural attenuation.

However the state of the knowledge on contaminated soil is still not mature; some parts of the risk assessment are not yet completely reliable; the introduction of in-situ bioremediation has still to deal with metabolites etc.

What are possible responses of research? Do the results of research have any influence on policy or practice, if so what kind of response if not why not?

In general terms it can be stated that research is leading to more certainty and flexibility. A better knowledge of the background of the problem of contamination by the experts and the authorities is leading to lower costs and a more effective management of the problem. More specific responses of research are:

- EU risk assessment methodology for chemicals (793/93/EC): research on the fate of metals in the environment has led to the improvement of the methodology to assess the risks of metals in the environment –including soil;
- The setting up of risk based soil criteria; these are based on impact assessment studies. Standards can be improved through research and knowledge improvement;
- The acceptance of the use of crop protection chemicals is based on research on the effects and biodegradation potential of these chemicals; or in more general terms: in-depth and scientifically sound knowledge about risks related to pollutants, provide a more secure basis for authorities in decision making (i.e. less stringent);
- EU directive on groundwater is based on the knowledge of the groundwater quality;
- National policies in Germany and The Netherlands have been adjusted based on the results of research programmes.

3. Research needs

An overview of the research needs is presented below. Research needs are grouped into clusters as defined by W. Blum. More detailed information on research needs can be found in Annex II.

Cluster 1

-Identify and quantify contamination sources (both geogenic and anthropogenic), especially diffuse, the route of entry and fate of contaminants into/in the environment and assess the spatial and temporal variations.

- Understand the capacity controlling factors in soil influencing long-term behaviour of contaminants in soil.

- Understand the impact of contamination on the soil/water/sediment system (the subsurface)

Cluster 2

Produce, validate, optimize, and harmonize in view of normalization, exhaustive, reliable, and economical measurement methods for all steps of the characterization of soil contamination (sampling, analysis, background levels, etc), specifically addressing:

- Sampling, identification and quantification of "non standard" substances (e.g. VOCs, known and emerging pollutants) in soils.
- Early warning systems (ex.sensors) of pollution in soils.
- Characterization of speciation and long and short-term fate of pollutants in soils.
- Passive sampling technologies related to soil pollution.
- Indicators/tracers for the assessment of soil quality and functioning
- Interdependencies of effects and behaviour of substances in soil under different conditions, in order to better organize the site characterization.

Cluster 3

- Define criteria and harmonize methodologies to allow the identification of chemicals, which may pose potential danger in the future (priority substances for the terrestrial environment).

- Identify the socio-economic driving forces (money, education, regulation, administration) and influencing management actions (e.g. change to different chemicals, system of crop rotation, cattle unit allowed per acre, no-till, soil–protection as a trade-off) influencing soil pollution and quantify their effects on soil pollution;

- Identify the measures for the control of non-point pollution from diffuse sources.

Cluster 4

- To improve and harmonize the conceptualization and the modelling of the transfers of contaminants from and within the soil and of the subsequent risks, specifically addressing:

  - Bioavailability for humans (soil ingestion, inhalation, dermal uptake);
  - Bioavailability to plant and soil organisms;
  - Vapour transfer from soil into outdoor and indoor air;

- Integration of the background exposure;
- (Eco)Toxicological reference values and their uncertainty/reliability;

- To improve risk assessment methodologies for:

  - Remediation activities on a contaminated site;
  - Re-use of waste as a soil (ashes from incinerator, foundry sands,…);
  - Impact of agriculture practices on soils (sewage sludge, fertilizers,…);
  - Fate and impact of diffuse pollution and eutrophication by deposition in near-natural ecosystems of Europe.

- To construct a" fit-for-use" tool box for risk modelling for use in (parts of) Europe, including:

  - Documentation on the sensitivity of calculated exposures to the input parameters and guidelines on when and how to measure concentrations in contact media.
  - Information on the uncertainty/ reliability of the calculated human and ecological exposure.

- To Develop flexible but harmonized methods for establishing "tolerable loading" in soil.

- To develop a conceptual basis for combining different sources of spatiotemporal variability (physical, chemical, biological) for complex soil and ground water systems

Cluster 5

- Identification of natural attenuation capacities of soil and its preservation (link with cluster 1)

- Improve the quantification, and the consistency with impact assessment, of natural soil rehabilitation processes.

- To develop a method for the comparison of alternative management options (evaluation of risk based approaches in decision support systems)

4. The questions from the mandate of the working group

The main questions for the working group from the mandate are:

- What is the state of the art of the available knowledge?
- What are the barriers in the implementation of the knowledge?
- What are the gaps in scientific knowledge?

What is the state of the art of the available knowledge?

A detailed overview of the art of available knowledge is given in the report of the working group contamination.

What are the barriers in the implementation of the knowledge?

Research results are not always taken into account because of remaining uncertainties, not understanding the new science, impractical to implement and time constraints (research takes too long). These reasons are often the basis for inconsistencies among legislations even within the same units. Available research should be better integrated in the policy development curve in such a way that in the different stages of the policy development research is leading to adequate knowledge. Communication of the success of the research programs is crucial to ensure it can be included in the process.

It seems that there is still little transfer between research and policy level in most of the transition countries. Environmental studies are scattered between different institutions and agencies with little coordination effort resulting in a limited assistance and support of scientific community to policy making. There is some progress, however, associated with the adoption of new environmental regulations, which impose a formal requirement to monitor contamination and implement remediation technologies. There is an increasing demand for remediation methodologies developed by research for reclamation of landfills. There is little progress in implementing protocols for reclamation of diffused pollution that is quite widespread in post-industrial areas.

There are some severe bottlenecks in the use of research results. These bottlenecks are:

- The dissemination of knowledge is poor; especially the knowledge of local authorities in Europe is not up to date. The consequence of this lack of knowledge is uncertainty and less flexibility in the permits for the application of new approaches and technologies. Another dissemination aspect is the geographical difference in the state of knowledge over Europe.
- The EU action plan for Environmental technologies has identified a number of "key barriers" in the application of new developments:

- Limitation in developing standards and standards methods: high costs in relation to small market;
- Gap between knowledge of scientists and end-users;
- Lack of a 'level' playing field for the demonstration of new technologies;
- For prevention:

  - Insufficient control from competent authorities on the application of agro-chemicals, manure and pesticides;

- For remediation:

  - Difficulty for other recovery and disposal options to compete with the very low prices of land filling;

- The short-term research is not enough demand driven. The result is that there is a mismatch between the knowledge supply and knowledge demand. End-users should have a prominent role in de definition of the short-term research.
- There is a gap between the researchers and users of research results, as well as in the language as in the problem definition. Research is originating in research programmes, the involvement of end-users of the research results in the definition of these programmes is lacking. Results of research are presented in reports and publications these are hardly accessible by end-users

What are the gaps in scientific knowledge?

A detailed overview of gaps in scientific knowledge is given in chapter 3 and ANNEX II.

5. Recommendations

The following recommendations are given by the task group contamination:

- Policy

  -The various policies such as the soil and groundwater policies and the New Chemicals Policy should be linked and should be compatible;
  -Standards limit values etc in soil, water, groundwater, sediment and air should be compatible.

- Organization of research

  -To have one European RTD agenda, that is compatible with the 25 national RTD agendas;
  -To improve the cooperation of national and European RTD programmes for example the ERANET project SNOWMAN;

- Dissemination and use of research results by RTD-funders by eg:

  -Stakeholder involvement in RTD projects;

  -The use EUGRIS as European portal (www.eugris.org);
  -To make public available databases for relevant substances (chemical, toxicological and eco-toxicological data);
  -Consequent use of topic related communication processes as it was initiated with e.g. ETAP;
  -To digest research results into information that can be used for practical applications;

- To continue the working research as a network of excellence to consolidate and update the soil RTD agenda;

- To make soil science more appealing for young scientists.

ANNEX I Research on contaminated soil in Europe

National and EU RTD programmes

Under the concerted action CLARINET the Working Group on "Co-ordination of RTD" have made an analysis of national and EU RTD programmes related to sustainable land and groundwater management. Programme managers from 11 European countries plus DG Research compose this Working Group. The working group have made a survey, in 2001, of national and EU research programmes related to sustainable land and groundwater management issues. (www.clarinet.at) The conclusions of this working group are:

- Budgets of national RTD programmes in Europe add up to a total of about € 20 million /year and about € 10 million from the EU budget. Altogether, there are about € 30 million/year available for contaminated land and groundwater research across Europe. The costs for contaminated land remediation in Europe are estimated to be at least about € 90 billion (EEA 2000). This means that the annual investment in RTD for sustainable land management is less only about 0.03 % of the total cost of the problem.

- Before the Clarinet RTD Working Group there was no co-ordination whatsoever between national RTD programmes in Europe. The consequence is that all countries go through similar learning curves, resulting in a considerable overlap of research projects and targets. Up to now, there has also been a lack of co-ordination between national and EU research programmes. Overall, the missing co-ordination of RTD activities in Europe is likely to result in parallel expenditures and less efficient management of the very limited resources for European research.

- Eligibility for almost all national RTD programmes is restricted to their own national research community and activities. Only a few countries provide limited funding possibilities for the exchange of experts with other countries, but real co-operation on a project level is rarely feasible. This means that cross-fertilisation and knowledge exchange among countries from focused partnership projects is not available.

- The dissemination of project findings through national RTD programmes is typically very modest. Opportunities provided by the WWW are not well used. The advantages of broad dissemination of project results at a European level do not seem to have been given particular consideration by most national RTD programmes so far. This situation has been one of the main reasons for the creation of various contaminated land and groundwater stakeholder networks in Europe over the past few years. A major aim of all these networks has been "to disseminate knowledge". A co-ordinated approach by various European RTD programmes would be of substantial benefit in this regard.

- There is no co-ordinated approach in focusing the various RTD programmes in Europe towards the major gaps in scientific knowledge. The stakeholder networks CLARINET (regulators) and NICOLE (industry) have identified priority research issues needed to implement sustainable solutions for contaminated land and groundwater related problems in Europe (CARACAS/NICOLE 1997, Ferguson *et al*, 1998). So far, these research demands do not appear to be considered in all national research programmes.

The Working Group's overall conclusion is that enhanced co-ordination between countries' national research approaches will considerably increase the effects and yields of the resources invested in RTD. This will accelerate the provision of focused scientific knowledge, which is urgently needed to meet the demands for sustainable solutions in Europe.

These conclusions are still relevant; many remarks of the members of the task group contamination are related to one or more of these conclusions.

Categories of research

Research is often divided in different categories, such as:

Short term	versus	Long term
Demand driven	versus	Curiosity driven
Applied	versus	Fundamental
Trans-disciplinary	versus	Mono/multidisciplinary

The left column is representing research to tackle acute problems, demand by public or private parties who owns contaminated land, and a team of representatives of universities/institutes and consultants/contractors carries out the research. The right column is representing research based on knowledge gaps identified by researchers, carried out by universities/institutes in research groups.
In the view of the task group both categories of research are needed, however it should be recognized that the output from both categories and the dissemination and use of the knowledge is different. The left column is more or less market driven, dissemination and use should follow the rules of the market. The right column should be disseminated and used by policymakers

ANNEX II Research gaps

Which are the gaps in scientific knowledge and the research needs

The gaps in needed knowledge have been defined as research needs in the chapter 3. These needs are mentioned and also is indicated if the "need" is short term or long term and who should promote the research. The research needs are ordered following the 5 following clusters:
Cluster 1: Processes behind (all kind) contamination + inter-dependencies: how does the contamination occur, where does it come from, how and to what extent should it be prevented.
Cluster 2: development + harmonization of methods to assess the state of contamination
Cluster 3: Cross linking with EU and other policies
Cluster 4: Analysis of impacts to other compartments and to humans
Cluster 5: Operational procedures for the mitigation of contamination

It should be noted that for the reader's convenience, only very synthesized topics are reported here, as main items. For the transparency of the process and an increased usability, more insight on the problematic and the needed content behind those topics can be found in the SOWA report, paper from CLARINET on research needs.

Short-term is < three years
Long term > three years

PS: the last three items are considered as "No research issue for our Contamination Group". They are supposed to be suppressed from this table in the final version.

Topic	**DG**	**Short-term**	**Long-term**	**Cluster**
CLUSTER 1: PROCESSES BEHIND (ALL KIND) CONTAMINATION + INTER-DEPENDENCIES: HOW DOES THE CONTAMINATION OCCUR, WHERE DOES IT COME FROM, HOW AND TO WHAT EXTENT SHOULD IT BE PREVENTED.				
Identification and quantification of relevant diffuse pollution sources to soils: e.g.: atmospheric deposition (road traffic,…), railway (oil and lubricants), antibiotics, organic substances, plant nutrients and protection agents,...	DG RES & ENV	×	×	1
Assessment of natural and anthropogenic fluxes of natural occurring substances	DG RES	×		1
Vulnerability of the soil properties influencing the soil pollution buffer capacity, to current land use and land use changes (taking into account the spatial differentiation) on the long-term (conversion of arable land to forest or wetland, conversion from intensive to extensive agriculture, changing groundwater tables, changes in salinity due to irrigation or intrusion of sea water)	DG RES		×	1
Trend analysis of diffuse soil contamination as a land management tool to drive the control and prevention of diffuse contamination.	DG ENV		×	1
Understand the impact of contamination on the soil/water/sediment system (the subsurface)	DG RES	×	×	1

CLUSTER 2: DEVELOPMENT + HARMONIZATION OF METHODS TO ASSESS THE STATE OF CONTAMINATION				
Generation of data on the current status and trend of soil contamination as a function of the magnitude of contamination, the type of land use and the parent material involved in soil formation	DG ENV	×	×	2
Improvement of protection devices such as early warning systems of soil pollution.	DG RES	×		2
Improvement of exhaustive, reliable and economic measurement technologies for: • The identification and quantification of "non standard" substances (eg. VOCs, known and emerging chemicals) • characterization of speciation and short and long term behaviour (methods taking into account the contamination source, the climatic conditions and the land use). • passive sampling technologies related to soil pollution. • indicators/tracers for the assessment of soil quality and functioning	DG RES & ENV (ETAP)	×		2
Tools for spatial analysis of contaminant contents in soil / cost-effective innovative screening and monitoring of soil pollution such as proxy mapping and identification of indicators for soil functioning.	DG RES (ETAP)	×		2
European standards for laboratory certification, sampling and analysis strategies for the EU as a key element of quality assurance, eg. For VOCs.	DG RES &ENV	×		2
Influence of conditions and impact of changing conditions (type of ecosystem, input patterns, pedological, geographical and climatic conditions) on the effects and long term behavior of substances; in order to better organize the site characterization: for example, requirements for field based process studies of retention and transport of substances like P, metals and organics in relevant pathways.	DG RES	×	×	2
Gathering, harmonizing and disseminating available knowledge of the natural contents and dynamics of natural substances in soils of different geographical regions, in relation to the spatial differentiation of soil properties and characteristics.	DG ENV	×		2

CLUSTER 3: CROSS LINKING WITH EU AND OTHER POLICIES				
Evaluation of effectiveness of available and new management strategies and side effects on soil contamination. For example: • nitrogen losses to groundwater from biological farming; • present and EU regulations being introduced (e.g. limit values in soils, sewage sludges, composts, fertilizers), in relation to regional variation in soil types, climate conditions, type of crop production.	DG ENV	×	×	3
Harmonization of methodologies for the identification of priority substances for the terrestrial environment	DG ENV	×		3
How to deal with “urban soils” large scale pollution (lead, PAHs,…) and how to prevent future ones.	DG RES &ENV	×	×	3
Identify the socio-economic driving forces (money, education, regulation, administration) and influencing management actions (e.g. change to different chemicals, system of crop rotation, cattle unit allowed per acre, no-till, soil–protection as a trade-off) influencing soil pollution and quantify their effects on soil pollution.	DG ENV	×		3

CLUSTER 4: ANALYSIS OF <u>IMPACTS</u> TO OTHER COMPARTMENTS AND TO HUMANS				
Evaluation and harmonization of risk assessment methods, economically reasonable, suitable for different types of substances and for different types of land-use, considering local, regional and continental variations, and dealing with uncertainty in a proportionate and transparent manner. For example: • amount of soil ingested by children (current uncertainty: ~ factor 5); • dermal contact (current uncertainty: factor 10 or ∞); • Taking into account the background exposure for threshold-effect substances; • bioavailability (see below); • speciation and long term behaviour depending on contamination source, climatic conditions and land use.	DG ENV	×	×	4
Development of a toolbox and of a policy for human risk assessment: • for surrounding population during remediation of a contaminated site; • re-use of waste as a soil (ashes from incinerator, foundry sands, thermally treated contaminated soil); • agriculture use of manure / sewage sludge, fertilizers,…, (e.g. Cd risk) taking into account crop production systems, species and cultivar variation, diet type, etc.	DG ENV	×		4
Risk evaluation and policy for "emerging", i.e. until now not studied, potential pollutants (i.e. such as human and animal pharmaceuticals, steroids and hormones, personal care products (PCP), antiseptics, surfactants, flame retardant, industrial additives and agents, gasoline additives).	DG RES &ENV	×	×	4
Dynamic modeling of transport and dispersal effects of pollutants in and from soil – e.g.: • transfer of VOCs from soil into indoor air (current uncertainty: ~ factor 100), • transfer to plants (current uncertainty: ~ factor 10; see below), • attenuation of diffuse pollution at the soil surface, depending on the source.	DG RES &ENV	×	×	4
Long term impact of loads of nutrients and protection agents on plants, soil and groundwater, e.g. on the natural capacity of substance decomposition	DG RES &ENV	×	×	4
Assessment of the bioavailability of substances in soils for plants, soil org, humans, under different conditions (type of ecosystem, input patterns, pedological, geographical and climatic situation, land use, “age” of contamination), and assessment of the evolution of the bioavailability in time and when conditions change.	DG RES &ENV	×	×	4
Harmonization of quality and relevancy criteria for the evaluation of site data in the EU: • (eco)toxicological reference values; • (flexible) "tolerable" loading of substances in soils (+ groundwater), in the EU: indicators for fit-for-use.	DG RES &ENV	×	×	4
Setting up a light monitoring system of the transfers from manure / sewage sludge used for agriculture, gathering the routine measures and obtaining complementary measures, on sludges, soil and plants.	DG RES &ENV		×	4
impact of diffuse pollution and eutrophication by atmospheric deposition in near-natural ecosystems of Europe	DG RES		×	4
To construct a” fit-for-use” tool box for risk modelling for use in (parts of) Europe, including: • documentation on the sensitivity of calculated exposures to the input parameters and guidelines on when and how to measure concentrations in contact media. • information on the uncertainty/ reliability of the calculated human and ecological exposure • documentation on the sensitivity of calculated (eco)toxicological reference values to the input data. • information on the uncertainty/ reliability of the calculated (eco)toxicological reference values	DG ENV	×		4

Cluster 4 – Continued…

CLUSTER 4: ANALYSIS OF IMPACTS TO OTHER COMPARTMENTS AND TO HUMANS				
Development of true Farm and Field gate balances that take into account all in- and outputs. Currently various outputs (crop uptake, leaching, gaseous emissions) are not properly quantified or even neglected.	DG ENV	×		4
To develop a conceptual basis for combining different sources of spatiotemporal variability (physical, chemical, biological) for complex soil and ground water systems	DG RES	×		4

CLUSTER 5: OPERATIONAL PROCEDURES FOR THE MITIGATION OF CONTAMINATION				
Quantification of the natural rehabilitation potential of the soil, esp. in the natural attenuation in the unsaturated zone, which is still "terra incognita" in comparison with natural attenuation in the unsaturated zone.	DG RES &ENV	×	×	5
Procedure ensuring consistency between remediation goals and site assessment methods of cluster 4. E.g. impact of re-vegetated sites on the surrounding ecosystem and human health.	DG ENV	x		5
Identification of natural attenuation capacities of soil and its preservation (link with cluster 1) -Improve the quantification, and the consistency with impact assessment, of natural soil rehabilitation processes.	DG RES		×	5
To develop a method for the comparison of alternative management options (evaluation of risk based approaches in decision support systems)	DG ENV	×		5
Improvement or development of low cost remediation technologies.	DG RES &ENV	×	×	5
Assessment of the sustainability/persistence of different remediation technologies.	DG RES &ENV	×	×	5
"NO RESEARCH ISSUES FOR OUR CONTAMINATION GROUP"				
The economic impact (both form farmers and governments) of changing regulations on the allowed content of unwanted substances. For example reducing the amount of Cd in P-fertilizer will result in higher prices for fertilizer. What are economic consequences for this? How new composts regulations affect organic waste management.	Research issue for TG 7 Policy			/
Organic matter decline can be compensated by organic fertilizers, like animal manure, sewage sludge or compost. How do these potential sources of soil organic matter compare to the real natural input (decomposition of the local vegetation). What are the long-term consequences and are they reversible if negative. Organic matter decline may be faster than can be replenished by organic fertilizers because persistent contaminants in these fertilizers accumulate in soil. How is the life support system and biodiversity affected by current "high input" high output' agriculture?	Research issue for TG Org Matter			3

ANNEX III

SOWA paper, Integrated Soil and Water Protection: Report 1, February 2004. EU project EVKT-CT-2002-80022

CLARINET report: “An Analyses of National and EU RTD Programs related to Sustainable Land and Groundwater Management. H.J. van Veen ISBN: 3-85457-677-3

RESEARCH, SEALING AND CROSS-CUTTING ISSUES

Task Group 3 on
ORGANIC MATTER AND BIODIVERSITY

Stephen Nortcliff and Carlos Garbisu

Part 1 Organic matter

Gaps and needs of research are numerous in the domain of SOM and soil biodiversity .

The priority will go to the functions performed by OM and organisms and how we can manage the consequences for the soil. Practical aspects are necessary like carbon capacity to retain C and under which form, specific quality criteria are necessary for exogenous MO in relation with benefits; new bioindicators and the knowledge of ecological benefits (including economy).

SOM levels and the nature and quality of SOM determine different soil functions. Whilst this subject area has been the subject of considerable research over many decades, there are still gaps in our detailed knowledge and understanding of the nature, properties and ecological significance of the overall levels of SOM and the different pools. There is a need to more specifically understand the relationships between SOM levels and quality, and soil function, soil properties and behaviour, land use and land management, climatic fluctuations over different time scales, etc.

With respect to the relationships between SOM levels and quality and the nature and function of soil biodiversity there are still many gaps in our knowledge. Whilst it is widely acknowledged that maintenance and improvement of biodiversity is in itself an important target of current policies and conventions, it is important to establish the roles of a diverse community of organisms within the soil. There is a need to establish the nature of the relationships present under a range of conditions and how these relationships vary across the complex natural and managed environmental conditions across Europe. It is also important to establish what are the natural variations in these relationships and how robust the relationships are under scenarios of changing climate and environment.

<u>Cluster 1 – Analysis of Threats</u>

We need to more fully understand the role of SOM in optimising soil functions.

To understand the importance of changes in SOM the following has to be investigated:

- The role and turnover dynamics of the fractions of SOM
- The role of dynamics of soil organisms at sub-molecular and physiological levels.
- The nature of the relationships between SOM fractions and soil organisms.
- The value of soil organisms/soil ecological capital

Furthermore research has to be done on:

- development of methods to extrapolate information obtained from the sample through to the field, regional and global scales.
- characterisation of soil biodiversity at selected key natural and managed ecosystems, and ecosystems currently undergoing change in natural and anthropogenic processes.
- Relationships between SOM and soil biodiversity
- Management of SOM and soil biodiversity

At present knowledge of soil biodiversity threats is mainly qualitative. The results of the research should provide possibilities to quantify the threats. This implies research on the ecological, economic and social valuation of soil biodiversity, and the effects of human activities and on composition and activities of soil ecosystems.
Much of the questions may be investigated by setting-up of "EU coordinated" long term controlled field experiments (such as Rothamsted) in different places in Europe.

In the past much of the emphasis has been focused on SOM in mineral soils. Carbon 'hot spots' (e.g. peat soils) should be given equal emphasis. In particular the rate of decline of organic matter under a management of agricultural production and forestry must be investigated. Similarly the consequences (and the reversibility thereof) of removing agricultural or forestry practices on these soil must be understood.

<u>Cluster 2 – Development and harmonisation of monitoring and characterisation methods</u>

- Development and harmonisation of standardised methods for characterisation of the nature and function of the SOM pools from a biological and structural perspective in contrasting environments across Europe.
- Development and harmonisation of appropriate standardised methods to characterise biodiversity of soil organisms.
- The selection of organisms to be monitored in monitoring programmes should be based on:
    - ease of measurement;
    - value as an indicator;
    - relationships with other organisms;
    - relationship with soil function.
- There is a need to provide a scientific basis for a minimum data set appropriate for this purpose across the contrasting natural and managed ecosystems in Europe. These methods will probably be at a range of scales from whole organisms and communities through to characterisation at the genetic (DNA, mRNA) and at the protein level.
- To facilitate reproducibility of sampling and to enable comparison of monitoring data standardised sampling techniques must be developed and adopted.
- To facilitate comparison of monitoring data, fast and preferentially automated characterisation and identification techniques of soil organisms must be developed and adopted.
- For standardisation of the above mentioned techniques activities of ISO should be stimulated.
- Development of techniques to extrapolate the results of monitoring activiteis of SOM and soil biodiversity to the appropriate spatial and temporal scales.

<u>Cluster 3 – Driving Forces and Pressures</u>

This Cluster comprises research on:

- Effects of climate change and associated land use changes on SOM levels and pools and biodiversity.
- Effects of management practices in farming and other land uses (e.g. additions of EOM to soil; changes in tillage practices; conventional-v-integrated-v-organic farming; incorporation of residues from GM crops; restoration of damaged land) on SOM levels and pools and biodiversity. Optimisation of SOM and soil

biodiversity by application of (combinations of) management techniques

- Contributions of different agricultural crops and plant covers on SOM levels and pools and soil biodiversity.
- The effects of contaminants on the role and function of the SOM pools and soil biodiversity.
- Characterisation of the potential of soils to sequester carbon under different environmental conditions. Assessment of the broad principles, which can be provided across Europe and within specific climate:landscape combinations.
- Establishment of the requirements for development of models to assess effects of land-use on SOM and soil biodiversity for policy and guidance frameworks.

Cluster 4 – Analysing impacts

- Analysis of the role of the SOM pools in determining soil functions.

- Analysis of the relationships between the structural and functional properties of soil biodiversity and soil functioning. It is of particular the 'tolerances' of these relationships, the resilience to change in soil functioning and the extent and rate of recovery. This is also true for the SOM pools.

Cluster 5 – Responses

- Investigation and evaluation of the effects (positive and negative) on SOM pools and functions of different levels of tillage across a range of environmental conditions.
- Investigation and evaluation of the effects (positive and negative) of the incorporation of a range of exogenous organic materials on SOM pools and functions and soil biodiversity.
- Investigation of the possibilities to influence the resilience of SOM levels and pools and soil biodiversity to changing environmental conditions
- Development of indicators to facilitate management of soil biodiversity on local level (e.g. for farmers and regional nature development), on the national level (e.g. spatial planning) and on an international scale (e.g. evaluation of the success of international treaties).
- Development of an evaluation system for soil quality to enhance the interpretation of indicator values (good or bad quality, desired or undesired quality, suitable or not suitable for a particular soil use).
- Development of statistical techniques and models for the assessment of trends in space and time.

PART 2: BIODIVERSITY

After carefully revising the most relevant documents provided by the EC (*e.g.*, Framework Mandate for all Working Groups/Co-ordination, Working Methods and Common Planning/Specific Mandates, etc.), Task Group 3 (Organic Matter, Biodiversity) proceeded to answer the three main questions indicated in those documents: (i) what is the state of the art of the available knowledge?, (ii) what are the barriers in the implementation of the knowledge?, and (iii) what are the gaps in scientific knowledge?

Following the recommendation given by the WG Chairman during the first meeting of the Research WG in Vienna, we have worked according to the DPSIR scheme (Driving Forces, Pressures, State, Impact, Responses).

"DPSIR" ANALYSIS ON SOIL BIODIVERSITY

"The aim is to halt further degradation of soil biodiversity and to assure that soil can provide all its functions for human activities and ecological needs (i.e., food and other biomass production; storing, filtering and transformation; habitat and gene pool; physical and cultural environment for mankind; source of raw materials; but we must also value nature/soil biodiversity for its own sake, as a provider of services and as a source of scientific interest)."

Loss of biodiversity

Although biodiversity is currently a key area of concern for sustainable development, providing a source of considerable economic, aesthetic, health, and cultural benefits, so far, human society seems unable to halt the depletion of resources and the degradation of the environment (e.g., the soil environment), and then biotic impoverishment is an inevitable consequence of the ways in which humans use (better, misuse) the environment. Unfortunately, we do not seem to remember that the well-being and prosperity of the earth´s ecological balance as well as of our human society directly depend on the extent and status of biological diversity.

In this respect, soils have a central role as organizers of most terrestrial ecosystems and, so, in the last years, there have been quite a few declarations capturing the fact that soil health is a central component in sustaining the world´s ecosystems and the myriad of natural and socioeconomic systems they support. In this respect, the ecological functions of soil depend on a healthy and dynamic community of soil biota.

Introduction to biodiversity

According to the Convention on Biological Diversity, biodiversity means "the variability among living organisms from all sources including, inter alia, terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part".

Although, currently, biodiversity is evaluated at three fundamental levels of biological organization (genetic diversity, species diversity, and ecosystem diversity), the species is still the most commonly used currency when referring to biodiversity.

As applied to macroscale organisms, measures of genetic and taxonomic diversity traditionally rely on information about the number of species present (species richness) and the relative abundance of each species (evenness). But for soil microorganisms, we cannot easily and accurately determine their numbers and relative abundances, nor characterize species' boundaries in these systems.

Indeed, soils differ from the above-ground and aquatic ecosystems because of their immense biological and physicochemical diversity and complexity, the dominant heterotrophic character of processes, and the size of the organisms. Soil is certainly not characterized by easily observable, colourful-looking organisms since even the larger groups of organisms in soil are included in the category of cryptobiota (hidden organisms), not to mention the microorganisms.

Our inability to culture most microorganisms present in soils has, until recently, impaired studies of the relationships between the structure and function of soil microbial communities. This shortcoming has been partly overcome by the utilization of a number of molecular techniques that allow detection, enumeration, and characterization of soil microorganisms but that do not depend on cultivation.

Finally, although most research on the relationship between biodiversity and ecosystem functioning has focused on species diversity, it is also important to consider the functional diversity or the range of species traits in a habitat or in a regional or experimental species pool. Most interestingly, the functional traits of each species could be determined, and the proportion of a multidimensional trait space covered by a particular suite of species used as a measure of the functional diversity of the community. Recent advances in the techniques available to study microbial communities have led to a growing realization that microbial community composition can also play a critical role in ecosystem functioning.

DPSIR Scheme

What are the driving forces behind research on soil biodiversity?

- The integrity of our soils is thought to depend on the extent and status of their biological diversity.
- The current management of soils (agricultural and forestry practices, soil pollution, sealing, etc.) might lead to a decrease in soil biodiversity.
- Following the ethical principle of intergenerational responsibility, we must protect a biota that has been created over billions of years.

What are the pressures to research on soil biodiversity?

- Our lack of knowledge on soil biodiversity, especially at the prokaryote and fungi levels.
- Our lack of knowledge on the relationship between soil biodiversity and soil functioning.
- The possibility of using soil biodiversity as a tool to quantify the effect of land use on soil ecosystem health (the possibility of using biodiversity as a biological indicator of soil quality/health).
- The possibility of using soil biodiversity to monitor the efficiency of a soil remediation process.

What is the state of research on soil biodiversity?

- A lot of research has been carried out on soil micro- and macrofauna.
- Research has also been carried out on soil microbial ecology and diversity.
- Links have been established between land use management practices, the community structure of invertebrates, and their activities.
- Research has been carried out on the importance of food web on soil functioning.
- Main areas of research: (i) development of new techniques to evaluate soil biodiversity; (ii) effects of land use on soil biodiversity; (iii) utilization of soil biodiversity as a biological indicator of soil quality/health; (iv) utilization of soil biodiversity as a biological indicator to monitor the efficiency of a remediation process; (v) the on-going topic of the relationship between soil biodiversity and soil ecosystem functioning; and (vi) the relationship between above- and below-ground biodiversity.

What are the impacts of the state of research on soil biodiversity?

- An increasing awareness of the importance of soil biodiversity for soil functioning.
- An increasing awareness of the importance of preserving soil biodiversity for ethical and moral reasons.

What are the responses of research on soil biodiversity?

- A minimization of the pressures leading to loss of soil biodiversity.
- The utilization of soil biodiversity as a tool to monitor the efficiency of a remediation process and as a biological indicator of soil quality/health.

WHAT ARE THE BARRIERS IN THE IMPLEMENTATION OF THE KNOWLEDGE ON SOIL BIODIVERSITY?

- The fact that soil biodiversity is still a relatively new field of research (mainly, research on soil microbiota).
- The quantification of soil biodiversity is indeed difficult.
- The measures of diversity being formulated for microbial communities usually fail to describe their metabolic talents, their ability to respond to environmental determinants, their interactions with one another, and their spatial distributions throughout the soil matrix.
- The complexity of soil biodiversity implies that time and money are major impediments for thorough monitoring.
- Although applicable to many other areas of research, it is a fact that the dissemination of knowledge on soil biodiversity is inadequate and insufficient.

WHAT ARE THE GAPS/RESEARCH NEEDS IN SCIENTIFIC KNOWLEDGE?

(Note: this section is common to both parts of this reports, i.e. OM and Biodiversity; The information has been presented in Clusters)

CLUSTER 1 – ANALYSIS OF THREATS

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- The nature of the relationships between SOM fractions and soil organisms.
- The value of soil organisms/soil ecological capital.

Furthermore research has to be done on:

- Development of methods to extrapolate information obtained from the sample through to the field, regional and global scales.
- Characterisation of soil biodiversity at selected key natural and managed ecosystems, and ecosystems currently undergoing change in natural and anthropogenic processes.
- Relationships between SOM and soil biodiversity.
- Management of SOM and soil biodiversity.

At present, knowledge of soil biodiversity threats is mainly qualitative. The results of the research should provide possibilities to quantify the threats. This implies research on the ecological, economic and social valuation of soil biodiversity, and the effects of human activities and on composition and activities of soil ecosystems.

Much of the questions may be investigated by setting-up of “EU coordinated” long term controlled field experiments (such as Rothamsted) in different places in Europe.

In the past, much of the emphasis has been focused on SOM in mineral soils. Carbon ‘hot spots’ (e.g., peat soils) should be given equal emphasis. In particular, the rate of decline of organic matter under a management of agricultural production and forestry must be investigated. Similarly the consequences (and the reversibility thereof) of removing agricultural or forestry practices on these soil must be understood.

CLUSTER 2 – DEVELOPMENT AND HARMONISATION OF MONITORING AND CHARACTERISATION METHODS

- Development and harmonisation of standardised methods for characterisation of the nature and function of the SOM pools from a biological and structural perspective in contrasting environments across Europe.
- Development and harmonisation of appropriate standardised methods to characterise biodiversity of soil organisms.
- The selection of organisms to be monitored in monitoring programmes should be based on:
  - ease of measurement;
  - value as an indicator;
  - relationships with other organisms;
  - relationship with soil function.
- There is a need to provide a scientific basis for a minimum data set appropriate for this purpose across the contrasting natural and managed ecosystems in Europe. These methods will probably be at a range of scales from whole organisms and communities through to characterisation at the genetic (DNA, mRNA) and at the protein level.
- To facilitate reproducibility of sampling and to enable comparison of monitoring data standardised sampling techniques must be developed and adopted.
- To facilitate comparison of monitoring data, fast and preferentially automated characterisation and identification techniques of soil organisms must be developed and adopted.
- For standardisation of the above mentioned techniques activities of ISO should be stimulated.
- Development of techniques to extrapolate the results of monitoring activities of SOM and soil biodiversity to the appropriate spatial and temporal scales.

CLUSTER 3 – DRIVING FORCES AND PRESSURES

This Cluster comprises research on:

- Effects of climate change and associated land use changes on SOM levels and pools and biodiversity.
- Effects of management practices in farming and other land uses (*e.g.*, additions of EOM to soil; changes in tillage practices; conventional-v-integrated-v-organic farming; incorporation of residues from GM crops; restoration of damaged land) on SOM levels and pools and biodiversity. Optimisation of SOM and soil biodiversity by application of (combinations of) management techniques.
- Contributions of different agricultural crops and plant covers on SOM levels and pools and soil biodiversity.
- The effects of contaminants on the role and function of the SOM pools and soil biodiversity.
- Characterisation of the potential of soils to sequester carbon under different environmental conditions. Assessment of the broad principles, which can be provided across Europe and within specific climate: landscape combinations.
- Establishment of the requirements for development of models to assess effects of land-use on SOM and soil biodiversity for policy and guidance frameworks.

CLUSTER 4 – ANALYSING IMPACTS

- Analysis of the role of the SOM pools in determining soil functions.
- Analysis of the relationships between the structural and functional properties of soil biodiversity and soil functioning. It is of particular the ‘tolerances’ of these relationships, the resilience to change in soil functioning and the extent and rate of recovery. This is also true for the SOM pools.

CLUSTER 5 – RESPONSES

- Investigation and evaluation of the effects (positive and negative) on SOM pools and functions of different levels of tillage across a range of environmental conditions.
- Investigation and evaluation of the effects (positive and negative) of the incorporation of a range of exogenous organic materials on SOM pools and functions and soil biodiversity.
- Investigation of the possibilities to influence the resilience of SOM levels and pools and soil biodiversity to changing environmental conditions.
- Development of indicators to facilitate management of soil biodiversity on local level (e.g., for farmers and regional nature development), on the national level (e.g., spatial planning) and on an international scale (e.g., evaluation of the success of international treaties).
- Development of an evaluation system for soil quality to enhance the interpretation of indicator values (good or bad quality, desired or undesired quality, suitable or not suitable for a particular soil use).
- Development of statistical techniques and models for the assessment of trends in space and time.

SPECIFIC RESEARCH RECOMMENDATIONS ON SOIL BIODIVERSITY

Research in the following areas is needed:

- Research on new and improved methods to determine soil biodiversity, especially at the microorganism level.
- Research is also needed at the functional (mRNA) and at the protein levels.
- Functional soil biodiversity with respect to enzyme activities.
- Relationship between structural and functional biodiversity and soil functioning (including relations between biodiversity and soil and plant health).
- Effect of land use on structural and functional soil biodiversity (*e.g.*, effect of exogenous OM, GM crops, tillage, remediation techniques, integrated and organic farming).
- Structural and functional BIOD as a biological indicator of soil quality/health.
- Relationship between above- and below-ground biodiversity.
- Effect of climate change on soil biodiversity.
- Interaction between soil biodiversity and site *x* soil use constellations. Interaction between soil biodiversity and management techniques at different site *x* soil-use constellations.
- Soil biodiversity and pollution.
- Soil biodiversity and soil compaction.
- Research on the scale at which the evaluation of soil biodiversity is to be undertaken.

<u>Recommendations on soil policy (soil biodiversity):</u>

- Support for the necessary research activities as well as for soil uses and soil management techniques which contribute to maintaining and improving soil biodiversity.
- Minimization of pressures leading to loss of soil biodiversity through legislation, education, research, etc.
- Creation of a group of European experts aimed at improving public awareness and education on the importance of soil biodiversity.
- Creation of a group of European experts to “translate” scientific terms, concepts, research discoveries, etc. on soil biodiversity to policy-makers, legislators, natural resource managers, environmentalists, and the public in general, and to design efficient systems to disseminate information on soil biodiversity.
- Design of efficient systems to improve dissemination of research findings on soil biodiversity to other scientists, policy-makers, legislators, natural resource managers, environmentalists, and the public in general.
- Creation of a database on soil biodiversity.

ANNEX 1: INTRODUCTION ON SOIL BIODIVERSITY

Research on soil biodiversity has been carried out at the micro- and macrofauna level during the past decades. The importance of food web on soil functioning, from organic residues to fungi and bacteria and to grazers and predatory organisms, is recognized. Links have been established between land use management practices, the community structure of invertebrates, and their activities. Much less is known on microorganisms because of methodological difficulties to assess their biodiversity. Although relationships between soil functioning and soil biodiversity have been postulated, there is little evidence of direct links between them. However, because of the precautionary principle, these relationships should not be jeopardized by negatively affecting biodiversity. Finally, the moral and ethical imperatives of conserving a planet and a biota created over billions of years carries tremendous weight on its own. Together with the precautionary principle, ethics provide the basis for the principle of intergenerational responsibility. In view of the unprecedented changes that are taking place in the soil ecosystems of the world, the importance of soil ecosystem services to human welfare requires that we adopt the prudent strategy of preserving soil biodiversity in order to safeguard ecosystem processes vital to society.

INDICATOR LEVEL: DRIVING FORCES

What are the driving forces behind research on soil biodiversity?

Soils have a central role as organizers of most terrestrial ecosystems and, so, in the last years, there have been quite a few declarations capturing the fact that soil quality is a central component in sustaining the world´s ecosystems and the myriad of natural and socioeconomic systems they support. The integrity of our soils is thought to depend on the extent and status of their biological diversity.

The main driving forces behind the loss of biodiversity (also behind soil degradation, in general) are:

- Human population growth.
- Economical growth.
- Cultural driving forces (such as the lack of a sustainable approach to soil use, and also to the fact that the role of soil has not been sufficiently recognized, etc.).

INDICATOR LEVEL: PRESSURES

What are the pressures to research on soil biodiversity?

- We know very little about the biodiversity (structural, functional) of soil organisms, especially at the prokaryote and fungi levels.
- We know very little about the links between biodiversity and soil functions. These links must be quantified. Biodiversity must be preserved so that soils can keep on performing their central role as organizers of most terrestrial ecosystems. The integrity of soils is a central component in sustaining the world´s ecosystems and the myriad of natural and socioeconomic systems they support.
- We need to provide society with tools (based on biodiversity) to characterize the effect of land use on ecosystem health.
- We need to conserve this biodiversity. There are certainly moral and ethical imperatives to preserve a biota created over billions of years.
- The possibility of using biodiversity as a biological indicator of soil quality.
- The possibility of using biodiversity to monitor the efficiency of soil remediation (bioremediation, phytoremediation, etc.) processes.

INDICATOR LEVEL: STATE

What is the state of research on soil biodiversity?

Research on soil biodiversity has been carried out at the micro- and macrofauna level during the past decades. The importance of food web on soil functioning, from organic residues to fungi and bacteria and to grazers and predatory organisms, is recognized. Links have been established between land use management practices, the community structure of invertebrates, and their activities. However, the absolute diversity of prokaryotes is widely held to be unknown and unknowable at any scale in any environment, particularly soil, where their diversity is extremely high. Even using gene-based assays (arguably the best current approach to microbial diversity), we are unable to easily quantify the richness and evenness of microbial species. In consequence, there is a clear and urgent need to keep on doing (*i.e.*, funding) research in this topic, if we are to understand soil functioning.

So far, the main areas of research on soil biodiversity have been the following: (i) development of new techniques to evaluate soil biodiversity, (ii) effect of agricultural practices, forestry management practices, pollution, soil amendments, application of exogenous organic matter, etc. on soil biodiversity, (iii) utilization of soil biodiversity as a biological indicator of soil quality and to monitor the efficiency of remediation processes, and (iv) relationship between soil biodiversity and ecosystem functioning.

INDICATOR LEVEL: IMPACTS

What are the impacts of the loss of biodiversity?

In general terms, the three most important impacts of the loss of soil biodiversity are: (i) the effect on soil functioning, in particular, on the capacity to degrade and transform most of the organic compounds that reach the soils into nutrients and humus, (ii) the moral and ethical consequences of losing a biota created over billions of years, and (iii) the loss of gene resources.

What are the impacts of the state of research on soil biodiversity?

Research on soil biodiversity is essential if we are to understand soil functioning. After all, the ecological functions of soil depend on a healthy and dynamic community of soil biota. The soil contains vast assemblages of organisms responsible for soil functions such as decomposition and recycling of nutrients from dead plant and animal tissues, fixation of nitrogen, maintenance of soil structure, regulation of the quality of air and water, detoxification of pollutants (the soil acts as a sink for pollutants, including global gases), and so on. Biodiversity is without any doubt an important prerequisite for biological activity.

INDICATOR LEVEL: RESPONSES

What are the responses of research on soil biodiversity?

- Minimize, insofar as it is possible, the pressures leading to loss of biodiversity through legislation, education, research, etc.
- It is essential to keep on doing research on the existing gaps and research needs (see below) so that we can use soil biodiversity as a tool to evaluate soil quality, the efficiency of a remediation process, etc., and above all, to understand soil functioning.
- So far, the role of soil biodiversity has not been sufficiently recognized when dealing with biodiversity issues in general, and so it would be important to create a group of European experts on soil biodiversity aimed at improving public awareness and education on the importance of soil biodiversity.
- Create a group of European experts to "translate" scientific terms, concepts, research discoveries, etc. on soil biodiversity to policy-makers, legislators, natural resource managers, environmentalists, and the public in general. This group should help to disseminate the information on soil biodiversity to the different groups of our society.
- Design efficient systems to improve dissemination of research findings to other scientists, policy-makers, legislators, natural resource managers, environmentalists, and the public in general. Among the scientific community, it is becoming more and more evident that all scientific papers should be easily (freely?) available through Internet. It would be useful to create a database with all the publications (papers, proceedings, conferences, courses, webpages, etc.) on biodiversity, and a system to be sure that this database is updated on a regular basis.

ANNEX 2: EXISTING INFORMATION ON SOIL BIODIVERSITY

There has been a great deal of research on soil biodiversity in the last few years, mainly, in relation to the four following topics:

- Development of new techniques to evaluate soil biodiversity.
- Effect of agricultural practices, forestry management practices, pollution, soil amendments, application of sludges, manures and other organic residues, etc. on soil biodiversity.
- Utilization of soil biodiversity as a biological indicator of soil health and to monitor the efficiency of remediation (bioremediation, phytoremediation) processes.
- Relationship between soil biodiversity and ecosystem functioning, as well as other studies on soil microbial ecology such as the relationship between above- and below-ground biodiversity.

ANNEX 3: WHAT EXISTING INFORMATION ON SOIL BIODIVERSITY IS NOT BEING USED AND WHY

Soil biodiversity is a relatively new field of research and we are still far from many of the challenges posed by it. Some of the reasons that explain why current knowledge on soil biodiversity is not being applied are:

- The quantification of soil biodiversity is certainly difficult due to the extremely high complexity of the matrix and the nature of some of its inhabitants.
- The measures of diversity being formulated for microbial communities usually fail to describe their metabolic talents, their ability to respond to environmental determinants, their interactions with one another, or their spatial distributions throughout the soil matrix. We have to admit that most of the research being done on molecular soil microbiology is not yet applicable. In fact, it can be said that soil microbial ecology is still in its infancy.
- The complexity of soil biodiversity implies that time and money are major impediments for thorough monitoring.

ANNEX 4: EXISTING GAPS WHERE RESEARCH ON SOIL BIODIVERSITY IS NEEDED

Being a relatively new topic of research, it is not surprising that there are still quite large gaps where research is needed. The following points can be equally applied to soil microbes (bacteria, archaea, actinomycetes, fungi, and algae) as well as to soil fauna (earthworms, enchytraeids, mites, springtails, nematodes, protozoa, etc.). Research in the following areas would be desirable:

- Methods to determine structural and functional biodiversity, especially at the microorganism level. Research is needed at the functional (mRNA) and at the protein levels. Research on the development of high throughput techniques such as microarrays based on rRNA gene oligonucleotide probes derived from already existing sequences as well as from soil clone libraries to monitor structural and functional biodiversity. Functional diversity with respect to enzyme activities needs substantial support.
- Relationship between biodiversity (microorganisms, micro- and macrofauna) and soil functioning (including relations between biodiversity and soil and plant health), with special emphasis on functional biodiversity (diversity of soil enzyme activities, diversity of substrate utilization profiles, etc.).
- Effect of land use on soil (structural and functional) biodiversity (including the effect of exogenous OM, GM crops, tillage, remediation processes, integrated and organic farming, etc.).
- Structural and functional biodiversity as a bioindicator of soil quality.
- Relationship between above- and below-ground biodiversity.
- Effect of climate change on soil biodiversity.
- Interaction between biodiversity and site x soil use constellations, as well as interaction between biodiversity and managements techniques at different site x soil-use constellations (*e.g.*, organic farming).
- Biodiversity and pollution. Biodiversity and soil compaction.
- Defining scale at which the evaluation of soil biodiversity is to be undertaken.
- Studies on soil biodiversity related to the different foci of activity (rhizosphere, detritusphere, drilosphere, etc.) in soils. In addition, typically, soils are also largely stratified habitats, with distinct horizons, each of them may be regarded as a separate entity. How to incorporate the diversity of these soil microhabitats in a general soil diversity concept is not known, and models are needed.
- Understand the non-linear decline in species richness that accompanies habitat loss. There is evidence that the decline in species richness that accompanies habitat loss is a non-linear process, with species

extinctions becoming more and more frequent as habitat continues to disappear, but this type of research, to our knowledge, has not been done yet for the soil environment.

- Define key and indicator species.
- Biodiversity and the capacity of soil to suppress soil-borne plant diseases.
- Biodiversity of arbuscular mycorrhizal fungi.
- Understand the evolutionary role of the genetic reservoir we find in soils.

RESEARCH, SEALING AND CROSS-CUTTING ISSUES

Task Group 4 on SALINIZATION

Francesco Bellino, Gyorgy Varallay

Salinisation

Salinisation is the process that leads to an excessive increase of soluble salts in the soil solution, if compared with the normal and natural moisture of them.

This process could have natural origins, such as:

- movements of transgression and regressions that in some particular geological conditions bring about an increase of the concentration of salts in groundwater and consequently in soils.
- floods of fluvial waters coming from areas with geological substrates that release high amounts of salts .
- wind activities that, in coastal areas, bring moderate amounts of sodium chloride in soils;
- groundwater seepage in areas laying below sea level.

or it could have anthropic origin, such as:

- use for irrigation of waters rich in salts,
- use of fertilizers and amendments rich in salts, especially in situations of intensive agriculture with low permeability and scarce possibilities of leaching,
- use for irrigation of wastewaters rich in salts,
- pouring into soils of wastewaters, rich in salts.
- contamination of soils with substances rich in salts.

The main cause of salinisation is undoubtedly the use for irrigation of groundwater coming from areas rich in salts (principally sodium chloride). This is due to an excessive and uncontrolled exploitation of deep soil layers mainly in calcaric and dolomitic areas.

The process of salinisation is nearly always accompanied by sodicisation and alkalinity. Sodicisation consists of an excessive increase of sodium, with respect to calcium and magnesium in the exchange complex. Excessive saturation of exchange capacity with sodium, provokes clay deflocculating and consequently destruction of the soil structure which, with low permeability conditions, may become irreversible.

Alkalinity consists in an excessive increase of pH so that to exceed the value of 8,6 (buffer pH of carbonate); in this situation, due to soil structure degradation, most agricultural and forestry plants cannot survive.

Damage caused by salinization to soils and environment

Damage caused by salinisation and sodicisation/alkalisation to soil and environment is of interest both for plant life and the integrity of soils.

High levels of salinity in soils provoke the withering of plants both for the increase of osmotic pressure and for salt toxic effects; when alkalinity processes do take place, pH high levels, in most cases, do not permit life for plants. Damage due to an excess of sodium on the exchange complex, directly concerns the structure of soils, that, deprived of their own structure, do not fit plant growth and are not fit for animal life, as they are asphyctic, easily eroded by water and wind; moreover, salinisation increases impermeability of deep soil layers, does not permit land working activities and, in some particular pedological and geological situations, salinisation may lead to desertification.

Furthermore, it is necessary to take into account all the socio-economical aspects resulting from the impossibility of cultivating these kind of soils and consequently making any profits from them. It must be pointed out that, unfortunately the soils which are mainly concerned with this process, are coastal areas cultivated with precious and profitable crops.

The areas that are mainly interested by the threats of salinisation/sodicisation/alkalisation are mainly coastal areas on those regions characterized by a low annual rainfall rate, concentrated in short periods of time. The problem is much more severe in those areas where intensive cultivation is practiced; therefore, nearly all Mediterranean coastal areas are concerned with this problem the problem is also severe is in the Carpathian Basin (Central Europe) as well as in areas laying below sea level, especially in the Netherlands .

Existing information on soil salinity

On salinisation and sodicisation many studies and researches have been already carried on, principally in those countries that are mainly concerned with these issues, such as the United States, Australia, Israel, Mediterranean regions, the Carpathian Basin and areas laying below sea level, especially in the Netherlands.

Research mainly concerns effects and management of irrigation water, impacts to soils, and the behaviour of agricultural and forestry plants.

On irrigation water studies aim at:

- developing new systems in order to obtain best quality waters;
- finding alternative supplies;
- developing new irrigation system.

On agricultural and forestry plants, studies aim at:

- finding out more sensitive phenological phases;
- selecting and creating new resistant varieties
- developing new cultivation systems that could better tackle the problem.

On soil, research has been aimed at:

- finding out biochemical processes in which salinisation and sodicization are concerned;
- developing new monitoring systems that improve processes assessment;
- finding out new soil conservation practices in order to avoid degradation due to salinisation;
- developing new agricultural techniques in order to reduce the problems related to salinisation and sodicisation.

Furthermore, several projects designed to tackle soil degradation and land management problems have been set up and run. In these projects, usually the above-mentioned issues are faced on a general perspective with a large scale approach, considering wide areas of different countries without analysing specific processes with a soil type related approach.

Which existing information is not being used and why

It is difficult to single out specific studies and research focused on salinisation which results could be used directly by stakeholders (farmers, agricultural expertise, farmers' consultants, local administrations, industries which produce technical equipment for agriculture, etc).

Moreover, it is not easy to determine whether there is actually application of research results once studies have been completed. If it does happen, generally, it takes a long time. Another severe problem is the unfair application of results which, in some cases, causes damage.

Usually, the productive world is eager to find solutions in order to solve the various and ever increasing number of problems related to soil management.

There are several reasons why research results are not quickly applied:

- lack of full awareness and knowledge of soil as a resource;
- lack of systems for knowledge dissemination and for technical assistance to the agricultural sector;
- no link between local administrations and Research Institutes;
- studies and research are not promoted by stakeholders and cannot be directly verified at the moment of their application;
- results of monitoring studies and mapping are at large scale; therefore, data application is not enough soil type oriented;
- financial resources are mainly used for research and not for results dissemination;
- researchers usually do not care about results application once projects have been carried out, in order to correct any possible mistakes and find out any gaps.

There are particular situations in which research is carried on for the development of new agricultural techniques for the mitigation of salinisation related problems, on the basis of initiatives promoted by farmers; this is the reason why often the techniques adopted to face salinisation threat are not taken from far away, but directly developed by simple intuitions of agricultural operators.

Research gaps and needs

Since in a society characterized by fast technological developments a continuous contact and link among departments, institutions and economic operators is needed, it is vital to create a strong link among research, public administrations, technical assistance and decision makers.

There are two main demands about research approach coming from stakeholders, that are:

- the need of stakeholders' involvement throughout the phases of research planning in such a way that research is developed in order to solve the real problems of land and that its results may be soon applicable.

- the need of reliable data about soil salinisation coming from soil monitoring and mapping both from soil and other compartment sides.

Another important item is the lack between expertises and decision makers in contexts where issues on soil salinisation are discussed and debated; people who talk about soil publicly, that is politicians and environmentalists, often do not have competence about that and have very poor knowledge about soils properties and threats.

Final recommendation for research

1. To single out the areas concerned with these problems, collecting and assessing soil monitoring and mapping data and results of research carried on in these areas.

2. To develop research programmes focused on soil types of concerned areas and to build up programmes for detailed monitoring (scale of surveying between 1:50.000 and 1:10.000) specific for the areas concerned with both salinisation and sodicisation, evaluating research applicability on soils and on the different conditions of the singled out areas.

3. To develop a European networking on salinisation and sodicisation to allow an exchange of stakeholders' experience in order to monitor the developing situation, and to build up programmes for detailed monitoring (scale of surveying between 1:50.000 and 1:10.000) specific for the areas concerned with both salinisation and sodicisation..

4. To single out and develop, within the EU soil monitoring network and the EU soil database, all the elements and features concerning salinisation and sodicisation, in order to insert them in every monitoring programme and project regarding salinisation and sodicisation.

5. To develop research programmes focused on crops and forestry plants aiming at evaluating resistance to salinisation and sodicisation in relation to different soil type, climate conditions and water availability, and at selecting and developing, also with the use of genetic engineering, crops and forestry plants with high resistance and adaptability to soils concerned with salinisation and sodicisation;

6. To develop research programmes focused on irrigation waters aiming at finding economical systems to diminish the content of sodium and of salts in irrigation waters, coming from ground waters, and at searching economical systems in order to clear wastewater and re-use them for irrigation purposes.

7. To develop research programmes focused on hydrogeology particularly on deep layers of ground waters employed for irrigation purposes, aiming at identifying sustainable systems for the use of groundwater and at finding new systems of monitoring groundwater conditions.

8. To develop research about land planning that takes into account issues of salinisation and sodicisation in order to avoid cultivation which may render the problems much more severe and to develop dissemination activities to apply techniques resulted from research in the field with the involvement of farmers and technical consulting.

Clustering research needs according to the TWG research agreed scheme

Statements above reported have guided the choice of recommendations for short, medium and long-term research objectives needed to tackle future problems of salinisation and sodicisation.

The areas concerned with the issues of sodicisation and salinisation are generally cultivated with profitable crops; therefore, the process of both sodicisation and of salinisation, hindering a normal cultivation, causes economic damage; Furthermore, generally, farmers of these areas, are technically advanced and are keen to employ new techniques and solutions in order to tackle the problems of both salinisation and of sodicisation.

Therefore, it can be affirmed that the impact of research results on the agricultural sector and the response of society are highly positive, as research results solve both economical and environmental issues.

CLUSTER 1 - Deeper knowledge of processes behind threats to soil
Short term

To single out the areas concerned with these problems, collecting and assessing soil monitoring and mapping data and results of research carried on in these areas.

Long term

To develop research programmes focused on soil types which can be found in areas concerned with these issues aiming at:

- developing irrigation systems which allow the accumulation of salts away from crops and plants and an easy delavation;

- investigating the processes linked to hydrological characteristics of soils.

- identifying techniques in order to reclaim soils rich in salts and sodium;

- developing cultivation techniques which allow the use of soils and water rich in salts and sodium both in agriculture and forestry;

CLUSTER 2 - New and harmonised methods for soil mapping and monitoring
Short term

To evaluate research applicability on soils and on the different conditions of the singled out areas.

To develop a European networking on this issue to allow an exchange of stakeholders' experience in order to monitor the developing situation.

Medium term

To single out and develop, within the EU soil monitoring network and the EU soil database, all the elements and features concerning salinisation and sodicisation, in order to insert them in every monitoring programme and project regarding salinisation and sodicisation.

To build up programmes for detailed monitoring (scale of surveying between 1:50.000 and 1:10.000) specific for the areas concerned with both salinisation and sodicisation.

CLUSTER 3 - Relating threats to pressures; cross linking with EU and other policies
Medium term

To single out and develop research aimed at different soil typologies to solve problems concerning each particular kind of soil, involving in this process farmers, soil consultants and public administrations.

Long term

To develop research programmes focused on crops and forestry plants aiming at:

- evaluating resistance to salinisation and sodicisation in relation to different soil type, climate conditions and water availability, in areas concerned with these issues;

- selecting and developing, also with the use of genetic engineering, crops and forestry plants with high resistance and adaptability to soils concerned with salinisation and sodicisation;

CLUSTER 4 - Analysis of impacts to other compartments
Long term

To develop research programmes focused on irrigation waters aiming at:

- finding economical systems to diminish the content of sodium and of salts in irrigation waters, coming from ground waters;

- searching economical systems in order to clear wastewaters and re-use them for irrigation purposes.

To develop research programmes focused on hydrogeology particularly on deep layers of ground waters employed for irrigation purposes, aiming at:

- identifying sustainable systems for the use of groundwater;

- finding new systems of monitoring groundwater conditions.

CLUSTER 5 - Operational procedures for the mitigation of threats
Short term

To develop dissemination activities to apply techniques resulted from research in the field with the involvement of farmers and technical consulting.

Medium term

To develop reaserch about land planning that takes into account issues of salinisation and sodicisation in order to avoid cultivations which may render the problems much more severe.

RESEARCH, SEALING AND CROSS-CUTTING ISSUES

Task Group 5 on
SEALING SOILS, SOILS IN URBAN AREAS, LAND USE AND LAND USE PLANNING

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Executive summary

The report focuses on soil consumption by Sealing (part I of the report), Urban Soils (part II), Land use and Land use planning. Special contributions from planning and economics are included in the final report. The executive summary will show up the soil – urban environment relationships, land use and land use planning aspects and incomplete the research needs. Details about research contain the report and in addition in compressed forms chapter I – 6 The Main Research Cluster for Sealing, chapter IV on Land use planning and V on Economics.

Soil Sealing is the most visual form of appropriation of land by humans. Most of the natural soil functions are hampered, although not all of them are completely disrupted. Sealed soils raise the question, if we use our land in a sustainable way. Are we currently bringing land use into line with the soil characteristics? One of the major roles of land use planning in the future will be to define best practice models for land use according to the soil characteristics and derived soil functions. The most obvious land use changes appear due to urbanisation processes and the construction of transport infrastructure. In the future rules are needed to bring land use in line with soil characteristics.

In urban areas we have to face two main problems. Urban areas consume soils and soils get a new environment, which changes soil properties. Primary net production is reduced or shifts to new types of soils. **Drivers** are the increase of urban population in the European Union up to 80 % and the kind and intensity of land use in urban agglomerations. In addition there is an inadequate response by land use planning as the common administrative tool to manage such problems.

Soil consumption occurs by sealing and by total erosion due to soil excavation. These processes affect not all parts of landscape equally, e.g. costal and other alluvial plains are preferred.

There are strong **pressures** on soil consumption, which cannot be avoided. These are fundamental socio – economic factors such as the high dependence of gross national income from land consumption. Housing, mobility and communication, supply with goods and services, security, health, traditional construction and urban architecture demand sealing. Land use type and demands of land users will bring some differentiations.

The **impacts** of soil consumption are immense. Some areas lose their soil cover, others get new ones by soil material deposition. Sealing acts as a barrier. The storage capacity of soils for solid material, water and heat is not any more accessible from the surface. Sealing also means dissection of landscape, interruption of horizontal exchange in biosphere, diversion or concentration processes at the edges of sealed areas, floods by inhibition of storm water infiltration, costs for storm water discharge canals, health threats from dust (PM10) due to faster drying on sealed areas.

The documentation of the **state** of soil consumption by excavation and sealing has to regard the areas already affected and the today and potential future trend. Some cities have sealing maps. Statistics about total and daily soil consumption are in part available. There are also some examples for maps of sealing degree and de-sealing potentials of particular soil use types. There is also some recycling and renewed use of before sealed areas. Contributions are also roof top plantings. What is lacking is the understanding of new soil covers and the combination of sealing and underlying soils as one soil. Below sealed areas often a soil exists, and its volume and other properties can be used for many purposes.

Even though there is a strong pressure on soil consumption we are not helpless to respond to this. For the first we need a **European convention on soil consumption restriction**. This will demonstrate that soil consumption is an undesirable process. Decrease of soil consumption can be achieved by technical and socio – economic measures, and can be assisted by fiscal ones.

Drivers for **soils in urban** areas, such as increase of urban population and the nature and intensity of land use act as ecosystem factors leading to new soil properties, which are eco – components for all kind of urban life including habitats. The new soil properties also determine soil functions available in urban areas. The pressures from soils of urban areas beside soil consumption are contamination, change of soils by new man – made materials, layering and mixing of material, strong compaction, reduction of valuable fine earth by accumulation of stones in soils. We know about the occurrence of these pressures, but there are no systematic research findings available beside contamination on brownfields. For the normal living sphere of citizens the information base is meagre. We can say that most of the pressure is a result of improper land use and could be avoided.

The instrument of **land use planning** is used for many purposes of urban area development. What is missing is the systematic use of land use planning for development of soil eco-components and soil functions both in urban as well as in rural environment. Also the response of the environment on land use planning is not carefully analysed.

Research aims and questions to be answered

- Define sealing thresholds and regional differentiated threshold values for sealing. Identify landscape types showing a similar sealing dynamic. Develop best practices in land use management for these landscape types.
- Contributions of soil consumption to socio–economic development. Consequences of different kinds of land uses, transport and housing. Sizes and distribution pattern of land consumption. De-sealing, change to in-part-sealing or permeable covers, quality parameters of sealing, changes of underlying soils, protective functions of sealing cover. Land users' demands and those of town/landscape planning and policy. Relationships to population size, structure, economic development, and working performance.
- The effects of total soil erosion by excavation and construction of new soil covers. Effects on soil water household, ground water renewal, on soil heat storage, climate, health, greenery and urban habitats, and soils as sinks and sources of

pollutants, dust and gases. The socio-economic costs of the direct and indirect effects of soil sealing.

- Data collection, analysis on the regional level, and specification of data. The extend of sealed soils and similar phenomena in nature. The characteristics of excavation, deposition, and sealing as part of urban ecosystems, identification of the socio-economic feed backs.
- The rationales for a convention of soil consumption restrictions. How and to what extend can technical, socio – economic and fiscal measures enable soil consumption reduction, how can sealing effects be diminished, what are the instruments for controlled city growth, soil consumption compensation and substituting measures, what are capacities for de-sealing, reuse of former industrial land?
- Pressures and impacts resulting from new urban soil properties, their relation to land use and possibilities to avoid them.
- Most soils in urban areas are already hit by considerable impacts. Thus, research has to focus on their state, their management and ways to reduce pressure. As contamination is one of the great threats investigation of the basics for soil contamination mapping is an urgent task
- The response of the environment to land use planning. Which sectoral and/or horizontal programmes and legislations affect the environment in general. What are the main driving factors?

Sealing, soils of urban areas, land use and land use planning

This second Interim Report focuses on soil sealing, and soils of urban areas (urban soils). Land use and land use planning will be added in a third draft.

0.1 Introduction

There is an increasing awareness that the soil is fundamental in the preservation of local, regional and world-wide environmental quality. The soil is the interface between different spheres, the biosphere, the atmosphere and the hydrosphere. Being more buffered than air and water, it can act as a sink for contaminants which can reside in the soil or be degraded by its microbial biomass. In broader terms it contributes to water, food, and air quality. Contrary to other natural systems the soil might not always respond to changes in a linear way rather it often has an abrupt reaction once its *carrying capacity* is exceeded. Then, it acts as a source of threats to other ecosystems. It is then of paramount importance to define and control its quality status.

Urban environments are areas where soils interact with human society most intensely. This happens on a continual and dynamic basis. The three-dimensional soil system, as perceived by society, has a fourth dimension - time, less obvious, is nevertheless the most important factor that determines the position of soil in the context of pressures and driving forces due to the functioning of human society. We should not only be fully aware of changes in function and characteristics of soil with time, we should also appreciate the dynamic characteristics of human urban ecology. This challenge is perfectly summed up in the following statement (Pacione, 2003):

"…we must consider both the city on the ground AND the city in the mind."

This approach is derived directly from the social geographical perspective, and a number of recent studies have reviewed the concept of “life quality”, “human environmental quality and well being” (e.g. Pacione, 2003; van Kamp et al, 2003) and “urban ecology” (e.g. Pickette et al, 2001). The context of this for the EU soil protection strategy WG’s, particularly “research” is to identify the linkages between soil consumption and human ecosystem dynamics, building the bridge between description and function from a soil perspective and the progression of society, its governance and politics. This is an ambitious undertaking, but one that can be influenced by the planning system and efforts to “join up” the process within the framework of an integrated ecosystem approach that includes human activities with other environmental variables.

While spatial planning focuses on the segregation of different economic and social functions, efficiency in filling of space, transport and resource issues, adoption of urban ecology in city planning includes life cycle analysis, use rather than medium, resource efficiency and exploitation of green infrastructure.

Many authors have highlighted the need for a better understanding of urban soils with special attention to the lack of information that is needed for soil management. There is also a need to adapt current methods for studying and classifying soils in urban settings and the necessity for an integrated urban ecosystem research that encompasses all ecosystem elements.

There are many models for the complex interrelationships between the components of human society and natural resources. The role of soil in these models needs to be amplified. Two perspectives are presented in Figures 1 and 2. Numerous others exist in literature. Figure 1 shows an integrating framework for “human ecosystems”, balancing resource-based action with social systems (Pickett et al, 2003). In Figure 2 the concept of “quality of Life” is presented from the diverse components considered to contribute to this fluid indicator (van Kamp et al, 2003). The position of “soil” as a primary contributor has been identified

It has recently been suggested that to achieve “joined up working” in urban management (Brown, 2003) the planners require environmental specialists to

- Understand urban policy and urban development processes and the decision-making context.
- Understand the language, tools and way of thinking,
- Adopt approaches to provide environmental quality information that assists development players to propose and test scenarios that allow novel action to shift urban development in preferred directions.

Clearly there is a dialogue issue that if addressed may provide the route to more effective use of resources in cities.

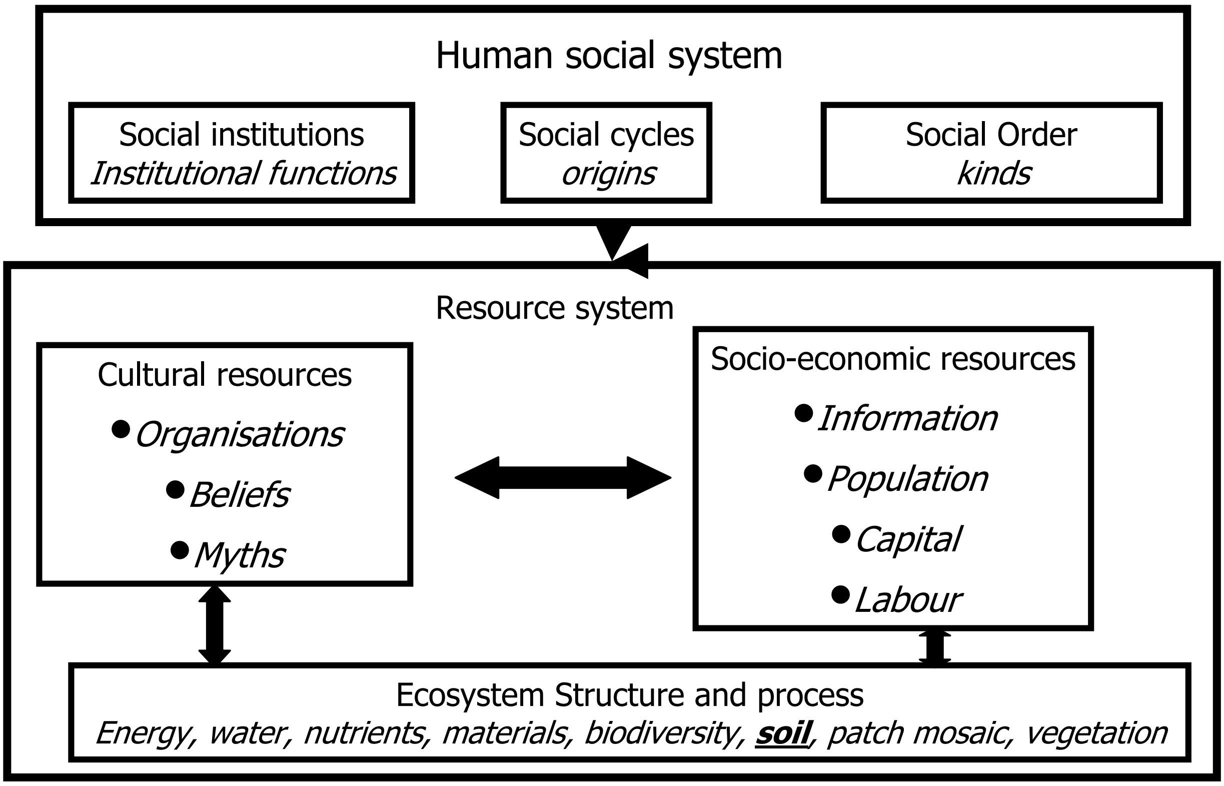

Figure 1: Human ecosystem framework (Pickett et al, 2003)

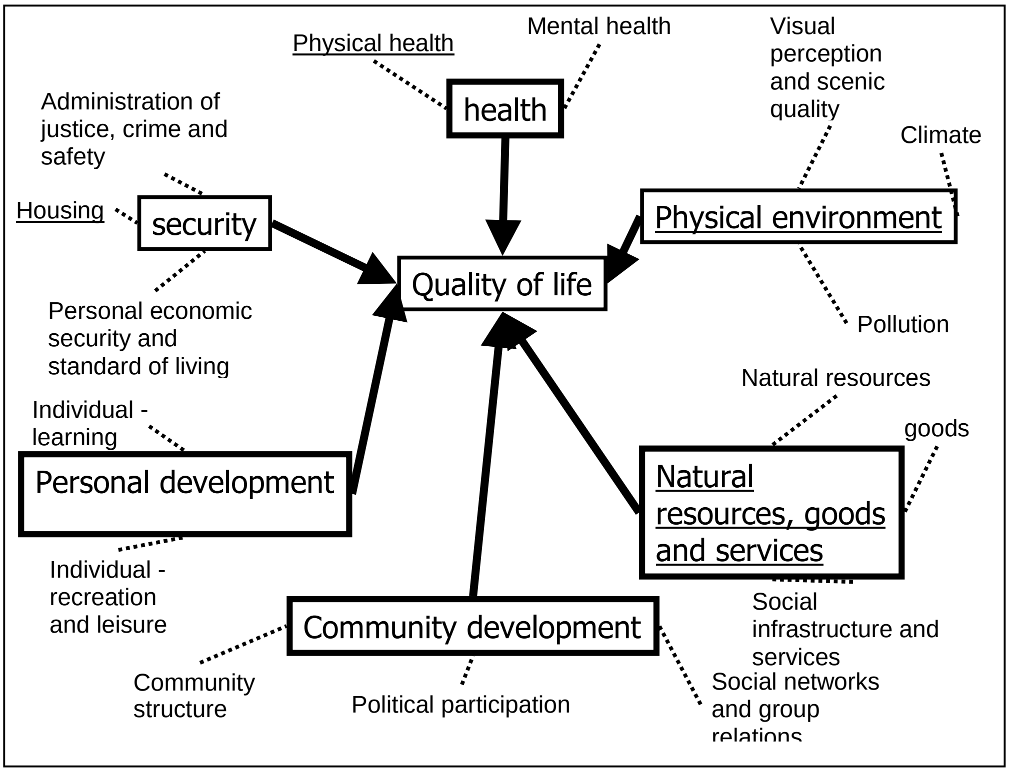

Figure 2: Urban quality of life framework (van Kamp et al, 2003).

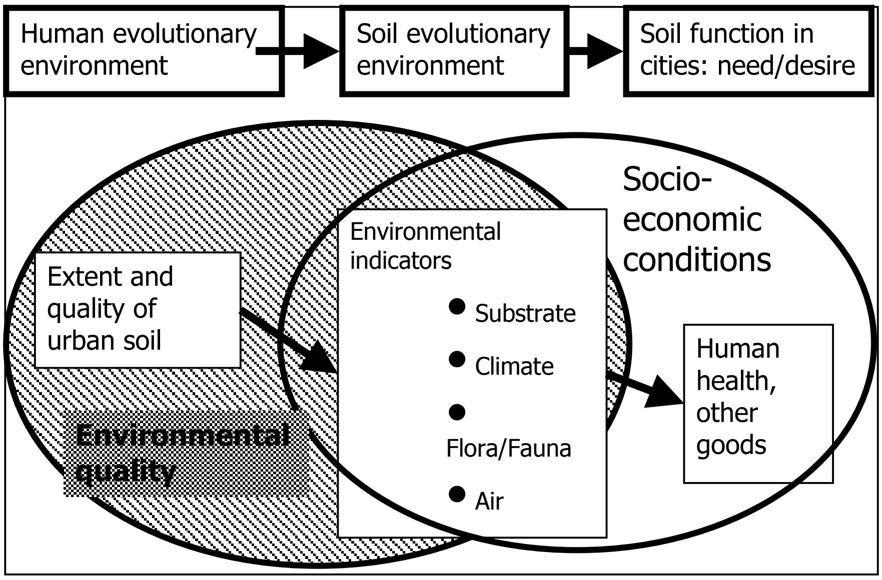

Figure 3: Chain of human evolutionary to soil evolutionary environment and soil function

Whilst the investigation of the interplay of soil between the components of these models is an important aim for future soil protection policy, Figure 3, from discussions of the sub group on soil sealing, urban soil, land use and planning, attempts to present a system-based context for soil function and corresponding characteristics.

0.2 Definitions

For "soils of urban areas" and "sealing" the definitions are as following. They will be not final but describe the authors' intentions.

Soils of urban areas (Urban Soils)

Compared to other areas soils of urban areas have specific benefits and dis-benefits for quality of live spectra such as health, social, economical, technical and environmental qualities. Soils of Urban Areas are soils, which occur within the boundary of an urban community. They include natural, man – modified and man – made soils.

Man – modified and man – made soils occur also outside of urban communities.

Sealing

There are hardly any internationally recognised definitions of soil sealing. Soil Sealing can be defined in a very general way, using a systems approach:

Soil sealing is the separation of soils from other compartments of the ecosystem, such as biosphere, atmosphere, hydrosphere, anthroposphere and other parts of pedosphere by layers and other bodies of completely or partly impermeable material. Alternative definitions are given in the annex, table A0.1(S).

Table 0.1: Types of sealing according to the system approach of separating soils from other

soil compartments and other spheres

1. horizontal barriers a. on the surface b. subsurface c. subsoil d. underground	1. vertical barriers a. walls b. drainages

Part I : SOIL SEALING

1. Drivers

<u>General remarks:</u>

Soil sealing has the greatest impacts in urban and metropolitan areas where large portions of the land are covered with constructions. The development of transport infrastructures is another important cause. Built-up land is lost for other uses such as agriculture and forestry, and the ecological functions of soil, such as storage of carbon and habitat for unique biota, are limited or impeded. In addition to the direct effects on the sealed surface itself the indirect impacts affect large areas due to fragmentation of habitats and disruption of ecological corridors. Moreover, water runoff may increase, resulting in a higher risk of floods.

Land consumption, built-up areas and soil sealing

Soil Sealing has to be regarded as dynamic process within the activities of human beings. Every human activity alters the nature and processes at a specific location. Soil sealing can be regarded as the last step within the consumption of land for human usage. Human use of land alters the properties of a single land parcel from natural conditions to completely man-made conditions. Using the concept of appropriation of net primary production (NPP) one can distinguish various steps as table A1 and A 1.1.3 (both in the annex) show.

Sealing is part of land uses. Figure A1.1 (annex) shows this in a context of land consumption.

1.1 Types of sealing

Sealing in the context of this report is seen in the frame of a strong anthropogenic approach. Typical types of human induced soil sealing are shown in table 1.1.1 .

But beside the sealing due to urban and transport infrastructure development various types of soil sealing exist, which can also be of natural origin such as soil crusts, rocks, compacted subsoil horizons. Table A1.1.2 in the annex gives some examples.

Table 1.1.1: Examples of types of human induced soil sealing

Types of sealing	
buildings without cellar	supply lines (gas, water)
buildings with cellar	tunnels
streets	underground
airports, runways	barrier layer of landfills
greenhouses	barrier layer of contaminated lands
plastic covers (greenhouses), vegetable farms	soil cover of concrete etc. for erosion protection
stone plates of burial grounds	coffin layer of burial grounds

1.2 Preferably sealed areas

Preferably settled areas are usually situated at traffic routes or at the border of different landscape types, trying to have an access to water. Some city agglomerations are founded by mineral resources. Plains are favourite settlement areas, especially with young, fertile soils. They are easy to develop. So, coastal areas, river valleys and alluvial plains are mainly populated. An important point is that the climatic conditions are usually favourable near water bodies (oceans, lakes, rivers).

1.3 Soils of preferred landscape for peculiar needs of soil use

The soils of the preferred landscapes are often the fertile loess and alluvial soils. These are the best agricultural sites but even these soils will be sealed by buildings, highways, airports, railways and constructions for leisure activities. For airports and railways the plain areas are inalienable, for highways and also building areas they are - on the first view - cost-cutting.

1.4 Landscape dimension of sealing

Climatic conditions in combination with geomorphologic constraints determine the areas where sealing for human purposes can occur. These areas typically include coastal strips, flat plains, valley bottoms and similar areas. Concerning a landscape-ecological approach various dynamics of soil sealing can be defined within each of these typical landscapes. Therefore thresholds for soil sealing will vary from one landscape type to another. In alpine valleys for example the potential habitable area is a major constraint in limiting the potential area to be sealed.

Questions:

- How can we define regional thresholds for soil sealing?
- Can regional thresholds be linked to a systematic landscape approach (e.g. differentiation of various landscape types according to a harmonised nomenclature)
- Can we define landscape types showing a similar sealing dynamic?
- Are best practices available for these landscape types?

2. PRESSURE

2. 1 Classification of sealing degree

The pressure by the degree of sealing can be described by existing classification systems. Examples of these systems contains the annex A2.1 and A2.1.1.

Question:

- clear definition of sealing degree

2.2 Socio-economic importance of sealing

We can simply make the statement that most of our modern social and economic activities depend on the construction, maintenance and existence of sealed areas. This concerns housing, transport, industrial production, trade, administration, health care. Most of our gross product is related to sealed areas or construction of sealed areas. On the other hand socio – economic policy can have tremendous pressure on sealing. Examples are the tax allowances for the distance between living place and working place. Table A2.2.1 in the annex gives a general overview about which socio – economic fields are concerned.

Question:

- Contributions to socio - economic development by sealing and alternatives?

2.3 Dependence of sealing from land use type

Soil use changes soils. This happens also by sealing. The individual soil use type will generate particular soil sealing characteristics. Relationships of soil use types and sealing degree are already established. They are used for surveying of sealing degree by aerial photos.

Table A2.3.1 and A2.3.2 in the annex shows an example for this. At least in Germany maps of sealing degree are available for many cities.

Question:

- Knowledge about city maps on sealing and method to establish maps.

- Relationships of types of land use to sealing degree.

There is only little knowledge about other kinds of pressure from sealing characteristics, such as sizes of sealed areas, type of sealing, de-sealing potential on soils. Table A2.3.3 in the annex gives some examples.

Questions:

- Contribution of different kinds of land use to sealing.
- Size of sealed areas.
- Area and distribution pattern of different types of sealing
- What are the quality parameters of sealing?
- Change of underlying soils by sealing.
- Protective functions of sealing cover
- Real need of sealing.
- Options of change from sealing to in - part sealing and more permeable sealing layers.
- De - sealing potential of different land uses.

2.4 Land user demand for sealing

Numerous types of land uses will be improved by sealing. Therefore there is often a strong demand of land users to seal soils. This means that the development of land use by diverse measures will follow the demand of the land users for proper sealing which will increase pressures on soils and soil consumption. Table A2.4.1 in the annex gives an overview of ways of pressure by land user demands.

Questions:

- Degree and performance of sealing due to land user demands.
- Degree and performance of sealing due to planning and policy demands.
- Relationship of sealing to population size and structure, economic development.
- Request for sealing by site maintenance and re-construction.

3. IMPACT

3.1 Effects of sealing on environment

3.1.1 Effects on mass-, element-, and energy flows

Sealing interrupts the contact between pedosphere and atmosphere and thus changes the gas fluxes. Also rain water cannot directly infiltrate into the soil below the sealing cover. Its flow direction is changed. It may either infiltrate beside the sealed area (small roads) or be lead into pipelines. Along with the water flow go the fluxes of gas, dust and sediment particles, elements, and energy. Thus, these fluxes are changed in the same way as the water flow in the way of:

- separation of pedosphere (soil) and biosphere, atmosphere, hydrosphere by horizontal
- barriers
- interruption within spheres by vertical barriers
- diversion (by passing), canalisation, concentration, redirection, discharge and deposition .

Questions:

- How does sealing effect the mass-, element- and energy flow in rural areas and in the city?

3.1.2 Effects on the hydrosphere

In sealed areas, rain water cannot directly infiltrate into the soil below the sealing layer. It either infiltrates beside the sealed area (e. g. in the case of small roads) or is discharged by drainage ditched and drainage pipes (e. g. large roads, parking lots, buildings). Complete sealing generally reduces water infiltration, evapo-transpiration from soils and plants, and thus soil humidity above and below the sealing cover. Sealed soils do not act as water storage bodies any more. If the rain water is not allowed to infiltrate beside the sealed area, ground water recharge decreases.

On the other hand, increase of water amounts at the edges of sealed areas will favour the break through of surface water to ground water. The possibilities of groundwater pollution increases (table annex A3.1.2.1).

Question:

- What are the effects of sealing on soil water household?

3.1.3 Effects on the micro- and meso - climate

Sealing changes the albedo and evaporation of a location. These changes result in a temperature rise above the sealed area (micro scale) and within the cities (meso scale).

Question:

- Reduction of the role of soils as climatic factor by sealing.

3.1.4 Effects on the biosphere

Sealed areas are life hostile places. They do not allow the establishment of plant communities and accompanying fauna. Furthermore, they dissect ecosystems and habitats of plants and animals. If the resulting fragments get too small, either with regard to the space required by certain species or in terms of sufficient genetical exchange, biodiversity decreases in these areas.

Development of biosphere

- o life hostile site features of sealed areas
- o interruption and isolation of habitats by sealed areas, cutting effect.

Question:

- What is the effect of sealing on the abundance of species.

3.1.5 Relief and chemical properties of sealing and sealing material.

The natural relief is changed by the shape of the construction (e. g. flattened by the establishment of a parking lot or an airport / steepened by buildings). The building material (natural stones, concrete, bitumen, tar) may chemically influence the adjacent and underlying soils. More examples are given in annex table A3.1.5.1(S).

Question:

- What is the quantity and quality of contributions from construction on sealing?

3.1.6 Effects on the landscape

Sealed areas, depending on their measures in each dimension, may act as barrier for surface water, perched slope water and ground water. These water flows may be hold up or redirected by the sealing. They may also be lead into a pipeline system. The barrier effect of the sealing may lead to a concentration of water in and on the adjacent unsealed soils, leading to stimulation of erosion in the surrounding of the sealed area.

Landscape development will be affected by

- stimulation of erosion by soil flush from sites adjacent to sealed ones
- interruption of flow, diversion and discharge of surface water, perched slope water and ground water
- change and put out of functions of catchments.

Question:

- In which way is the water catchment changed by sealing?

3.1.7 Effects on life quality

Sealing has a similar effect as drainage. It keeps our immediate urban environment dry. On the other hand an increase of sealed areas generally results in a decrease of life quality, because it goes along with a decrease of green space and usually also with an increase of noise and emissions (e. g. from traffic). The effects of sealing on the water dynamics (4.1.1) influence life quality, too, because soils below sealing layers cannot store rain water any more. Therefore, the water reaches the rivers faster than under natural conditions. Thus, the likelihood of catastrophic flooding events is increased.

Question:

- Pro and contra of contribution of sealing to life quality.

3.2 Effects related to establishment, use, maintenance and demolition of sealing construction

3.2.1 Effects of the establishment of the construction

The construction works usually start with levelling or digging in order to establish a base for the construction. Thus, in some places the soil is (in part or completely) removed, while in other places it is covered by natural or artificial material. The effect is that of total soil erosion. Sand, gravel, ballast, and man made material are brought in as a base of the construction. Also contaminated material may be used. This base is compacted for reasons of stabilization. This also leads to compaction of the underlying soil. The use of heavy machines also results in compaction of the adjacent soils.

3.2.2 Effects of the use of the construction

During use of the construction emissions (e. g. from vehicles or domestic heating) are released. The use may also lead to further compaction due to driving and footstep effects.

3.2.3 Effects of the maintenance of the construction

Maintenance of constructions includes drainage to protect the construction from disintegration due to moisture. Pesticides may be used to keep plants away from drainage systems. Roads generally include the use of de - icing salts and granulates. Weathering of paints on walls release chemical compounds to soils.

3.2.4 Effects of the demolition of the construction

The demolition of constructions may be accompanied by partial or complete de - sealing. However, parts (e. g. of the basements of buildings) may be left, so that no complete de - sealing is achieved. The building rubble is levelled, used as landfill or taken to a dumpsite.

Question:

- Kinds and assessment of accompanying effects of sealing.

4. STATE

We have to take notice that sealed layers at least in part are accepted as part of the urban soil system. But we have also to regard sealing as part of urban ecosystem and socio-economic system. The state of sealing should describe this context.

4.1 Definitions of sealing areas as soils

By the definition of soils by some soil classification regulations also sealed areas are soils. Annex table 4.1 contains some examples of soils distinguished in urban areas. Protosyrozems are soils in an initial soil development stage on sealing covers. Lichens are found on them. Dialeimmasols are interval soils in the gaps of pavement stones. Ekranolith are soils of solid sealing layers such as streets. Stagnic Ecranozems are Ekranozems with a perched water table.

Question:

- To what extend match sealed soils and similar phenomena in natural soils and what are the differences?

4.2 Sealing as part of urban ecosystem

We need a knowledge base on

- distribution between natural and highly artificial zones – central business district, old versus new zones, urban construction zones, urban fringe, rural
- cultural history, a - biotic and biotic features of zones
- land use function in terms of engineering stability.

Question:

- Characterization of sealing as part of urban ecosystem.

4.3 Sealing as part of urban socio-economic system

Knowledge should be available on

- residential, commercial, leisure, communication, economic development, undeveloped, maintenance and construction
- re-use versus new development
- socio - economic feed back.

Questions:

Characterization of sealing as part of urban socio - economic system.
- Soil sealing as link between urban socio - economic system and urban ecosystem.

4.4 Amount and soil quality of sealed area due to land use sub - indicators

Amount and soil quality of sealed areas are of interest at different scales. Therefore they should be investigated on city level, on district level and on regional level. Examples of current assessments are found in Indicator TELC03 (EEA: http://eea.eionet.eu.int:8980/Public/irc/eionet-circle/core_set/library?l=/material2/facts&vm=detailed&sb=Title)

4.4.1 Assessment

Over the past 20 years built-up area has been steadily increasing all over Europe. Most dramatic changes occurred in Western Europe countries, where area of built-up land is increasing at a faster rate than the population (EEA, 2002). This decoupled growth rates origin in steadily increase of number of households and average residential space per capita since 1980, a trend that speeded since 1990 (EEA, 2001a). At the same time travelling distances to services increased at expenses of private transport (EEA, 2001b). As a result the demand for building land and better infrastructures continues to rise. In addition, increasing prosperity increased the demand for second homes. Denmark, Belgium and Netherlands are the countries with the highest share of built-up areas (between 16 and 20% of the land area). The new built-up areas have been at expenses of agricultural land in most cases, and forests to a lesser extent (EEA, 1999; EEA-UNEP, 2000). In the Mediterranean countries, as a consequence of increasing pressure of tourism, urbanization has been growing in the coastal zones (EEA-UNEP, 2000, see also Integrated Coastal Zones Management fact sheet).

Built-up area in Accession countries was more or less stabilized during the end of 70's and the first half of 80's. Political and economic changes occurred in late 80's resulted in development of new infrastructures, migration of rural population to the cities and development of new settlements (Baltic Environmental Forum, 2001). Hungary and Czech Republic are the Accession countries with the highest percentage of built-up area (about 10%). Pressure is also increasing in some coastal zones, like in the Baltic coast of Latvia.

Soil sealing is still a minor problem in NIS countries compared to other soil degradation process, like erosion, salinity and contamination. However, built-up areas increased at a rate close to the EU during early 90's. This pressure is located around industrial areas, cities, rural settlements and tourism in the coast of the Black Sea (UNECE, 1999).

A report about meta data is included in the annex A4.4.(S).

4.4.2 Quality information

1. Strength and weakness (at data level):

Due to the lack of precise information built-up area has been used as a proxy of the amount of soil being sealed and quantifying land-take by urban expansion. For example in Germany it is estimated that 52.2% of the soil in built-up areas is actually sealed. However, the indicator gives a broad idea of the extension of the problem, because non-sealed area is also affected in different ways. Another weak point is that there are different ways of defining and computing built-up areas (for example the area covered by transport infrastructure may be estimated from total length of highways or railroads and an area factor applied). Hence, the indicator should be considered as an early warning. Harmonization of this information at country level is needed.

2. Reliability, accuracy, robustness, uncertainty (at data level):
   Data quality is quite different among countries. The main issue is to know the methodology for data collection and the precise definition of built-up area. Information are not always available.
3. Overall scoring (give 1 to 3 points: 1=no major problems. 3=major reservations):
   Relevancy: 1 Comparability over time: 2
   Accuracy: 2.5 Comparability over space: 2

Question:

- Data collection and analysis at national level. Better specification of data.

5. RESPONSE

5.1 Convention on soil consumption restriction

City growth is accompanied by sealing. This means that control and decrease of city growth will also reduce the growth of sealed areas. To express the political will for this urgent target an international convention on soil consumption restriction of cities should be achieved. This should be performed at least on the area of the European Union or even better for all cities world wide.

Questions:

- Prepare the rationales for a convention of soil consumption restrictions.

5.2 Controlled city growth

Most cities are expanding in the direction of the most fertile soils. This means that the cities are not only consuming soils. They are consuming and sealing the best soils in their neighbourhood. This is not acceptable. City growth should be controlled that way that only soils of lowest fertility of the region are used for expansion of the city. For that purpose soils must be surveyed and their quality assessed.

Questions:

- Assessment methods for soils to achieve controlled city growth.

5.3 Measures of sealing restriction

5.3.1 Technical measures

The amount of sealed area could be restricted by constructing buildings like large factory halls and warehouses no longer as one-storey buildings which consume large areas, but as taller buildings with smaller base. This would require a change of production lines and storage from horizontal to vertical arrangement. Buildings for certain purposes (car parking, production and trade) could also be located below ground, as techniques to get fresh air and daylight in (by glass fibres) are available, today.

Some of the soil functions lost by sealing could be retrieved by establishment of a new soil layer on building roofs. Another solution to reduce sealing could be the construction of buildings on pillars. Movable lightweight constructions (Frei OTTO) and easily removable prefabs (Walking City, Todd DALLAND) already exist or are as visions presented. Surface or underground connections by horizontal lifts, treadmills and conveyors will reduce sealed areas. Advancing e-commerce can reduce traffic and thus road extension. The same effect can be achieved by reduction of unnecessary long distance transports of goods. Introduction of pipe transport systems for goods similar as pneumatic delivery will be another most effective and realistic future contributions. Table A5.3.1(S) in the annex gives an overview on this.

5.3.2 Fiscal measures

Sealing should entail payment for lost natural resources. The originator of the sealing should be committed to either re-establish the original (soil) state before sealing or to pay for the re-establishment. He should also pay the social costs (loss of life quality for residents) and health costs of sealing (if the sealing results in increased noise, emission of dust, toxic substances etc.). In table A5.3.2(S) in the annex examples are listed.

5.3.3 Measures with social impact

The present trend of increase of living space per person has to be stopped and reversed. Sealing can be reduced, if the use of buildings is organized in a more efficient way, e.g. by using parking lots by trade during the day and by adjacent residents during the night, and by using office buildings by two shifts per day.

Question:

- To what extend can technical and fiscal measures contribute to sealing reduction.

- What visions are suitable to establish a sealing reduced city.

5.4 Measures of diminishing sealing effects

The growth of trees in total sealed areas indicates that the tree are rooting underneath the sealing layers. The biological activity of soils below sealing layer could be increased by allowing tree root growth. This requires a construction which prevents destruction of the sealing by roots. Furthermore, the soils below sealing layers could recover their ability to store water, if the rain water from the surface of the sealing layer was distributed in the soils by subsoil irrigation systems.

Questions:

- What can the soils under sealed areas contribute to the sustainability of the city.

5.5 Roof top planting

Artificial thin soil covers can be established on roofs. By this way roof top plantings are a measure of reduction of sealing effects.

Questions:

- What can soils of roof top plantings contribute to the sustainability of the city.

5.6 Soil compensation and substituting measures

In some countries there is already an instrument of compensation and substituting of biotopes which are consumed by urban development. Similar is necessary for the consumption of soils. In the same way as biotopes also pedotopes (soil areas) should be defined and used for compensation and substituting measures of sealed soils.

Questions:

- Criteria and assessment methods for the performance of compensation and substituting measures.
- Define soil areas as pedotopes, analog to biotopes.

5.7 Planning effect on sealing

Sealed areas are items of planning measures. Often city planners design particular city views by sealing large areas to give cities the special sphere of urbanity. This is part of their art as designers. That means sealed areas have not a practical necessity for the use of the site but an aesthetic one.

On the other hand high skilled planning will be able to minimize sealing and will choose sealing types with low negative effects. The demand of low sealing and low effect sealing should be part of any new established plan. City extension plans and construction plans for any site in or at the fringe of the city, should be assessed for its effect on sealing. Annex table A5.7(S) gives an overview of planning effects on sealing. This does not mean that city planners should neglect aesthetic aims. Alternatives should be developed.

Questions:

- Reasons of planning for sealing.
- Contribution of planning to an acceptable soil sealing.

5.8 Planning measures

To achieve sealing reduction there are a larger number of planning helps available such as efficiencies of resources use, life cycle analysis of constructions, exploitation of green infrastructure. Annex - table A5.8(S) contains a list of some more.

Question:

- Improvement of diverse planning criteria to reduce sealing and increase sealing quality.

5.9 De – sealing

The process of de-sealing uses mostly technical (active), seldom natural (passive) or combination of both methods. Technical de-sealing means the active demolition by man or machine with the aim that the former sealed area can fulfil a part of the natural soil functions again. In some cases the sealing has preserved the underlying soil and these soils were protected against contamination and may have a good soil quality.

In case of the natural de-sealing or de-sealing by natural attenuation of sealing, the areas are to leave to their natural succession.

Both methods have pros and cons. So, for example the pros of the technical de-sealing are in its velocity and potential hazardous material will be removed, jobs will be created. The cons of the active de-sealing are high cost, a high energy input, dust- and gas emissions, contamination and the former sealing material must be prepared or deposited.

The advantages of the natural de-sealing are low costs. In contrast to the active de-sealing it does not take effects as a catastrophic (lethal) intervention for a lot of yet settled organisms. The ecosystem changes slowly and often has a high biological potential. For example, ruins are a life habitat for a lot of birds, bats, other animals and plants. A disadvantage is, that potential hazardous material may stay at the location.

The velocity of the natural de-sealing requires monitoring. It will differ in dependence of climate, construction materials and their condition and the geo - potential of the surroundings.

In many cases a combination of active and passive methods might be the best way for de-sealing. But first, the pros and cons of the different de-sealing possibilities are to be exactly investigated.

Annex table A5.9(S) shows some aspects of de – sealing.

6 THE MAIN SOIL RESEARCH CLUSTERS FOR SEALING

(and urban, industrial, traffic area soils)
– 1 to 3 to 5 to 10 years project

Summary of Research Questions with Highest Priority

- *Establish methods to assess how much sealing is necessary and bearable under a given economic development and area limitation due to mountainous topography, rivers, coastal plains and others (I),*
- *Investigate the numerous effects and threats from sealing on soil qualities and soil functions, to health, human environment and nature, to quantify them and establish assessment procedures (I),*
- *Establish monitoring and assessment methods for sealing which include the original and today quality, occurrence and rarity of soils, and sensitivity of soils to sealing (I).*
- *Developing methods how to monitor soil use, socio – economic, technical and planning parameters, and population development, and their importance for sealed areas (I),*
- *Establish a convention on the restriction of soil consumption and possible effects on soil protection at a local, regional and in the European Union level (I),*
- *Assess the benefits and negative impacts of land use planning on sealing (I).*
- *Develop legal instruments such as economic, technical, fiscal and planning instruments needed to reduce sealing and sealing effects (I),*

Signature: (I) – highest priority in research.

The following chapter contains an overview of a more complete long term research plan. It is structured by 5 clusters.

Cluster 1: Analysis of threats of sealing to soils and the interdependency to other threats
(erosion, organic matter, contamination, compaction, salinisation, floods and land slides)

Sealing consumes soils and soil functions. It is perhaps the today biggest threat to soils. Sealing means either loss of access to soils or in case sealing occurs together with excavation total loss of soils.

Sealing occurs in different quantities and qualities. We have to distinguish

- Area quantity and quality parameters such as different percentage of sealing of an area, different sizes of sealed areas, different pattern and spaces between sealed areas,
- Sealing layer quality, such as total, in part and subsoil sealing,
- The soil volume under a sealed area will be often existing and can be used, that means not all soil functions must be out of action.
- Neighbouring spatial influence of sealed areas

Research question would be to

- *Establish methods to assess how much sealing is necessary and bearable under a given economic development and area limitation due to mountainous topography, rivers, coastal plains and others (I),*
- Establish methods to survey sealing in respect of area quality and quantity parameter (linkage to ongoing GMES-projects),
- Analyse ways of flexible use and intercourse with sealed areas
- Establish a harmonised nomenclature for the terms sealing, land consumption, soil consumption that can be applied to compare data between countries.

Sealing is the source for a number of cross cutting threats. The quantity and quality parameter of sealed area must be linked to the role of sealing in stimulating and prevention of wind and water erosion and land slides, of organic matter production, conservation and decay, sealed areas as sources for contamination, floods by inhibition of water infiltration, decrease of ground water renewal, polluted water break through to ground water, dissection of habitats leading to biodiversity losses and water catchment areas. Threats from sealing are also health and wellness parameters such as climate, urban overheating, concentration of noxious compounds, gases, dust, fine-dust (PM10, PM 2.5). We have also to suggest sealing in relation to social and ecological problems due to worsen living conditions and decrease of habitat quality. There will be perhaps more threats, which are not clear seen today. Threats from sealing should be part of a 3 to 5 years study which should be linked to urban soils and the dissection effects in rural areas.

Research questions would be to

- *Investigate the numerous effects and threats from sealing on soil qualities and soil functions, to health, human environment and nature, to quantify them and establish assessment procedures (I),*
- Investigate the indirect effects of soil sealing with special focus on the fragmentation of habitats
- Investigate the threats to social and ecological fields.

Sealing can have benefits, such as water conservation or protection against contamination. Other benefits are socioeconomic ones.

Research questions would be

- To investigate the benefits for soil and nature and develop assessment methods,
- To investigate the economic benefits and develop assessment methods

Cluster 2: Development and harmonisation for the analysis of the state (S) of the threat of sealing to soils and their change with time, soil monitoring in EUROPE

For the survey of sealing degree are already several methods available or currently under development (see GMES-activities and urban soil maps). For quality parameters they are not existing. Threats from sealing are in some few examples studied such as flood stimulation, ground water renewal and dissection of habitats by sealing. Most of this can be developed in a 3 to 5 years comprehensive project of sealing and urban soils where pilot survey projects would play a major role.

Research questions would be

- Developing sealing survey and monitoring methods,

- Prove of the existing methods of examination of sealing degree and developing a standard sealing degree assessment procedure,
- Develop a standard sealing quality assessment methods under the inclusion of regional demands and specifications such as differences in nature,
- To perform pilot project of sealing survey, monitoring and assessment , and attach the other research questions to them as appropriate.

The effect of sealing is dependent from the unsealed and sealed soils of the area. Sealing is dominant in urban, suburban, industrial, traffic areas as well as in areas, where the potential living space is reduced to a small percentage due to topographic reasons (e.g. and alpine valleys). That means we have to investigate together with sealing soils and soil forming substrates of those areas. For some urban areas already urban soil survey (in Germany for about 20 cities in total or in part) had been performed. Countrywide surveys are being carried out mainly for agricultural areas.

Research questions would be

- Establish methods for soil and soil substrate survey and monitoring in the dominant areas,
- Perform pilot projects for surveying urban, suburban, industrial, traffic areas as well as in areas, where the potential living space is reduced to a small percentage due to topographic reasons.

Soils are struck in different degrees by sealing. This can concern the size of area hit by sealing but also the decrease of individual and particular functions. Soils vary in their regional quality and importance of quality. There will be also large regional differences.

Research question would be

- *To establish monitoring and assessment methods for sealing which include the original and today quality, occurrence and rarity of soils, and sensitivity of soils to sealing (I).*

Sealing is linked to socio – economic development. Therefore it will change by a high temporal and spatial dynamic.

Research question would be

- To develop criteria for the determination of intervals of sealing and hot spot soil monitoring.

Sealing is depending from soil use, socio-economy, land use planning and population dynamic. Monitoring of sealing should include this.

Research question would be

- *Developing methods how to monitor soil use, socio – economic and planning parameters, and population development, and their importance for sealed areas (I),*
- Influence of LU-planning on the type of soil (greenfields, brownfields) being consumed.
- Changing economic value of soil according to the determination of land use in land registries
- integration of non-economic values for the assessment of the value of sealed soils

Cluster 3: Relating of sealing to driving forces (D) and pressures (P), cross linking with EU and other policies

Most economic and social activity demands sealing. That means the living standards but also parts of quality of live such as communication and contact is linked to sealing in Europe. Due to the cross cutting character of driving forces and pressures research should be linked to the 3 to 5 years basic clusters 1 and 2.

Research questions would be

- What are the socio – economic needs for sealing,
- Who are the land user, owner and planner and what are their demands and the demands of land use types for sealing.

For the quality of life of population a certain amount and structure of unsealed areas and local soil functions must be available. There is nothing known about this.

Research question would be

- What should be the amount and pattern, and quality of soils in areas which have a high sealing degree.

European projects with some relationships to sealing are ESPON (European spatial planning observatory network), TEN, structural funds, CAP.

Research questions would be

- Lessons learnt from the implementation of the ESPON (European spatial planning observatory network) project and integration of land consumption in the analysis of the effects of territorial policies like TEN, structural funds, CAP.

Cluster 4: Analysis of the impacts (I) of sealing, relating it to soil deliverables into other environmental compartments: air, water, biomass production, human health, biodiversity

Sealing means soil consumption or at least reduced access to soils and their functions. This has local, regional and global effects on geosphere, hydrosphere, biosphere and atmosphere. That means sealing measures must be not only evaluated on the effects and responsibility for them on the plot level. They have to be evaluated in different scales. This can be started by a sealing project. But the research will perhaps take longer than 5 years to come to a broad knowledge and information base.

Research questions would be

- To investigate how does sealing effect the mass-, element- and energy flow in urban, suburban and rural areas,
- To analyse kind and degree of impacts from sealing on local, landscape and global level in relation to sealing degree and quality parameters of sealing and soils.

Sealing rises socio – economic costs as such for mitigating poverty, health cost, maintenance and demolition costs, for risks of catastrophes (for example floods).

Research question would be

- Socio-economic costs of inadequate use (not corresponding with the preferred soil function) of soils by sealing

Land use planning plays a mayor role in the occurrence of sealing. Therefore the benefits as well as the impacts of planning should be better known.

Research question would be

- **Assess the benefits and negative impacts of land use planning on sealing (I).**

Cluster 5: Response (R) - Development of operational procedures for the mitigation of the threats from sealing

Response to sealing is a broad and diversified field. Different groups must be involved. But also the time scales for research will cover periods of 1 to 10 years.

A most important measure would be to rise awareness on the extreme dimension of soil consumption in Europe.

Research questions would be

- *What are the regional threshold values for sealing (I),*
- *Establish a convention on the restriction of soil consumption and possible effects on soil protection at a local, regional and in the European Union level (I),*
- Establish legal and other instruments for the control of urban growth and its harmonisation with soil quality, which soils and where should they be consumed,
- Integration potential of landscape types and their sealing potential into land development plans

Most of the areas are sealed by certain ways of constructions and demands by production, commercial, traffic and communication techniques.

Research question would be

- To solve sealing problems by change of used production, commercial, traffic and communication techniques and others.

Sealing can be also influenced by economic, fiscal and planning instruments such as productivity and social cots per square meter sealed area, trading of sealing rights, compensation and substitution measures for soils used for sealing, storey to ground relationships, funds for reclamation into natural or semi – natural stage after the end of use, development of soil protection instruments such as pedotops similar to biotopes and development of a concept of regional soil quality parameters and soil models. Sealing is also encouraged by the fee structure of architects and engineers which pays for cubic meters of moved and excavated soils and not for intelligent solutions which avoid this. Strong pressure on going on sealing comes from the huge amount of architects in Europe (in Germany 1 architect for 800 inhabitants) who need work. They should not be fixed on new building areas but on improvement of the existing ones.

.**Research question** would be

- *Develop legal instruments such as economic, technical, fiscal and planning instruments needed to reduce sealing and sealing effects (I),*
- What are the effects of fee structures for architects and engineers on sealing and who can they be improved to avoid sealing
- Develop models of better use of ground in the city instead of ground use outside the city
- What are the potential of a trading soil sealing rights - similar to the emission trading concept under the Kyoto protocol

Sealing effect can be mitigated by numerous other ways such as better use of soils underneath the sealing cover, by improving street tree soils, by roof top planting, de – sealing, change of type of sealing.

Research question would be

- Which measures are available to diminish sealing effects and how can they be used and improved.

Sealing is perhaps the biggest threat to soils today and will rise in Central Europe of the enlarged European Union. That means Soil Conservation Service must have a strong focus on mitigating soil problems in urban, industrial and traffic areas and by sealing.

Research questions would be

- Determine the tasks and develop instruments for a Soil Conservation Service in urban, suburban, industrial, traffic areas as well as areas, where the potential living space is reduced to a small percentage due to topographic reasons (e.g. and alpine valleys, coastal and river plains) and focus also on sealing.

7 MONITORING OF SEALED AREAS IN THE EUROPEAN UNION

- Contribution to the EU Soil Thematic Strategy, WG 4 – Soil Monitoring –

Traditional methods of sealing monitoring and mapping, and already often used by communities, water and other authorities, are aerial photograph interpretations. This enables to quantify approximately the sealing percentage by use of land use information. The group GMES gives an advanced example for this.

But of interest are not only quantity of sealed areas and their change with time. Also quality features are of interest. For that purpose on ground investigations and additional information from the communities are in addition necessary. Such a monitoring schedule which includes quantity and quality issues is presented by the Working Group Urban Soils.

7.1 Comments of GMES user group on soil sealing

The joint initiative GMES (Global Monitoring of Environment and Security) between the EC and ESA (European Space Agency) aims to develop operational services using remote sensing data by 2008. Currently several projects are conducted with the aim to improve the data quality for environmental reporting and some of them refer directly to the soil thematic strategy and especially on the threat to soils due to sealing and land consumption.

Several GMES meetings explored the needs for harmonisation among user requirements and the development of GMES service products for different environmental tasks at different geographical levels (see also http://www.gmes.info).

As a starting point a GMES user group on soil sealing was implemented representing users of various GSE-projects (SAGE, GUS, CoastWatch) dealing with the issue of land consumption, urban development, spatial planning etc. under the special focus of soil sealing and land use. To coordinate the activities and to harmonise user requirements the first user driven workshop was held from 1.-2. April 2004 in Vienna. The European Space Agency (ESA) welcomed this initiative – coordinated by the ETC/TE - as activities coming from the users are critical to ensuring the success of GMES.

We as users try to shape the potential services developed and implemented within the GSE-projects according to our needs and requirements, which are derived from various regional, national and European policies. The currently most important policy on European level therefore is the finalization of the Soil Thematic Strategy (STS) with the 3rd Advisory Forum taking place in Brussels on 19th of April 2004. Soil Sealing is one of the eight major threats defined within the STS.

As the summary reports of the thematic working groups (TWG) are now available for the public, we would like to deliver our comments:

The **summary report of the TWG monitoring** includes the recommendation of the Task Group on "Parameters and indicators to be monitored". These recommendations contain the following:

5. LUCAS and other EU environmental programmes should be examined as possible vehicles by which monitoring of some of the soil threats might be made.

<u>Recommendation of GMES user group on soil sealing:</u>

5. <u>GMES,</u> LUCAS and other EU environmental programmes should be examined as possible vehicles by which monitoring of some of the soil threats might be made.

The **summary report** of the **Task Group on "Parameters and indicators to be monitored"** contains the following under the chapter soil sealing (p. 11):

Monitoring of soil sealing can only be obtained from the appropriate statistics, as is already done by the Member States and collected by EUROSTAT. [.....] The most successful approach is likely to be based on remote sensing.

<u>Recommendation of GMES user group on soil sealing:</u>

The conclusions above seem to bear a contradiction between statistical data and remote sensing data. The GMES-approach clearly demonstrates that current monitoring systems must integrate both remote sensing observations and in-situ measurements. Due to the nature of the process "soil sealing" a spatially explicit and complete area coverage monitoring should be guaranteed.

The **Annex 1** of the Task Group on "Parameters and indicators to be monitored" contains detailed information on **LUCAS as a potential soil monitoring system data provider**.

<u>Recommendation of GMES user group on soil sealing:</u>

Within the GMES user group on soil sealing a huge amount of work is dedicated to discuss and define the geometric and thematic user requirements for soil sealing data. However the current summary report of the TG "Parameters and indicators" solely contains the description of the LUCAS nomenclature. The available documents within the GSE-projects SAGE and GUS clearly illustrate the need of data on scale 1:25.000 and 1:100.000 with minimum mapping units of 0.25 ha up to 1 ha (see also the conclusions of the first GMES user group workshop).

<u>Final Comment:</u>

We would like to point out that a monitoring proposal based on remote sensing should definitely include the user requirements defined within the various GMES-projects. This user requirements include proposed technical solutions (nomenclature, geometric accuracy) and the proposed methodology should be co-ordinated with the GMES user group on soil sealing. In this way an effective use of the invested research fundings scan be guaranteed.

7.2. Soil Monitoring Instruction on Sealed Areas in the European Union

Professor Dr. Wolfgang Burghardt, Dept. of Soil Technology,University Duisburg – Essen

and Working Group Urban Soils of the German Soil Science Society

0. Relevance to EU Soil Policy
1 Targets of sealing monitoring
2 Scale and information content
3 Area description, surface information
4 Horizon and layer description
5 Profile description

6 Assessment of in the field deducible soil functions of and next to sealed area

0 Relevance to EU –Soil Policy

0.1 Quantity and quality of sealing in Europe

Sealing is necessary for transport of goods and humans, for settlements, industry and commerce. All of them have already a strong European wide dynamic. That means what happens at one end of Europe is not independent from that what happens in other parts of the European Union or will have there strong effects. Thus mitigating sealing means to include soil policy for good transport, settlements, industry and commerce on an European level.

Sealing has quantitative and qualitative aspects. Quantitative by consuming soils. Qualitative that under a sealing cover can be still soils, which can perform functions, and after the end of sealing use and de-sealing soils will have functions.

For the temporal dynamic of sealing which would be item of sealing monitoring, it is known that

- local sealing changes in the way that after the end of the construction of a building still sealing is going on in the surrounding of the building.
- we have in Europe today also areas where settlements in a huge number are not longer used for housing. An example is eastern Germany where 350.000 flats will be demolished in the next years. Similar can be expected for the east European countries.
- On the other hand in the neighbourhood of many large cities new smaller satellite settlements are constructed today. An example is the area between London and Cambridge where 500.000 new flats are planned. Perhaps in 20 to 30 years the population will abandon these satellite settlements and return in the central large cities. The reason is that it will be easier to supply an aging population in central cities than in scattered satellite settlements.
- There are already many attempts to mitigate sealing effects.
- There can be the hope that research on sealing effects leads to reduction of sealing and improvement of sealing quality.

0.2 Monitoring quantity and quality of sealing in Europe

Today sealing is monitored in a quantitative way by estimation of the percentage of area covered by sealing, commonly by aerial photograph interpretation. But sealing has also numerous quality features. The report of the TG – Sealing, Soils of Urban Areas, Land Use and Land Use Planning in this scripture highlights these quality features. The quality features are as important for assessment of sealing effects as the quantity of sealed area. Solutions and performance for mitigating of sealing will be based on quality parameters of sealing.

Quality parameters of sealing cannot be determined by aerial photographs. Therefore it is not sufficient to monitor sealing by this approach only. It must be completed by on ground investigations. The herewith presented soil monitoring instruction on sealed areas recommends for soil monitoring of Europe both.

1 Targets of sealing monitoring

Sealing has numerous effects. Most of them are threats but not all of them. The effects which are related to sealing and the characteristics to be monitored to assess the effects are items of the monitoring instructions.

The effects are

1 Decrease of soil functions
2 Inhibition of storm water infiltration
3 Inhibition of storm water storage
4 Floods by inhibition of water infiltration
5 Reduction of ground water renewal in some cases
6 Health hazards by ground water contamination caused by break through of polluted water to ground water at the edges
7 Destruction of soil fertility
8 Reduction of urban green and bio – diversity
9 Dissection of habitats and water catchment areas
10 Unfavourable climatic effects
11 Health problems by urban overheating
12 Health threat from sealed areas as sources and transport route of contaminants
13 Health hazards by dust, fine dust (PM10, PM 2.5), concentration and release of hazardous compounds
14 Long lateral diffusion way of gases below sealing covers, reduction of soil gas exchange
15 Methan formation in soils underneath sealing cover
16 Gas concentration increase and threat by gases (e.g.radon) at the edges of sealed areas
17 Contamination effects on adjacent areas
18 Stimulating and preventing wind and water erosion and land slides
19 Change of organic matter production, conservation and decay
20 Exit of sewage water and other liquids into the soil from pipes
21 Pollutant sorption on surfaces of sealing materials
22 Social effects by reduced well being and life quality

Positive effects

23 Protection of soils against immissions
24 Increase acid neutralization capacity underneath sealing cover
25 Drainage function of the soil under streets
26 Reducing evaporation, improved water supply to street trees
27 Economic needs
28 Social needs
29 Communication and traffic needs
30 Security needs

Sealing is one of the most severe impacts on soils (table 1). It is the extreme of urban soil degradation and due to its exclusion of vegetation an extreme of desertification.

Table 1: Sealing characteristics which determine impact on soils

• sealing degree • sealed area • type of sealing • quality parameter of sealing	• change of underlying soil by sealing • real need of sealing • de – sealing potential

In general sealing and pressures from sealing cannot be avoided due to land user demands (table 2)

Table 2: Ways of pressure by land user demands on sealing

• land use type • maintenance and re-construction • population size and structure • economic development	• community planning and development • regional structure plan • EU/government policy

On the other hand sealing covers soils. There will exist under the sealing cover still soil which can perform many functions. Techniques for the access and use of this functions must be developed.

Our socio – economy is closely related and dependent on sealing. Therefore to understand sealing, to mitigate or even to un – seal or prevent sealing needs also information about this aspect. It is recommended to include it in the monitoring procedure.

The following instructions will include these aspects. Details of classification for the instructions are here not presented. For some criteria they are available from soil survey or from the Working Group Urban Soils (AKS 1998). For others they must be established. This paper will not go in these details.

Sealing is defined by an un-permeable or in part permeable surface or subsurface layer (table 3) of a minimum size of at least 1 m cross section in two directions.

Monitoring has to face the problem, that an area is in most cases not total sealed, what is also a scale problem. Between the sealed areas are areas of open ground. But sealed soils and open soils belong to one soil-scape unit and form in this unit a pattern. For monitoring means that in addition to the investigation point the surrounding area has to be included. For this procedure rules must exists.

Table 3: Definitions of soil sealing

A. Definition following a systems approach: Soil sealing is the separation of soils by layers and other bodies from totally or partly impermeable material from other compartments of the ecosystem, such as biosphere, atmosphere, hydrosphere, anthroposphere and other parts of pedosphere.
B. Definition following a purpose related approach Soil sealing is the covering of the soil surface with an impervious material or the changing of its nature so that the soil becomes impermeable, such that soil is no longer able to perform the range of functions associated with it.
C. Soil sealing including natural characteristics Changing the nature of the soil such that it behaves as an impermeable medium. This definition includes compaction of soils. Compaction of soils or sub - soils may affect larger areas than the sealing as defined with definition B

0.1 Monitoring procedure

A procedure which would meet the existing experiences about the situation in many urban areas would be

- to include around the monitoring point an area of at least 400 m^2 (20 x 20 m^2),
- to monitor in this area two additional points, that means totally 3 points,
- the additional points would be only on sealed area when the sealing degree is > 90,
- one additional point would be on open ground when the sealing degree is 60 – 90 %,
- both additional points would be on open ground when the sealing degree is less than 30 %.

2 Scale and information content

Which spatial information will be available from monitoring will be dependent from the scale. Table 4 makes this more clear. A fixed monitoring grid of 18 x 18 km would mean for Europe about 12250 monitoring points. About 280 would be located on sealed areas. The sealed area is calculated as an area absolutely covered by an impermeable artificial layer on the soil surface. The calculation is based on the assumption of 200 m^2 sealed area per inhabitant.

The small number of 280 sealed monitoring sites will give the opportunity to monitor quantity and quality parameters of sealing which would present tendencies of sealing changes of an all over Europe statistical character. For soil policy on an European level this might be adequate, but should be investigated more seriously. For local development policy it would be not sufficient. The data show that there will be also for the European level some additional monitoring points necessary or the selection of monitoring points should be changed to other criteria than systematic grids.

For sealing monitoring it is not enough to evaluate the development of a point. Sealing monitoring can be only performed on an larger area of at least the size of an attached house estate (400 m^2).

The following proposed characteristics to be monitored are generally valid. According to the procedure of sealing investigation of an area the results will not be depending on a particular scale. Scale dependent will be the interpretation of the results.

3 Area description, surface information

Problem: A surveyed and monitored sealing point will represent different sizes and forms of sealed areas. That means the surveyed point is difficulty to evaluate for its sealing effects.

Solution: an area around the sealing point should be included in the survey and survey characteristics in the neighbourhood of the sealing point should be described.

The size of the area will be dependent from the survey scale and the characteristics investigated. Minimum size will be 20 x 20 m.

Area and surface information will be used for

- loss of water infiltration area,
- loss of area for ground water renewal,
- predicting floods,
- overheating,
- threats by dust by quick drying,
- water and pollutants concentration at the edges with the threat of break through to the
- groundwater,
- erosion of the soils by water at the edges,
- concentration and exit of noxious gases at the edge,
- material release from the sealed area by weathering and tire and foot abrasion,
- the loss of exchange area of gas,
- vapour and water between soil and atmosphere,
- soil area loss for pollutant dilution,
- soil loss for flora,
- fauna and biomass production,
- dissection and chambering of green areas,
- susceptibility to accidents by transport of hazardous solids and liquids.

Area data will be:
General aspects

1 Use of area which contains sealing (table 4)
2 Type of sealed area (total sealed, in part sealed, subsurface sealed, roof sealed) (table5, 6, 7)
Geographic aspects
3 Location in the city (centre, fringe, industrial areas, lodging areas)
4 Neighbourhoods in the larger areas (urban, rural, urban centre, urban fringe)
5 round prize
6 Geological and soil maps, bore hole descriptions
7 Sealing degree, using aerial photo analysis
8 Land use type of the plot, accomplished by land use type of the adjoining plots in four directions
9 Frequency and time length of use
10 Type of construction of sealed area
11 Distances of the survey point to for edges of the sealed area
12 Distance from edges of the sealed area to the next sealed areas in four directions
13 Slope of the sealed area
14 Slope at the edges of the sealed area in 4 directions
15 Height over or under the adjacent areas in 4 directions
16 Age of the sealed area
17 Surface material of the sealed area
18 Relief and roughness of the sealed area
19 Colour of the sealed area
20 Erosion features of the sealed area
21 Erosion features of the areas next to the edges of sealed area in four directions

Table 4: Calculation of number of monitoring points of a grid 18 * 18 km for the total area of the countries of the European Union and for sealed areas under the assumption of 200 m^2/inhabitant sealed area.

Country	Area km^2	Population Mio	Monitoring points total	Number of sealed monitoring points	% sealed monitoring points
Estonia	45.227	1,40	140	1	0,7
Lithuania	64.589	2,30	199	1	0,5
Latvia	63.301	3,48	195	2	1,0
Malta	316	0,40	1	0	0
Poland	312.685	38,64	965	24	2,5
Slovak. Rep.	49.034	5,40	151	3	2,0
Slovenia	20.253	1,99	63	1	1,6
Czechia	78.866	10,30	243	6	2,5
Hungary	93.030	10,19	287	6	2,1
Cyprus	9.251	0,76	29	0	0
Belgium	32545	10.29	100	6	6,0
Denmark	43.096	5,36	133	3	2,3
Germany	357.023	82,33	1.102	51	4,0
Finland	338.144	5,188	1.044	3	0,3
France	543.965	59,19	1.679	37	2,2
Greece	131.957	10,59	407	7	1,7
Great Britain	242.910	58,80	750	36	4,8
Ireland	70.273	3,84	217	2	0,9
Italy	301.336	57,95	930	36	3,9
Luxembourg	2.586	0,44	8	0	0
Netherlands	41.526	16,04	128	10	7,8
Austria	83.871	8,13	259	5	1,9
Portugal	92.345	10,02	285	6	2,1
Sweden	449.964	8,89	1.389	5	0,4
Spain	504.782	41,12	1.558	25	1,6
EU-Europe	3973000	454,2	12.262	280(276)	2,3

Social aspects

22 Socio – economic functions of the sealed area (table 8)
23 Population structure
24 Social status of the area
25 Aesthetic aspects of sealed area
26 Sealed area as source for noise, odour
27 Intensity of use of sealed area (table 9)

Planning aspects

28 Security aspects of planning (catastrophe management – water, food, heating, fuel supply)
29 Area use plan (Flächennutzungsplan)
30 Storey area number of plot (Geschossflächenzahl)

31 De-sealing potential of the sealed area (Entsiegelungspotential)
32 Potential for change of the sealing type (Belagsänderungspotential)
33 Distance to other buildings in 4 directions
34 Vegetation features of the area next to the edges of the sealed area in four directions

Environment aspects

35 Annual precipitation, storm water events
36 Annual mean temperature
37 Frost days
38 Maintenance measures of the sealed areas
39 Trees shadowing the sealed area
40 Building shadowing the sealed area
41 Dust, dirt, waste, excrements(dogs, pigeon, horses) on and at the edges of the sealed Area
42 Irrigation and watering of sealed area
43 Surface drainage of sealed area
44 De-icing salt use
45 Materials placed and stored on sealed area
46 Accidents with release of hazardous liquids (chemical transport accidents) and other materials

Plant aspects

47 Planting on sealed areas
48 Vegetation on sealed area (mosses, lichens, overcome of sealing cover resistance)
49 Vegetation in slots between cobles, pathway plates

Table 4: Land use types and sealing degree - example City of Witten (Clever and Korndörfer, 1991)

Urban land use type	Sealed area, %
Closed block built up areas	80 - 100
Open block built area and block border built up area	70 - 90
Terraced houses	60 - 80
Large block built up area	50 - 70
Single houses	40 - 60
Single house property, farm	20 - 40
Allotments	20 - 40
Industrial and trade sites	70 - 100
Streets , large parking area, incl. accompanying green	80 - 100
Strong sealed sport ground	80 - 100
Public green, public gardens	0 - 20

Table 5: Types of sealing according to the system approach of separating soils from other soil compartments and other spheres

1. horizontal barriers	vertical barriers
a. on the surface b. subsurface c. subsoil d. underground	a. walls b. drainages

Table 6: Examples of types of human induced soil sealing

Types of sealing	
buildings without cellar	supply lines (gas, water)
buildings with cellar	tunnels
streets	underground
airports, runways	barrier layer of landfills
greenhouses	barrier layer of contaminated lands
plastic covers (greenhouses), vegetable farms	soil cover of concrete etc. for erosion protection
stone plates of burial grounds	coffin layer of burial grounds

Table 7: Natural counterparts of some sealing types

Sealing type by artificial means	Natural soil counterpart
- Complete surface sealing - In - part sealing - Subsoil sealing - buildings - others	- Soil crusts - Gravel layers, block layers, ballast layers - soils above rocks, stagnic gleyosols (perched water table soils) - rocks - ice - avalanche

Table 8: Socio – economic fields which profit from sealing

• health • security • personal and community development • physical and information environment • natural resources, goods and services • mobility and communication	• driving forces for social change (income, demography, culture, leisure, education, technology etc) • ecological constraints, economic exchange, authority, tradition, knowledge

Table 9: Intensity of use of sealed area

Building to street ratio Traffic frequency Storey area number of plots Production of sealed area	Turnover per plot by hours/m^2 Office use per plot by hours/m^2 Population stay per plot by hours/m^2

4 Horizon and layer description

Under the sealing layer there exist still a soil volume which has functions and which can be used for diverse tasks. It can

- be rooted,
- be living area of micro-organisms and other organisms,
- contain water and noxious compounds, and
- release noxious gases.

The sealing cover can also have a protection and preservation function.

In case of de-sealing the destroyed sealing cover and the soil underneath will gain functions of unsealed soils.

Therefore information on the properties of horizons and layers are of importance.

The problem of performance of investigations on sealed areas can be

- supply lines under sealed areas such as streets. Therefore augering would not be possible.
- Necessary will be a pit established by an excavator.
- buildings where excavation and augering would be at least extreme difficulty when not impossible.

A solution can be the in part the use of soil profile date from the nearest not sealed ground.

We must assume that also under buildings and also buildings with cellars and similar constructions

- a soil volume occur which can perform functions
- development processes occur which result in particular soil properties.

Detailed knowledge are for both not available. Soil taxonomists seem to agree that under buildings are soils.

Horizon and layer characteristics will be investigated according the survey instruction of the AKS (Working Group Urban Soils 1998). The horizon and layer characteristics are the basic for the soil evaluation and assessment.

1 Sealing type, full and in part sealing
2 Substrate, from natural and man-made material according to list of the AKS
3 Texture
4 Stone content(Vol) and fine earth content (Vol)
5 Structure
6 Colour
7 Smell
8 Organic matter content
9 Carbonate content
10 Roots, intensity and kind of roots
11 Occurrence of soot, coal, tare oil, oil, petrol and others
12 Wetness
13 Consistency
14 Degree of compaction
15 Voids
16 pH
17 EC
18 Redoxpotential

5 Profile description

The soil profile is composed from soil horizons and soil layers. Therefore the properties of soils are a sum and interaction of properties of individual horizons and layers.

19 Taxonomic classification of substrates

20 Taxonomic classification of soil (Ekranolith, Dialeimmasoil, Lithosol, Regosol, Reductosol, Liquid Intrusol)
21 Profile properties (calceric, stagnic, reductic, compacted, anthropic)
22 Occurrence, thickness and depth of relict Ah, Ap horizons. Peat layers, organic waste, compost deposits
23 Relict soils or part of them
24 Fossil soils or part of them
25 Wastes as sources of pollutants
26 Man made substrates as sources of pollutants
27 Excavation depth and soil material transport off the area (excavation erosion)
28 Degree of exchange of former upper soil layers
29 Degree of filling up over the adjacent areas
30 Rooting depth
31 Groundwater table
32 Depth of perched water table
33 Storage capacity of infiltration water
34 Capacity for acid neutralisation
35 Diffusion degree and distances
36 Aeration
37 Occurring supply lines
38 Vertical structures from filling of supply line ditches
39 Aeration, draining and rooting functions of fillings of pipe lines
40 Rootable by street trees
41 Roots in water and sewage water pipes
42 Soil quality indicators
43 Soil degradation indicators
44 Abundance of the soil covered by sealing in the area
45 Fertility of the soil covered by the sealing
46 Capacity of the soil for storm water infiltration underneath the sealing cover

6 Assessment of in the field deducible soil functions of and next to sealed area

The assessment of soil properties and functions should already start in the field to avoid mis – interpretations by evaluation procedures in the office. The surveyor should give a primary assessment on the following:

47 Protection of soils against immissions
48 Acid neutralization capacity
49 Potential for storm water infiltration
50 Potential for storm water storage
51 Potential for bearing urban green
52 Drainage function
53 Aeration, redox characteristics, air capacity
54 Lateral diffusion distances
55 Interception of precipitation water on sealed surfaces
56 Pollutant sorption on surfaces of sealing materials
57 Exit of sewage water and other liquids into the soil from pipes
58 Methan formation in soils
59 Methan and other gas exit in soils from gas pipes
60 Health hazards by dust, concentration and release of hazardous compounds
61 Health hazards by overheating, climatic disadvantages
62 Health hazards by ground water contamination
63 Reduction of ground water renewal
64 Hazards by floods
65 Transport lines for dust
66 Effects on adjacent areas

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Part II: SOILS of URBAN AREAS (URBAN SOILS)

1. Driving forces in urban areas

The city development follows socio – economic processes, which are not the item of this paper. But socio – economic processes are driving forces for the formation of the city as environment. A number of factors are involved in this. Table A1(U) in the annex shows an approach of the development of soils by the environmental and human quality of life system in urban areas.

Characteristics of socio-economic forces of urban areas are the strong accumulation of people resulting in large size of cities, and high population density. The driving forces differ by type of cities (mining, heavy industry, commercial, administration, over regional,

regional, local centre),(see also annex table A1.1(U)). Humans, soils, as well as all other items in the city get a new environment. In a factor – process - property - chain, the quality of soils is changed.

There are many **factors behind the driving forces** such as huge material and energy flows, dependency from resources outside the city, historical development, regional climate, supply management and others (see collection annex table A1.2(U)).

Research questions will focus on driving forces of quantitative and qualitative development of urban soils such as urban areas as new environment, new soil properties from this environment and - as a result - new soil functions, as well as on the meaning of soil use types. More research demands are listed in the annex, table A1.3(U).

2. Pressures

The new city environment will either consume soils or give soils numerous new characteristics. These new characteristics will provide soil functions, which differ from those of rural areas. This means that urban areas own a specific capacity and spectra of soil functions.

2.1 Soil consumption by socio–economic demands

Soil use for constructions results in soil consumption by sealing and soil excavation. This needs further research in the context of soils of urban areas and is part of the sealing chapter.

2.2 Changes of soils by man

This chapter is not complete, but perhaps presents some of the most obvious and tangible issues to consider. Many are generic and can be applied to a number of the other research issues, but emphasise overall the need to engage with the complex human urban ecosystem. After all "land" ownership and "territory" have driven human evolution…. and what covers the surface of the earth we cling on to?

We have to ask, what is newly generated. There are some frequent and dominant soil characteristics such as new soil macro - morphology and contamination. Other characteristics are also results of urban environment involvement but less dominant and frequent. There are specific roles and demands of humans but also of components of urban ecosystems in creating soil characteristics. A central political issue will be the definition and protection of soil functions, which are based on characteristics of soils, environmental and other components.

Frequent and dominant characteristics of soil morphology and chemistry concerns new sediments, deposition of man – made materials, layering and mixing of materials, strong compaction, contamination and others (see annex table A2.2.1(U)). By these actions, the soil body is newly composed in a way it did not exist before.

Associated with urban environment, but less dominant and frequent soil characteristics occur such as numerous morphological, mechanical, physical, chemical, biological and area structure characteristics and compositions of these. They are phenomena, which can dominate locally within an urban area and can be of high importance. Examples are alkalinity, acid neutralisation capacity, decrease of valuable fine earth content by accumulation of stones, increase of areas of varying soil characteristics. More examples are shown in table A2.2.2(U) in the annex.

Specific roles, demands and activities of humans in selected fields are creating new soil characteristics in cities. That means for urban soils that they have beside from built environment additional characteristics from permanent, temporal or occasional human interventions. Examples are vegetable garden, cemeteries, garages, earthworks, street cleaning, grass cutting, irrigation,. More examples are shown in table 2.2.3 in the annex.

According to the **composition of components of urban ecosystems** diverse soil characteristics and distribution pattern of soil characteristics will occur. Table A2.2.4(U) in the annex contains a collection of what we expect or which urban environmental factors are involved. Examples are climatic effects of urban relief, pollutant storage capacity of humus, influence of traffic lines, dogs and other pets.

2.3 Functions of urban soils

For rural areas a fixt catalogue of soil function is already available. This must be checked for urban areas and completed or modified. Beside those soil functions recognized for natural areas such of today soil use and of relicts of former soil use, peculiar elements of city planning, dust reduction, green keeping, health cost reduction, heat balance should be added. More examples are given in table A2.3(U) of the annex.

2.4 Research questions about consumption and changes of soils by man

Natural soil relicts, man - modified soils and soils from man - made substrates or mixed with man - made substrates, altered by soil use and other processes will have strong deviation of composition and characteristics found in nature. There is a wide field of research to be established on urban soil characteristics, the methods for urban soil investigations and for recognition and evaluation of soil functions. Among the most important research objectives will be the spatial parameters of size, shape, distribution, boundaries, sequences of soil areas within properties and between them. Some research questions are listed in table A2.4 (U) in the annex.

Questions:

- Characteristics of substrates
- Characteristics of urban soils
- Methods for urban soils
- Spatial parameters of urban soils

3. Impacts

The question of impacts related to soils in an urban area includes impacts on soils and impacts of soils on the other spheres also affecting humans and surrounding ecosystems. The soil impacts on humans are those of health, of catastrophes such as floods and land slides, cost of maintenance of green areas, insurance costs. Ecosystem impacts are losses of habitats and soils as archives of urban development.

With respect to qualities of impacts we will find beneficial and dis - beneficial impacts on soils.

Regarding Impacts on soils there are numerous smaller and larger impacts due to the soil characteristics owned by soils in an urban environment. They mostly include increased alkalinity, in some cases extreme acidity, different degrees of contamination, many effects from compaction and erosion. Many of the impacts on soil are not new and have been studied on natural soils already. The frequency and specific characteristics of impacts on soils in urban areas and the resulting soil properties are unique. Table A3.1(U) in the annex gives a broader overview of impacts on soils.

In respect of **impacts on humans** most attention was paid to the health effects of contaminants from soils. But there are a number of other soil effects which perhaps have also a strong influence on health and which are depending from soil characteristics (see table A3.2(U) in the annex). These are climatic conditions, release of dust, pathogenic soil organisms, gases released from soils but also influences on physical and mental development of children.

Impacts on ecosystems: It is improbable that urban areas will not be habitats. But they differ according to their soils and the built environment from such in nature. Our knowledge on this is still deficient, but we can assume that we will find very unique habitats. We have also to learn that highly polluted areas and such of other dis - beneficial impacts on soils and humans can be important habitats, so for research or preservation and development of species of economic interest. A collection about impacts on ecosystem is listed in table A3.3(U) in the annex.

Economic impacts will be caused by health costs and - connected with these - costs for insurances, soil cleaning costs, costs of maintenance of green cover, but also for move away of people from the city due to low environmental quality (for more examples see table A3.4(U) in the annex).

Questions:

- new urban soil properties, their relation to land use and possibilities to avoid them,
- information on the normal living sphere of citizens is meagre. It can be stated that most of the pressure on soils of urban environments is a result of improper land use and can be avoided,
- exposure assessment to contaminants, dust, climate, litter, soil organism, soil micro-organisms, to open soils,
- health effects of soil compounds, positive and negative,
- soils of urban areas as habitats.

4 State

4.1 Definitions of substrates and soil

Many soils of urban areas are very young and not developed and not in an equilibrium stage with their environment as soils of rural areas are. This means that the properties of the substrate of the young urban soils dominate the soil properties. In this case the common soil classification systems, also the international ones such as the World Reference Base (WRB) and US Soil Taxonomy fail.

This problem does not occur in the soil taxonomy, which is used in Germany, and was adopted by the German Working Group on Urban Soils (Burghardt, 1997). The soil classification is split in two parts: the classification of substrates and the classification of soils. The advantage of the system for urban areas is that urban surface layers can always be assessed as bodies with or without soil functions, which can contribute to the urban environment in a specific way.

Soil classification systems such as World Reference Base are developed for scales of 1:200.000 up to 1:5 Mill. They are not suitable for urban areas. The mapping and assessment procedures in urban areas have to deal with small sized plots. For these, mapping scales of 1:5000 or less are necessary.

4.2 Natural and new soils in the urban ecosystem

In urban areas many of the natural soils are left. Sometimes they are better preserved than in rural areas. In rural areas deep ploughing, soil amelioration and erosion on farmlands have destroyed many natural soils. Natural soils in urban areas have got a new environment. This can mean that they have got or will develop new properties. That means for example that the morphology of soils remains, but the acidity state changes to more acid or alkaline, other changes may occur by contamination.

We already know that in urban areas new soils develop within a few decades. There are also soils which are not existing in nature or which show strong deviations from natural soils. Details and distribution of the different urban soils are almost unknown. We can assume that we will find numerous other soils with specific properties and qualities for soil functions.

4.3 Soil survey instruction

The soil survey instruction of the German Working Group Urban Soils is developed for use in scales of 1:5.000. The instruction must be proved for other European regions and extended to the demands of the users of soil information (Arbeitskreis Stadtböden, 1997).

4.4 Urban soil maps

There already exists some experience in Germany. Soil mapping was performed already in about 20 cities, but the scale was mostly 1:20.000 to 1:50.000 and therefore not satisfying. First attempts to establish soil contamination maps have been initiated in the federal state Northrhine Westfalia in Germany. But there are still many unsolved problems. In general we can say that already some promising steps of soil survey and development of soil maps for urban areas have been made. But we are still far from the knowledge base, which is available for rural areas.

4.5 Soils as part of urban socio-economic system

For rural and natural areas the processes of soil development and indicators for these are well-known. On the base of other natural factors the occurrence of soils and their future development can be predicted. Urban soils are not only dependent from the natural factors. The socio-economical processes including planning processes are additional and often dominant factors. What kind of soils, soil properties and soil functions will be the result is unknown. This information is essential. It will enable us to derive the future soil inventory of cities from the socio-economic processes.

4.6 Amount and soil quality of urban soils due to land use sub - indicators

4.6.1 Assessment

Assessment systems for urban soil qualities, which are focused on the spectra of urban soil properties, are missing. What are in part available are assessment systems for health effects of contaminants. The large numbers of other fields are not covered.

4.6.2 Quality information

For the definition of urban soil qualities specific urban background values must be available. There are only a few attempts available for contamination state, so for example for the Ruhr area in Germany.

4.7 Constructed substrates

We know that most products will later turn to wastes and will be parts of soils or will form soils. From this, the question arises, if we should already define waste products in terms of soils and design products for use with additional properties for soils of high quality (Burghardt, 1994).

5. Response

We know not much about soils in urban areas, but what we know, tells us that it will be possible to use much of the knowledge that we have from rural areas, also in urban areas. Of course, this has to be proved and adopted. In part new soils and soil properties occur. Monitoring is at least one essential response to get better knowledge. As soils are formed by their static and mobile environment we should know more about its effects on soils. There is an urgent need to improve knowledge about the influence by which soils are degraded, but also about influences that will improve soils in urban areas.

5.1 Acquisition and processing of soil data

There are only a few examples of urban soil survey and maps. Thematic maps are missing. Therefore one essential part of response must be to prove available soil survey instructions for use in urban areas, to improve the survey methods and to start with urban soil survey pilot projects. These should include survey of soil forming substrate and soil types, modification by humans and man - made substrates.

Thematic maps are necessary for many measures on soils, e.g. for urban water management, water storage and infiltration, for health protection, soil contamination, dust release and also heat mitigation. Suitability of soils for urban green, microorganism and contribution of soils to the urban habitat should be mapped. Maps about sensitiveness of soils in urban areas against sealing, erosion, structure disruption, compaction, loss of organic matter and more are also necessary.

This has to be supported by methods for field survey, field investigations and measurements, laboratory investigations, and for long term and permanent soil observation plots.

We also need evaluation methods for soil functions, soil threats and sensitiveness, and soils as eco-components. Soil maps, soil data and assessment tools should be available in a soil information system. Table A5.1(U) contains a collection on the soil data acquisition and processing aspects.

5.2 Measures

The long list of measures for soil protection and soil maintenance in rural areas has to be introduced to urban areas and to be adapted to urban conditions. In addition, measures to mitigate effects on soils from the numerous types of urban soil use, high population density, industry and traffic density are needed. The probability of emissions and the emission of very divers compounds in urban areas is greater than in rural ones. Therefore we have to develop tools to respond to this. We also have to use more planning measures and to prove effects of planning on soils. Of particular importance will be the establishment of soil protection areas. This could be one of the tools of active soil policy. Table A5.2(U) in the annex contains a collection of response by measures.

5.3 Soil Conservation Service

The care for sealing and urban soil problems is not or only marginal organized, so for landfill management, de-sealing, sewage sludge use, use of recycling material as soil. The soil care of urban areas should be organized together with the soil care of rural and natural areas in a Soil Conservation Service.

5.4 Response of the environment to land use planning

Land use and land use planning will be the topic of the third draft of the Task Group 5 - Sealing, Soils of Urban Areas, Land use and Land Use Planning. The third draft has not been completed yet.

Part III: Land use and land use planning

1. Land use

1.1 Drivers: Importance of land use for soils

All parts of the European Union are dedicated to any type of land use. This also includes natural reserve and heritage areas. Land use generally changes soils or even consumes them in part or totally, e.g. by sealing and excavation.

Soils are defined by the formation of particular properties under the influence of the environment as soil-forming factor. Land use always has a particular influence on soils. Therefore, in most areas land use is a main factor of today's soil formation and soil properties. This means that what happens to the soils is not only a matter of natural environment of soils, but also one of artificial constructions and management by human activities. For example the pH levels of soils can be distinguished for many areas in Europe according to the following land use definition:

forest - grassland - arable land - urban land ? pH4 - pH5 - pH6 - pH7/8
(extreme acid - very acid - slightly acid - neutral to slightly alkaline).

We must be aware that the fate of soil today is in our full responsibility. The capacity of soils to supply fertility, to contribute to a particular quality of life and to prevent hazards is in the hands of European land users and is accessible to the legislative and administrative bodies in the European Union.

In general, what happens at which place in Europe is a matter of planning. This also includes any particular kinds of use of soils. It is therefore extremely important for soil policy to gain sufficient knowledge about the effects of different types of land use on soil properties and on the capacities of the soils to fulfil certain functions. With such knowledge planners would be able to set the course in a way that irreversible destruction of soil properties and functions is minimized.

Research:

- how do different land use types consume and change soils, to which new amount and properties of soils do they lead, and what does this mean for the people living in the European Union?

1.2 Pressure: New soil qualities by socio - economic and technique area relationships

Land use leads to new soil qualities, which are not defined, solely by natural conditions of the landscape. The new factors are those of socio - economy and technique that determine land use patterns. Many of the socio - economic and technical factors act as short catastrophes such as establishing constructions or dislocating soils. After this the new environment acts in a natural way by physical, chemical and biological processes. We still have to learn, how such new or changed soil systems behave. We already know that there are many adverse effects not only by soils themselves which react slowly, but also more dramatically by climate on soil changes.

Research:

- how are the new soil qualities resulting from different land use types defined, and what are the contributions of new soil qualities to soil functions?

The interdependence of natural areas and therewith soil formation and soil characteristics of natural landscapes follows gravity laws. Land use creates new dependencies, which are artificially established by socio - economic relationships of plots. This happens on a local as well as on a global scale. This means that socio - economic processes far from the region in landscapes with completely different conditions may influence soil properties elsewhere.

Research:

- what is the interdependence of soil properties and functions of different areas due to socio - economic processes?

1.3 Impact: Loss and change of soil resources

Soils will be lost or will get new properties from new land use. For landscapes, this means that they will get a new feature such as new substrates, which will change biosphere, climate, and regional water household. The character of the landscape will change. For example slightly acid loess plain will change by urbanisation into a stony and calcareous "mountainous area". Diverse types of land use will occur in adjacent areas. The resulting soil properties may differ extremely. Thus, we will get new combinations of soils in landscapes. This means that humans will get a new environment with new living conditions and threats. But also the availability and distribution of soil resources will not be the original one.

Research:

- description and classification of modern soil landscapes due to the influence of land use
- change of availability and distribution of soil resources in modern landscapes
- contributions of different types of land use and combinations of them to threats, dis-functions of soils, and the relationships to socio - economic and technique criteria.

1.4 State: Types of land use

Investigations on types of land use are not new. Classification systems were developed for adequate use of soils for agriculture and forestry. They were the basis for development plans of agriculture and forestry areas.

One of the recent land use classification systems developed for Europe is that for CORINE Land Cover monitoring on a scale of 1:100.000 which distinguishes 42 types of land use. On national, regional and local level there exist many more classification systems, surveys and maps of land use types on different scales. A ground construction plan of scale 2.500 can be already interpreted as land use plan. The problem is the restricted availability of land use data in information systems.

Research:

- describe the availability of land use data

- improve the basis for establishing information systems on land use.

Different types of effects of land use on soils occur. Some effects occur nearly as a point reaction or local, others more regional or global. For example the heating effect of sealing will be assessed on a scale of 1: 25.000, the effect of sealing on tree stands or break through of surface water to ground water on a scale of 1: 1.000. This means that the interference of land use and soil must be observed and described with regard to the effect on different scales. The effects on soils will vary between different types of land use. This means that the adequate scale for assessing land use effects on soils are not the same everywhere.

Research:

- develop systems for selecting scales for description of different effects of land use on soil properties.

1.5 Response: Soil availability restriction to particular land use types and classification of soils by land use

Some soils are to valuable due to their role in nature to be used for other purposes than nature reserve areas. Other soils are very fertile and productive. These soils should be available only for food production. Some soils are suitable for drinking water harvesting. They need protection and management in order to gain high water quality and to secure the amount of extractable water. Many more examples could be given.

Research:

- establish assessment procedures to characterize, define and disclose priority areas for certain soil use types.

Threats to soils such as erosion, contamination, humus reduction, sealing, total loss by excavation can be linked to land use. The catalogue of threats as well as beneficial effects is much larger. There have already been some attempts to establish soil maps on the basis of land use maps. This is performed where soil survey is difficult, such as in urban areas or where financial resources for soil survey are limited. The problem is that we still know only little about the kind, quality and quantity of soil parameters changed by different types of land use, about which land use type results in which soil parameter changes, and about how susceptible different soils are with regard to these changes. It looks very complex as many of such new questions.

Research:

- establish, qualify and quantify the effects of different types of land use on soils
- identify the role of the individual local soil and its environmental conditions such as climate, vegetation, relief, groundwater.

Land use is not static. It has different dynamic features such as production processes, maintenance measures, repair and improvements, or change of land use type in part or totally. This means that a site has a land use history as well as a present intensity and peculiar performance of a land use type.

Research:

- differentiation of a land use type by history and present peculiarities of use.

The relationship between soil characteristics and land use type should be used to distinguish and to classify different soil groups according to their genesis by land use type. This would simplify many of our soil monitoring procedures and soil development predictions.

Research:

- establish a soil taxonomy based on land use type effects on soils and make it compatible to the existing soil taxonomic systems.

The knowledge about the effects of land use type on soils will enable us to predict the change of soil properties by future change of land use type.

Research:

- develop predictive assessment systems of soil change by change in land use type.

2 Land use planning

2.1 Drivers: Relation of soils to availability of land and selection of land resources

Demands for land use planning are based on two criteria:

1. The amount of land is fixed. The extension of one land use type inevitably results in the reduction of others.

2. Land is immovable. It is impossible to bring it to another place.

Essential features connected with land use are site characteristics such as soils. Thus, soils are also immovable. But they can be altered or consumed.

The objective of land use planning is to decide which type of land use will be located at which place. This decision should consider site characteristics such as soils and also the question, which soils there will be in future, being closely related to land use planning.

Research:

- what are the demands and availability of land in Europe, what are the land and land use patterns in Europe, and what is the amount of soil, soil properties, capacities and functions available on this land due to availability of land and demand of different land use in Europe?

2.2 Pressures: Strong change of land use

There is a strong change of land use and its demands to the ground. Land use planning has to react to this. Demands are declared by socio - economy, technology and ecology. But there are also other strong necessities associated with society to react by land use planning. Examples are the aging of population, the body overweight of large groups of the population, shift of mobility from streets into the internet, overheating of the cities or allergies by low contact with soils. This means that land use planning should preserve a certain minimum of unsealed soils and soil functions.

Research:

- what is the minimum of soil area and soil function necessary that land use planning should support and what are the assessment criteria and procedures?

Land use occurs mainly on valuable soils, which should be preserved. But many land use types do not need valuable soils, particularly those, which are today the most, soil consuming ones.

Research:

- what type of land use needs what type of soil?
- on which soils with what soil qualities and soil functions did extension of land use take place over the last 50 years, at present and according to projects being planned?
- what are the barriers for the extension of land use types in areas of low soil qualities?

2.3 Impact: Loss of soil resources

Low degree of inclusion of soils in land use planning results in:

- irreversible loss of soil resources (e.g. fertility, humus, rootable soil volume) and soil functions (e.g. water storage capacity, ground water renewal, soil as sink and diluter for pollutants, transformation of organic wastes)
- loss of quality of life by shortage of unsealed soils, vegetated soils and wet soils (and others).

Research:

- which soils and soil parameters must be available and integrated into the different types of land use planning, and to which degree should they be included?

2.4 State: Use of soil information for diverse types of land use planning

There is already a high diversification of land use planning such as object planning (for example traffic line, environment protection area, nature reserve area), branch or subject planning (Fachplanung) (for example, ground water harvesting and protection, traffic, housing, recreation, sport), landscape plan (Landschaftsplan), land utilisation plan (Flächennutzungsplan), area development plan (Bebauungsplan) and other types of land use planning. An overview of existing and used soil information for the different types of land use planning is missing.

Research:

- establish a draft of the soil information being used in the different types of soil use planning for Europe
- what was the effect of soil information in the land use planning process for proper soil use and avoidance of soil consumption?

2.5 Response: Integration of soil objectives in land use planning

It must be ensured that soils are included in all types of land use planning. For this purpose, soil information has to be worked out in a way that it can be incorporated in the individual types of land use planning and can serve as planning base.

Land use may preserve and protect soils, but therefore the planning instruments and procedures for the particular objectives of soil protection must be available.

Land use influences soils. This means that soil - land use conflict planning has to be developed.

Planning must be homogenous on all scales. This means that information about the occurrence, availability, properties, quality and capacity, use and development of soils must be available on different planning levels and scales.

Soils should be included into economic, social, technological, health, wellness, and ecological processes by land use planning.

Soil objectives from land use planning must be considered in economic, social, administrative and political decisions.

Traditional land use planning does not consider all soil resources. Due to fast technological, socio - economic and society development this consideration should be improved and extended.

Soils will change and get new properties and patterns of properties with time due to their new environment caused by diverse land use type combinations. Land use planning must find ways to react on this by regular updating and future prognosis of the state of land use and assessment of the soil objectives concerned.

There must be a solid foundation for decisions concerning soils in the process of land use planning. Assessment systems and procedures must be available to meet this need.

Research:

- how can soil objectives be integrated into land use planning in a way that soils are protected against unnecessary demands and will be also able to develop in relation to their changing environment?

Part IV: Contribution from planning - Instruments of landscape planning for soil sealing management

By Prof. Johannes G. Quast, University Duisburg - Essen

1 Instruments of economy

An import part in labour market and traffic policies is the journey from home to the work place. In many countries this journey is often supported by tax relief and increasingly additional road space will be necessary.

Research question would be

- what would be the sealing reduction by suspension of mileage compensation by tax relief for commuters?

Through land speculation and exchange many areas are not used for construction purposes within cities. That means instead land would be sealed at the city fringe or outside the city. Additional tax on land not being built on within the city would force the owner to sell the land for construction purposes.

Research question would be

- how would the collection of tax on land value for non built areas within urban environments reduce sealing outside the city.

1.3 In many countries the areas between cities are consumed by constructions. The priority for rural and recreation use is damaged. Similar happens in cities for areas, which should have priority for fresh air ventilation, parks, urban woods. The result is that by non-sealed land disappears and by this the quality of a non-sealed landscape. Urban sprawl consumes more land for sealing than within compact built up areas in the city.

Research questions would be

- what is the additional soil consumption by sealing of urban sprawl,
- how to reduce the rise in sealing and establish sealing tax for land consumption in areas between cities and in urban open space

1.4 Urban residential quarters differ in their population density locally and with time. Therefore the sealed area per inhabitant is varying. To correct this the land should be kept by co – operatives which can steer the population density by the multiplier of land rent. **Research question** would be

- how can sealing demands of the build up areas be steered by adoption of land rent to population density (Garden city model).

1.5 Excessive sealing can be governed by communal land trade. **Research question** would be

- the effect of inter - communal real estate funds on sealing.

1.6 The example of brown fields demonstrates the quick change of land use and the land remediation costs for reuse. At present in eastern Germany about 350.000 flats will be demolished. Between London and Cambridge some 500.000 new will be built. But we expect that the sprawl will not offer the infrastructure for an aging population. That means the aging population of Europe will return in 2030 into the cities. **Research question** would be

- investigate the use of reverting and remediation funds.

2. Panning instruments (Planungsinstrumente)

2.1 For many areas sealing has adverse effects. Therefore it is necessary to fix priority areas for the open space development such as flood plains, costal strips, shore zones of rivers, lakes and coasts, narrow mountain valleys. **Research question** would be to

- develop a catalogue and assessment procedures for land use types in Europe where sealing is not permitted.

2.2 A planning instrument to reduce the pressure to seal the urban fringe by settlements is to force the land owners in the city to establish constructions. This can be achieved by temporal limitation of construction rights. **Research question** would be

- the effects of temporal limitation of construction right on sealing and to optimize the right.

2.3 Infrastructure needs sealed space. When infrastructure is scattered the sealed space will increase. That means centralisation of infrastructure should be enhanced and concentrated in selected areas. The **research question** would be

- to investigate the effect of strong centralised development on soil consumption by sealing.

2.4 Land should be used effectively. This would also reduce the demand for sealed land. That means the minimum intensity of land use should be fixed. Therefore **research question** would be

- to evaluate the use and benefit of construction type/intensity on sealing.

2.5 Natural land is lost by construction measures such as sealing and there is a need to compensate this loss. **Research question** would be

- to establish and justify suitable compensation measures for sealed areas and soil consumption.

2.6 Until now city growth does not consider land quality for other purposes than settlement development. Huge areas of good quality soils are already consumed and will be lost if this practice is not changed. The city has the choice between different areas of development but the soil of good quality is bound to its site. Therefore **research question** would be

- to develop soil preservation instrument for use in the planning process to protect areas for the preservation of high - quality cultivation soils or soils of particular relevance for nature reserve areas.

2.7 Wise construction of settlements can reduce sealed area. One example is the establishment of pocket gardens by arranging houses around one collective garden. Another example is the combination of living room for different generations.

Research question would be

- to prove the effect of sealing avoidance by wise construction measures such as establishment of zoned housing estates.

2.8 Land use is mostly dependent on local demands. That means it is difficult to protect in all cases soils at local and regional administration levels. The administrative responsibility for land use type and change should be fixed at local, regional, national and European governmental bodies. **Research question** would be

- the prove of ways of establishment of horizontal associations of protection administrations (for areas such as of European Union protection areas the competence for permissions of exceptions for change of land use should be in the hand of European and not of subordinate national, regional or local corporate bodies).

Part V : Contribution from Economics - Cost benefit analysis of soil sealing and renaturation

Prof. Dr. Ewin Amann, University Duisburg - Essen

Research aims and questions to be answered

1 We consider that sealing has numerous disadvantageous effects. Therefore ways to prevent or to mitigate sealing effects must be available. For this it is necessary to know who and what is **a**ffected by sealing.

Research question would be

- Identify the subjects - households, agricultural and industrial enterprises, local authorities, counties and regions, countries - affected by soil sealing.

2 The degree of effects of sealing will locally vary and will depend on several parameters.

Research question would be

- Quantify the effects of soil sealing dependent on landscape types, sizes and distribution patterns, pattern of utilisation, area of settlement and urbanisation.

3. Sealing has several disadvantages. To avoid them creates costs.

Research question would be

- Estimate marginal cost of soil sealing, e.g. by evaluating the willingness to pay to prevent the loss/willingness to accept or to tolerate the loss, actual cost of prevention, medical costs (actual and potential future cost).

4 Sealing has benefits and is for many reasons necessary. In part exists a strong demand to seal.

Research question would be

- Quantify the benefits of soil sealing, profits of the firm/enterprise, public revenues, social benefits, e.g. by evaluating opportunity cost.

5 Sealing can be performed in many ways and with different degree of quality. Each of them differs in effects and items concerned. There will be also different effects on different scales.

Research question would be

- Compare alternative scenarios with respect to regional effects, employment, settlement and spill-over effects (industrial settlement)

6 Sealing is a feature of socio - economics. That means the variety of sealing degree and quality of sealing must be assessable by cost - benefit assessments.

Research questions would be

- Investigate alternative scenarios of soil sealing and compare cost and benefits, e.g. by evaluating additional cost and loss avoidance.

7. Large sealed areas already exist. There is a high rate of conversion of built up areas in cities of the European Union due to the enlargement of the Union and aging population. Reanimation of large cities is expected (see planning contribution). There are chances to reduce sealing but also a need to find ways of mitigating sealing effects in areas of future population concentration.

Research question would be

- Identify possibilities of renaturation or alleviation of soil sealing.

8 In the European Union many sealed areas, which are not used efficiently. The ratio of economic

benefit to size of sealed area and negative sealing effects could be improved.

Research question would be

- Evaluate total economic value (actual use value plus option value) and detect efficient patterns of utilisation.

9 Different land use types have potentials for sealing demands reductions. The question arises, how to encouraged to use sealed areas more efficient and to make aware of dependencies of individual land use types. That means that objectives of sealing reduction should be complexes of land use types. **Research question** would be

- Identify strategic aspects and determine optimal/second best incentives to establish optimal patterns of soil utilisation.

ANNEX I: SEALING (S)

0 Definition of soil sealing

There are hardly any international recognised definitions of soil sealing. Soil sealing is often percept as the loss of soil surface. But soils are a three dimensional media that change over time, and therefore the awareness of the manifold functions of soils are often underestimated when reducing the complex media soil to a simple two-dimensional soil surface. Soil Sealing can be defined (table 0.1)

- in a very general way, using a systems approach,
- in a purpose related approach, that narrows down the significance to land consumption due to human activities.

A third definition

- includes natural impermeability.

All three definitions are given in the following, whereas the collection of research questions within this report are based on the purpose related definition (Definition B).

Table A0.1(S): Definitions of soil sealing

A. Definition following a systems approach:
Soil sealing is the separation of soils by layers and other bodies from totally or partly impermeable material from other compartments of the ecosystem, such as biosphere, atmosphere, hydrosphere, anthroposphere and other parts of pedosphere.
B. Definition following a purpose related approach
Soil sealing is the covering of the soil surface with an impervious material or the changing of its nature so that the soil becomes impermeable, such that soil is no longer able to perform the range of functions associated with it.
C. Soil sealing including natural characteristics
Changing the nature of the soil such that it behaves as an impermeable medium. This definition includes compaction of soils. Compaction of soils or sub - soils may affect larger areas than the sealing as defined with definition B

The general definition (A) does not restrict soils to the soil surface only. This definition is wide enough to include other soil sealing processes such as in table 0.2 summarized

Table A1.01(S): Alteration steps of land parcels from natural to man – made conditions by the concept of net primary production (NPP)

Level 1: • non-human usage vs. human usage NPP: no alteration of NPP vs. alteration of NPP This level distinct areas, where almost zero percent of NPP is appropriated by human usage (glaciers, rocks, nature protection zones).
Level 2: • productive vs. non-productive areas (in the sense of biomass production) NPP: areas dedicated for biomass production vs. areas not primarily dedicated to biomass production This levels distinct areas, where natural NPP is appropriated due to regular harvests for commercial biomass production. The range of areas includes sites with almost natural plant combinations (forests) to completely altered plant communities like agricultural crops. The appropriation of NPP lies between XY and ZZ percent. In a general definition all areas not primarily dedicated for biomass production are regarded as **land consumption**.

Continued…

Level 3: • built-up vs. other types of land consumption Rather than a differentiation based on the NPP a differentiation of green areas with regard to the public vs. private access is used within this level. Other types of land use include publicly accessible land (sport infrastructure, public gardens, cemeteries, …).
Level 4: • sealed vs. non-sealed Built-up areas comprise both sealed and non-sealed areas. On sealed areas the appropriation of NPP is almost 100%.

Table A1.02(S): Characteristics of levels of net primary production (NPP)

Level			
1	2	3	4
1. Human usage			
	1.1. Productive		
	1.2. Non-productive		
		1.2.1. Built-up areas	
			1.2.1.1. Sealed areas
			1.2.1.2. Non-sealed areas
		1.2.2. Other land consumption	
2. Non-human usage			

1.1 Types of sealing

Table A1.1.2(S): Natural counterparts of some sealing types

Sealing type by artificial means	Natural soil counterpart
- Complete surface sealing - In - part sealing - Subsoil sealing - buildings - others	- Soil crusts - Gravel layers, block layers, ballast layers - soils above rocks, stagnic gleyosols (perched water table soils) - rocks - ice - avalanche

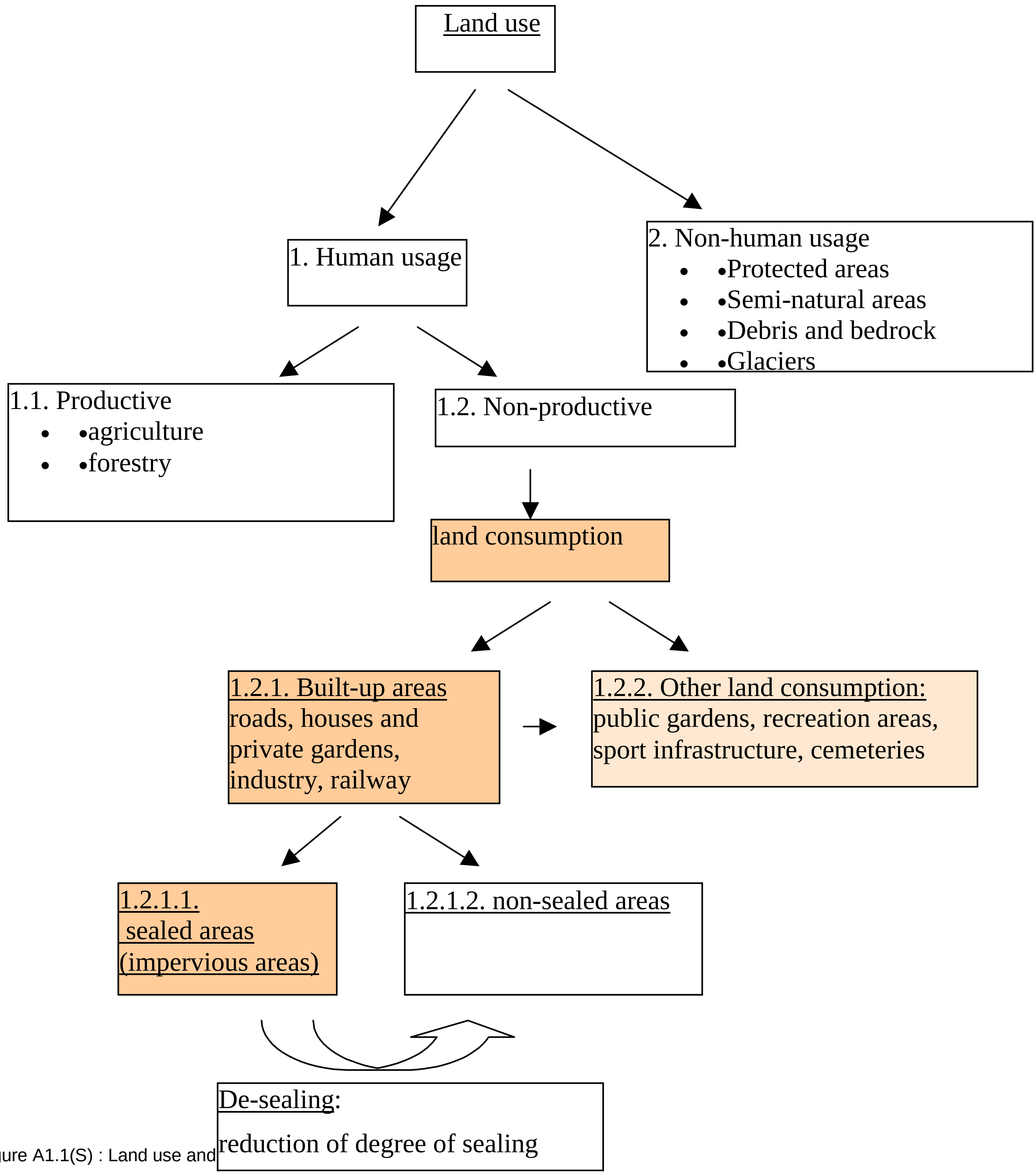

Figure A1.1(S) : Land use and

1 Sealing: Drivers
2 Sealing: Pressure
2.1 Classification of sealing degrees

A2. 1(S) Classification of sealing degree

A robust definition of sealing degree is needed. Projects applying a standardised nomenclature in Europe are:

- Working Group Urban Soils: 5 categories (table 2.1.1)
- CORINE Land Cover
  - o mainly 2 categories (111 and 112 – see also table A2 of the annex)
    - 80-100
    - 30-80
  - o often a third category is needed
    - 80-100
    - 50-80
    - 30-50
- MOLAND/MURBANDY
- GMES Soil SAGE

Table 2.1.1(S): Sealing degree classification for particular land use types, using aerial photo analysis.

Signature	% sealed area	Class
S1	0 - 15	Very low
S2	10 - 50	Low
S3	45 - 75	Mean
S4	70 - 90	High
S5	85 - 100	Very High

2.2 Socio- economic importance of sealing

Table A2.2.1(S): Socio – economic fields which profit from sealing

• Health • security • personal and community development • physical and information environment • natural resources, goods and services • mobility and communication	• driving forces for social change (income, demography, culture, leisure, education, technology etc) • ecological constraints, economic exchange, authority, tradition, knowledge

2.3 Dependence of sealing from land use type

Table A2.3.1(S): Sealing degree of urban land use types - example City of Witten (Clever and Korndörfer, 1991)

Urban land use type	Sealed area, %
Closed block built up areas	80 - 100
Open block built area and block border built up area	70 - 90
Terraced houses	60 - 80
Large block built up area	50 - 70
Single houses	40 - 60
Single house property, farm	20 - 40
Allotments	20 - 40
Industrial and trade sites	70 - 100
Streets , large parking area, incl. accompanying green	80 - 100
Strong sealed sport ground	80 - 100
Public green, public gardens	0 - 20

Table A2..3.2(S): Characteristic sealing degrees of particular units of land use types.

Level 1	Level 2	Class	Description
1.1.1	Continuous urban fabric.		Most of the land is covered by structures and the transport network. Buildings, roads and artificially surfaced areas cover more than 80 % of the total surface. Non-linear areas of vegetation and bare soil are exceptional. When roads and structures along
	1.1.1.1	Residential continuous dense urban fabric.	Residential structures cover more than 80 % of the total surface. More than 50 % of the buildings have 3 or more stories.
	1.1.1.2	Residential continuous medium dense urban fabric.	Residential structures cover more than 80 % of the total surface. Less than 50 % of the buildings have 3 or more stories.

1.1.2	Discontinuous urban fabric.		Most of the land is covered by structures. Buildings, roads and artificially surfaced areas are associated with vegetated areas and bare soil, which occupy discontinuous but significant surfaces. This type of land cover can be distinguished from continuous
	1.1.2.1	Residential discontinuous urban fabric.	Buildings, roads and other artificially surfaced areas cover between 50 % and 80 % of the total surface.
	1.1.2.2	Residential discontinuous sparse urban fabric.	Buildings, roads and other artificially surfaced areas cover between 10 % and 50 % of the total surface. The vegetated areas are predominant but is not land dedicated to forestry of agriculture.
1.2.1	Industrial (and), commercial, public and private units.		Artificially surfaced areas (with concrete, asphalt, tar macadam, or stabilised, e.g. beaten earth) devoid of vegetation, occupy (most) more than 50 % of the area in question, which also contains buildings and/or vegetated areas.
	1.2.1.1	Industrial areas.	Surfaces occupied by industrial activities, including their related areas.
	1.2.1.2	Commercial areas.	Surfaces basically occupied by commercial activities, including their related areas.
	1.2.1.3	Public and private services	not related to the transport system. Surfaces occupied by general government, semi-public or private administrations including their related areas (access ways, lawns, parking areas).
1.2.2	Road and rail networks and associated land.		Motorways, railways, including associated installations (stations, platforms, embankments). Minimum width to include: (100 m) 25 m.
	1.2.2.1	Toll ways	Fast transit roads and associated land. Motorways, by-pass roads, toll-ways, etc.
	1.2.2.1	Other roads	and associated land.
	1.2.2.3	Railways	and associated land.
1.2.3	Port areas.		Infrastructure of port areas, including quays, dockyards and marinas.
1.2.4	Airports.		Airport installations: runways, buildings and associated land.
1.3.1	Mineral extraction sites.		Areas with open-pit extraction of industrial minerals (sandpits, quarries) or other minerals (opencast mines).
1.3.2	Dump sites.		Landfill or mine dump sites, industrial or public.
1.3.3	Construction sites.		Spaces under construction development, soil or bedrock excavations, earthworks.

Table A 2.3.3(S): Pressure on soils by sealing characteristics

• sealing degree • sealed area • type of sealing • quality parameter of sealing	• change of underlying soil by sealing • real need of sealing • de – sealing potential

2.4 Land user demand for sealing

Table A 2.4.1(S) : Ways of pressure by land user demands on sealing

• land use type • maintenance and re-construction • population size and structure • economic development	• community planning and development • regional structure plan • EU/government policy

3 Sealing: Impact

3.1 Effect of sealing on environment

Table 3.1.2.1(S): Effects of sealing on hydrosphere

- water infiltration reduction - ground water recharge reduction - change of dynamic of ground water recharge	- break through of surface water to groundwater - soil humidity changes

Table A3.1.5.1(S): Effects due to properties of constructions

Construction and material of the construction influences - shaping of relief - remove parts of the soil profile - thickness and structure of the building - building material (natural stones, concrete, bitumen, tar) Use of the construction - substance release (emissions from vehicles, domestic heating) and footstep effects Maintenance of construction - delivery of de - icing salts and granulates - use of pesticides - street and construction drainage) - planting. Demolition of the construction - de - sealing - residues of the construction - remain of building materials - following site use.

4 Sealing: State

4.1 Definition of sealing areas as soils

Table A4.1(S): Taxonomy of some sealed soils.

- Protosyrozem - Dialeimmasol	- Ekranolith - Stagnogleyic Ekranozems (Pseudogley Ekranozem)

Table A4.1.1(S): Meta data

Technical information

1. Data source:

For EU15 and Accession Countries: Eurostat's New Cronos (2001); Denmark's Ministry of Environment (2001); Federal Statistical Office of Germany (2002); Statec-Luxembourg (2002); Lithuania. Baltic Environmental Forum (2001). For NIS countries: data request EEA (2001)

2. Description of data:

Earlier data from Eurostat was used in the report "Environment in the European Union at the Turn of the Century" (EEA. 1999). The same data from Eurostat's New Cronos. presented in this indicator. was used in "Environmental Signals 2002" (EEA. 2002).

Data from Denmark's Ministry of Environment (2001). Federal Statistical Office of Germany (2002). Statec-Luxembourg (2002) and Baltic Environmental Forum (2001) specifically relates to built-up areas.

Data from NIS countries was obtained by a questionnaire sent by the end of 2001 to develop this indicator.

Data from Eurostat New Cronos is related to land uses. not specific for soil sealing/built-up areas. On the other cases. data is described in the context of soil sealing. it means that is not a simple matter of aggregating different land classes. but some refinement or specific inquiry has been done to be more precise.

3. Geographical coverage:

EU-15 includes Austria. Belgium. Denmark. France. Germany. Luxembourg. Netherlands and Spain. AC-13 includes Czech Republic. Latvia. Lithuania. Poland. Romania and Slovakia. NIS countries include Armenia. Azerbaijan. Belarus. Georgia. Moldova. Tajikistan. Ukraine and Uzbekistan

4. Temporal coverage:

Data covers the following years 1950. 1970. 1975. 1980. 1985. 1990. 1991. 1992. 1993. 1994. 1995. 1996. 1997. 1998. and 1999. However. not all countries cover the full period. Most countries have data for 1990. 1995 and 1999.

5. Methodology and frequency of data collection:

Data comes from different national ministries or statistical offices. Original data was obtained by different procedures: some countries have specific inventories of industrial areas. urban areas and transport infrastructures. In other cases information is obtained from satellite images. Frequency of data collection increased in recent years. with data available almost every year.

Methodology of data manipulation. including making 'early estimates':

Data series were selected according to maximum number of countries available for each period. Countries were grouped by EU15. AC13 and NIS. and data was aggregated accordingly. Data was aggregated on 5 years period. We used as reference years 1980. 1985. 1990. 1995 and 1999. When data for a reference year was missing we used the nearest availabe data. Azerbaijan: data from 2000 was used for 1999. Belarus: data from 1991 was used for 1990. Denmark: data from 2000 was used for 1999. Georgia: data from 2000 was used for 1999. Latvia: data from 1995 is an average from 1990 and 1999. Lithuania: data from 1998 was used for 1999. Moldova: data from 2000 was used for 1999. Slovakia: data from 1998 was used for 1999. Spain: data from 1998 was used for 1999. Tajikistan: data from 1996 was used for 1995. Ukraine: data from 1996 was used for 1995. Uzbekistan: data from 1991 was used for 1990.

Built-up area (%) was obtained dividing aggregated built-up area (km2) by land area (km2).

5 Sealing: Response

5.3.1 Technical measures

Table A5.3.1(S) Construction, engineering and socio-economic measures to reduce sealing

- change of techniques of construction, production, trading etc. from horizontal to vertical level, direction, - bringing production, trading etc. underneath the surface, - alternative establishment of a new soil layer above constructions, - double use of parking places by trade during the day and dwelling during the night, - longer daily and weekly use of office areas, - reduction of living space per person, - better integrating parking areas in sky-scrapers, - reducing traffic by improving electronic communication, - constructions on pillars, - solution of day light transport into compact buildings, - movable lightweight constructions (Frei OTTO) - surface or underground connections by horizontal lifts, treadmills and conveyors - easily removable prefabs (recycable, portable fabric skyscraper, Todd DALLAND) - reduction of goods storage, - reduction of goods transport (distances, time, frequency), - introduction of pipe transport systems for goods similar as pneumatic delivery

5.3.2 Fiscal measures

Table A5.3.2(S): Fiscal measures to guide sealing

- payment for lost natural resources, - payment for re-establishment of the original (soil) state before sealing (example quarry, sand pit, open cast mining) - payment for the social costs of sealing, - payment for the health costs of sealing - tax - deductible amount for car

5.7 Planning effects on sealing

Table A5.7(S): Planning effect on sealing

• surface cover/removal • spatial heterogeneity and scale • material use • balance of planning traditions and approach

Table A5.8(S): Planning measures to mitigate sealing

• incorporation of ecological principle and environmental justices • make environmental amenities available to residents • reduce negative impacts of urban resource demand and waste disposal • federal versus regional versus unitary power in spatial planning • European instruments: EU regional development fund, social fund, Agricultural Guidance Fund, CAP (II) • Urban - rural surrounding relationships • life cycle analysis, climate change • planning on use rather than medium, • efficiency of resources use • exploitation of green infrastructure • monitoring requirements of sealing

5.9 De- sealing

Table A5.9(S): De-sealing aspects

- demolishing of sealing cover - natural attenuation of sealing cover	- removal of material of bearing layer - soil quality underneath sealing cover

ANNEX II: URBAN SOILS

1. URBAN SOILS: Drivers

Table A1(U): Urban soils – system approach

Environmental system		Human quality of life system
Factors – Processes – Properties Relationship	Soil as Eco – component	Soil functions
Soil – environment relationship	Soil availability, properties and qualities	
Change in urban areas of - kind of rocks, rock composition - vegetation, fauna - water household, quality - climate - area segmentation - neighbourhoods of soils **Results** **New environment** for soils therefore - NEW SOILS, new soil properties and qualities, - NEW SOIL ENVIRONMENT for humans, habitats, domestic and wild life	**Reduction** and **loss** of **soil** by - soil consumption from sealing and total erosion (excavation) **Change** of soils by - new materials (new rocks) - accumulation of diverse materials, - contamination - fertilizing, eutrophication - layering of material - mixing of material - compaction - stoniness, loss of fine earth - structure destabilisation **Results** - in part **destruction** of eco - components and soil functions - **changed or new** eco-components and soil functions	

Table A1.1(U): Socio – economic forces

- demographic development, migration - better life chances and exspactations in cities - increase of urban population - population density - size of the city - type of the city (mining, heavy industry, commercial, administration, over regional, - regional, local centre, administration center) - wish to increase life quality by increased living area (m^2 per person has much increased - within the last decades), by living in smaller houses (refusal of skyscrapers), and by low - density building development with larger gardens

Table A1.2(U): Factors influencing the driving forces

- technology and knowledge development
- income increase
- gross domestic product
- consumption behaviour
- type and intensity of land use in urban agglomerations
- sealing
- material and energy flow into the city and out of the city
- material and energy flow between plots according to soil use type pattern in the city
- kind and level of contribution of natural and man made features from the city surrounding to the environment in the city
- dependence from areas outside the city
- resources available in the city
- limitations of the city area
- limitations construction sizes, ground stability, swamps, earth quakes, river plain floods, hard rocks, slopes, physiographic town type
- limitations by availability of transport and traffic lines
- planning models in use
- historical development
- old city centres
- protected archaeological sites
- protected historical buildings, quarters
- regional climate
- regional physiography of landscape
- management of waste, sewage water, drinking water and food, fresh food supply

Table A1.3(U): Research questions about driving forces of quantitative and qualitative development of urban soils

- eco-components for all kind of urban life inclusive habitats
- elements of urban environment as ecosystem factors
- new soil properties
- the soil functions available and not available in urban areas
- kinds, amount and distribution of soil functions
- soil pattern by soil use on plot level and patterns within types of use
- change of natural features by urban soil use
- amount of urban areas.

2. Pressures
2.1 Soil consumption by socio–economic demands
2.2 Changes of soils by man

Table A2.2.1(U): Frequent and dominant characteristics of soil morphology and chemistry

- new sediments
- deposition of man–made materials
- contamination
- layering and mixing of materials
- strong compaction
- floods
- water pipe leakage
- groundwater lowering
- increase of surface high
- use of compost as fertilizer
- soil litter spreading

Table A2.2.2(U): Less dominant and frequent soil characteristics from urban environment involvement

- eutrophication
- alkalinisation and acidification
- phosphorous accumulation
- change of acid neutralisation capacity
- surface crust formation, structure instability
- dominance of single grain structure
- increased shear resistance due to sharp edged grains of any size (broken material, construction material)
- flat loose soil over compacted/sealed layer
- development of roof top soils
- enlargement of surfaces by constructions
- enlargement of boundaries between diverse areas
- new neighbourhoods of areas of different soil characteristics
- decrease of valuable fine earth by accumulation of stones in soils
- in some cases strong accumulation of organic matter
- subsurface drainage, e.g. due to street bearing layers, sand fills in supply lines
- deep burying of organic matter, fresh organic matter
- changes in gas concentration, methane formation
- increase of preferential flows
- increase of small areas with increased seepage
- abundance of soil organisms

Table A2.2.3(U): Specific roles and demands of humans in creating soil characteristics

- use of planning technology
- development of industrial technologies
- irrigation in the city
- construction and operation of cemeteries
- sewage water release, sewage pipe leakage, sump seepage
- fire, traffic accidents, dangerous product transport (oil tanks, chemicals tanks)
- controlled and uncontrolled waste burning
- street cleaning
- parks and green areas maintenance
- domestic garden maintenance
- urban agriculture
- zoo
- vegetable garden use (fresh food supply)
- some kinds of sport (e.g. horseback riding, golf, soccer)
- swimming pool lawn, park lawn
- dust release by earthwork and construction, walking, transport, traffic, industry
- constriction and closing of valleys and alluvial plains
- low soil care

Table A2.2.4(U): Aspects regarding the influence of the components of urban ecosystems

- habitat for pathogenic organisms (fungi, bacteria)
- micro- and meso-climatic effects of the urban relief
- distance open soil – street
- pollutant storage capacity, e.g. by humus, iron
- distribution pathways of pollutants by dust
- storage and retention capacity of porous stony material
- structure between stones
- DOC formation and transport functions for pollutants
- historical development of the city, material, contamination
- war influences
- decade, century of expansion of city, time of city growth
- climatic influences
- main wind direction
- trees as filters
- rock influence
- natural relief influence
- traffic line influences
- kind of industry, big plants
- harbour cities
- mining cities
- dogs and other pets, pigeons
- available city green
- sufficient outdoor free space for children
- sufficient free area for old people walking
- sufficient free area for young and middle aged people outdoor sporting (jogging etc.)
- climatic and weather effects on dust, dust effects and dust release from soils
- contributions of the surrounding as well as far areas to the city
- material, water, energy import, export balances

2.3 Functions of urban soils

Table A2.3(U): Functions of urban soils

- often well preserved relicts of natural soils
- relicts of natural habitats
- relicts of former soil uses, of soil use change, soil use sequences influence
- new habitats, biotopes by new soils
- new soils formation, new soil types
- soil type protection
- soil as archive of the city development
- soil as document of industry history
- soil as document of particular soil use (e.g. railway sidings, airport)
- peculiar soils as element of city planning
- soil as carrier of information
- contribution of soil to green keeping → dust reduction by green keeping → reduction of dust-health costs
- diluting role of soils for dust
- heat balance

Table A2.4(U): Research questions about consumption and changes of soils by man

- peculiar soil characteristics in urban areas related to urban environment, soil use
- characterisation of soil functions in and for the city
- soil evaluation for city purposes, uses
- pattern by soil use on plot level and patterns within types of use
- role of soils for establishment and maintenance of green space

4 Urban Soil: Impacts on soils

Table A4.1(U): Impacts on soils

- reduced soil aeration
- reduces water storage capacity
- reduced heat storage capacity
- inhibited decay of organic substances
- deceleration of storm water infiltration
- increase of reductive features
- alkaline features
- increased frequency of salinity
- contamination of brownfields
- dust formation
- technical soil erosion by excavation, land leveling
- soil erosion by water
- soil erosion by wind
- lack of dilution effect of contaminated dust by soils in winter time
- land sliding
- weathering of building materials
- abrasion from streets
- inhibition of formation of weathering layers by maintenance, wheel and food erosion
- ammonium formation in urban soils
- nitrate in urban soils
- denitrification potential in urban soils
- sinks for dust, contaminants of slots between cobbles
- accumulation and stabilisation of organic matter
- water harvesting by sealing

Table A4.2(U): Impacts on humans

- loss of construction areas
- loss of living area
- restriction of areas for play grounds, sporting, recreation, housing
- health effects by dust
- health effects by contaminants
- health effects by pathogenic organisms
- health effects by climatic conditions
- health effects of gas release, exchange
- children development effects, mental and physical

Table A4.3(U) Impacts on ecosystems

- loss of unique habitats
- loss of archives, loss of information from soils
- loss of extreme environmental factor conditions for scientific studies, e.g. high contamination fields, extreme stony fields

Table A4.4(U): Economic impacts

- health costs
- soil cleaning costs
- soil remediation costs
- flood costs, insurance costs
- land sliding costs
- tax losses by move away of people from the inner city
- fee structure of architects and engineers, paid for amount of excavated and moved soil
- construction pressure by high number of architects

5 Urban soils: Responses

Table A5.1(U): Response by acquisition and processing of soil data

- urban soil survey parameters - urban soil type mapping - urban substrate mapping - urban soil contamination maps - urban soil dust release and catching maps - urban water storage maps - urban heat storage maps - urban soil organism, soil micro-organism maps - mapping, sampling, investigation and monitoring instructions for urban soil types, substrates, contamination, dust release and catching by soils, water storage, heat storage, soil organisms and micro-organisms, soil functions, eco-components, sensitiveness, sealed areas and sealing type composition - assessment instructions, threat calculation instruction - maps of urban soil function - maps of soils as eco-component - soil sensitiveness maps - ratio of soil area to sealed area figures - evaluation maps - on-line availability of urban soil information - completion of definition of urban ecosystem (not only climatic characteristics) - definition of soil functions in an urban as well as in an rural environment

Table A5.2(U) Response by measures

- rules for human behaviour in cities in respect of soil threats - prove in which fields we need targets value - definition of urban soil quality types, classes, and their parameters and criteria they have to be established for - systematic use of land use planning for the development of soil eco-components and soil - construction techniques of low soil compaction - construction techniques of low dust release - transport and production techniques of low dust release - control and management of sensitive areas, soil use types - establishment of dust catching areas - steering of weathering of building materials, surfaces - establishment of soil protection areas - soil cleaning techniques for different levels of contamination - soil loosening techniques for flat compacted soils - soil loosening techniques for deep compacted soils - soil aeration techniques - soil maintenance techniques (fertilizing, composting, liming) - erosion reduction - planting of vegetation covering the surface permanently, or mulch from organic material, not only trees and bushes - definition and establishment of protected soil areas - soil transport rules - soil movement on the site rules

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RESEARCH, SEALING AND CROSS-CUTTING ISSUES

Task Group 6 on
MONITORING, HARMONISATION , SPATIAL DATA, GIS

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Executive summary

An essential point of the European Union political soil strategy launched in 2002 is the availability of high quality information in space and time. The need for soil data was highlighted as one of the main goals of the EU statement on the implementation of the soil monitoring program.

The spatial variability of soils is very high and its diversity is large in Europe. Soil monitoring must include the spatial component of the soil cover. Research is an essential part of soil mapping and monitoring programs to overcome the difficulties in collecting, managing, interpolating and conveying relevant and reliable data.

While abundant information on soils in Europe does exist, organized in geographic databases derived from national soil mapping or monitoring programs, this data is scattered and non-harmonised between countries. From a geographic perspective, large European surfaces have never been surveyed. In addition, existing maps date back several decades and rarely contain the data required to tackle new problems (e.g. contents of trace elements). This is due to the virtual freeze on most surveying activities. Soil monitoring programs are more recent, but still of limited extend. Frequently, they are not linked with basic information on soils coming from pedological databases and maps.

For the development and improvement of spatial and temporal information on soil in Europe the following action are recommended:

<u>Concerning general actions at the European scale:</u>

1. Establish a soil inventory on a common method at medium scale (minimum information 1:250 000) in order to help stratification or zoning for soil threats or to extrapolate local information from soil monitoring programs.
2. Establish a network of pilot areas representative of the main soil landscapes in Europe for quantifying the variability of soil properties in space and time under climatic and human changes.

These two points will constitute a multi-scale soil information system, which is an essential component for an operational soil monitoring system over Europe.

<u>Concerning research actions, final recommendations are:</u>

1. Evaluation, recovery, upgrading and accessibility of existing data. This recommendation includes the understanding of relationships between different analytical methods, the development of pedotransfer functions, the generalisation of local data from existing sources (soil maps, remote sensing…).
2. Acquisition of new data at different scales by using new technologies (e.g. geophysics, digital terrain models…) and development, standardization and validation of innovative methods allowing a quantitative approach of the spatial and temporal variability of soils (e.g. geostatistics, 3D modelling…).
3. Answers to many questions that have been put forward for soil monitoring and that require new research, e.g. how to monitor without disturbance? How to take into account soil volumes or soil patterns (horizons, typological units)? How to measure slow changes in time? How to integrate soil variables with other environmental components? Are local studies representative for larger areas? How far away can we extrapolate data values without losing too much accuracy?
4. Understanding basic mechanisms (and their interactions) that are responsible for the spatial differentiation of soils and their changes resulting from combined effects of climate, biological activity and human actions (i.e. comparison between human impact at short term with pedogenetic factors at long term).
5. Developing mechanistic and stochastic models (or combination of both) for the variability of soils and their properties in space and time, and establishing scenarios under climate change and impacts of human activities. These models should lead to operational tools for assessing soil policy (land and water management, agricultural policy, waste recycling, etc.).

Extended Report
General statements

An essential point of the European Union political soil strategy launched in 2002 is the availability of high quality information in space and time. The need for soil data was highlighted as one of the main goals of the EU statement on the implementation of the soil monitoring program. In the future, this need will increase for assessing the effects of these regulations on soil and land use in Europe.

The spatial variability of soils is very high and its diversity is large in Europe. Soil monitoring must include the spatial component of the soil cover. Research is an essential part of soil mapping and monitoring programs to overcome the difficulties in collecting, managing, interpolating and conveying relevant and reliable data.

In the past, demands for soil data have mainly come from the agricultural sector, which traditionally has taken into consideration the diversity and limitations of soil as a primary production factor. It has been subsequently found that the soil had been damaged, sometimes irreversibly, with consequences not only for its fertility, but also for other natural resources such as water or the atmosphere.

Thus, the environment has become the sector where the majority of demands converge. As a matter of fact, every economic and social sector is now concerned since soil fulfils so many essential, but often neglected, functions for society such as water filtering, bio-geochemical components recycling or carbon storage capacity.

While abundant information on soils in Europe does exist, organized in geographic databases derived from national soil mapping or monitoring programs, this data is scattered and non-harmonised between countries. From a geographic perspective, large European surfaces have never been surveyed. In addition, existing maps date back several decades and rarely contain the data required to tackle new problems (e.g. contents of trace elements). This is due to the virtual freeze on most surveying activities. Soil monitoring programs are more recent, but still of limited extend. Frequently, they are not linked with basic information on soils coming from pedological databases and maps.

Few harmonized programs exist at European scale. The only information available on soil variability is derived from the European soil geographical database at 1:1,000,000 scale. A procedure manual for the establishment of a European soil database at 1:250.000 scale was published in the 1998 framework of the European Soil Bureau Network (ESBN) activities, but only a small number of regions used this manual for soil mapping at 1:250,000.

Finally, the only Pan-European soil monitoring initiative is the forest soil condition survey in the framework of the ICP Forest. This survey is based on a regular 16 x 16 km grid, but limited to soils under forests. Consequently, there is little recent harmonised information covering all of Europe, and what does exist is imprecise, incomplete, or inadequate to the demands for soil protection and sustainability of natural resources.

The soil parameters to be monitored will be indicated by the 3 Working Groups that are handling the threats to soils and by the Working Group on Soil Monitoring.

It is important for the development of further research on soil monitoring and mapping that soil monitoring is performed with harmonized methods; this means that for the recovery of already available data comparability studies are required to correlate data originating from different methods. Pre-normative and co-normative research is an essential step to elaborate European standards for sampling, pretreatment, analysis, data evaluation, etc.

Soil monitoring requires the characterisation of representative sites in terms of soil type, climate conditions, land use and threats to monitor; the same requirements are needed for research to assess process evolution under different conditions. For this a common soil database at EU level at medium scale (at least 1:250,000) could be very useful.

To reduce costs for monitoring existing data, organised in a common soil database, can be used to derive new data using pedotransfer functions, to be defined on the basis of still to be defined common methods and criteria.

Research gaps and needs

These statements have guided our recommendations for short-, medium- and long-term research objectives for future mapping and monitoring programs.

In the **short term**, we propose:

- the evaluation and synchronization of existing data, including a comparability study of data collected and measured using different methods.
- pre-normative and co-normative research for a reliable and complete set of European standards
- the development of an information system that could integrate the diversity of available data and render this information easily accessible using web tools;
- the establishment, from these datasets, of "pedotransfer functions" on the basis of common methods and criteria that have to be developed through research work, to estimate user-required variables (for analytical methods, we could recalculate them on a common basis); this task needs to involve experts from other fields for defining what general queries are the most valuable;
- the improvement of methodologies for risk assessment of many threats (e.g. erosion, compaction, floods and landslides) and to update risk (or vulnerability, or capability, or susceptibility) maps as basic information;
- the improvement and the enlargement of the use of existing information by combining them with new data coming from remote sensing, digital elevation models and geophysics.

Finally, the active participation of researchers in data harmonisation and integration at a European scale and beyond is obviously essential for the optimal use of existing information and for improving accuracy and efficiency in data collection. This last point is essential for harmonization and standardization of general procedures in the European Union , especially for soil monitoring protocols.

In the **medium term**, it is clear that existing information is not sufficient. Thus, acquiring new information that directly addresses the questions posed is required. Recommendations involve:

- the development of an innovative multi-scale method for soil mapping needs based on:
  - (i) resolving and modelling soil spatial distribution laws for major European pedological units from studying small pilot areas;
  - (ii) developing spatial generalisation methods (or scale transfer) to obtain exhaustive and affordable information on European land (e.g. at 1:250.000 as recommended by the ESBN); less costly than a systematic sampling strategy, this approach will provide all the flexibility required to answer to new questions within a reasonable period of time;
- the answers to many questions that have been put forward for soil monitoring and that require new research: for example:
  - (i) How to monitor without disturbance?
  - (ii) How to take into account soil volumes or soil patterns (horizons, typological units)?
  - (iii) How to measure slow changes in time?
  - (iv) How to integrate soil variables with other environmental components?
  - (v) Are local studies representative for larger areas?
  - (vi) How far away can we extrapolate data values without losing too much accuracy?

Soil mapping and soil monitoring should be merged into one objective, which could explain soil evolution under anthropogenic impacts on large areas.

A multi-scale method should replace inventory programmes and allow the spatial extension of results coming from benchmark sites of soil monitoring.

Regarding the development and the validation of new techologies:

1) A common problem in environmental assessment is to determine the value of a continuous attribute at any particular un-sampled location, the uncertainty of un-sampled values, and the probability that a soil criterion is exceeded for any un-sampled location. Most soil parameters are sampled and measured with a very low resolution compared to the large surface to be estimated. Representativeness and extrapolation of measurements are thus needed. Geostatistics provide the base for analysing data that varies continuously spatially and for inferring values of the same variable at un-sampled locations through interpolation techniques. It is accepted that almost all environmental processes are scale-dependent. This fact is important not only for defining a suitable scale of spatial resolution appropriate to bring to light the variation / relationship of interest, but also for describing the nature of the spatial variation among data. Consequently, geostatistical methods need to be developed and/or adapted in order to quantify the spatial and temporal variability of soils.
2) Geophysical methods are now employed in the description of the near sub-surface of the earth in order to characterize landfills or to determine the pathway for pollutant migration, in addition to the physical characterization of soils. Geophysical methods are: (i) non-intrusive, non-penetrative, (ii) considered cost-effective in comparison with other methods, and (iii) time effective. All these features make geophysics a desirable method for the environmental assessment of soils. These methods or any other approach, given the exhaustive information needed for large areas, require further research in order to provide operational tools for the assessment of soil evolution in large territories.

In the **long term**, the research will focus primarily on developing mechanistic and stochastic models based on the understanding of basic processes responsible for the spatial organisation of soils into «functional pedological systems». This objective needs to quantify soil-time factors, for example, thanks to measurements on long term monitoring observatories. Soil is also an archive of past events and its spatial variability could be used to measure the soil-time factor. New methods such as isotopes should allow quantifying past changes. Deterministic models will increase our understanding of rapid modifications that have occurred recently due to of changes in climate or human activities, and will help build forecast scenarios. Priority has to be given to more specific aspects of certain soil components, such as, speciation of trace elements and their bio-availability, long-term changes in physical and hydrological properties, and the understanding of the biological functioning of soil, always in relation with the other environmental compartments (air, water, biosphere, etc.).

Final recommendations

<u>Concerning general actions at the European scale, final recommendations are:</u>

1. Establish a soil inventory on a common method at medium scale (minimum information 1:250 000) for stratification or zoning for soil threats or for extrapolation of local information from soil monitoring programs.
2. Establish a network of pilot areas representative of the main soil landscapes in Europe for quantifying the variability of soil properties in space and time under climatic and human changes.

These two points will constitute a multi-scale soil information system, which is an essential component for an operational soil monitoring system over Europe.

<u>Concerning research actions, final recommendations are:</u>

1. Evaluation, recovery, upgrading and accessibility of existing data. This recommendation includes the understanding or relationships between different analytical methods, development of reliable European standards, the development of pedotransfer functions, the generalisation of local data existing sources (soil maps, remote sensing…).
2. Acquisition of new data at different scales by using new technologies (e.g. geophysics, digital terrain models…) and development of innovative methods allowing a quantitative approach of the spatial and temporal variability of soils (e.g. geostatistics, 3D modelling…).
3. Answer to many questions that have been put forward for soil monitoring and that require new research, e.g. how to monitor without disturbance? How to take into account soil volumes or soil patterns (horizons, typological units)? How to measure slow changes in time? How to integrate soil variables with other environmental components? Are local studies representative for larger areas? How far away can we extrapolate data values without losing too much accuracy?
4. Understanding basic mechanisms (and their interactions) that are responsible of the spatial differentiation of soils and their changes resulting from combined effects of climate, biological activity and human actions (i.e. comparison between human impact at short term with pedogenetic factors at long term).
5. Developing mechanistic and stochastic models (or combinations of both) able to describe the variability of soils and their properties in space and time, and establishing scenarios under climate change and impacts of human activities. These models should lead to operational tools for assessing soil policy (land and water management, agricultural policy, waste recycling, etc.).

Clustering research needs on spatial and temporal information on soil in Europe according to the TWG Research agreed scheme

There are two general actions that are fundamental for further research on soil monitoring, although properly spoken they are no research goal as such . They are:

1. the establishment of a soil inventory on a common standardized method at medium scale (minimum

information 1:250.000), creating an effective and easily accessible EU Soil Information System (EUSIS);

2. the establishment of a network of pilot areas representative of the main soil landscapes in Europe in which to set up main research initiatives related to investigation of different soil types

Research actions for soil monitoring on the basis of 5 clusters are the following:

CLUSTER 1 - Deeper knowledge of soil characteristics, soil properties and soil functions

Short term

Recovery, evaluation, upgrading and accessibility of existing data. This includes:

- the comparability between different sampling and analytical methods,
- the development and adopting of European standards,
- the development of common methods and criteria to define pedotransfer functions,

Medium term

- the upscaling of local data (multi-scale approach) and the definition of soil quality indicators on the basis of available data (existing soil maps, remote sensing, etc.)

CLUSTER 2 - New and harmonised methods for soil mapping and monitoring

Short term

For soil monitoring many questions are awaiting answers from research on, for example:

- how to improve soil sampling representativity?
- how to monitor without disturbance?
- how to take into account soil volumes or soil patterns (e.g. horizons, typological units)?

Medium term

Development of:

- new technologies (e.g. geophysics, digital terrain models, etc.) for the acquisition of relevant data at different scales,
- innovative methods allowing a quantitative approach to the spatial and temporal variability of soils (e.g. geostatistics, 3D modelling, etc.);
- methodologies to integrate basic soil data, soil monitoring data and information coming from these new methodologies;

Long term

- new approaches to measure slow change in time (e.g. long term monitoring sites, time soil sequences…)
- integration of soil variables with other environmental components for a global monitoring

CLUSTER 3 - Relating threats to pressures; cross linking with EU and other policies

Short term

Merging soil mapping and soil monitoring into one objective, which explains soil evolution under anthropogenic impacts on large areas in order to answer to the following questions:

- Are local studies about threats and related pressure and driving forces representative for larger areas?
- How far away can we extrapolate data values without losing too much accuracy?
- Which are the best methodologies to compare data coming from different studies about soil degradation processes and collect and elaborate them for the unique purpose of threat impacts assessment?

Long term

- Understanding basic mechanisms that are responsible of the time-related contribution to impact to soils resulting from combined effects of human actions, biological activity and climate (e.g. comparison between human impact at short term and pedogenetic factors at long term).

CLUSTER 4 - Analysis of impacts to other compartments

Long term

Development of mechanistic or stochastic models (or their combinations), including their comparison and validation (to perform in devoted sites that are part of research pilot areas network), able to:

- consider the variability of soils and their properties in space and time (for this a common soil database at EU level is needed),
- integrate them with information regarding other environmental compartments,
- establish impact scenarios on soil status under different human activities and climate conditions.

This includes:

- the development of a common dataset on soil properties and characteristics through a multi-scale approach from which data for impact assessment are available for every competent structure at European , national and regional level ;
- the comparison of different models for the assessment of threats impacts to soil in relation to the same dataset mentioned above and in relation to their use for risk assessment;
- the improvement of information coming from soil mapping and monitoring to be used by modelling the assessment of threats to soil and related environmental compartments.

CLUSTER 5 - Operational procedures for the mitigation of threats

Medium term

- develop methods to derive maps from soil databases (combined with other databases) for assessing policies (land and water management, soil planning, agricultural policy, waste recycling, etc.).

Long term

- establish scenarios for estimating impacts of climate and/or anthropogenic changes. Operational tool to forecast the consequences of the Common Agricultural Policy or other European policies.

RESEARCH, SEALING AND CROSS-CUTTING ISSUES

Task Group 7 on
SOIL AND DATA PROPERTY, SOIL LEGISLATIVE FRAMEWORK, SOIL CONSERVATION SERVICE

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A: Summary

Soil ownership is a very old phenomenon in the European Union's Member States, but the way of using this ownership is subject to the spirit of the times. The value of soil as a raw material or a tool for production has decreased over the years. Its modern value is closely linked to its use rather than its composition. Owners have an interest in keeping their property in the best possible condition. Ownership is therefore an indicator of the use of the land and should be analysed as such.
We recommend:

> Monitoring of several aspects of the Community soil ownership (its nature and duration) and the development of soil value as a function of time, use and region.

Ownership of soil data is a very relevant theme to the Community. There are different kinds of existing data. Some data are published and are for common use; other data are subject to commercial use and are only available after payment. There are also data that for a variety of reasons are only available to (mostly private) owners.
The EC dedicates herself to transparency by developing eEurope. The way in which data are disseminated is subject to a legal Community discussion, the so-called INSPIRE project. This project outlines the policies and framework needed to create an infrastructure for spatial data in Europe. So there are good opportunities for the Soil Thematic Strategy to join this initiative.
We recommend:

> Close cooperation with the INSPIRE initiative. This will be beneficial to the activities of both INSPIRE and Soil Thematic Strategy. Initiatives to this end should be taken. The Commission will soon adopt proposals from either. These proposals should refer to each other.

Soil legislative framework. The goal of the policy and legal framework to be developed is the effective protection of the soil. This goal is not dogmatic and it is not the intention to create partial solutions. The basis is to create sustainable solutions that harmonize with other policy areas. In other words, it is an integrated holistic approach that is sought after.

Until recently soil has been considered a raw and neutral material to fulfil the population's immediate or short term needs. State-of-the-art scientific knowledge has not prevented the degradation of soil and landscape resulting from the pressure of the consumer society. Sustainability and biodiversity have recently become new major goals, which neither planners nor ecologists used to take into account.

To ensure the best possible use of the policy tools the framework should be quality management based - solving problems by a cyclical method of planning, taking action, evaluating and fine-tuning. A specific policy on soil has to be defined before a legal framework could be introduced and accepted.
Legal regulations contributing to various soil protection themes on EU and MS level are already valid in the Community. The question whether they are protective enough belongs to the last stage of the policy life cycle, the fine-tuning. Many other soil themes, however, have not been dealt with yet. Here the policy life cycle is in its first stage, in which the problem still has to be identified and afterwards the action to be taken has to be planned. The stage of soil policies also differs geographically.
The soil policy and legal framework has to arrange all stages in order to arrive at a sustainable solution. It will be quite a challenge to bridge these differences in policy.
Qualified studies are important tools to enhance the rise of new policy approaches. However, strategic studies concerning the soil policy and legal framework are hardly available. This virtual absence of integrated soil policy and legal studies is a serious shortcoming. Therefore we recommend to produce in the short term:

> An in-depth evaluation of existing EU policies having direct or side effect on soil.

and:

> An in-depth evaluation of successful regional experiments with respect to the scaling up to larger parts in Europe.

We recommend the following action to produce results in the long term (within several years):

> Analysis of the variety of existing soil protection laws in EU member states not including remediation aspects, and in-depth evaluation of existing EU soil protection legislation, with specific reference to legal and political instruments and competence

The blueprint of what the soil policy and legal framework has to be and a clear vision on the means to achieve it has to be produced in the years to come. The building phase of the soil policy and legal framework will start as soon as these blueprints have been adopted. Balanced decision making on structuring and implementing the soil policy and legal framework can only take place if thorough studies as proposed above are available.

Soil conservation service. The debate about the implementation structure is closely linked to realization of the soil policy and legal framework. Apart from the traditional discussions about subsidiarity, it is clear to us that the Framework requires an approach that does justice to the large, spatially determined differences in soil type, soil use and social-cultural soil aspects. The debate about the soil conservation service very much belongs to this context.

The idea behind the soil conservation service is that it can be difficult for individual land users to protect and improve the soil. Cooperation between well-organized and specialist regional services, financed by the central government, has been the traditional answer to this. A wide range of soil-related implementation aspects (soil protection, soil improvement, information, soil remediation, research etc.) can be incorporated in this. The Service should especially focus on urban, suburban and industrial areas as the European population suffers most from soil problems there than in rural ones.

We recommend the following research in order to work out the idea of the soil conservation service in greater detail (medium term):

Research into objectives, structure and capacities of regional and national Soil Conservation Services that have already been well established, and research into the reasons why regions have not been covered by administration, management, improvement measures and research.
The demands on Soil Conservation Service objectives, structure and capacities at regional, national and European levels.

B: Soil Ownership

Authors: Stef Hoogveld and Marie-Alice Budniok

Soil ownership is a very old phenomenon in the European Union's Member States, but the way of using this ownership is subject to the spirit of the times. The soil can be either privately or publicly owned. The use of the land, and the economic and political situation influence the nature of the ownership.

The main driving force for national and European legislators to regulate the use of soil has been the public interest. This complex them has to take into account the balance of interests linked to the intended uses of soil, which can vary from one period of time to another. A modern approach of this phenomenon is the need for an optimum use of the soil by its owners (private and public), operators and users (tourists), for the best interest of the community. Examples that owners are involved in durable soil management are abundant. The European and Member States' policy should aim at supporting this behaviour.

The negative impact of an activity could lead to a liability of the "operator" or user of the soil, in compliance with existing regulations. On the other hand, compensation for a positive impact due to undertakings going beyond the baseline should be more developed. These actions must be orchestrated to ensure a maximum of success.

The value of soil as raw material or a tool for production has decreased over the years. Its modern value is closely linked to its use rather than its composition. Poor soil may have a high value in tourist areas. Land used for production has decreased in value while the value of urban soil has increased. Owners have an interest in keeping their property in the best possible condition. Ownership is therefore an indicator of the use of the land and should be analysed as such.

Therefore the following should be monitored:
- The nature of the ownership (public, private, individuals, companies etc.);
- The duration of the ownership (short term, medium term, long term);
- Owner as direct or indirect operator of the soil;
- Development of soil value as a function of time, use and region.

C: Ownership of Soil Data
(Identical to the report of the monitoring task group on private ownership)

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Introduction:

The monitoring mandate under 4.5 "Access to information" draws attention to the fact that we have to take into account that soil is largely privately owned in the EU. Therefore the working group has been asked to analyze the difficulties of setting up a soil monitoring system linked to the private ownership of the land. In particular the relationship between

1. Public access to information,
2. Rights on environmental and health protection and
3. Private ownership of the land

will be analyzed.

1 Public access to information

Discussing the public access to information requires the existence of data. Various kinds of data are available. Some data are published and available to the public; other data are subject to commercial use and are only available after payment. There are also exist data that for several reasons are only available to the (mostly private) owners.

Directive 2003/4/EC of the European Parliament and the Council of 28 January 2003 on public access to environmental information and repealing Council Directive 90/313/EEC exclusively regulates the public access to environmental information.

Everything becoming part of the monitoring directive must comply with Article 7 of Directive 2003/4/EC. Therefore, every proposal for the monitoring directive must be in line with the spirit and the regulations of Directive 2003/4/EC (see Annex 1).

The way in which existing data are disseminated is subject to a legal Community discussion, the so-called INSPIRE project. The Data Policy and Legal Issues Working Group of INSPIRE has outlined the policies and legal framework needed to create an infrastructure for spatial data in Europe in a Position Paper. This paper is extracted below.

"In some cases soil data have been gathered, but are not available for common use. To protect commercial, personal or national security interests data can be exempted from information systems or restricted in use. It concerns large amounts of data if there are large interests (for instance mining activities). Within the European Community there are different interpretations of "personal data" and different approaches to managing certain information, which, although possibly not "personal" as such, may be closely related. This leads to situations where similar information will be available in some states and not in others.

To address this issue, it is recommended that data about the state of land or the nature of activities on that land, except to the extent that they give information about how individuals contribute to such activities, should be disclosed and that in any event emissions data must be disclosed. Such a provision would minimise conflict with human rights obligations to provide information necessary to protect health and property."

2 Rights on environmental and health protection

All the constitutions guarantee the private ownership of land. Legal restrictions and obligations derived from the private ownership of land differ from member state to member state and are mostly linked to the nature of the threats and their possible impact on the general public.
In cases of acute danger or threat to the environment most of the Member States have legal provisions to force, if necessary, private landowners to tolerate measures to avert the danger as long as those measures are unavoidable and in the special interest of the general public. These measures, action driven monitoring included, take place locally during a limited period of time, for a specific purpose and have to remain exceptional. Therefore this kind of monitoring cannot be used for a survey, large in scale and time and dealing with the Community wide soil status.

3 Private ownership of the land

3.1 Active and passive sampling

The monitoring directive shall indicate whether landowners are expected to contribute and if so, to what extent and nature. Private landowners may contribute actively or passively to the soil monitoring system.

- Active: Data and information, landowner e.g. concerning land use, management, kind and amount of fertilizers to be provided by the landowner,
- Passive: Sampling and measuring activities to be tolerated by the landowners resulting from the right of certain authorities to act on private land.

3.2 Global soil monitoring in Europe

To draw valid conclusions concerning global soil quality in Europe it is generally accepted to gather information using a (stratified or gridded) randomized method. Because land in Europe is mostly owned by private persons or organizations it is inevitable that monitoring plots will be located on their properties. It will harm the validity of the outcome if too many sampling plots have to be abandoned. As long as there is no acute threat the landowners have the right to refuse sampling.

So here we may encounter a problem. How can access to a particular site, located on privately owned land, and of special concern and necessity for representative reasons, be achieved? A solution can be found to enforce access within the mechanisms of the national legal frameworks. Should a solution on the basis of a contract be considered, or should the right of sampling for more global purposes be more specific? This has to be discussed within the Soil Thematic Strategy.

To shape the contours of the future EU monitoring system further discussion on the following possible elements is needed:

- From a subsidiarity point of view: Is there any need for some Community wide concord in gathering the necessary information.
- As the monitoring directive aims among others at comparing the soil aspects between the member states, the differences between the national legal frameworks at this point have to be taken adequately into account.
- The type of storage of data is of importance. If the information gathered on private land can be stored in an anonymous manner, landowners may be less hesitating to cooperate.
- The way in which the information is published may also influence the willingness of the (land)owners. Recently Europe has adopted a Directive on the re-use and commercial exploitation of public sector documents (COM (2002) 207, Directive on Public Sector Information, see annex 2). Is there any possibility to compensate the owner?
- Obligation and time frame for a report on soil status at regular intervals to the public, the parliament and the council might be of importance. If a landowner experiences benefits from the monitoring on her property (e.g. the knowledge of having a good soil quality) she might be more cooperative.
- Linking with or integration into other on EU level available databases with relevance to changes in soil and/or relevant to the right interpretation of monitoring results.

The discussion of these items should not be held by the Soil Thematic Strategy alone because the elements mentioned above are not specific to soil. This is a much bigger issue in other sectors of society, for example medical information about individuals. The Commission has recognized this problem and therefore started INSPIRE.

3.3 Cooperation with INSPIRE

INSPIRE is concerned with the preparation of Community legislation aiming at providing relevant, harmonised and quality geographical information for the purpose of formulating, implementing, monitoring and evaluating of Community environmental policy-making and for the citizen. After several years of preparation INSPIRE is now formulating its final proposal to be adopted by the Commission in the second quarter of 2004. This proposal will consist off scope and measures, and an extended impact assessment.

The soil data theme to be adopted within the scope of INSPIRE is of great significance. The Soil Thematic Strategy will benefit from the measures INSPIRE proposes. It is highly recommended to join forces. Since both STS and INSPIRE are coming to an interim end soon, full participation cannot be achieved at the moment. Both proposals must accept their interrelationships and prepare cooperation in the next phases.

It will be very useful to participate in the impact assessment, since STS also has to formulate the impact of its own proposals. The decision should be taken whether the STS or INSPIRE accounts for the impacts. The INSPIRE Expert Group has recognized this problem and is drawing up proposals about how to deal with it.

4 Recommendations

Directive 2003/4/EC exclusively regulates public access to environmental information. Everything becoming part of the monitoring directive must comply with Article 7 of directive 2003/4/EC. Therefore every proposal for the monitoring directive must be in line with the spirit and regulations of directive 2003/4/EC.

The use of data, either being subject to commercial use or privately owned, for the future EU monitoring system has to be regulated by contract.

Close cooperation will be beneficial to the activities of INSPIRE and Soil Thematic Strategy. Initiatives to this end should be taken. The Commission soon will adopt proposals from either. These proposals should refer to each other.

D: Soil Legislative Framework

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1 Terms of reference

In order to formulate a soil protection strategy, an approach has been selected to analyse the most important threats (erosion, soil pollution, biodiversity) by theme-related working groups.

These working groups have analysed the threats and have made recommendations how to respond. The nature of their responses depends on the characteristics of the threats analysed. Thus a multicoloured palette of actions with various dimensions has been created:

- Time: Generally speaking a day-to-day approach has mainly been used up to now. Considerations of medium and long term approaches are put forward now;
- Scale: Problems are defined not so much by administrative boundaries but primarily by regional and local differences in soil properties and use;
- Impact: The measures proposed are usually not evaluated in terms of the social and economic side effects.
- Interests: proposed actions can be formulated to improve soil utilization in accordance with landowners' interests.
- Organization: Measures that have been proposed will also have to be carried out. The organizational structure should make maximal use of the skills of soil specialists cooperating with other relevant disciplines

The challenge is to use this palette in such a way that a balanced picture emerges - the policy framework for efficient soil protection.

The goal of the policy and legal framework to be developed is the effective protection of the soil. This goal is not dogmatic and it is not the intention to have partial solutions. The basis is to have sustainable solutions harmonized with other policy areas. In other words, it is an integrated holistic approach.

Based on the results of the theme-related working groups and the DPSIR analytical framework the following questions will be addressed:

- What is the status of this policy and legal framework?
- What will stimulate the development of this framework and what will tend to do precisely the opposite?
- How will we respond to the situation as indicated?

Using this approach the Task Group aims at identifying research issues and gaps in current knowledge.

2 What is the status of this policy and legal framework?

Until recently soil has been considered a raw and neutral material to fulfil the population's immediate or short term needs. State-of-the-art scientific knowledge has not prevented the degradation of soil and landscape resulting from the pressure of the consumer society. Sustainability and biodiversity have recently become new major goals, which neither planners nor ecologists used to take into account.

The first policy and legal measures emerged some decades ago. Until now they have been made on a one-aspect approach basis, a step-to-step approach, linked to the specific uses of the soil. For instance, products used on soil have been authorized to ensure sufficient production and human and animal food safety (cf. ergot); soils are declared unfit for building to ensure human security against floods or rock falls, and specific legislation has been introduced to handle contaminated sites.

The analyses of the working groups show that the protection of soil has been in part successful but that despite this success deteriation is ongoing. Until now the policy and legal system has not been able to deal adequately with its negative impacts like side effects or even adverse effects.

The call for a more mature soil policy is therefore arising: " ... We need to select a more strategic approach. We have to make the best possible use of a whole series of instruments and measures in order to influence the decisions taken by the business community, consumers, general public and decision makers." (6.eap).

The soil policy and legislative framework can be considered the translation of this strategic approach. To ensure the best possible use of policy tools the framework should be quality management based - solving problems through a cyclical method of planning, taking action, evaluating and fine tuning.

A specific policy on soil has to be defined before a legal framework could be introduced and accepted.

The responses of the working groups cover the broad palette of policy tools such as prohibitory stipulations, enforcement, stimulation, covenants, protection of special areas, levies, free market forces, soil remediation rules, and education. The responses formulated by the thematic working groups are in line with this new type of soil protection. The Working Group on Organic Matter states that existing thematic policies influence directly or indirectly soil organic matter. The Working Group on Contamination admits that legal Community regulations contributing to various soil protection themes on EU and MS level are valid, but questions whether they are protective enough.

So the policy tools have to be harmonized with each other as well as with other interests that deserve protection. These policy tools are not a goal in their own right but have to be subordinate to the interests of soil protection as a whole.

3 What stimulates the development of this framework and what tends to do precisely the opposite?

Qualified studies are important tools to enhance the rise of new policy approaches. We have the impression that there are barely any strategic studies available concerning the soil policy and legal framework. International studies into such issues as the legal aspects of soil remediation have carried out on a regular basis, but they are essentially always sub-studies. They will undoubtedly make a valuable contribution to the desired integrated approach.

Initial attempts have been made in the past. Blum, for example, wrote about the need for an integrated approach like this early as 1989. The recently revised Charter of the Council of Europe (2003) also underlines the need for integrated action.

Balanced decision making about structuring and implementing a soil protection policy and legal framework can only take place if thorough studies are available.

As stated before legal regulations are already valid in the Community, contributing to various soil protection themes on EU and MS level. The Working Group on Contamination has noted that the question whether they are protective enough belongs to the last stage of the policy life cycle, the fine-tuning.

Many other soil themes, however, have not been dealt with yet. Here the policy life cycle is in its first stage, in which the problem still has to be identified and afterwards the action to be taken has to be planned.

The stage of soil policies also differs geographically. The policy and legal framework has to deal with the different levels of maturation between Member States and regions as well.

The soil policy and legal framework has to arrange all stages in order to arrive at a sustainable solution. It will be quite a challenge to bridge these differences in policy.

4 How can be responded to the situation as indicated?

Societies have always been conscious of the impact of their acts on soil resources. The idea of a hardly reversible negative impact on natural resources has become unacceptable only recently for developed and modern societies. Soil pollution takes time to build up and it can only be combatted, if at all, by substantial efforts.

The fact that expensive soil remediation activities have taken place throughout Europe since than demonstrates that society is aware of the importance of good soil quality. However, under the integrated soil protection concept, these sorts of measures, no matter how important they are, remain sectoral activities. The key is to protect the many functions that the soil has in a coordinated way in an integrated policy and legal framework.

We consider the virtual absence of an integrated policy and of legal studies to be a serious shortcoming. These types of studies bring harmonization and legitimacy to the theme-related soil protection strategy that is to be developed. It is urgent that studies should be started to analyse and work out the concept of integrated soil protection in more detail. Multidisciplinary expertise (an excellent research team with multidisciplinary expertise like soil science, economics, law, sociology) should be mobilized to this end as soon as possible.

It is important in this regard to select a method initiating a dynamic and holistic process involving the theme-related working groups so that their science-based recommendations, the framework and other EU frameworks can be harmonized with one another.
As mentioned before efforts must be made to report the draft findings as soon as possible to ensure that recommendations support the political discussions.

Actions to be taken in the short term (within one year) will lead to some good results soon. The following suggestions have been made:

<u>In-depth evaluation of existing EU policies having direct or side effect on soil.</u>

This evaluation must result in concrete proposals to optimise the functioning of these policies with regard to the sustainability of soil. Current discussions about Good Agricultural Practice are an opportunity to implement the soil sustainability main goals on contamination, biodiversity and erosion.

The Water Framework Directive could also be of great use as there are similarities between the needs of the soil environment and the needs of the water environment. The main purpose of the European water policy is "to prevent further deterioration and protect and enhance the status of aquatic ecosystems and, with regard to their water needs, terrestrial ecosystems and wetlands directly depending on the aquatic ecosystems"[1] whereas the main purpose of the soil policy could be defined as "to prevent further deterioration and protect and enhance the status of soils and, and hence, with regard to their soil dependencies, aquatic ecosystems and wetlands".

In-depth evaluation of successful regional experiments with respect to the scaling up to larger parts in Europe.

The last few years a lot of successful regional experiments aiming at integrated and sustainable soil management have been conducted. A good overview is found at Europe's regional website[2].

A global analysis of the reasons why these projects are successful leads to the conclusion that scaling up these successes might be hindered by existing policies. An observed shortcoming is that sectoral legislation might be too rigid when it hampers innovative strength, for instance by a strong top down remedial policy. Another barrier might be that optimising soil fertility and landscape conservation are no core concepts in legislation, causing incompatibility of soil functions with soil uses. As a result of this many actions are externally driven; causing unbalanced measures from a soil point of view.

As there is little scientific evaluation of this type of regional soil policy great efforts should soon be made to this soon since it will result in cornerstones for the blueprint of the soil policy and legal framework.

Actions producing results on the longer term (within several years) should be started soon as the results will be needed then. The next suggestion has been made:

Analysis of the variety of existing soil protection laws in EU member states not including remediation aspects, and in-depth evaluation of existing EU soil protection legislation, with specific reference to legal and political instruments and competence.

The first years to come the blueprint of what the soil policy and legal framework has to be and a clear vision on the means to achieve it must be produced. The building phase of the soil policy and legal framework starts as soon as these blueprints are adopted. At that time there will be a need of the results of the proposed analysis.

E: Soil Conservation Service

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Introduction

Soil conservation is an old instrument of the sovereigns to secure and increase the budget of the state by soil management. The shift from agricultural use of soils to urban, industrial, traffic and mining one, but also increasing military damage did result in disorder of Soil Conservation objectives. Soil Conservation did not follow new trends and demands on soils. Therefore there exists today no organisation which bundles the concerns for soils, soil monitoring for various fields and soil conservation. The situation is that they are extremely scattered and to a large extent not covered by any information, monitoring, managing and legislation structure in Europe and elsewhere. To overcome this soil protection and soil management politics has to be reorganized by inclusion of all soils such as of rural, urban, industrial, traffic, mining and military areas in Soil Conservation. The Soil Thematic Strategy of the European Parliament (European Parliament, A5-0354/2003, 10 October 2003) insists on the performance of soil conservation which administrative instrument is the Soil Conservation Service.

The following report will show the needs for notice of the traditional Soil Conservation and of the change of soil use and profit from soil use in respect of financial objectives and of such of life quality for the population.

1 Driving forces of Soil Conservation Services

Soils have particular features and properties. To study, monitor and to map them is the task of soil survey services.

Soils are used by humans. The capacity of soils for use are depending on two features

- the natural long time capabilities of soils for use and

- the capacity to convert short time investments into yields and other benefits.

Therefore soil policy must administrate three areas
1. Soil Survey and Monitoring for occurrence of soils, their characteristics and properties.
2. Soil Conservation Services has to make sure a sustainable soil use by protecting, maintaining and developing natural long time capability of soils to produce yields, to fulfil functions and to secure health by avoidance of hazards from soils, preserving soil functions and avoiding harmful soil changes.
3. Soil Management for productive short time investments in soils.

Most famous examples for the three areas are
1. Soil mapping
2. Soil fertility conservation and establishment by amelioration measures, remediation of polluted soils, management of landfills, avoiding sealing and to protect natural reserve areas against destruction by drainage,
3. Soil productivity by yearly investments such as fertilizers, pesticides, farm work, sowing and harvesting.

2 State - historical and recent examples

Soil protection had some of its most dramatic events in the wind erosion in the central plains of North America in the thirties of the 20th century. The response was the establishment of the US Soil Conservation Service in 1935.

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[1] Water Framework Directive art. 1a
[2] http://europa.eu.int/comm/regional_policy/projects/stories/index_en.cfm

In Europe Soil Conservation has already a very long tradition. The fight against hunger and the income of states were from the beginning of land take based on the stability and rise of natural soil fertility as long as there were no fertilizer and engineering techniques in agriculture available. The Prussian King Friedrich the Great did bring the work of soil conservation services on a short remark: to win a province in times of peace, or translated: give your population the chance to stay in your country and not make them emigrate to America.

Very early examples of engineering techniques for soil improvement are the use of the River Nil sludge, irrigation, drainage and salinity control in Mesopotamia, the drainage of the Pontic Swamps in Italy by the Romans, dyke constructions along the North Sea by the Frisians, the peat land cultivation in Holland during the High Middle Age, followed by examples in Germany, Scotland, Ireland, Poland, Scandinavia, the settlement of refugees by farm land repartition, etc.

Missing measures of soil protection and rise of short time economic demands above soil protection did emerge in large eroded areas in the Mediterranean countries. On the other hand the occurrence of species rich habitats in Europe of the 19th century is a success of soil conservation measures. The flourishing cultural landscape of that time was established by soil amelioration. The diversity of soil properties increased and gave numerous individuals a place to live.
Very recent soil protection disasters occurred in Western Australia. Change of water balance of landscape by deforestation increases rainwater infiltration and washing salts into the fertile river plains. The problem of loss of the fertile organic soil layer in the tropics and the decrease of organic matter in our soils should be already well known since some years.

The use of organic and inorganic wastes has been always an important part of soil conservation. Recently its importance grew extreme by waste production of the fast increasing urban population in Europe.

Urbanization means also soil sealing with tremendous negative effects. To mitigate sealing and its effects will be a very important new field of Soil Conservation for the large urban agglomeration areas of Europe.

Finally sustainability is not a new idea. The preservation and development of a sustainable soil fertility was the basic idea of agricultural and forestry policy in the 19th century. E.g. old books on plant productions start with chapters on sustainable soil fertility and how to achieve this by soil amelioration techniques.

3 Pressure

3.1 Establishing a Soil Conservation Service administration

The above-described examples show that soil protection and improvement is difficult to achieve by individual farmers or other users of the ground. It means an efficient management structure, the availability of large financial resources and long time planning capacity. It is a task of the governors to make them available. Therefore soil policy of the European Union needs Soil Conservation Services.

3.2 Bundling of soil management activities

Soil conservation concerns other areas of tasks than soil survey and soil monitoring and short time productivity management. But soil conservation is based on knowledge from survey and monitoring, and soil development and protection by soil conservation should be again item of monitoring. So both soil conservation and soil survey and monitoring should be established under the umbrella of one organisation.

Short time soil management on farm level should be task of local organization structures as it is already today.

3.3 Modern tasks of Soil Conservation

So soil conservation had a long tradition in all European countries. But change of economy from agriculture to industry and commerce did lead to the neglect and decrease of soil conservation activities. Today there are increasing demands for soil protection measures and coordination from new threats to soils but also from soils, such as pollution, sealing, compaction, acid rains, change of albedo, change of climate, and loss of habitats, but also of old ones such as erosion, loss of organic matter and water, and salinity.
Soils are sinks and sources of noxious substances and fine dust (PM10). The conservation of buffer, filter, retardation and decomposition functions of soils grow to great importance in human health protection.
So the tasks fields of soil conservation are today not also soil fertility preservation and development but also health and wellness.

3.4 Securing awareness of soils

Due to the characteristic resilience of soils, which distinguishes soil from air and water, it is necessary to have an organization structure, which is devoted to the sustainability of soils and soil functions. Recently the European Parliament (A5-0354/2003, 10 October 2003) highlighted this strong importance of resilience of soils in contrast to air and water and insisted on a soil conservation strategy.

The idea to incorporate these tasks in a Natural Conservation Service or in a Natural Resources Conservation Service fails. National experiences show that in Natural Conservation Services the biosphere dominates nearly totally the targets. Soil themes are marginal considered, often not at all. Natural Resources Conservation Services do not include modern forms of soil and land use such as occurring in urban and industrial areas, which are far off of natural resources concepts.

Problems of sealing, soil consumption, strong contamination, health and artificial landscapes, use of sewage sludge, compost, waste disposal, planning, housing, social and economic demands to soils and ground, introduction of technologies to soils are not objects of Natural Resources Conservation Services.

Finally all ways of incorporating soil matters under the umbrella of other sciences or more wider defined working spheres did result in a decrease in soil awareness.

So we have a big problem of awareness of soils, because they are not visible and normally people have lost contact to soils (think of somebody living in the 10th floor of an apartment house), it is very important to demonstrate the soil as independent field of political and administrative responsibility as it is performed already for water and air.

Thus a Soil Conservation Service would concentrate all problems of sustainable soil use, protection, measures against soil impact, hazards from sealing, health threats from soils and also soil improvement in one hand. Soil Conservation Service as one of the most neglected original three columns of soil administration would be restored. It should be organized together with soil monitoring under the umbrella of one institution to boost efficiency.

4 Soil impacts and responses by Soil Conservation

The soil conservation secures and increases the well fare of the states and their population by soil protection and soil improvement. It secures a sustainable availability and use of soils, culture techniques and others. It prevents hazards from soils. It provides techniques on different fields, such as regulations, planning, measures to achieve soil protection and soil improvement.

Table 4.1: The impacts and fields of activities of soil conservation services are traditional:

IMPACT:	RESPONSE:
- restriction of utilisable soil volume by groundwater	- drainage, regional outlet channels
- lack of soil water	- irrigation
- low base saturation, acidification	- liming
- restriction of utilisable soil volume and of permeability by compaction	- soil loosening
- as above	- deep ploughing
- low content of organic matter	- composting (e.g. wine yards)
- loss of fertile top soil	- wind and water erosion prevention
- plant growth restriction by increased osmotic potential of soils	- soil salinity und alkalinity prevention.

Table 4.2: Optimising long-term factor of soil use, such as

IMPACT:	RESPONSE:
Low efficiency of field work	- field size increase - field shape improvement - location of buildings near the fields - field roads construction - put together of fields.
No or limited use of land	- settlement projects

Table 4.3: Modern objectives will be

IMPACT:	RESPONSE
- soil degradation, reduction of soil quality	- setting of soil quality standards, regional and for diverse soil uses,
- lack of soil functions assessment and	- setting soil functions and soil
- destruction of soil functions	- properties for functions

and

table 4.4: measures against modern impacts such as

- remediation of polluted soils, abandoned and derelict sites (brown fields)
- preventing sealing and mitigating sealing effects
- preventing wind and water erosion in other than farm land
- prevention of organic substance decrease in other than farmland
- managing climatic effects of carbon dioxide release and albedo change by land use and soil moisture content
- preventing and amelioration of soil compaction, enable soil aeration
- preventing ground water pollution and decrease of ground water renewal
- protection and managing biodiversity, also of locations of extreme soil properties (e.g. of high pollution, stoniness, sealed)
- sustainable soil cover of land fills, cover of contaminated sites
- sustainable use, deposition or destruction of communal and industrial sludge
- conservation measures for sustainable play grounds, school yards
- conservation measures for sustainable tourism
- conservation measures for sustainable soil use as recreation areas, sporting areas (horse riding, golf, skiing, trekking, camping, hunting)
- remediation of mining areas
- remediation of industrial, pipe line and traffic accident areas
- de-sealing and remediation of de-sealed soils

- remediation of soils affected by construction residues
- preservation of soil filter, transfer, conversion and decomposition functions
- amelioration of acidified soils
- remediation of eutrophicated soils
- remediation of by pesticides polluted soils
- remediation of soils containing pathogenic organisms
- prevention and remediation of drug polluted soils
- improving burial grounds
- protection of soils for habitats
- peat and wetland protection
- renaturation of wet lands, marshes, river plains, peat lands, dry lands
- storm water infiltration
- soil protection of abandoned rural, urban and industrial sites
- establishing permanent green soil cover, also in cities
- forestation of abandoned and degraded sites
- mitigating and amelioration of soil degradation by military use.

5 Response by Soil Conservation Organisation

To maintain and to develop a sustainable and by this a long time capability of soils to produce yields, preserve nature and to avoid hazards from soils of a modern industrialized and post - industrialized society the establishment of a European Soil Conservation Service is necessary. The European population suffers directly more in urban, suburban and industrial areas from soil problems than in rural ones. Therefore soil conservation must today focus on soil problems of an urban and industrial society and organisation structure must be orientated on this.

The target of Soil Conservation Service in general is establishing conditions by the above measures for a sustainable soil use and soil functions by different soil and ground user groups. The instruments to achieve this are

- monitoring
- administration
- controlling
- planning
- land development
- land improvement measures
- soil conservation information systems
- communication and creation of awareness
  and
- the necessary research.

Traditionally it did concern agriculture and forestry. Industrialized and urbanized societies have extended the demands, so that soil problems of urban, industrial, traffic and mining areas dominate. They must be considered in particular in a Soil Conservation Service today.

6 Research

Individual objectives described in chapter 4 and 5 are in part and to a different degree administrated and managed by different organizations in the member states of the European Union.
For the task of establishment of Soil Conservation Service we should know
and concentrate research on the items of table 6.1.

Table 6.1: Research for or as a first step of the establishment of a European Soil Conservation Service.

- existing state and regional organizations in the European Union which are concerned with the objectives of Soil Conservation Service; their structure, main focus and capacities, and which region they cover and support,
- existing state and regional organizations in the European Union which are concerned with the objectives of Soil Monitoring service; their structure, main focus and capacities, and which region they cover and support,
- objectives of Soil Conservation Services of different regions of Europe which are already well established and those objectives and regions which are not, covered by administration, management, improvement measures and research,
- the demand on structure, objectives and capacities for a European Soil Conservation Service,
- contributions of Soil Conservation Service for local, regional and European Union wide soil protection, soil improvement and soil use, and in general quality of life,
- research structure for a successful European Soil Conservation,
- fields of institutes attached to Soil Conservation Service.

The establishment of a SOIL CONSERVATION SERVICE would be a beneficial measure for the life quality of the population of Europe as well as for the landowner to protect and increase the sustainability of the value of their soils and land. To push the targets of soil thematic strategy the implementation of the SOIL CONSERVATION SERVICE and of SOIL MONITORING SERVICE, and the accompanying research to organize it should start soon.

Annex B1:

DIRECTIVE 2003/4/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 28 January 2003 on and repealing Council Directive 90/313/EEC .

Directive 2003/4/EC exclusively regulates the public access to environmental information.
Everything becoming part of the monitoring directive must comply with Article 7 of Directive 2003/4/EC. Therefore, every proposal for the monitoring directive must be in line with the spirit and the regulations of Directive 2003/4/EC.

The use of data for commercial purposes or being privately owned either for the future EU monitoring system, or deriving from it, has to be regulated by contract.

“The objectives of the Directive are:

(a) to guarantee the right of access to environmental information held by or for public authorities and to set out the basic terms and conditions of, and practical arrangements for, its exercise; and

(b) to ensure that, as a matter of course, environmental information is progressively made available and disseminated to the public in order to achieve the widest possible systematic availability and dissemination to the public of environmental information. To this end the use, in particular, of computer telecommunication and/or electronic technology, where available, shall be promoted. “

The definitions point out clearly that for all the possible contents of the upcoming monitoring directive directive 2003/4/EC must be applied. The most relevant wording reads as follows:

“1. ‘Environmental information’ shall mean any information in written, visual, aural, electronic or any other material form on:

(a) the state of the elements of the environment, such as air and atmosphere, water, soil, land, landscape and natural sites including wetlands, coastal and marine areas, biological diversity and its components, including genetically modified organisms, and the interaction among these elements;

(b) factors, such as substances, energy, noise, radiation or waste, including radioactive waste, emissions, discharges and other releases into the environment, affecting or likely to affect the elements of the environment referred to in (a);

(c) measures (including administrative measures), such as policies, legislation, plans, programs, environmental agreements, and activities affecting or likely to affect the elements and factors referred to in (a) and (b) as well as measures or activities designed to protect those elements;

(d) reports on the implementation of environmental legislation;

(e) cost-benefit and other economic analyses and assumptions used within the framework of the measures and activities referred to in (c); and

(f) the state of human health and safety, including the contamination of the food chain, where relevant, conditions of human life, cultural sites and built structures inasmuch as they are or may be affected by the state of the elements of the environment referred to in (a) or, through those elements, by any of the matters referred to in (b) and (c).

2. ‘Public authority’ shall mean:

(a) government or other public administration, including public advisory bodies, at national, regional or local level;

(b) any natural or legal person performing public administrative functions under national law, including specific duties, activities or services in relation to the environment; and

(c) any natural or legal person having public responsibilities or functions, or providing public services, relating to the environment under the control of a body or person falling within (a) or (b).

Member States may provide that this definition shall not include bodies or institutions when acting in a judicial or legislative capacity. If their constitutional provisions at the 14.2.2003 date of adoption of this Directive make no provision for a review procedure within the meaning of Article 6, Member States may exclude those bodies or institutions from that definition.

3. ‘Information held by a public authority’ shall mean environmental information in its possession which has been produced or received by that authority.

4. ‘Information held for a public authority’ shall mean environmental information which is physically held by a natural or legal person on behalf of a public authority.

5. ‘Applicant’ shall mean any natural or legal person requesting environmental information.

6. ‘Public’ shall mean one or more natural or legal persons, and, in accordance with national legislation or practice, their associations, organizations or groups.”

Article 3 regulates the access to environmental information upon request .

> “Member States shall ensure that public authorities are required, in accordance with the provisions of this Directive, to make available environmental information held by or for them to any applicant at his request and without his having to state an interest.”

Article 4 more or less regulates the exceptions to limit the free access to the environmental information; it reads as follows:

“1. Member States may provide for a request for environmental information to be refused if:

(a) the information requested is not held by or for the public authority to which the request is addressed. In such a case, where that public authority is aware that the information is held by or for another public authority, it shall, as soon as possible, transfer the request to that other authority and inform the applicant accordingly or inform the applicant of the public authority to which it believes it is possible to apply for the information requested;

(b) the request is manifestly unreasonable;
(c) the request is formulated in too general a manner, taking into account Article 3(3);
(d) the request concerns material in the course of completion or unfinished documents or data;
(e) the request concerns internal communications, taking into account the public interest served by disclosure.

Where a request is refused on the basis that it concerns material in the course of completion, the public authority shall state the name of the authority preparing the material and the estimated time needed for completion.

2. Member States may provide for a request for environmental information to be refused if disclosure of the information would adversely affect:

(a) the confidentiality of the proceedings of public authorities, where such confidentiality is provided for by law;
(b) international relations, public security or national defense;
(c) the course of justice, the ability of any person to receive a fair trial or the ability of a public authority to conduct an enquiry of a criminal or disciplinary nature;
(d) the confidentiality of commercial or industrial information where such confidentiality is provided for by national or Community law to protect a legitimate economic interest, including the public interest in maintaining statistical confidentiality and tax secrecy;
(e) intellectual property rights;
(f) the confidentiality of personal data and/or files relating to a natural person where that person has not consented to the disclosure of the information to the public, where such confidentiality is provided for by national or Community law;
(g) the interests or protection of any person who supplied the information requested on a voluntary basis without being under, or capable of being put under, a legal obligation to do so, unless that person has consented to the release of the information concerned;
(h) the protection of the environment to which such information relates, such as the location of rare species.

The grounds for refusal mentioned in paragraphs 1 and 2 shall be interpreted in a restrictive way, taking into account for the particular case the public interest served by disclosure. In every particular case, the public interest served by disclosure shall be weighed against the interest served by the refusal. Member States may not, by virtue of paragraph 2(a), (d), (f), (g) and (h), provide for a request to be refused where the request relates to information on emissions into the environment.

Within this framework, and for the purposes of the application of subparagraph (f), Member States shall ensure that the requirements of Directive 95/46/EC of the European Parliament and of the Council of 24 October 1995 on the protection of individuals with regard to the processing of personal data and on the free movement of such data are complied with (1).

3. Where a Member State provides for exceptions, it may draw up a publicly accessible list of criteria on the basis of which the authority concerned may decide how to handle requests.

4. Environmental information held by or for public authorities which has been requested by an applicant shall be made available in part where it is possible to separate out any information falling within the scope of paragraphs 1(d) and (e) or 2 from the rest of the information requested."

Article 7 regulates the obligation of active dissemination of environmental information and reads as follows:

"1. Member States shall take the necessary measures to ensure that public authorities organize the environmental information which is relevant to their functions and which is held by or for them, with a view to its active and systematic dissemination to the public, in particular by means of computer telecommunication and/or electronic technology, where available.

The information made available by means of computer telecommunication and/or electronic technology need not include information collected before the entry into force of this Directive unless it is already available in electronic form.
Member States shall ensure that environmental information progressively becomes available in electronic databases which are easily accessible to the public through public telecommunication networks.

2. …..

3. Without prejudice to any specific reporting obligations laid down by Community legislation, Member States shall take the necessary measures to ensure that national, and, where appropriate, regional or local reports on the state of the environment are published at regular intervals not exceeding four years; such reports shall include information on the quality of, and pressures on, the environment.

4. Without prejudice to any specific obligation laid down by Community legislation, Member States shall take the necessary measures to ensure that, in the event of an imminent threat to human health or the environment, whether caused by human activities or due to natural causes, all information held by or for public authorities which could enable the public likely to be affected to take measures to prevent or mitigate harm arising from the threat is disseminated, immediately and without delay.

5. The exceptions in Article 4(1) and (2) may apply in relation to the duties imposed by this Article."

Article 8 sets the requirements for the quality of environmental information:

"1. Member States shall, so far as is within their power, ensure that any information that is compiled by them or on their behalf is up to date, accurate and comparable.

2. Upon request, public authorities shall reply to requests for information pursuant to Article 2(1)b,

reporting to the applicant on the place where information, if available, can be found on the measurement procedures, including methods of analysis, sampling, and pre-treatment of samples, used in compiling the information, or referring to a standardised procedure used. "

Fazit:

- Directive 2003/4/EC exclusively regulates the public access to environmental information.
- Everything becoming part of the monitoring directive must complain with Article 7 of directive 2003/4/EC. Therefore every proposal for the monitoring directive must be in line with the spirit and the regulations of directive 2003/4/EC.
- Please remember: The directive entered into force on 14. February 2003. Member States have to comply with the Directive by 14.February 2005 and Directive 90/313/EEC will finally be out of force by that day.

The use of data being subject of commercial use or privately owned for the future EU monitoring system has to be regulated by contract.

Annex B2:

Outline of the Directive on Public Sector Information (PSI Directive)

(derived from http://wwwlmu.jrc.it/ginie/doc/d293_issues_pse_fv3.pdf)

Aim of the PSI Directive

The Directive on Public Sector Information (PSI Directive) aims to ensure that in relation to the reuse of public sector information the same basic conditions apply to all players in the European information market, that more transparency is achieved on the conditions for reuse and that unjustified market distortions are removed. The PSI Directive offers legal certainty for the market players and establishes deadlines for changes, while leaving the Member States to choose the precise way in which its provisions would be adapted to local circumstance. The terms of access to Public Sector Information are left to the Member States to implement.

Principles behind the PSI Directive

The PSI Directive is guided by compliance with EU competition policy to ensure the existence of a workable single market. Additionally it sets out some basic principles for the establishment of an internal EU market for PSI based on:

1. Availability (Article 4)
2. Principles for charging (Article 6)
3. Transparency (Article 7)
4. Facilitating re-use (Article 8)
5. Non-discrimination (Article 9)
6. Fair trading (Article 9)
7. Prohibition of exclusive arrangements (Article 10)
8. Monitoring (Article 12)

Implementation of the PSI Directive

As a result of the Environment Council on the 27th October 2003 agreeing with the European Parliaments amendments and text the PSI Directive is now set to become law by the end of 2003 with Member States having 18 months to transpose the PSI Directive into their national legal frameworks.

RESEARCH, SEALING AND CROSS-CUTTING ISSUES

Task Group 8 on
AWARENESS, EDUCATION, NETWORKING, CAPACITY BUILIDING AND COOPERATION

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Executive Summary

Introduction:

This task is concerned with the development of effective structures that will lead to increased awareness of soil issues through improved education of Europeans at all levels of society, better networking and cooperation of researchers working in soil sciences and related subjects to develop capacity building and critical mass to deliver solutions to combat soil threats and protect and enhance soil resources.

- The development of the EU Soil Strategy is itself a significant Driving Force, as it will require a greater knowledge and debate about soil quality issues.
- Many legislative and stakeholder demands for better management of non renewable resources, for sustainability, and environmental protection.
- The various real world issues which have driven forward the development of the EU Soil Strategy include: Soil Erosion, Flooding, Water pollution, Sustainable agriculture, The need for development on contaminated land, Food safety, Climate change.
- At European and National Level, there is a need to develop Sustainable Development Indicators, which often will include some soil indicators.
- The need to raise public awareness on the value of soil as a finite and invaluable resource and link this to the merits of soil protection legislation.
- Good management of soils requires resources and attention to detail from land managers.

Pressures:

- The primary factor is the need to manage all tasks within limited financial resources.
- The need to develop more cross-cutting (multi-disciplinary) approaches to research and information management
- The opportunities arising from greater availability of IT and improved IT capability.
- The opportunities arising from FP6 in relation to developing good information transmission.
- The need to develop greater openness and involvement of the general public in the management of environmental issues.

State:

- There is a perception that **Public awareness** of soil issues is generally poor, in comparison with the public's knowledge of other environmental issues such as air pollution, water pollution and wildlife conservation.
- Soil issues have a low priority in **basic education**, and there is need to strengthen soil science and soil geochemistry education in schools and **Universities**.
- There is a perception that the **political commitment** to soil protection is less marked than the commitment to protection of air and water and wildlife conservation.
- There has been some development of **professional and scientific networks**, on soils.

Impacts:

Damage to soils generally occurs slowly, is relatively difficult to reverse, and often causes significant effects at places distant from the soil itself. In some cases the response is not linear and there can be abrupt and catastrophic change, which is typical of highly buffered systems. Often land managers do not realise the damage that they are causing off-site, or in the longer term to their own land, by managing soils in a particular way. Furthermore policy makers often do not appreciate that the solution to some problems may lie in better soil management within the catchment rather than trying to develop end-of-pipe solutions to environmental problems.

Responses:

- There is a need to improve public awareness of soil related issues.
- There is a need to increase the awareness of scientists and professionals to the importance of soil.
- Scientific societies could also be involved such as the International Union of Soil Science (IUSS).
- Actions aimed to help express the social demand toward soil and to renew the teaching of Soil Science should be sustained and encouraged.
- It is important to develop robust indicators of soil quality, soundly based in scientific evidence, in order to develop a political commitment.
- There is a need to demonstrate that it will not be possible to achieve Sustainable Development unless we have a full regard for soil quality, both at the policy and operational level.
- It is necessary to continue to develop information for Land Managers and their advisers.
- Methods should be developed for integrating different issues of soil protection into agricultural and rural development programmes.
- There is scope for much better exchange of information on soils research.
- It is necessary to continue to develop relevant networking opportunities.
- There could be benefits in developing an ERA-NET proposal on soil protection to help develop better transnational collaboration on soil issues.
- There would be benefit in creating a single website for soils information.
- Evidence is needed to show that soil does matter beyond the legislative "contamination" issues and the agricultural productivity/fertility context.

Conclusions:

Soil Protection is a pan-national issue requiring networks and cooperation. The European Commission and MS should enhance or develop effective research instruments to address awareness, education, networking, capacity building and cooperation in relation to soils.

There is a need to:

- raise the general understanding of soils and issues affecting soils through education.
- reaffirm the importance of soil in society in a general and in a political sense.
- promote the transfer of knowledge and experience from the research domain to the public

Introduction

This task is concerned with the development of effective structures that will lead to increased awareness of soil issues through improved education of Europeans at all levels of society, better networking and cooperation of researchers working in soil sciences and related subjects to develop capacity building and critical mass to deliver solutions to combat soil threats and protect and enhance soil resources.

The successful implementation of the conclusions of this task will lead to a substantial increase in the knowledge level and understanding of soil issues of the European citizen, and the development and more effective use of soils knowledge and expertise in managing practical issues. Soils have a profound economic, environmental and social role and soil related research addresses many of society's most fundamental questions (food supply, water quality, bio-diversity, human health, etc.)

These goals can only be made effective through improved collaboration and education.

We followed the mandate of the Research Working Group, and took up the suggestion of the Vienna meeting that we should follow the framework of DPSIR, i.e.

- **D**riving forces
- **P**ressures
- **S**tate
- **I**mpacts
- **R**esponse of the society

Driving Forces

What are the Driving Forces affecting awareness, education, networking, capacity building and cooperation in soil protection in Europe?

There is some difficulty in differentiating between Driving Forces and Pressures in the context of this Task Group. The Group has decided that the most appropriate way of dealing with this is to consider that Driving Forces are those which directly influence the direction of the Task, whereas Pressures are external influences which have to be taken into account.

The development of the EU Soil Strategy is itself a significant Driving Force, as it will require a greater knowledge and debate about soil quality issues. There is a need for better information on the state of soils through the development of indicators of soil quality.

There are many legislative and stakeholder demands for better management of non renewable resources, for sustainability, and environmental protection (e.g. environmental legislation, soil reclamation guidelines, soil use regulation –e.g. Environmental Management Systems). These require that stronger awareness, education, networking, capacity building and cooperation on soils is created.

The various real world issues which have driven forward the development of the EU Soil Strategy are also Driving Forces in their own right. These include:

Soil Erosion
- Flooding
- Water pollution
- Sustainable agriculture
- The need for development on contaminated land
- Food safety
- Climate change

etc.

At European and National Level, there is a need to develop Sustainable Development Indicators, which often will include some soil indicators.

Another Driving Force is the need to raise public awareness on the value of soil as a finite and invaluable resource and link this to the merits of soil protection legislation. In many cases, the public perception of environmental legislation is not fully understood and should be communicated in a more effective manner. One key area is through education – not only at school and university level but also to the public at large. It is clear that if we are to improve the appreciation of soils, and improve the recognition of good soil management and conservation of soils, it is necessary to increase the perception of the importance of soils in many sectors of society.

Good management of soils will require resources and attention to detail from land managers. Sometimes there will be compromises between good management and economic returns (e.g. the need to harvest crops under wet conditions), and management decisions need to be made with the benefit of good scientific information.

Pressures

What are the Pressures affecting awareness, education, networking, capacity building and cooperation in soil protection in Europe?

Pressures are external influences that affect the needs of this Task Group but are not Driving Forces. There are several such Pressures:

- The primary factor is the need to manage all tasks within limited financial resources.
- The need to develop more cross-cutting (multi-disciplinary) approaches to research and information management
- The opportunities arising from greater availability of IT and improved IT capability.
- The opportunities arising from FP6 in relation to developing good information transmission.
- The need to develop greater openness and involvement of the general public in the management of environmental issues.

State

What is the current state of awareness, education, networking, capacity building and cooperation in soil protection in Europe?

The state for this Task Group is different for the different issues under consideration:

- There is a perception that **Public awareness** of soil issues is generally poor, in comparison with the public's knowledge of other environmental issues such as air pollution, water pollution and wildlife conservation. There are already some good-practice-examples concerning awareness raising for general public, e.g. the Worldwide EXPO-Project "Fascination of Soil" (www.obe2000.de), the soil exhibition "under.World – The Univers under our feet" (www.osnabrueck.de/unterwelten/) and the European Geopark Terra.Vita (www.naturpark-terravita.de).

- Soil issues have a low priority in **basic education**, and there is need to strengthen soil science and soil geochemistry education in schools and **Universities**.

- There is a perception that the **political commitment** to soil protection is less marked than the commitment to protection of air and water and wildlife conservation. However there are signs that this is changing as initiatives such as the EU Soil Strategy, Landfill and Sewage Sludge Directives demonstrate.
- There has been some development of **professional and scientific networks**, including:

  - European Soil Bureau (ESB) is a network which tries to harmonize national soil data,
  - ESB has good connections especially to people dealing with agricultural and other vulnerable soils;
  - Forest soil experts have the ICP Forest monitoring programme;
  - Geologists have the FOREGS Geochemical Baseline mapping programme providing data on natural background and diffuse anthropogenic concentration of elements in soils and sediments;
  - experts working with local soil contamination problems have networks such as Cabernet;
  - CLARINET also operates effectively on the contaminated land side
  - the European Environment Agency contacts soil experts through the EIONET network and collects soil related environmental data for indicators.
  - International Soil Conservation Organisation (ISCO) advocates the sustainable, productive, and efficient use of soil and water resources with am international perspective.
  - From a US perspective, the Soil and Water Conservation Society fosters science and the art of soil, water and related natural resource management to achieve sustainability.
  - The International Soil Reference and Information Centre (NL) is is the World Data Centre for Soils of the International Council for Science
  - The International Soil Science Society (ISSS) was established in 1924 as a private, non-profit organization to foster all branches of soil science and their applications
  - COST programme on Phosphorus Loss from Agriculture (now completed).
  - URBSOIL network based on FP5 project in progress that deals with urban soil quality definition (http://urbsoil.paisley.ac.uk) and decision support processes…NOT from a contaminated land point of view.
  - Other FP6 soil related programmes are listed on CIRCA website.
  - The European Land and Soil Alliance (ELSA) is a network of European local authorities as well as organisations, institutions and NGOs (in accordance to the European Climate Alliance). ELSA considers itself to be a platform and lobbyist for municipal soil conservation and sustainable use of soil and land.

Some of these networks have arisen from EU Framework Programmes, and so tend to have a limited life span.

Impacts

What will be the impact of either poor or good status of awareness, education, networking, capacity building and cooperation in soil protection in Europe?

Damage to soils generally occurs slowly, is relatively difficult to reverse, and often causes significant effects at places distant from the soil itself. In some cases the response is not linear and there can be abrupt and catastrophic change, which is typical of highly buffered systems. The implication is that if we can improve knowledge about soils and embed the knowledge into normal management there should be less risk of creating off-site damage, and damage which may be difficult to reverse. Often land managers do not realise the damage that they are causing off-site, or in the longer term to their own land, by managing soils in a particular way. Furthermore policy makers often do not appreciate that the solution to some problems may lie in better soil management within the catchment rather than trying to develop end-of-pipe solutions to environmental problems.

A further impact of poor networking and cooperation is the feeling of isolation. Many people feel impotent to combat environmental issues as they are not aware of similar efforts. Additionally, research programmes on soil issues are not co-ordinated across EU Member States leading to a dilution of effort and resources.

What evidence do we have that ignorance of soil issues leads to poorer management decisions?

1. These are not well documented, but evidence does exist on e.g. inappropriate agricultural soil management having an impact on water resources and human health; erosion resulting from deforestation activities; soil sealing and increased incidence of flooding
2. Greenbelt v brownfield development decisions – many across the UK: see figures from Germany, also high speed rail network in Italy? Housing, industrial developments etc http://moland.jrc.it/
3. Allotment management decisions often at odds with users especially when utility owned sites
4. Across the EU the status of non agricultural or non contaminated soil is very diverse and influenced by a wide spectrum of legislation, cultural attitudes, history etc. (eg try getting to sample grave yards in EU countries!)
5. There are a number of examples of soil contamination by industrial plants for lack of soil knowledge.
6. Accidents as a result of mining (e.g. Aberfan, Aznacollar, Baia Mare)

What evidence is there that better networking between scientists produces benefits?
We know it does (or should)…but not sure how to gather the evidence.

- European Soil Bureau has led to the development of harmonized data on soils for EU Member States, Accession and Candidate Countries, NIS and North Africa.

- o Research networks initiated through FP5 Shared Cost Actions have delivered research solutions to soil protection issues (http://pesera.jrc.it)

  - Could we look at "soil research networks" and their composition….the idea being that since soil has such a central context, programmes with multidisciplinary teams and (real) end user interactions are likely to produce results with broader impacts?
  - There should be evidence from the harmonization efforts of the networks listed above. Can these by quantified?
  - There are examples of topics which require a multidisciplinary approach, e.g. Issue of soil quality indices requires fundamental soil science understanding, but also incorporates aspects of environmental change (as well as the socio economic context).

Responses

What should we do to improve the level of awareness, education, networking, capacity building and cooperation in soil protection in Europe?

There is a need to improve the elements of this Task Group in a number of ways:

- On awareness, there is a need to improve public awareness of soil related issues. This could be achieved by providing funding for the production of publicly accessible information on soils and their interpretation. There are some good examples around (e.g. soil safari trails for schoolchildren http://www.soilsafari.com/ , http://www.bbsrc.ac.uk/news/features/99jan/99_01_soil.html , an interactive soil teaching CD-ROM http://www.une.edu.au/agronomy/ozsoils.html, the website http://www.bodenwelten.de which deals with all kinds of information about soils for general public, the MetaSoil-project, an Internet based database which includes links and projects about soil. Users can add their own links and comment and assess the contents of the database http://www.bodenbuendnis.org/metaSoil.) but these have to be locally produced and focused to regional needs in order to be relevant, and so there is a need to create further opportunities for their development. It would be helpful to develop a resource pack which would allow local soil specialists to easily develop local soil trails (blueprint for production, availability of standardised soil descriptions, availability of soil related clip-art). In order to assess the current state of awareness and assess the success of future actions there is a need for a survey of current awareness of soil issues.
- On scientific awareness, there is a need to increase the awareness of scientists and professionals to the importance of soil- there are some good examples, particularly from the USA where there is a significant resource dedicated to soil protection issues. Example documents include the "Soil Thunderbook" - http://soils.usda.gov/sqi/soil_quality/what_is/thunderbook.html and associated documents, which help to provide tools and interpretation to professionals to increase their awareness of what they can do about soils. There is also the website of the International Soil Reference and Information Centre (ISRIC) in Wageningen (http://www.isric.nl/), which provides useful links to soil information.
- Scientific societies could also be involved. In the framework of the International Union of Soil Science (IUSS) the activity of Commission 4.4 Soil education and public awareness is aimed to "contribute to build the missing link between Soil Science and Society by developing awareness about the vital importance of soil for life, for every citizen".
- Actions aimed to help express the social demand toward soil and to renew the teaching of Soil Science should be sustained and encouraged by specific programmes (e.g. developing multidisciplinary field studies for students and training courses for teachers of primary and high schools, etc). Educational aspects are only likely to be achieved is there is a continuing political commitment to the importance of soil.
- On political awareness, it is important to develop robust indicators of soil quality, which are soundly based in scientific evidence. This should create a clear political direction for future protection of soils.
- There is also a need to demonstrate the way in which soil is intimately linked to the Sustainable Development agenda. It will not be possible to achieve Sustainable Development unless we have a full regard for soil quality, both at the policy and operational level.
- It is necessary to continue to develop information for Land Managers and their advisers. The lack of a common understanding of soils leads to a difficulty in communicating the important factors in land management.
- In particular, materials and methods should be developed for integrating different issues of soil protection (soil biodiversity, erosion, pollution, etc) into agricultural and rural development programmes and training processes for farmers and technicians. This might include policy briefs for decision makers and manuals for farmers and technicians. Interdisciplinary teaching processes within universities and colleges should be improved in order to train researchers, technicians and extension staff on how to address soil management from a more comprehensive and systemic perspective.
- There is scope for much better exchange of information on soils research. It is not easy to obtain information on soils research conducted across the EU. We need to develop better networking and collation of research information, both funded from the Commission and from National funds.
- It is necessary to continue to develop relevant networking opportunities. In most cases, these are best focussed on specific sectoral issues, such as Contaminated Land, or Phosphorus loss from Agriculture.
- There could be benefits in developing an ERA-NET proposal on soil protection to help develop better transnational collaboration on soil issues.
- There would be benefit in creating a single website where links to information about soils could be collated.
- We should also consider the "environmental scenarios" debate (http://ewindows.eu.org/) which tries to focus on "what happens to soils" or "why soil should be considered". Essentially we need to produce evidence that it does or could matter beyond the legislative "contamination" issues and the agricultural productivity/fertility context.

Conclusions

Soil Protection is a pan-national issue requiring networks and cooperation. The European Commission and MS should enhance or develop effective research instruments to address awareness, education, networking, capacity building and cooperation in relation to soils.

There is a need to:

- o raise the general understanding of soils and issues affecting soils through education.
- o develop new innovative ways of education (“education through entertainment”). Main target groups should be school classes, young people and families as well as the general public
- o reaffirm the importance of soil in society in a general and in a political sense.
- o collect all available information about soil and promote the transfer of knowledge and experience from the research domain to the public in order to initiate activities on the local level and to raise awareness and influence policy making at national/regional/international levels.

RESEARCH, SEALING AND CROSS-CUTTING ISSUES

Task Group 9.1 on GOOD STATUS, SOIL AND WATER SYSTEM AND SOIL QUALITY/ HEALTH

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Executive summary and recommendations

There is an increasing awareness that the soil is fundamental in the preservation of local, regional and world-wide environmental quality. The soil is the interface between the biosphere, the atmosphere, the hydrosphere and the lithosphere. Being more buffered than air and water, it can act as a sink for contaminants which can reside in the soil or be degraded by its microbial biomass. In broader terms it contributes to water and air quality. Contrary to other natural systems the soil might not always respond to changes in a linear way rather it often has an abrupt reaction once its *carrying capacity* is exceeded. It then can be seen as a source of contaminants to other ecosystems. It is then of paramount importance to define and control its quality status.

Soil quality is commonly viewed as its capacity to perform certain productivity, environmental, and health functions and is closely associated to the notion of resilience that indicates the ability of a soil to resist adverse changes and to return to its original equilibrium after disturbance. Its assessment is achieved through the identification and measurement of chemical, physical and biological indicators which are usually connected by simple empirical functions.

Soil quality is often seen in relation to the absence or presence of contaminants. However soil quality means much more if we think on salinisation, erosion, organic matter accumulation, sealing, compaction etc.

Many studies have been conducted on soil emissions in Europe, America, and Asia. All the soils studied are reportedly contaminated by pollutants of various origin but the lack of a common approach or methodology was evident when the studies were compared. It became apparent that the resulting data sets were inconsistent, and do allow neither for a comparative assessment of the soil qualities and their relationships to other environmental or health properties nor for setting up target levels or limits of soil quality parameters. Thus, political decision making and legislative regulations on a European scale are much more difficult.

Therefore, a common methodology to study and evaluate soil in different environmental settings is urgently required. Furthermore, the concepts and methods for the definition of soil quality need to be generalized all over Europe.

Soil will be defined as the upper layer of the earth's crust composed of inorganic particles, organic matter, water, air and organisms (ISO 11074-1). This means that the unsaturated and saturated zone are included. *Soil quality* is seen as all current positive or negative properties (biological, chemical and physical) with regard to soil *functions* and soil *services/potentials.* Soils are natural bodies, which change in space and time.

Soil performs a multitude of key environmental, economic, social and cultural *functions*, vital for life. The functions can be defined:

- *Biomass production for food, feed, raw material and energy purposes*
- *Storing, filtering and transformation*
- *Habitat and gene pool*
- *Physical and cultural environment for mankind*
- *Source of raw materials*

Soil can provide to the society several services or has several potentials:

- *Natural vegetation – Green areas ;*
- *Agriculture (plant and animal production) and Forestry;*
- *Residential / Commercia/ Traffic/ Countryside;*
- *Recreation / Leisure ;*
- *Industry / Mines / Storage of waste and residues;*

The concept of soil as a natural system is even more fundamental within the modern perspective of sustainable development, either from an ecological, economical or aesthetical point of view. The need to integrate these objectives in spatial planning strategies and in land use into line with soil characteristics asks for new terminology. In this communication when referring to the sustainable use of soil system in spatial planning the terms ***geodiversity*** and ***geoheritage*** are introduced.

Recommendations

Soil quality will always be seen as the presence of certain functions in relation to its service or potential. Once everybody agrees about this relationship a need does exist on indicators that will allow to identify this relationship or lack of relationship.
In that way some *recommendations* for research*,* presented in function of the 5 main soil clusters, can be made:

1. Analysis of the processes of the 8 threats to soil and their interdependency: erosion, organic matter loss, contamination, sealing, compaction, decline in biodiversity, salinisation, floods + landslide

- Definition of criteria/limits of soil potential (internal) and soil use (external) that lead to initiation of soil degradation and irriversible changes of soil parameters
- List of soil functions of importance for each soil use, soil properties that determine soil functions, properties to characterize soil quality in relation to soil potential
- Identify specific soil potential (is this "soil potential" or "potential services") requirements in relation to soil types
- Upscaling and downscaling of the understanding of the functioning of the different processes

2. Development of Soil Quality Indicators and harmonisation of methods for the analysis of the *State* of the 8 threats to soil and their changes with time = soil monitoring (in Europe)

- Evaluation of dynamics indicators for e.g. land use changes and its impacts on soil quality and assessment of the vulnerability to changes (buffer capacity)
- Identification and selection of Soil Quality Indicators (SQI) and their relationships (models/functions). SQI are needed to establish reference or benchmark values to which preservation or restoration activities should aim. Also they could help to determine the environmental damage. Definition of a minimum data set of parameters for soil quality assessment (biological, chemical, etc.) in a hierarchical scale

- Monitoring of soil quality in various settings (agriculture / forestry / natural areas / urban) to create a knowledge basis for decision support systems. This should be concerted with and conducted in the European country. It is especially needed for the NAS which have had very diverse environmental legislations and social and economical development. Database of good quality for each of the soil properties

- Standardization of methods and procedures for soil quality assessment in relation with soil functions and soil potential

3. Relating the 8 threats to *Driving forces* and *Pressures* = Cross linking with EU and other policies (agriculture, transport, energy, environment etc.)

- Link between soil quality, environmental indicators and social, economical, and human health indicators

- Effect of land use planning and changes on the functioning of the soil and landscape system

– How to act on diffuse pollution and:

- Agriculture - forestry
- Transport
- Energy
- Mining areas in country side
- Tourism
- Waste management

4. Analysis of the *Impacts* on the 8 threats, relating them to soil influences (deliverables) into other environmental compartments (air, surface water – groundwater, biomass production, human health, biodiversity)

- Impact on soil quality related to changes

– Influence of climate change on soil quality
– Changes of soil use?
– How to deal with changing soil potentials?
– Impact of diffuse pollution
– Assessment of multisources impacts in a catchment area (different land uses, different soils, different stakeholders)

5. Development of operational procedures for the mitigation of the threats = *Responses*

- Monitoring of the efficiency of prevention, conservation and mitigation technologies

- Identification and qualification of levels of risk related to the different threats and their acceptance by the different users

– Mixed pollution treatment
– Control (risk management) versus total clean up
– DNAPLs (Dense Non-Aqueous Phase Liquids) – LNAPLs(Light Non-Aqueous Phase Liquids)
– Plume catchment
– Residual concentrations – rebound
– Dynamic behaviour of soil services/potentials
– Prevention of contamination due to flooding

Soil services or potentials can be seen in a dynamic way**.** It means that soil, providing a certain service (e.g. allowing industrial activity) or having a certain potential (e.g. nature with the potential for residential activities), can be changed into an other service or potential by implementing certain measures (e.g. tilling, remediation, increasing of the fertility etc.). Sustainable use means just that this dynamic behavior does exist and that with low costs and low working load the services and potentials can be changed and upgraded.

Long-term goals of soil research should be in harmony with basic life principles: functionality, adaptability and sustainability. Most important is the first one because it is necessary to evaluate if some activities (in research, policy or practice) are functional from the view point of reaching concrete goals.

Report

1. <u>Definitions</u>

The following definitions will be used.

Soil : Upper layer of the earth's crust composed of inorganic particles, organic matter, water, air and organisms (ISO 11074-1)

Geodiversity: Geodiversity refers to the topography, structure and natural form of the land: the natural range of soil, geomorphological and geological features. It includes their assemblages, relationships, properties, interpretations and systems (Gray, 2004).

Geoheritage*:* Geoheritage comprises concrete examples of geodiversity which may be specifically identified as having conservation significance.

Geoconservation: Geoconservation is the endeavour of trying to conserve geodiversity and geoheritage.

Task group 9 proposes to use the slightly adapted definition: All current positive or negative properties (biological, chemical and physical) with regard to soil *functions* and soil *services/potentials*

Soil functions :

Soil performs a multitude of key environmental, economic, social and cultural functions, vital for life. The functions can be defined (see "Towards a Thematic Strategy for Soil Protection"):

- *Food and other biomass production*
  Food and other agriculture production, essential for human survival, and forestry are totally dependent on soil. Almost all vegetation including grassland, arable crops and trees, need soil for the supply of water and nutrients and to fix their roots.

- *Storing, filtering and transformation*
  Soil stores and partly transform minerals, organic matter, water and energy, and diverse chemical substances. It functions as a natural filter for groundwater, the main source for drinking water, and releases CO_2, methane and other gases in the atmosphere.

- *Habitat and gene pool*
  Soil is the habitat for a huge amount and variety of organisms living in and on the soil, all with unique gene patterns. It therefore performs essential ecological functions.

- *Physical and cultural environment for mankind*
  Soil is the platform for human activity and is also an element of landscape and cultural heritage (inclusive paleoecological traces).

- *Source of raw materials*
  Soils provide raw materials such as soil, clay, sands, minerals and peat, oil.

The first four of these functions are generally interdependent and the extent to which soils perform them is highly relevant to sustainability. When soil is used as a source of raw materials or the land it occupies as support for human activities, its ability to perform its functions may be reduced or changed leading to competition between functions.

Soil services/ potentials (uses):

- *Nature – Countryside, green areas ;*
- *Agriculture (plant and animal production) and Forestry;*
- *Residential / Commercial ;*
- *Recreation / Leisure ;*
- *Industry / Mines / Storage of waste and residues;*

Soil quality : All current positive or negative properties (biological, chemical and physical) with regard to soil *functions* and soil *uses* (ISO 11074-1).

"The continued capacity of a specific kind of soil to function as a vital living system, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, to maintain and enhance the quality of air and water environments, and to support human health and habitation" (Doran and Parkin, 1996).

Sustainable management of Soil quality:

Sustainable management of soil quality can be seen as:

- Prevention of further degradation of Soil Quality;

- Long-term maintenance or restoration of soil quality if degraded (for predefined or agreed uses /functions of the soil) in a multisectoral approach;

This means that all stakeholders and governmental organizations are directly involved in the management, i.e. Integration of the management of soil, water, nature, agriculture, environment and urban planning.

Soil and water system :

The first statement from the GW Directive group, if required by the GW management (still to be discussed within this group), is that the global principle to manage large-scale deteriorated (both quantity and quality) groundwater has to be integrated in the Soil strategy (contamination, compaction versus infiltration, …). This will be illustrated by some case studies (see annexes) on diffuse pollution, urban soil quality, contaminated soils and flooding, mining areas, brownfiels, soil quality and organic matter, salinization, sealing, compaction and erosion.

2. Soil quality

Soil quality is an emotive term which has been widely and variously used, frequently providing the basis for extreme viewpoints. For example, some have argued that soil of good quality may only be found under natural ecosystems. Consequently any intervention in, or disruption to, natural ecosystems will result in a loss of soil quality and should not take place. At the other extreme, where the concern is with restoration of land which has been subject to heavy contamination – perhaps following industrial use – some have argued that the fact that something will grow on the restored soil is sufficient indication that the soil is of adequate quality. It is possible to present arguments in support of both these viewpoints, but it is obvious that a more realistic approach is somewhere between these two extremes. These widely contrasting viewpoints do, however serve to illustrate that soil quality has no single meaning. It means different things to different people, and it is therefore not possible to present a single universally acceptable definition of soil quality. There are many soil variables, some single measurable properties others derived by combining measurable properties, which might be used as indicators. Those most likely to be used in these evaluations might include: soil texture, soil structure, soil hydraulic properties, soil pH, some measure of plant nutrient status, indicators of biological activity and contaminants content. Therefore the particular soil property or suite of soil properties will depend upon the function being evaluated (S. Nortcliff).

In this way soil quality will always be seen as the presence of certain functions in relation to its service or potential. Once everybody agrees about this relationship a need does exist on indicators that will allow to identify this relationship or lack of relationship.
The relation between land utilization and soil potential is important when soil quality has to be identified. Once this relation is agreed upon, indicators allowing to idientify this relation are needed. In that way some *recommendations* for research can be made:

- List of soil functions of importance for each soil use the terms "soil use" and soil service/potential" are mixed. The document starts with definitions. Can we not use the same tem everywhere?, list of soil properties that determine soil functions, list of properties to characterize soil quality,
- Assessment of Land use change and its impacts on soil quality,
- Assessment of the vulnerability to changes (buffer capacity),
- Reversibility of impacts to identify future potential uses (versus time scale, possible changes),
- Assessment of multisources impacts in a catchment area (different land uses, different soils, different stakeholders)
- Identification and selection of soil quality indicators (SQI) and their relationships (models/functions. SQI are needed to establish reference or benchmark values to which preservation or restoration activities should aim. Also they could help to determine the environmental damage),
- Database of good quality for each of the soil properties,
- Definition of a minimum data set of parameters for soil quality assessment (biological, chemical, etc.) in a hierarchical scale,
- Harmonized method to identify soil requirements (for specific use and soil type)
- Monitoring of soil quality in various settings (agriculture / forestry / natural areas / urban) to create a knowledge basis for decision support

systems. This should be concerted with and conducted in the European countries. It is especially needed for the Enlargement countries which have had very diverse environmental legislations and social and economical development,
- Standardization of methods and procedures for soil quality assessment in relation with soil functions and soil uses,
- Proposal of win-win situations for land use planning,
- Awareness rising (education, dissemination) about the role of soil and its quality,
- Influence of climate change on soil quality
- Socio-economic and ecological aspects of the upgrading of soil quality

Soil services or potentials can be seen in a dynamic way**.** It means that soil, providing a certain service (e.g. allowing industrial activity) or having a certain potential (e.g. nature with the potential for residential activities), can be changed into an other service or potential by implementing certain measures (e.g. tilling, remediation, increasing of the fertility etc.). Sustainable use means just that this dynamic behavior does exist and that with low costs and low working load the services and potentials can be changed and upgraded.

<u>3. DPSIR analysis</u>

- **Driving forces / what are the driving forces behind research on soil quality ? Why is research needed ? What goes wrong where there is no research ?**

- Soil is now highly used for anthropogenic activities, but economical and societal benefits from these activities can not compensate the negative externalities related to soil use/utilization that activate or maintain the degradation of environmental constituents, soil inclusive..
- Soil use can and will change in the future (expansion of soil use).
- Important differences of Soil economic values in relation with uses.
- Prevention of further deterioration of Soil Quality to allow soil uses (at least maintaining the current soil quality, restoration of some soil functions to allow defined uses).
- Need for research for explaining :

  i) Relationship between a) soil functions and soil properties, b) soil functions/properties and degradation processes, c) soil functions/properties and soil use/management;
  ii) Soil functions versus Soil uses (approach based on the suitable-for-use principle integrating the future changes – determination of ‘beneficial use’ value);
  iii) The needed level of protection;
  iv) On which parameters we can act for preventing further deterioration and restoration for future defined uses.

- **Pressures / What are the pressures to research on Soil quality ? Who is funding research ? Who is asking for the new knowledge ?**
- Complex problem (biological, physical, chemical processes, spatial and time scales)
- need for an integrated approach (multisources of inputs, lots of potential impacts, i.e ; links between soil and GW);
- Multi-stakeholders (no one really liable for the actions / coordination / integration);
- Fragmented and fundamental research, nothing really on the holistic approach;
- Demanders : Land managers/planners, water suppliers, authorities (different levels of decision-making and management) etc…

- **State / What is the state of research on Soil quality ? What is known what is unknown ? What are the research needs at short and long term ? What is the quality of the national / European research infrastructure ?**
- Information coming from the different task forces of WG Research, + other WG of the Soil Protection Communication;
- Fragmented research (in Erosion, in Contamination, but without links between), mainly focused to soil quality deterioration, to short to mid-term issues;
- Mostly in relation with agriculture issues, not really related to all soil uses (needs for urban soils for example);
- Need for research for decision-makers (what do they need for decision-making ? which parameters for a ‘good’ decision ? time scale issues) at different levels of management;
- Gap between the research results (too fundamental, too detailed, too precise) and the end-users (decision-makers) needs (upscaling of parameters, translation of scientific and technical results);
- Need for concerted actions and ERA (coordination of existing national programs).

- **Impacts / What are the impacts of the state of the research on soil quality ? what kind if mistakes is made due to the lack of knowledge ? What kind of thinks are going well due to research results ?**

- Reuse of the soil for inadequate uses (unacceptable risks), mis-management of the soil uses, equilibrium between soil uses for sustainability of the soil system;
- Lack of information on long-term issues (both for qualification and quantification aspects);
- Too much focused on a case by case approach, needs for a broader and more integrated approach (i.e. megasites, large-scale problems, multi-problems at the same scale – Bitterfeld and flooding, Kempen area);
- Large space and time scales (i.e. intensive agriculture since the 70s, use of copper in the vineyards since several decades).

- **Responses / what are possible responses of research ? Do the results of research have any influence on policy or practice ? If so, what kind of response ? If not, why not ?**

- Research done on certain problems (erosion, restricted number of contaminants) has lead to some new legal framework (WFD, GWD, some national Soil legislations);
- Standardization research (pre-standardization research) leading to new and harmonised protocoles/methods, …., needed for monitoring issues;
- New problems identified (i.e. MTBE mobility, endocrine disruptors, SCAPs (Single Chain Alkyl Phenols);

- Further research is needed for the topic of *biological indicators* of soil health. There remain substantial conceptual difficulties associated with the development of bioindicators:
- Absence of a any clear base line data which might act as a reference point for soils of known health levels.
- How to deal with systems (e.g., different soil types) that show no consistency in their responses to perturbations.
- How to deal with the high levels of temporal and spatial heterogeneity that affect all measurements in most systems. Sampling effect.
- How to deal with the fact that the requirements for estimates of soil health vary between end-users (farmers, researchers, conservationists, etc.).
- Areas for research on physical, biological and chemical parameters in an integrated process, criteria for soil quality indicators + socio-economic indicators (BATNEEC concept, biodiversity as an indicator of 'well being » of soil).

Existing gaps where research is needed

- Definition of new methods to quantify soil quality (e.g. biological indicators)
- Effect of agricultural practices, forestry management practices, pollution, soil amendments, application of sludges, manures and other organic residues, etc. on soil quality,
- Scale at which the evaluation of soil quality is to be undertaken,
- Soil quality in organic farming.

Reflection on different opinions

There is still discussion about the definition of soil health:

- Soil health must be seen in relation to its function and utilization

or

- Nowadays, many scientists seem to prefer the term "soil health" because it clearly portrays the idea of soil as a living dynamic organism that functions in a holistic way depending on its condition or state rather than as an inanimate object whose value depends on its innate characteristics and intended use.

Inconsistency between long-term (WG issues) and short-term (soil uses) objectives in the Environmental Liability Directive.

Annexes

Annex I: Cases as illustrations

Diffuse pollution: e.g. Heavy metal contamination in the Kempen area

Problem:
At both sides of the Belgian-Netherlands border an area of more than 700 km² is contaminated by heavy metals due to historical emissions of zinc manufacturing companies. This soil contamination threatens the groundwater and surface water (inclusive the sediments) quality.

Management:
Classical soil remediation strategies are not applicable due to the large quantity of contaminated soil. This means that soil use must be linked to soil quality and his functions. This lead to restricted use (e.g. restrictions on crop cultivation) and to the development of additives that can be mixed with the soil in order to reduce the metal bioavailability.
Other management techniques are necessary in order to prevent a massive influx of metals into the surface water. At the hot spots *in-situ* bioprecipitation of metals is under development. For the diffuse pollution other management techniques will need attention (e.g. natural attenuation at the interface).
A framework plan is under development since 22 November 2002 by a transboundary workgroup. This plan will be based on:

- exchange and integration of knowledge and experience
- standardization of the approach and the measures at European level
- formation of a broad social platform supporting the proposed measures
- adding to a sustainable development of the project area (inclusive the industry, agriculture, residential and ecological uses).

Megasites and flooding: e.g. The flooding at the Bitterfeld site

Problem:
The Bitterfeld site is a megasite highly contaminated by chlorinated organics and many other compounds as well in the soil as in the groundwater. A complete cleaning of the site is not feasible from a technical and economical point of view. Flooding was an unexpected risk the increase the urgency of the remediation management.

Management:
The remediation of the Bitterfeld site is based on the general approach of the Integrated Management System (IMS) under development in the EU-project WELCOME.

The possible remediation scenarios for the clusters of the Bitterfeld megasite are divided into four phases (namely definition of the megasite, determination of the risks and risk reduction, management scenarios, long term monitoring and evaluation). Not all four phases are constructed identically in all clusters, nor are they implemented in each of the clusters. They constitute the framework concept allowing for the implementation of complimentary measures in specific areas, such as innovative technologies, which are described in more detail within this deliverable. The final design of the remediation concept for the megasite is still in the planning process. So far, necessary hydraulic measures are undertaken to meet the requirement regarding the depth to groundwater table and to hinder further expansion of the contaminated groundwater.

Within all phases, the measures are always subject to optimisation with regard to cost-efficient implementation. Further, an appropriate monitoring to survey the efficiency of the measures and the spreading of the contaminants is required.

The measures proposed for the remediation of the different elements of the source-pathway-receptor sequence are described regarding their technical feasibility. In terms of the options for source removal, these are firstly elaborated, whereas the pathway-measures correspond to the management options. These measures constitute the basics of the remediation framework concept for Bitterfeld.

Soil and Soil Water Quality of Urban Sites

Problem:

Man's activities influence the soil- and groundwater regime of urban sites to a great extent. The most important changes especially for metropolis are:

- decrease in actual evapotranspiration and increase of air temperature as a result of transformation of areas with natural vegetation into industrial, residential, traffic, and other zones,
- increase in surface runoff and decrease of groundwater recharge due to surface sealing and soil compaction
- traffic induced input of organic contaminants and heavy metals

Until now, traffic and surface sealing have the greatest influence on soil quality, climate and hydrological conditions. However, recent studies in Berlin show that topsoils are often enriched with nutrients and pollutants as well as fine material from road and tire abrasion and other dusts. As a result of pore-filling process by dust input, the topsoil looses a considerable portion of its infiltration capacity; the sorption capacity, however, increases. Apart from the accumulation of silt and clay, a strong accumulation of organic material has been observed. The infiltration rate of gaps in partly sealed pavements of 80 years old was decreased by more than 50% compared to that in the recently built pavements. Another research project of the Federal Institution of Road Traffic (BAST) that was completed in 2002 show, among other things, that

1. Heavy metals (Pb, Zn, Cu, Cd) in the upper horizon of road site soils are relatively high and quite often exceed the preventative limits of the Federal Law of Soil Protection. However, aqua regia extract form of these elements (Pb, Cd, Cu, Ni), as required by the Federal Law of Soil Protection, were lower than the preventive limits, regardless of traffic load.
2. Cu, Cd and Zn are the main elements that showed an increased concentration in the soil solution. Increased values occur at a distance of 5 to 10 m from the roadside. The contamination with organic pollutants can be regarded as rather unproblematic so far.

According to previous studies, the following demand for research still exists:

- Analysis of the soil organic matter constitutions.

- Input/output balances for dust, nutrients, salt and contaminants.
- Relevance of methyl-tert-butylether (MTBE) and palladium in soil and groundwater in view of traffic input.
- Integration of sorption behavior and hydraulic properties in a numerical simulation model to predict various soil and traffic scenarios.
- Recommendations for road construction and groundwater protection.

Urban areas often also contain multiple sources of groundwater pollution. An example are drycleaning facilities which are well-known sources of groundwater pollution by chlorinated solvents (PCE and daughter products). Remediating only a few sources while others remain represents high cost/gain ratios. One of the problems is that not all source-locations are known or accessible. A more effective approach could be to 'cluster' these sites and remediate them in an integrated way instead of each site individually.

Management:

In urban areas soils acquire new functions and play a distinct environmental role. They have esthetical and recreational functions in parks and gardens and contribute to the preservation of biodiversity. They directly influence the citizens' health: in fact soil material in an urban environment can come more easily in contact with humans and be transferred through the metabolic chain either as resuspended dust or by direct contact. While being rarely subject to ordinary agronomic operations, it receives higher than normal loads of contaminants from traffic, industrial activities and waste disposal. It undergoes more rapid than normal use changes which often end up with extensive sealing, which alters its relationships with water fluxes. Its substrate can be mixed with other anthropogenic materials that may modify its functioning. The need for a better understanding of the urban soils with special attention to the lack of information that is needed for soil management has been highlighted by many authors. There is also a need of adapting current methods for studying and classifying soils in urban settings and the necessity for an integrated urban ecosystem research that encompasses all the ecosystem elements

The URBSOIL project

Project Workplan

Six cities throughout Europe have been selected for this study. General characteristics of the cities to be studied are summarised in the table below. These cities offer a wide range in climate, geology, population, sources of pollution as conditions for anthropogenic soil changes, green areas type and extension and are diverse in social, cultural and economic structure. This variety should ensure that the data and models have a wider validity and greater transferability. The possibility that too much a variety could prevent comparisons and homogenization to be made has been duly considered and, in case, compensating actions will be taken
The work to be done in the URBSOIL project is divided into **six** work packages that will include the following points:

a) The work will start with the collection of data about the urban ecosystems, their conversion to a common format and the compilation of a database for all the cities selected. In this aspect <u>city administrators will participate providing available data and local needs definition.</u>

b) The urban soils will be mapped and classified according to their current use, the sampling strategy will be defined and the soils will be sampled accordingly.

c) Analytical procedures and parameters of soil quality to be measured will be selected and cross-validated and a set of soil quality indicators will be defined.

d) Quality control/quality assurance procedures will be implemented for analytical methods.

e) Samples will be exchanged between partners and each of them will carry out part of the characterisation analysis according to the relevant facilities/expertise.

City	Population	Main pollution sources	Mean annual temperature (°C)	Mean annual precipitation (mm)	Geological substrate	Green areas extension (ha)
Torino (Italy)	900 000	Industry, traffic	12.6	750	alluvial	125
Glasgow (UK)	600 000	Industry, traffic	8.9	991	basalt, alluvial	n.a.
Sevilla (Spain)	706 000	Traffic	18.2	540	alluvial	278
Aveiro (Portugal)	68 000	Industry	17.5	1000	alluvial	n.a.
Uppsala (Sweden)	187 000	Traffic	5.6	550	granite, glacial and postglacial deposits	100 forest 800 parks
Ljubljana (Slovenia)	100.000	Industry, Traffic	9.1	1123	alluvial	10

f) In a second phase each lab will focus on specific determinations/experiments to be carried out on selected samples to widen the range of indicators of soil quality.

g) The development of the Decision Support Tool/s on soil quality will use information derived from the database on urban ecosystem, from sample characterisation and specific determinations and experiments and data in the form of expert judgements (scientists/local authorities). The design and construction of the DST will work hand in hand with the experimental programme, but in terms of work activity be weighted towards the end of the project. However, given the need for the DST development to guide the data specification, collection and organisation, this work activity will commence from the beginning of the project. City administrators will participate in an **Advisory Group** providing feedback on testing and validation of the DST.

Objectives

The **overall aim** of this project is to identify soil quality parameters and their use in urban areas to provide local, national and European authorities with decision support tools for the correct planning and sustainable management of the soil resource in the cities and towns of Europe.

Specific or intermediate objectives are:

1. To compile a comprehensive database of the main components of the urban ecosystem that influence (directly or indirectly) soil quality in the urban ecosystem
2. To test, validate and implement a set of cross-checked analytical procedures for the evaluation of soil quality parameters that are required for future political regulations to preserve or improve the quality of urban soils in Europe.
3. To develop a transferable methodology for the determination and assessment of quality parameters of the soil resource in urban areas.
4. To build and apply GIS decision-support tool for the evaluation of soil quality in urban environments.
5. To help develop and harmonise new urban environmental management techniques.
6. To raise the awareness of local governments and other end-users (authorities, interest groups, general public) to appreciate the role of the soil resource in sustainable land use planning and natural, unrenewable, resource management by involving them in all stages of the work.
7. To produce sensitivity analysis of the planning process to soil quality/vulnerability under a range of typical urban scenarios and to educate local authorities in the newly developed methodology for soil quality assessment and decision support systems.
8. To train personnel (young researchers) on validated methods.

The BROWNIES project

First all known pollution sources should be mapped. Still many older or non-reported pollution sources will remain. To look for sources in large polluted areas, a 'standard' soil investigation with monitoring wells will be inadequate: pollution plumes are often narrow and can be 'missed'. One way of studying such areas could be to use the INCORE-approach: groundwater quality is studied using a number of strategically placed pumping wells instead of monitoring wells. By extracting groundwater during certain times, and following pollutant concentrations as a function of time, a better picture of the general groundwater quality can be generated: concentration(C)-time(t) diagrams. These can be transformed to concentration-distance (C/x) diagrams. By combining data from all pumping well tests, a 3-D represention of the pollutant sources can be developed ('backtracking'). I.o.w. one starts from plumes and calculates most probable locations of pollution sources. Once these are known, further detailed ('classical') research using borings, monitoring wells and/or soil-air investigations. Areas in which most likely no sources are present, need not be studied in detail.

Mining areas:

Problem:

Many large sites across Europe are abandoned mine areas. All these areas are contaminated by heavy metals and mostly due to low pH water (Acid mine drainage) the mobility and leaching of the metals into the groundwater and surface water is very high. The sites threaten surface water and drinking water wells.

Management:

These sites are very large and contain hot spots, contaminated soils or waste heaps, and large diffusively contaminated areas. Hot spot remediation can be based on classical technology although in most cases the costs are too high. Management must be based on prevention of further spreading (e.g. permeable Reactive Barriers, Pump & treat), use of more ecological processes (e.g. wetlands), use of natural attenuation processes of metal sorption and precipitation etc.
An Integrated Management System (IMS) will be applied based on the calculation of metal fluxes.

Brownfields

Problem:
Many large industrial sites are contaminated by a mixture of pollutants. Plumes and sources are interfering with each other and remediation is nearly impossible from a technical and economical point of view.

Management:

In order to preserve soil quality it is very important to use old industrial sites again for industrial activities. In many cases, especially in some new accession countries industry has the tendency to use clean green fields in order to avoid costs for clean up. However these brownfiels are soils that have from a soil quality point of view restrictions in their use. In this way the management of the soil can be based on the reduction of any spreading of the contaminants and the re-use of the soil for industrial use. Also some management and remediation actions can lead to a certain increase in soil quality which makes that the use of the soil can be extended tot e.g. residential, recreation or commercial activities.

Soil quality and organic matter

Problem:
Loss of organic matter, breakdown of soil structure, water and wind erosion, salinization, and chemical contamination are accelerated by inappropriate land use and management practices (Figure 1). These processes reduce the ability of the soil to grow crops and to maintain a healthy environment.

Management:
Protecting the soil against degradation usually involves management of organic matter content keeping it covered with crops or crop residues. Using methods such as conservation tillage and residue management, green manure, continuous cropping, and winter cover-cropping helps to maintain soil cover and a high organic matter status.

Loss of soil organic matter may be related to the loss of topsoil through erosion. Organic matter is also lost by microbial oxidation, in which soil micro-organisms use organic matter in the soil as a food source during their normal metabolism. Management practices that add little organic matter to the soil or increase the rates of organic matter decomposition (such as summer fallowing and excess tillage) lead to reduced levels of organic matter in the soil.

Because organic matter is rich in nitrogen, phosphorus, and other nutrients, loss of soil organic matter reduces soil fertility and its capacity to produce crops. Organic matter holds more water per unit weight than mineral matter and is needed for a well-aggregated soil structure. Its loss also reduces the soil capacity to accept, store, and release water for plant growth.

Soil erosion is a natural process and all soils have an inherent organic matter status, based on soil features such as vegetation and climate. However, human activities such as tillage, livestock grazing and urban development can greatly accelerate natural rates of organic matter. Loss of soil organic matter usually degrades soil quality and a soil of poorer quality is less able to withstand further degradation thus creating a downward spiral of soil degradation. Anthropogenic induced soil organic matter losses on agricultural land is a result of farming system affected by different management practices and varies with landscape position. It influences most of the soil attributes that determine soil quality. Reduction of organic matter content leads to depletion of plant available water and a reduction in water use efficiency. Reductions in organic matter are closely linked to reductions in water-stable aggregates. Thus, soil organic matter content as the most important property in influencing aggregate stability. Water-stable aggregates are also important in protecting soil carbon compounds from microbial attack; when aggregates collapse, the organic compounds held in close association with clays are exposed to attack by organisms such as soil bacteria The effect of organic matter content on the structural stability is illustrates in Figure 2, where a soil under prairie and an eroded adjacent field are compared. (Taboada Castro, 2001).

The organic binding agents between the soil particles in the aggregate have been classified into: (i) transient - mainly polysaccharides; (ii) temporary - roots and fungal hyphae, and (iii) persistent - resistant aromatic components associated with polyvalent metal cations, and strongly sorbed polymers.It was concluded that roots and hyphae stabilize macroaggregates (>0.25-mm diameter) and the persistent organic binding agents stabilize microaggregates. Chaney and Swift (1984) used wet sieving to measure the aggregate stability of 26 soils with differing properties, selected from agricultural areas. The aggregate stability results were correlated with sand, silt, clay, nitrogen and iron contents and with cation exchange capacity. A high significant correlation was obtained for the relationships between aggregate stability and organic matter and some properties associated with it. No other soil constituent investigated had a significant relationship with aggregate stability, suggesting that organic matter is the main factor responsible for the stabilization of aggregates in these soils.

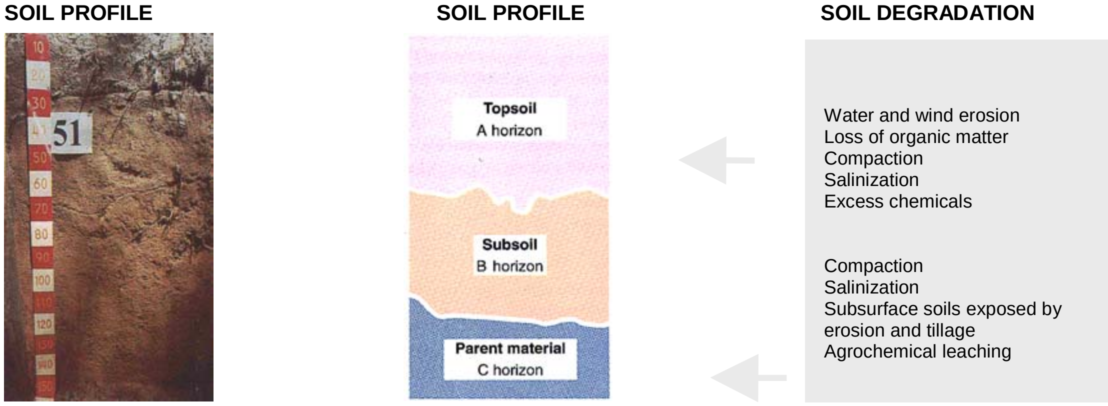

Figure 1. Degradation problems throughout the soil profile.

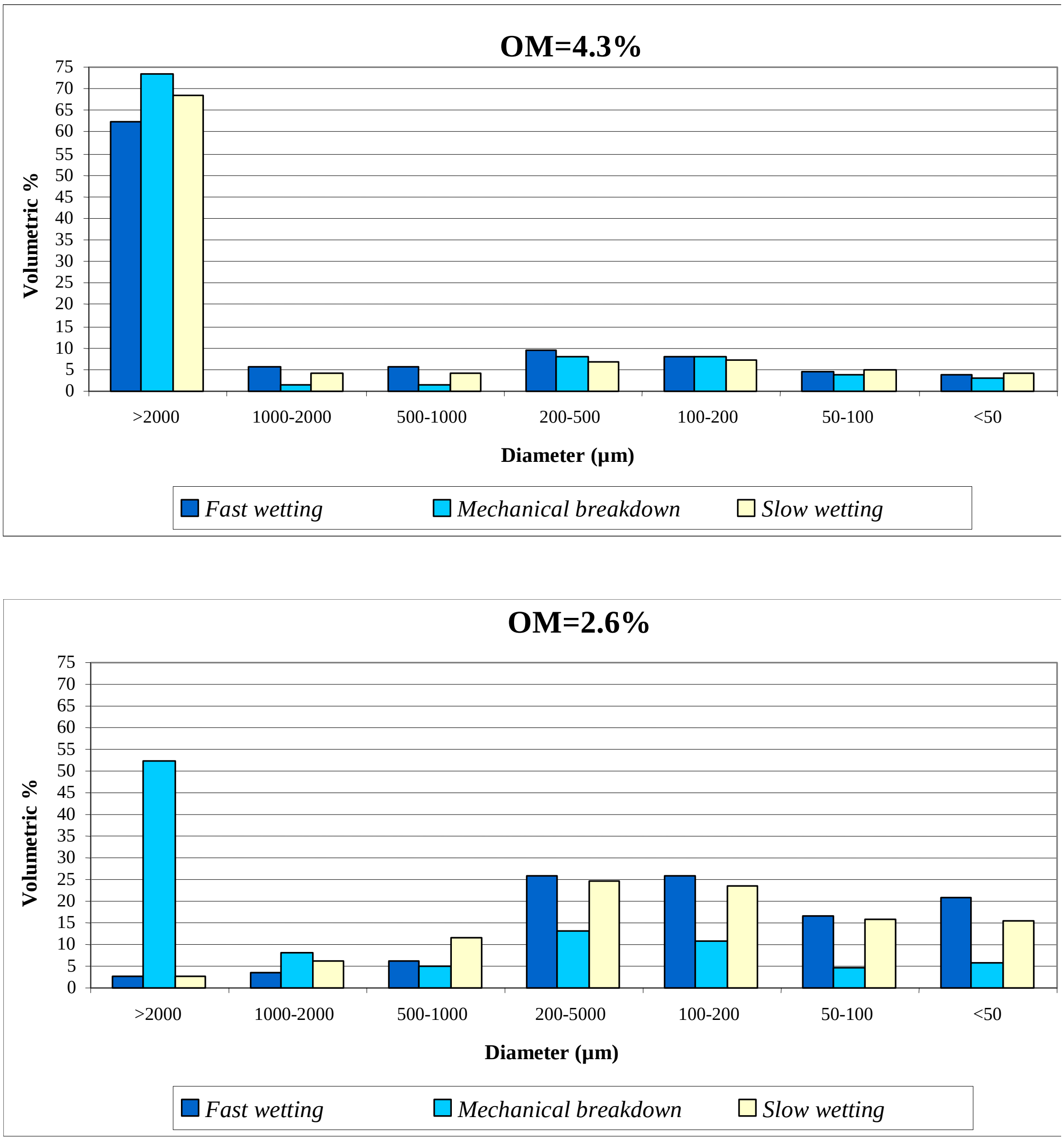

Figure 2. Results from a structural stability test for two soils with contrasting organic mater contents. (Taboada Castro, 2001).

Organic matter loss could significantly affect not only the soil aggregate stability but also detachment, infiltration rate and soil losses of crusted surfaces. In general, the lower the aggregate stability at the soil surface, the higher the susceptibility of the soil to detachment and to seal formation. Consequently, under seal formation conditions, the infiltration rate and the inherent susceptibility of the soil to interirll erosion are affected by the upper soil layer properties and they should be correlative. Interrill erodibility factor decreased exponentially as the final infiltration rate of the soil increased, for a wide range of soils, with differing soil organic matter content ranging from 1.23 to 5.64%.

Reduction of the organic carbon content in loamy soil below 1.5-2% decreased the aggregate stability and the soil infiltration rate under rainfall simulator conditions. Likewise, loamy sands with organic matter contents <~2% are very prone to erosion. Using a rainfall simulator to measure infiltration rate, runoff and soil loss in sandy loam soil containing various organic matter contents. It was concluded from this study that the soil organic matter content played an important role in aggregate stability and soil erodibility. Organic matter content of 3% was found to be a threshold value below, which the aggregates were unstable and the soil erodibility was high.

High OM **LOW OM**

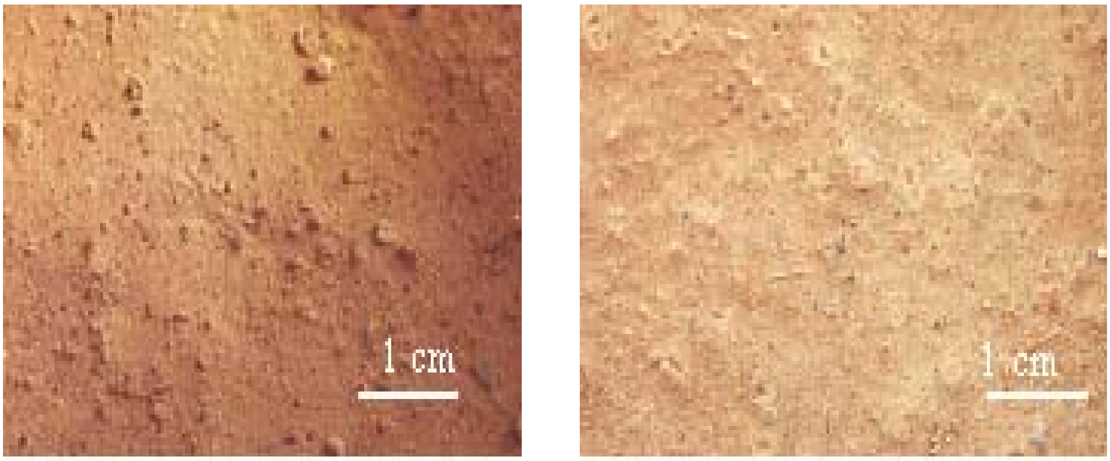

Figure 3.- Soil crust from soils with different organic matter content. (Ben-Hur, personal communication).

The effect of organic mater content on soil sealing and soil infiltration rate is now illustrated. Soil samples collected also from adjacent fields, a cultivated cornfield and a grassland with no tillage. The organic carbon content was 2.3% and 3.5 %, respectively. The soil in both fields was sandy loam. Samples with different aggregate sizes from each of the two soils were subjected to 80 mm of distilled water via a rainfall simulator. Figure 3 shows surface crust obtained at the end of the experience for aggregate sizes < 2mm. The final infiltration rates ranged from 4.2 to 5.2 mm h^{-1} in the low-organic matter soil and from 5.8 to 10.8 mm h^{-1}, respectively, in the high-organic matter soil, as shown in Figure 4. Thus, for each aggregate size, the infiltration rate, after 80 mm cumulative rainfall was significantly higher in the soil with higher organic matter content. The high organic matter content also reduced aggregate breakdown and prevented soil dispersion, which, in turn reduced seal formation and soil loss and increased the infiltration rate.

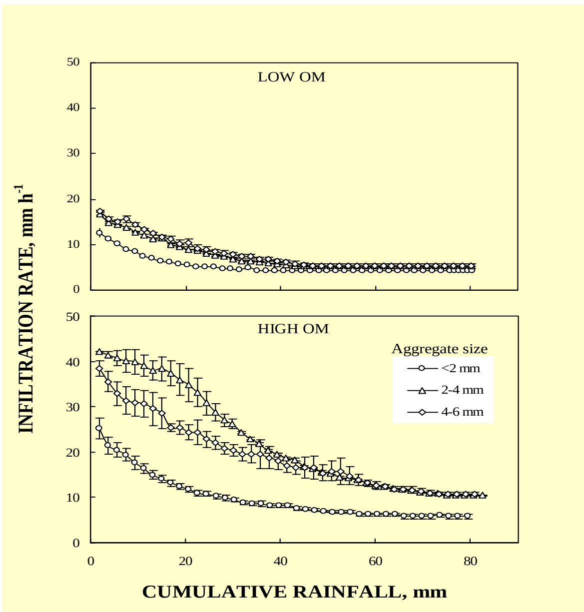

Figure 4. Infiltration rate as a function of cumulative rainfall for two soil samples with different organic matter contents and three different aggregate sizes. (Ben-Hur, personal communication)

Information about effects of farming systems and erosion risk/rate on soil biological parameters is very limited and sparse. Soil biological properties include soil microbial biomass and enzymes and their activity. Soil microbial biomass is an important component of the soil organic matter that regulates transformation and storage of nutrients. The effects of tillage, crop rotations, and soil type on organic C and nutrient turnover can be assessed by following nutrient pools and activity associated with the soil microbial biomass. It also has been shown to be a sensitive indicator of differences in sustaining cropping systems.

The toxicity of pollutants and the degradation of organic compounds, like pesticides, can be monitored by following changes in the soil microbial biomass. Microbial activity is also associated with aggregate stability through specific structure stabilising compounds. Any reductions in soil fauna associated with erosion will also have a detrimental influence on aggregate stability. Studies carried out in China show that enzyme activity in sediments is higher than in corresponding topsoil, and that with increasing slope steepness microbial activity decrease.

Soil management systems minimizing soil organic matter losses can improve soil quality. This is the reason why the conventional tillage gives room to environmental sound farming systems like reduced tillage, conservation tillage and no tillage. A 28-year study in Ohio showed that no-till increased significantly organic carbon and cation exchange capacity. Hydraulic conductivity in no-till plots was 12-15 times higher than in chisel plough and moldboard plough plots. The benefits of reduced cultivation are also seen in improvements to soil drainage as there is less disturbance to drainage pores within the soil. Field experiments in Germany showed that conservation tillage significantly increased aggregate stability over the whole topsoil. Under Mediterranean climatic conditions lower mineralization rate under no-tillage resulted in an increase of soil organic matter within a few years.

Higher organic matter content of soils from using no tillage and rotations may reduce disease. Many of the soil organisms that are rapid colonizers of organic matter are antagonistic to disease-causing organisms. Therefore, improved soil quality due to environmental sound farming systems will produce high quality crops.

Let us summarize the above findings. When soil organic matter is removed and lost there are consequent reductions in fertility, biological activity, aggregation and rooting depth. Other potential effects of soil organic matter reduction on soil quality include reduced porosity and infiltration, formation of crusts on the soil surface, changes in soil texture and compaction. Surface crusts limits the infiltration of air and water, impeding the emergence of seedlings as well. These changes in turn reduce the capacity of the soil to supply nutrients, filter and degrade toxic materials, store and supply moisture and sustain plant and biological productivity. Sealing of the surface results in increased runoff, less biomass production and plant cover and greater susceptibility to further erosion. Erosion increases the variability in soil quality across the field and is associated with declining water quality. When conventional managed, agricultural soils are particularly susceptible to water erosion and also to tillage erosion. The interaction of accelerated soil erosion and soil quality is complex. Soil erosion usually reduces soil quality and a soil of poorer quality is prone to further erosion and further degradation.

However, many soil conservation practices have been used successful in mitigating the effects of organic matter reduction. Reduced tillage systems limit soil disturbance and build soil organic matter.

Soil sealing, compaction and erosion

Problem

In the central part of Italy large areas are representative of the hillside environments of the Tuscan-Romagna Mountains (site 1) and of the clay hillside environments of central southern Italy (site 2), respectively.

The soils, containing low amounts of organic carbon, are characterised by low structure stability and poor regeneration capacity: they must be managed correctly to minimise the potential risk of formation of surface crusts, sealed surfaces and the risk of compaction caused by traffic of farming machinery. The effects of such hazardous degradation in a hilly environment, the reduced rainwater infiltration rate and the creation of preferential surface runoff courses play a role in triggering off widespread and channelled erosion processes.

Management:

Soil management is crucial for the prevention and control of degradation. Different tillage systems, i.e. deep ploughing (DP), shallow ploughing (SP), minimum tillage (MT) and ripper subsoiling (RS), have different effects on soil conditions. Adoption of ripper subsoiling tillage is capable of reducing structural damage caused by deep ploughing, lessening the risk of formation of surface crusts and presence of compacted layers in the profile. This was revealed by the findings of the micromorphological analysis and quantification of the pore system in the site 1. Moreover, ripper subsoiling conserves higher organic carbon content than does deep ploughing, especially in the top soil layer, as well as the amount of humified matter in soil managed by RS is greater than observed after DP.

At the second site, the effects of the different types of soil management (continuous wheat and continuous lucerne) were assessed, in a field experiment established in 1994.

Also in this case, the porosity values obtained in the top layer (0-5 cm) of the two crop growing areas show that after heavy rain the lucerne growing area presents higher porosity percentage than the wheat growing area. The protective action of the vegetation cover guaranteed by lucerne for the coming seasons, reduces soil surface vulnerability to the impact of rainfall and thus lessens the risk of formation of crusts. Moreover, wheat did not seem to be the most suitable crop as it depleted the organic matter in the top horizon of the soil, while lucerne farming conserved the organic matter status better. Removal of the finest soil particles by water erosion led to preferential loss of the most stable and most tightly bound part of the organic fraction (humin) that, on the contrary, was prevalent in the deeper layer.

The rational answer to this environmental risk is to avoid sowing wheat in these soils, but indubitably wheat cropping is more lucrative than, for example lucerne. It is clear that the radical changes in agriculture where the aims are to produce high yield and at the same time conserve “landscaping farming” environments, must strike a balance or set a limit of degradation.

Landfills

Problem:
More than 50 000 old landfills exist in Europe and most of them are leaking in a certain way. The leachates of these landfills contaminate the groundwater and are threatening in this way large drinking water resources especially in the neighborhood of large cities. The clean up and re-installation of a landfill is very expensive and in many cases economically not acceptable.

Management:
As mentioned management of such a problem can be based on source removal. It mean the installation of a new more or less tight landfill and the excavation of the old one. Other management systems can be based on immediate increase of the groundwater quality by the installation of e.g. a Multibarrier system (developed in the EU Fift Framework Program). This is a Permeable Reactive Barrier based on the combination of several systems as chemical, biological and physical treatment which allows to treat large mixtures of contaminants (inclusive mixtures of organics and inorganics). This allows that the use of the landfill can go on and that no other area or greenfield must be used to install a new barrier. This shows the approach based on soil quality where function and use are combined.

Annex II. The state of Geodiversity and Geoheritage in the EU countries

The data presented here are summarized from the book *Geodiversity* by dr. Murray Gray published by Wiley in 2004. A more elaborated description of the state of geoheritage in Europe will be published this summer by ProGEO, the European association for the conservation of Geological Heritage. The first copy of this book will be presented during the ProGEO conference in Florence in August 2004.

The country systems

UK

The UK currently has *13 National Parks* or equivalent, 8 in England, 3 in Wales and 2 in Scotland. It is usually only coincidental if important soils, landforms and geology are included within these areas, though their scenic beauty and often ancient geology inevitably mean that landscape and geoscientific interests often coincide. Thus many of the British national parks, such as the Lake District, Snowdonia, Dartmoor and others, although designated for their landscape beauty, all contain important geological and/or geomorphological interests.

National Nature Reserves (NNRs) are areas preserved primarily to maintain and enhance their scientific status and research potential. Marine Nature Reserves (MNRs) are also designated. They are generally owned by the State and managed by one of the three national conservation agencies. A few of the NNRs and many of the MNRs contain important geological and geomorphological sites.

The main way in which geoheritage is conserved in the UK is through the designation of *Sites of Scientific Interest (SSSIs)*. Originally this status did not give a site direct protection, but rather it simply ensured that local authorities were notified of the sites and that a full consultation process took place if developments affecting SSSIs were proposed. Most SSSIs are on private land. The situation has been strengthened significantly in England and Wales by the Countryside and Rights of Way Act (2000) (usually known as the CROW Act). This puts the emphasis on positive site management and partnership between the conservation agencies and landowners and occupiers, rather than paying them not to carry out operations that could damage sites. However, if agreement cannot be reached the new Act allows it to be imposed, and this allows action to be taken to prevent site deterioration through neglect or deliberate damage. The Act also makes it an offence for anyone to knowingly or recklessly damage an SSSI. The Act also gives powers to introduce bylaws on SSSIs to further protect them from third party damage, and strengthens their right to enter private land to investigate offences and monitor the condition of SSSIs. The Act gives public right of access to several categories of open land and therefore is helpful in giving access to geoheritage features. A major review, the Geological Conservation Review (GCR), took place between 1977 and 1990 to establish a systematic list of important geological and geomorphological sites. The site series was intended to reflect "the range and diversity of Great Britain's Earth heritage" About 2300 SSSIs are currently being designated by the three UK nature conservation agencies as of value geodiversity and geoheritage. This represents over one third of the UK's 6,573 SSSIs as of April 2002, the remainder being biological. GCR-site descriptions are being published in a set of 42 volumes, each made up of blocks covering a particular geological period, rock or landform type and/or part of the country. It has been referred to as the most comprehensive review undertaken by any country. In Northern Ireland the equivalent of the GCR, has identified about 300 sites, and these are being designated as Areas of Special cientific Interest (ASSIs).

The *RIGS (Regionally Important Geological/geomorphological Sites) scheme* was introduced in the early 1990s to meet the need for more local involvement in earth science conservation in the same way that many local wildlife groups operate. The aim was to set up a country-wide network of sites, established and managed locally by volunteer groups. Most English counties now have active groups though the situation in Wales and Scotland is more patchy.

Limestone Pavement Orders (LPOs) are one of the few pieces of legislation to protect a specific landform type and make it a criminal offence to damage the landforms so designated. About 100 orders have been made, and all significant limestone pavements in England are now protected.

The Wildlife & Countryside Act (1981) provides a framework to regulate fossil collecting at designated SSSIs or NNRs, but there is still no law relating specifically to fossils.

Ireland

Ireland is an interesting example since, apart of the geological importance of its *six National Parks*, including The Burren with its important karst geomorphology and limestone pavements, there has been no significant tradition of geological conservation (there) until relatively recently. As a \ consequence a major review has been undertaken and the *Irish Geological Heritage Programme (IGH)* instituted. The IGH Programme is run as a partnership between the Geological Survey of Ireland (GSI), which undertakes scientific site selection, and Dúchas, the Heritage Service of Ireland which carries out the statutory designation of Natural Heritage Areas (NHAs) under the Wildlife (Amendment) Act (2000) and their management. Sixteen themes have been identified, and or each one expert panels are established to select the sites. The system is intended to establish is a representative selection of Ireland's geodiversity, but unique, exceptional and internationally important sites are also included. In addition to the NHAs, a *County network of non-statutory sites* is being established (similar to RIGS in the UK) with some level of protection achieved through the Irish land-use planning system. Concern over damage to limestone pavements at The Burren has led to the introduction of the *Burren Code* which discourages visitors from removing limestone or building cairns and dolmens from shattered limestone or field wall stones.

Finland

Finland has *34 National Parks* some of which include important geological or geomorphological features. For example, Päijänne National Park includes some of Finland's best esker systems. In fact Finland has a *conservation programme for esker protection*, and also has *developed management guidelines applying to all its protected areas*. One of the the main principles is not to interfere with natural processes without good reasons related to nature conservation. Mining is prohibited within protected areas but traditional gold panning is permitted by license.

Sweden

Sweden's Nature Conservation Law has allowed the designation of *national parks, national reserves and natural monuments* incorporating landscape types, terrain forms and geology. Other legislation, policies and inventories aim to protect inland dunes, ravines, wetlands, lakes and rivers. Since 1999 the *Natural Resources Law* has allowed the selection and designation of national objects. The Nature Conservation Council and regional councils undertake this work with geoscientific input from the Swedish Geological Survey.

Denmark

In Denmark over ***200 national areas of geological interest*** have been identified since the 1980s and include landscapes, landforms, bedrock exposures and soils. Each of these areas/sites has a documentation including description, values, threats, references and administration. There is *regular site monitoring* and public interpretation of suitable sites. A survey of Denmark's coastline has been undertaken with the aim of identifying areas of geological, geomorphological or coastal dynamic interest. The Wilhjelm Committee was appointed in 2000 to prepare a report as a basis for a government action plan on biodiversity and nature conservation. This report was completed in 2001 but it contains few references to geodiversity and geoconservation though it does promote the operation of natural processes.

Germany

Germany identifies *geotopes* defined as "distinct parts of the geosphere of outstanding geological and geomorphological interest". An inventory of over *10,000 geotopes* has been compiled by Länder, but questions of use, management and accessibility have yet to be resolved and there is cross-Länder inconsistency. Germany also has a *Federal Monument Protection Law (1973)* though its implementation also varies widely across the country. Baden-Württemberg uses its Monument Protection Law in a similar way to the Danish Museum Act, i.e. to pay compensation to finders of fossils deemed to be of importance to the State. However, other Länder have no such Act.

France

France also has limited geoconservation programmes apart from *the spectacular Haute Provence Geopark* and about *12 geological nature reserves* designated on palaeontological, stratigraphic, mineralogical and stratotype grounds.

Netherlands

The Netherlands has about *120 areas considered to be of (inter)national importance*. The areas were designated through expert judgement, an initiative of the government in cooperation with the Platform for Earth Heritage and Geodiversity. The areas were selected mainly on geomorphological and landscape criteria. The areas have no legal protection although the idea of national government protection is introduced in the National Nature and Landscape Policy Scheme of 1985. The areas will be part of the Memorandum Landijs announced by the government for 2004. Eleven of the twelve provinces have designated *provincial areas of geodiversity and geoheritage value*. As in Germany the legal system and enforcement differ from province to province. The strongest legal protection is by designating *areas of geodiversity and geoheritage value to the zoning schemes of the local authorities*. An overview of areas with this local protection will be available from 2005 onwards. The areas considered of (inter)national importance and the geomorphology units scale 1:50.000 are part of Monitoring System Landscape, a database for monitoring landscape development under construction (www.meetnetlandschap.nl).

Although the first Earth Monument was assigned in 1926, further activities remained limited to a few gardens of erratics. From the mid 1990's the provinces of Utrecht (6, 6 in preparation), Zuid-Limburg (40 excavations), Overijssel (2) and Noord-Holland (2, 14 in preparation) started to appoint Earth Monuments. These are sites with scientific as well as touristic and recreational value. Only in the province of Noord-Holland these sites have an additional legal protection through the Soil Law. The other provinces now start allocating Earth Monuments.

Belgium

no data available

Luxembourg

no data available

Austria

Austria has a series of geotopes but there is no nationally co-ordinated scheme. In 1928 Austria passed one of the first *laws dedicated especially to the protection of a geological feature caves*. Criteria for establishing protected caves include scientific value, for historical research, palaeontology, geological structures, sediments, etc. The law also made it possible to create buffer zones around cave entrances. Over *10,000 caves* are now documented and the protection system has been regionalised, though this has led to inconsistencies in enforcement.

Spain

Spain has *two national laws protecting Spain's geological heritage* passed during the 1980s. First, the Law of Conservation of Natural Spaces and Wild Flora and Fauna (1989) established four categories of protected natural area defined as "areas or natural features composed of elements of known uniqueness, rarity or beauty which merit being the object of special protection". The four categories are: *National Parks, Natural Reserves, Natural Monuments, Protected Landscapes*.

National Parks are designated by the Spanish Parliament and managed by both the State Administration nd the Autonomous Communities in which they lie. Responsibility for designating and managing theother categories of sites lies locally. Natural monuments include geological or palaeontological sites designated for their special interest due to the unique importance of its scientific, cultural or scenic value. The *Law of Historical Heritage (1985)* gives protection to sites of cultural interest including geological and palaeontological sites related to the history of mankind, generally treating them as subordinate to archaeological sites. These are the responsibility of the *Autonomous Communities* and some of the latter have also developed their own heritage laws. For example, Catalonia, Galicia, Valencia and Madrid have introduced legislation to protect their fossil heritage. Responsibility for enforcing these laws lies with the 17 existing Autonomous Communities and enforcement is inconsistent. The emphasis on geoconservation in Spain has tended to centre on landscape criteria rather than geological science stratotypes, tectonic structures or depositional systems. The Geological Survey of Spain has developed a National Inventory of Points of Geological Interest (PIGs), though the sites identified have yet to be given legal protection.

Portugal

Portugal has *5 natural monuments* all based on palaeontology (dinosaur footprints), and *12 natural parks* many of which contain important geological features. Attempts are being made to promote these interests.

Greece

Greece has *10 national parks*, five of which have buffer zones and geological and geomorphological interests are recognised in several of these parks. A number of the *53 protected monuments of nature* are specifically designated for their palaeontological or geomorphological interests.

Italy

There has been an upsurge of interest in geoconservation in Italy, partly through the passing of the *outline Law on Protected Areas (L.394/91)*. This includes in its provisions scope to protect geological and geomorphological features of national or international significance due to their natural, scientific, aesthetic, cultural and recreational value. The categories of protected areas include *parks, reserves and natural monuments*. More recently, the Italian Geological Survey has been compiling an *Italian Geosites database.*

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RESEARCH, SEALING AND CROSS-CUTTING ISSUES

Task Group 9.2 on
SUMMARY OF TASK GROUPS 7,8 AND 9 ON CROSS-CUTTING ISSUES

Stef Hoogveld

1. Abstract and recommendations

The so-called crosscutting issues are closely related to the Response phase of the DPSIR framework. Within this phase, five sub-phases can distinguished: Description of strategic goals, development of a policy plan, production of an operational plan, execution of the plan and evaluation of the results. The crosscutting issues integrate the thematic threats to or from soil at the level of the strategy and policy plan, whereas the operational plan incorporates the thematic actions.

Several actions to support strategic decision-making are needed. The most important and urgent actions are listed below.

High level of protection.

The relation between land utilization and soil potential is important when soil quality has to be defined. Once this relationship is agreed upon, indicators allowing to identify this relation are needed. The most important and urgent actions are:

- Identifying Soil Quality Indicators (SQI) and their relationships (soil type, models/functions, land use change) to establish reference or benchmark values at which preservation or restoration activities should be aimed.

- Developing a minimum SQI set of parameters (biological, chemical, cultural etc.), linked with other environmental indicators and social, economical, and public health indicators.

Existing and additional legislation related to soil objectives.

A soil policy that is more coherent, more visible and more streamlined is needed. The goal is the effective protection of the soil. This goal is not dogmatic and it is not the intention to create partial solutions. The basis is to create sustainable solutions that harmonize with other policy areas. To this end the most important and urgent actions are:

- In-depth evaluation of existing EU policies having direct or side effect on soil.

- In-depth evaluation of successful regional experiments with respect to the scaling up to larger parts in Europe.

Organizing the activities to be undertaken

The debate about the implementation structure is closely linked to the realization of the Soil Policy and Legal Framework. Apart from the traditional discussions about subsidiarity, it is clear to us that the Framework requires an approach that does justice to the large, spatially determined differences in soil type, soil use and social-cultural soil aspects. Therefore, the debate about the nature of soil conservation services is important and urgent:

- Objectives, structure and capacities of regional and national soil conservation services that have already been well-established, and research into the reasons why regions have not been covered by administration, management, improvement measures and research.

- The demands for soil conservation service objectives, structure and capacities at regional, national and European levels.

Disseminating awareness

Soil Protection is a pan-national issue requiring networks and cooperation. Awareness of soil issues through education of Europeans at all levels of society, networking and cooperation of researchers working in soil sciences and related subjects will develop capacity building and critical mass to deliver solutions to combat soil threats and protect and enhance soil resources. The most important and urgent issues are:

- Enhancing or developing effective research instruments to address awareness, education, networking, capacity building and cooperation in relation to soils.

- Producing evidence why soil should be considered beyond the legislative “contamination” issues and the agricultural productivity/fertility context.

- Promoting the transfer of knowledge and experience from the research domain to the public.

2. The policy life cycle as an integrating concept

The development of a the European soil thematic strategy is a dynamic process. The complexity and ignorance of the soil system are the main driving factors causing these dynamics. Many important aspects of this system are still obscure. Revealing these demands intensive research and consciousness-raising efforts.

At the same time, there is a loud call for measures, since people have become aware that soil is a threatened and non-renewable source of biodiversity and even of sustainable life on earth. There is pressure to take decisions based on the precautionary principle while sufficient information is lacking.

Global European soil monitoring information to support decision-making is not available yet. Some advanced soil monitoring systems that are functioning on national or lower levels, may even disturb the level playing field. Specific measures have been taken by some member states, but others have not for several reasons. Until now, soil related measures have been concomitant in existing Community legislation.

There is indeed complexity as well as dynamics. The success of the soil thematic strategy will largely depend on how we are going to deal with this seemingly tangled ball. To unravel it the working groups use the DPSIR framework: Information and indicators are required on the **D**riving forces resulting in **P**ressures on the environment affecting its **S**tate and potentially causing an **I**mpact (degradation). **R**esponses would include measures and policies to reduce the pressures and hence improve state and reduce impact.

There are many similarities between the DPSIR framework and the policy life cycle. They both analyse the phases of the policy system, relate the steps to each other, and they both are cyclical. The policy life cycle is widely used; a large variety focussing on the same line of thought exists. The policy cycle is mentioned in the output of the Working group on contamination: “Recognition, formulation, implementation, management and control." The Working group on Research also mentions it: "Quality management, solving problems by a cyclical method of planning, taking action, evaluation and fine tuning, resulting in flexible and sustainable solutions.[1]

We propose to use a version of the policy life cycle that has been somewhat adapted and elaborated in the response phase.[2] In fig. 1, the phases of DPSIR are in brackets behind the phases of the policy life cycle.

Developing a broadly supported global vision (**Drive, Pressure**)

Creating insight in the actual situation (**State, Impact**)

Describing strategic goals
Developing a policy plan
Producing an operational plan (**Response**)
Executing the plan
Evaluating the results

fig.1 Comparison between the Policy Life Cycle and DPSIR

The division of the DPSIR Response in five sub-phases has a clear benefit. It creates the possibility to go beyond the common statement that "something has to happen", by analysing Response as a process in its own right. We will use this approach in this report.

3. Driving forces, pressures, the state of soil and its impact

Mankind is able to destroy the soil. Whether this actually will occur, depends on the way it is used. Soil does not exist without any reason. It is not just a mass of material but a living part of the Earth with its own identity, pattern and process, interdependent in space and time. Its functional and potential values differ from place to place. Soil exists by the grace of unique combinations of the litho-, atmo-, bio- and hydrosphere.

Within the modern perspective of sustainable development, either from an ecological, economical or aesthetical point of view, the concept of soil as a natural system is even more fundamental. Therefore, it is one of the objectives of the European Union is "to work for the sustainable development of Europe … with a high level of protection and improvement of the quality of the environment"[3].

And further on: "Union policy on the environment shall aim at a high level of protection taking into account the diversity of situations in the various regions of the Union. It shall be based on the precautionary principle and on the principles that preventive action should be taken, that environmental damage should as a priority be rectified at source and that the polluter should pay".

Without any doubt the Member States, lower governments and the Unions' citizens all have accepted these high objectives. Consequently, the establishment of a Soil thematic Strategy, as announced in the 6th EAP, has been broadly welcomed.

Soil quality is often seen in relation to the absence or presence of contaminants. Soil quality, however, means much more if we think of erosion, biodiversity, sealing, compaction, cultural aspects etc. Contrary to many other natural systems soil may not always respond to changes in a linear way. It rather shows an abrupt reaction once its *carrying capacity* have been exceeded.

If one browses in the CIRCA website with its hundreds of mostly high quality reports it is obvious that soil is threatened in many different ways and that these threats are delivered into other environmental compartments as well. Also the interdependencies of the threats attract attention: compaction causing erosion, erosion causing contamination, contamination causing organic matter problems and so on.

The soil community gathered around the Soil Thematic Strategy seems unanimously convinced that European soil is endangered by many threats in many places. The complex reactive processes induced by these threats endanger the soil and its use.

It is clear that most existing sets of data are inconsistent. They can neither be used for a comparative assessment of the soil qualities, nor in relationships to other environmental or health properties, nor for setting up target levels or limits of soil quality parameters. In addition, many aspects of the complex chemical, physical and biological processes in soil are not known yet. The objectives of the working groups on monitoring and research are to formulate proposals regarding this problem. There cannot be any excuse to delay the development of a soil protection policy, regarding the seriousness of the threats, the irreversibility of their impacts and the precautionary principle.

4. Responses

4.1 Responses: Strategic targets

Until now, there has been no disagreement in defining the Unions' environmental objectives and describing the Unions' state of the soil. So now Ideal must be confronted with Reality, leading to the formulation of strategic, supported targets. Answers must be given to the following questions:

How is the objective "high level of protection" regarding soil defined? Which aspects of the soil objectives have already been fulfilled by existing legislations? Which aspects need further regulation? How will the activities to be undertaken be organized? And how is soil-awareness disseminated?

- High level of protection

Defining a level presupposes the existence of some kind of soil protection scale related to soil qualitative aspects. Unfortunately, such a scale does not exist yet.

Soil is the upper layer of the earth's crust composed of inorganic particles, organic matter, water, air and organisms[4]. This means that the unsaturated and saturated zone is included. The relation between land utilization and soil potential is important when soil quality

[1] Henriëtte Gelinck, paper Soil Legislative Framework

[2] Rene Hornikx, Geloven in Gemeenschap. 2003, Berne publisher, The Netherlands

[3] Art.3 draft Constitution

[4] ISO 11074-1

has to be defined. Once this relationship is agreed upon, indicators allowing to identify this relation are needed.

Soil services or potentials can be seen in a dynamic way**.** It means that soil, providing a certain service (e.g. allowing industrial activity) or having a certain potential (e.g. nature with the potential for residential activities), can be changed into another service or potential by implementing certain measures (e.g. tilling, remediation, increasing of fertility etc.). Sustainable use just means that this dynamic behaviour must exist and that the services and potentials can be changed and upgraded with low costs and low working load.

The concept of soil as a natural system is fundamental within the modern perspective of sustainable development, either from an ecological and economical or aesthetical point of view. The need to integrate these objectives in spatial planning strategies and in land use asks for new terminology. When referring to the sustainable use of the soil system in spatial planning the terms soil health, geodiversity and geoheritage have been introduced.

There is still some discussion about the definition of soil health. Soil health must be seen in relation to its function and utilization. Nowadays, however, many scientists prefer to define soil health as a living dynamic organism that functions in a holistic way depending on its condition or state rather than as an inanimate object whose value depends on its innate characteristics and intended use.

Geodiversity refers to the topography, structure and natural form of the land: the natural range of soil, geomorphologic and geological features. It includes their assemblages, relationships, properties, interpretations and systems. Geoheritage comprises concrete examples of geodiversity which may be specifically identified as having conservation significance.

- Existing legislation related to soil objectives

An evaluation must result in concrete proposals to optimise the functioning of the existing policies with regard to the sustainability of soil. Current discussions about Good Agricultural Practice are an opportunity to implement soil sustainability, as have been worked out in the thematic issues on contamination, biodiversity and erosion.

In addition, the Water Framework Directive could be of great use as there are several similarities between the needs of the soil environment and the needs of the water environment. The Community water policy's main purpose is "to prevent further deterioration and protect and enhance the status of aquatic ecosystems and, with regard to their water needs, terrestrial ecosystems and wetlands directly depending on the aquatic ecosystems"[1]. While the Community soil policy's main purpose can be defined as "to prevent further deterioration and protect and enhance the status of soils and, and hence, with regard to their soil dependencies, aquatic ecosystems and wetlands".

- Further regulation with new legislation

The results of the aforementioned evaluation will point out if a soil policy that is more coherent, more visible and more streamlined by cross-cutting approaches (Cardiff process) is needed.

The creation of a soil framework directive has often been mentioned. But there is also a possibility to link up soil items with existing policies. The approach to be chosen should be as flexible as possible, regarding the criteria that will be developed or applied to reach or maintain soil of good quality.

- Organizing the activities to be undertaken

The Soil Thematic Strategy requires an approach that does justice to the large, spatially determined differences in soil type, soil use and social-cultural soil aspects. The debate about the Soil Conservation Service very much belongs in this context. The idea behind the Soil Conservation Service is that it can be difficult for individual land users to protect and improve the soil. The traditional answer has been cooperation between well-organized and specialist regional services, financed by central government. A wide range of soil-related implementation aspects (soil protection, soil improvement, information, soil remediation, research etc.) can be incorporated. The Service should especially focus on urban, suburban and industrial areas as the soil is under great pressure there.

Most Member States already have some kind of soil conservation service. This services differ in organizational structure, be it a part of the civil service or an independent institution. The UK, for instance, has a two-stage integrated policy for improving the sustainability of soil. The first stage is to identify the current state of soil and to inform the decision-making process. The second is to match soil and its use, so land use is sustainable and appropriate. Another example is the Australian Landcare system. It offers a model for group participation in soil conservation. Over 2700 Landcare groups co-operate on local land degradation issues, which are usually managed at the catchment's scale[2].

The subsidiarity principle (who does what) will be a leading element in this debate.

- Disseminating awareness

If we are to improve the appreciation of soils, and improve the recognition of good soil management and conservation of soil, it is necessary to increase the perception of the importance of soil in many sectors of society. The lack of a common understanding of soil interferes with the communication about important problems in land management. Opportunities arise from larger availability and from improved capability of IT, from FP6 in relation to developing good information transmission and to developing greater openness and involvement in the management of environmental issues. Advisory services should supply information and advice to land owners, public and educational establishments in particular.

Regarding political awareness, it is important to develop robust indicators of soil quality, which are soundly based on scientific evidence. This creates a clear political direction for future protection of soils.

1 Water Framework Directive art. 1a

2 Fullen and others, 2003

4.2 Responses: Policy plan, Operational plan, its execution and evaluation

Once the strategic targets have been accepted the question arises how to reach them. Until now consensus has remained, but it will decrease as soon as more concrete answers have to be given in the phases to come. A blueprint for the implementation of the soil thematic strategy and a clear vision on the means to achieve this must be produced: the policy plan. It should be quality management based - solving problems by a cyclical method of planning, taking action, evaluation and fine-tuning. There is a need to make the best possible use of a whole series of instruments and measures in order to influence decisions taken by the business community, the consumers, the general public and the decision makers, attuned to the resources available. Occasionally a compromise between good management and economic returns will have to be reached, and management decisions will have to be taken based on proper scientific information. Both economic and social aspects have to be taken into account, creating a level playing field for all, if necessary with support of the Cohesion Fund.

The implementation of the soil thematic strategy must take place as soon as possible due to the irreversible nature of soil degradation. That “there would be time enough and measures could be postponed because soil appears an inert medium” is a big misunderstanding that must be rejected with force.

The decisions of the Union on the policy targets and plan form the framework of the actions to be taken. From this point on consensus will increase again. However, some problems on the operational level may emerge. An operational plan to deal with these problems will be useful. As the development of the soil thematic strategy has just begun, it is not yet possible to give an overview of the operational elements. There will be hundreds of good operational ideas, all differing in time, scale, effectiveness and efficiency to support the soil thematic strategy. They will be worked out in the operational plan in due time.

At the executive stage, guidance of the operational actions is the most important issue.

Evaluation is a very important aspect to be dealt with – not only in the soil thematic strategy. Have the right things be done in response to the threats? What have been the results until now? Do our efforts have to be expanded or can they be reduced? This kind of questions must be answered at this stage.

As the answers always refer to a situation before the actions were taken, that situation must already be known at the beginning. This means that all the objectives and actions to be evaluated must be monitored from the moment they started. The monitoring deliverables serve the description of the state of the soil (in fact this is not monitoring in sensu stricto since it is a once-only action) and the evaluation as well.

It is obvious that evaluative monitoring is an aspect to be considered in almost every stage of the policy life cycle and therefore should be given the proper attention.

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