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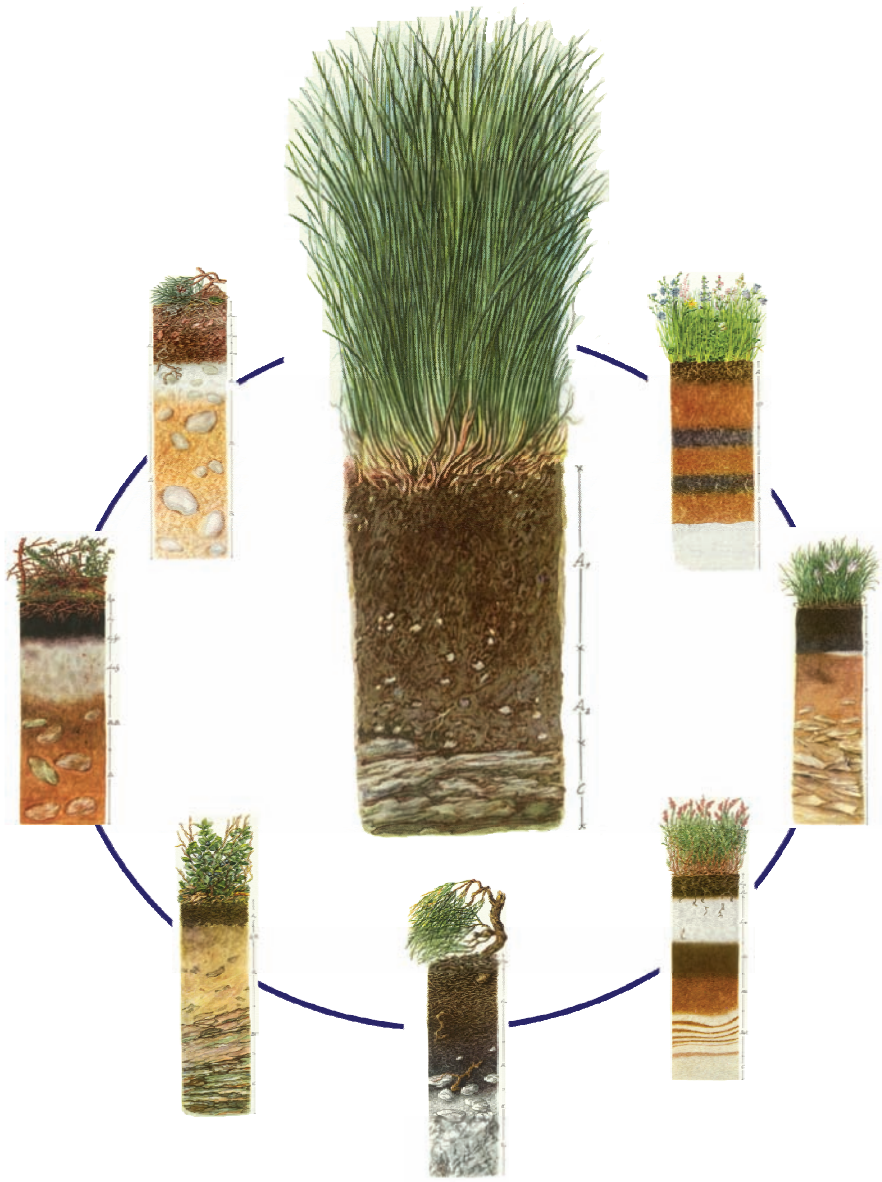
Environmental Assessment of Soil for Monitoring
Volume IVb: Prototype Evaluation – Pilot Studies

M. Stephens, E. Micheli, A.R. Jones, R.J.A. Jones (eds)



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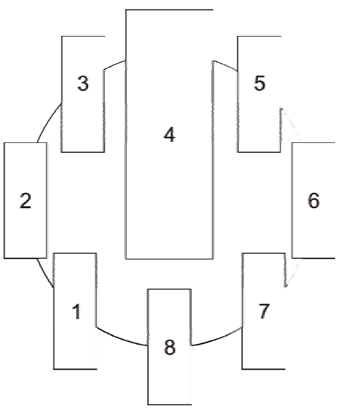

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Environmental Assessment of Soil for Monitoring
Volume IVb: Prototype Evaluation – Pilot Studies

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Preface

The ENVironmental ASsessment of Soil for mOnitoring – ENVASSO – Project (Contract 022713) was funded, 2006-8, as Scientific Support to Policy (SSP) under the European Commission 6th Framework Programme of Research. The project's main objective was to define and document a soil monitoring system for implementation in support of a European Soil Framework Directive, aimed at protecting the continent's soils. The ENVASSO Consortium, comprising 37 partners drawn from 25 EU Member States, succeeded in reviewing soil indicators and criteria (Volume I) that are currently available upon which to base a soil monitoring system for Europe. Existing soil inventories and monitoring programmes in the Member States (Volume II) were also reviewed and a database management system to capture, store and supply soil profile data was designed and programmed (Volume III). Procedures and protocols (Volume V), appropriate for inclusion in a European soil monitoring system were defined and fully documented by ENVASSO, and several of these procedures have been evaluated by pilot studies in the Member States (Volume IV). In conclusion, a European Soil Monitoring System (Volume VI), comprising a network of sites that are geo-referenced and at which a qualified sampling process is or could be conducted, is outlined.

This Volume (IVb), a companion to the summary results (Volume IVa) of testing 22 indicator procedures in 28 Pilot Areas in the Member Sates, describes each pilot area study in detail. These Pilot Area study reports adhere to a standard reporting template to aid comparison and evaluation. They represent a wide range of soil-landscapes from the north to the south of Europe, some of which are transnational, and also represent the most comprehensive investigation of indicator performance at European level.

Professor Mark Kibblewhite
Project Coordinator
Cranfield University

Dr Luca Montanarella
Secretary, European Soil Bureau Network
Joint Research Centre

29 June 2008

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Pilot Area:

Vale do Gaio watershed, Portugal

Lead Partner: INIAP
Maria C. Gonçalves
José C. Martins
Tiago Ramos

C. Kosmas (AUA)

Vale do Gaio watershed, Portugal

Name of pilot area		**Vale do Gaio watershed, Portugal**
Names of participating partners	**Lead partner**	**Maria C. Gonçalves**
	Partner A	Maria C. Gonçalves
	Partner B	José C. Martins
	Partner C	Tiago Ramos
	Partner D	C. Kosmas
Location and description	Member State(s)	Portugal
	Coordinates	38º 22' 22.11'' N 8º 02'' 59.15'' W
	Area of pilot area (km^2)	513
	Climate	Csa (Köppen), $C_2B'_2s_2a'$ (Thornthwaite)
	Mean temperature (FAO 2006*)	16,2 ºC (1979-2006)
	Average Annual Precipitation (FAO 2006)	584.4 mm (1979-2006)
	Outline description of topography	Gentle undulating relief
	Elevation (m)	39 to 418
	Vegetation (FAO 2006)	Cork trees, holm oaks, olive trees, wheat, maize, sunflower
	Major Land Use (FAO 2006)	Oak tree Mediterranean woodland, Agricultural crops, Pasture
	Major soils (WRB 2006 RGs**)	Cambisols, Luvisols

Indicator(s) evaluated

Threat	**Soil erosion, Land desertification**
Indicator 1	ER01 – Estimated soil loss by water erosion
Indicator 2	DE01 - Land area at risk of desertification

Rationale for selection

The main threats of land degradation for Vale do Gaio are: (1) soil erosion, and (2) desertification. Vale do Gaio is a small watershed, part of the Sado's river catchment area, located in the Alentejo region of southern Portugal where Mediterranean conditions prevail with high temperatures during summer and most of the rainfall concentrated during autumn and winter months. Cambisols, Luvisols and Regosols are the dominant soil units here and throughout the Alentejo region, having generally low organic matter content, infiltration rates and water retention capacity. The major land uses are rainfed agricultural systems and Oak tree Mediterranean woodland, also known as 'Montado', with its multiple land use that combines the *Quercus* trees (*Quercus suber* and *Quercus rotundifolia*), cereal cropping underneath and cattle breeding. Some irrigation areas can also be found.

With soil tillage practices coinciding with the start of rainfall period, soil erosion can occur due to surface water runoff and tillage which constitutes a major concern in land degradation in this pilot area. Soil erosion associated to shallow soils, hot and dry climatic condition and scarce vegetation lead Vale do Gaio region to be sensible to land desertification. Desertification is in fact a major concern, felt not only all over the Alentejo region but also in Algarve. Vale do Gaio watershed can be selected as representative for the Alentejo region, where both threats are felt but with less impact than in more marginal rural areas like Mértola's region and Algarve's mountains.

Description of the Pilot Area

Spatial extent

Vale do Gaio watershed has been chosen as pilot area for both indicators ER01 and DE01 evaluation. The pilot area is located in southern Portugal, covering an area of 51300 ha (Fig 1). The area is relatively smooth having a gentle undulating relief with a slope gradient very gentle to flat (<6%) in 96.1% of its area. The dominant parent material is granite. The major Reference Soil Groups (WRB, 2006) are mainly Cambisols and Luvisols but Regosols, Fluvisols, Vertisols and Leptosols can also be found in the area. Soil depth ranges from shallow (15-30 cm depth covering 13% of the area) to deep (>75 cm depth covering 36% of the area), being the major percentage covered by moderate depth soils (48%). Soil surface layers are generally coarse textured (79%). Water holding capacity ranges from low (< 50 mm in 10% of the area) to high (>150 mm in 14% of the area) but generally soils in the pilot area present values for water retention between 50-100 mm (39%) and 100-150 mm (37%). Rainfed agricultural land covers 48% of the area and is mainly located in the center and north-eastern part of the watershed, while in the western and south-eastern part, Oak tree Mediterranean woodland are dominant covering 34% of the pilot area. Based in the meteorological Vale do Gaio station, for the period 1979-2006, the average annual rainfall is 584 mm and the average air temperature is 16.2 ºC.

Figure 1. Location of pilot area Vale do Gaio watershed in Portugal

Data

Sampling design

The soil data used to access soil erosion and land desertification were based on Portuguese soil survey digital maps (1:25000). These maps only describe the soil mapping units and soil phases related to stoniness, drainage, and depth (shallow or deep). Soil analytical data corresponding to representative soil profiles were obtained from Portuguese soil survey reports and from Soil Science Department (INIAP-EAN) internal database ‘PROPSOLO’.

Data description and standards

Soil data, such as, textural classes of the surface layer, water holding capacity, soil depth and drainage conditions, were extrapolated from representative soil profiles of the Portuguese Soil Survey Service and from Soil Science Department of INIAP-EAN. The soil textural classes used are according to the International Society of Soil Science (Atterberg limits) and were grouped into the following: very coarse (S, LS); coarse (SL); medium (L, SiL, Si); moderately fine (SCL, CL, SiCL); and fine (SC, C, SiC). The soil classification used is the Portuguese Classification established by the Portuguese Soil Survey Service (soil families).

The parent material was defined according to the geological map of the area (scale 1:50000) supplied by the Portuguese Geological Service. The main parent material mapped in the pilot area is mainly granite with some minor areas of schists, sandstones and unconsolidated materials. Slope gradient was determined using the Digital Elevation Model (grid format 250 m x 250 m). Vegetation data were based on the Corine Land Cover 2001 and the dominant species are Corks, Holm Oaks, Olive trees and annual cereals. Climatic data was obtained from Vale do Gaio meteorological station. The following data was used: daily and monthly rainfall (1979-2006); monthly mean temperature (1979-2006); monthly Reference Potential Evapotranspiration Penman-Monteith (2001-2006). The Bagnouls-Gaussen aridity index for this region is 132.

Methodology used for calculations / estimations of parameters and indicators

Soil erosion rates due to overland surface water runoff were estimated by the PESERA model (Kirkby *et al.,* 2004, 2008).

Land desertification was assessed based on the methodology developed by the MEDALUS II EU research project (Kosmas *et al.,* 1999).

Commentary on original data

The indicators ER01 – Estimated soil loss by water erosion, and DE01 - Land area at risk of desertification for the Vale do Gaio watershed followed the ENVASSO procedures and protocols, namely the PESERA and MEDALUS methodologies respectively (Jones *et al.*, 2008). Data available in Portugal to run these two models are limited because there is no analytical database associated to the soil survey mapping. Consequently, all information on analytical soil data has to be extrapolated from representative soil unit profiles and to do that some knowledge on Portuguese soils is needed. Getting the information for meteorological data is not a difficulty. There are two different meteorological networks distributed all over the country. The “Instituto Nacional da Água” network is available free of charge and can be accessed through the internet. Alternatively, it can be used the data from the Meteorological Institute network but with associated costs. Around the Vale do Gaio watershed there are 6 meteorological stations belonging to these two networks. In this study, we chose to use only the values from the Vale do Gaio weather station because the values in all stations are quite similar. For the vegetation and land use, if no more information is available, Corine Land Cover gives a good work basis.

Soil Erosion estimation

The dominant class for soil erosion, according to the PESERA methodology, is <0.5 t ha^{-1}yr^{--1}, covering 32.1% of the studied area (Table 1). These lower soil loss values can be seen in the western and south-eastern part (Figure. 2) and correspond essentially to the areas where Oak tree Mediterranean woodland (*Montado*) prevails although some of the steepest slopes can also be found there. This traditional multiple land use combines *Quercus* trees, cereal cropping, natural or cultivated pastures underneath, and extensive cattle breeding where the animals feed on nuts, stubble and pasture. This land use allows some level of soil protection since the soil is covered throughout most of the year.

Higher values for soil erosion can be seen in the remaining area of the watershed, being more representative the classes of 5-10 t ha^{-1} yr^{-1} and 10-20 t ha^{-1} yr^{-1}, covering 23.3% and 16.9%, respectively. These areas, mainly located in the centre and north-eastern part of the watershed, are characterized by a more intensive agricultural land use and small irrigation areas.

Table 1. Distribution of soil erosion rates for Vale do Gaio watershed estimated by the PESERA model using the meteorological data of the period 2001-2006.

Erosion rate (t ha^{-1} year^{-1})	<0.5	0.5-1	1-2	2-5	5-10	10-20	20-50	>50
Area (%)	32.1	4.2	3.4	10.2	23.3	16.9	9.0	0.8

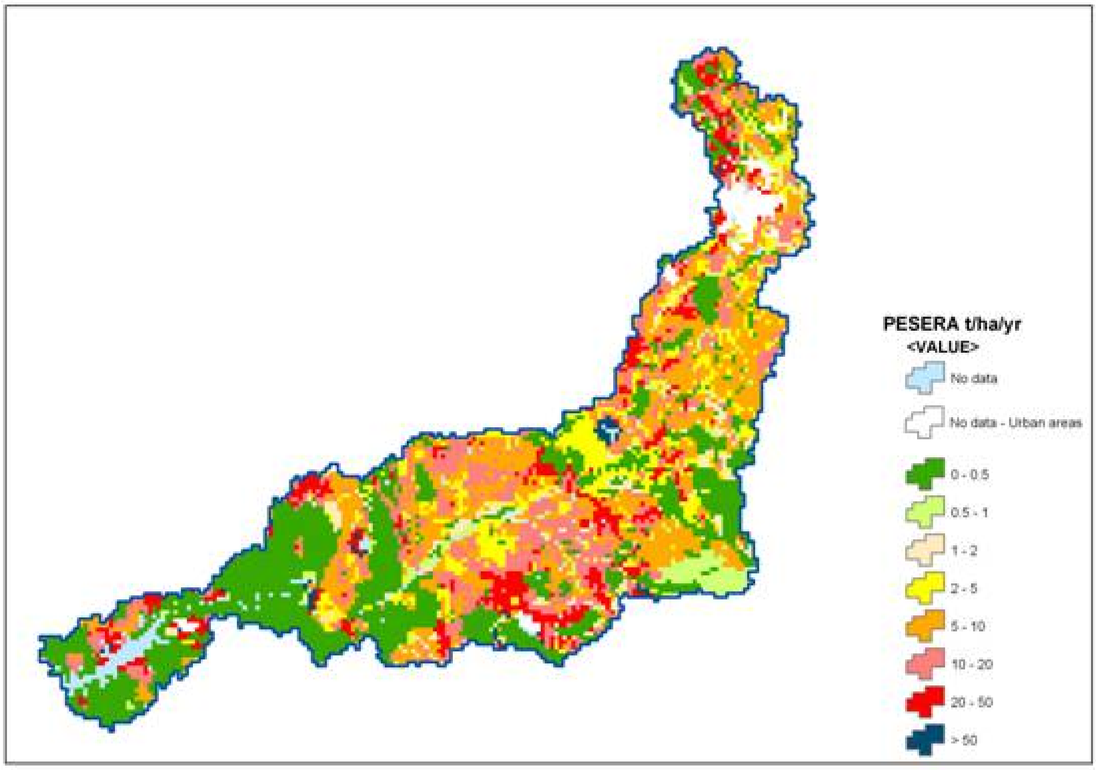

Figure 2. Soil erosion rates estimated by the application of the PESERA model for the Vale do Gaio watershed, Portugal (year 2001-2006)

Evaluation of pilot study results

Feasibility and experience of applying ENVASSO procedures and protocols

The PESERA model is a valuable tool for assessing soil erosion. Its predictions can be compared for different years, land use, land cover and tillage practices, enhancing soil protection practices. The model needs detailed information on soil, vegetation, climate and management data. The information needed is more complex, requiring the preparation of a large number of raster data layers (103 layers) which can be made by an expert spatial analyst using for example ArcGIS. Before running PESERA, even an ArcGIS expert needs some hours training before running the model. For Portugal, the main difficulty on running the model is the lack of local soil data. The database from running the PESERA model at Eruopean scale can compensate by providing some missing information on outstanding parameters such as vegetation or land use.

Output performance

Soil loss assessed by the PESERA model cannot be tested for Portugal. There is no soil monitoring system in Portugal with the exception of one erosion experimental centre located in Vale Formoso, near Mértola. Nevertheless, the estimated soil loss and land area at risk of desertification are in accordance with expert judgment in most parts of the study area. The largest estimated erosion losses are distributed sensibly in the same areas as those critical to desertification. New research projects, including erosion monitoring must be implemented in order to validate the modelled estimates obtained for this pilot area.

Identified strengths and weaknesses of;

1. the estimation of indicator values

The results obtained for soil erosion require validation. At present there is no available data to perform such task, and the final outcome is difficult to analyze without field data and observation. From a visual inspection of the pilot area it seems the results obtained are reasonably correct. As to be expected, 94% of the area is at risk (fragile or critical) of land degradation, presenting desertification as a problem to the region.

2. the interpretation of indicator values

Soil erosion rates estimated by the PESERA model are easily interpreted. The erosion classes defined are reasonable and meaningful to everyone.

Conclusions and recommendations

The current ENVASSO system provides a good basis for for organising the existing information, and identifies the best methodologies for assessing the soil threats of erosion and desertification, using indicators that are applicable all over Europe, and allow comparison between different countries. If the necessary information is already organised in electronic databases, it will be easy to apply such methodologies elsewhere. In this study the lack of data is a reality, making it more difficult to apply some of the methodologies needed for soil monitoring.

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Pilot Area: Chania, Crete and Philippi, Macedonia, Greece

Lead Partner: AUA
C. Kosmas
N. Moustakas
Or. Kairis

Chania, Crete

Name of pilot area		Chania, Crete
Names of participating partners	**Lead partner**	**C. Kosmas**
	Partner A	N. Moustakas
	Partner B	Or. Kairis
	Partner C	
Location and description	Member State(s)	Greece
	Coordinates	35^o 24’ 39’’N, 23^o 46’ 03’’ E
	Area of pilot area (km^2)	716.67
	Climate	Semi-arid
	Mean temperature (FAO 2006*)	18,7 ^{o}C
	Average Annual Precipitation (FAO 2006)	627 mm
	Outline description of topography	Hilly
	Elevation (m)	1320 highest peak
	Vegetation (FAO 2006)	Olives, vines, citrus, vegetables, pines, chestnuts, shrubs
	Major Land Use (FAO 2006)	Irrigated and non-irrigated tree crops, irrigated cultivation, intensive pastures, woodland
	Major soils (WRB 2006 RGs**)	Cambisols, Regosols, Luvisols, Leptosols

Philippi, Macedonia

Name of pilot area		Philippi, Macedonia
Names of participating partners	**Lead partner**	**C. Kosmas**
	Partner A	N. Moustakas
	Partner B	Or. Kairis
	Partner C	
Location and description	Member State(s)	Greece
	Coordinates	40º 59’39”N, 24º 19’15”E
	Area of pilot area (km^2)	23.068
	Climate	Semi-arid
	Mean temperature (FAO 2006*)	15.6^{o}C
	Average Annual Precipitation (FAO 2006)	591 mm
	Outline description of topography	Hilly area with a valley floor of organic deposits
	Elevation (m)	680 m
	Vegetation (FAO 2006)	Shrubs, wood forest, perennial trees (almonds, pears, etc), annual crops
	Major Land Use (FAO 2006)	Irrigated and non-irrigated tree crop cultivation, irrigated cultivation, intensive pastures, woodland
	Major soils (WRB 2006 RGs**)	Cambisols, Leptosols, Fluvisols, Histosols

Threat and related indicator(s) evaluated

Threat	Soil erosion
Indicator 1	ER01 Estimated soil loss by water erosion
Indicator 2	
Indicator 3	

Rationale for selection of study areas

Two of the main threats of degradation for both areas are: soil erosion, and land desertification. Soil erosion due to surface water runoff and tillage constitutes a major problem of land degradation in both pilot areas. Water erosion is attributed to climatic conditions, vegetation cover and land use management practices. The large scale deforestation of hilly areas occurring in the recent decades, accompanied by intense cultivation and overgrazing resulted in accelerated erosion and the formation of badlands in many cases. Tillage erosion is considered one of the most important processes of land degradation in the hilly cultivated areas. Extensive areas have largely degraded during recent decades due to erosion caused by the use of heavy powerful tillage implements.

Uncontrolled runoff and flooding of the lower valley bottom in the Philippi area causes severe environmental alterations to organic soils and damage to the growing crops. Soil erosion is the most important processes leading to gradual land degradation and desertification in the proposed pilot areas. The soils developed on Tertiary and Quaternary formations usually have limiting subsurface layer such as bedrock, and under high erosion rates and hot and dry climatic conditions, the soils can not economically support any rainfed crops, leading to land desertification

Indicator Evaluation

Indicator

The estimated soil erosion indicator has been selected for both pilot areas.

Description

Spatial extent

Two pilot areas: (a) Chania-Crete, and (b) Philippi-Macedonia have been selected for assessing the treats of soil erosion and land desertification (Figure. 1). Data on soils, vegetation, climate and land management have been collected during the execution of the following EU research projects: (a) OLIVERO, (b) Archimed Interreg IIIB-IMAGE, (c) Interreg IIIB Medocc – PROGECO), and (d) DESERTLINKS.

The Chania-Crete area

is located in western Crete, in the south western part of Chania prefecture, covering an area of 71.667 hectares. The area is characterized by a variety of landscapes, lithological units and climatic conditions. Systematic olive groves or mixed olive groves with other agricultural crops (vines, citrus, and vegetables) or natural vegetation cover more than 77% of the area. Pastures cover about 20% of the area and they are mainly located in the upper zone or they appear as patches in the lower zone surrounded by olive groves. Soils are formed on a variety of parent materials such as limestone, shale, marl, conglomerates and alluvial deposits. Slope gradient ranges from almost flat (slope <2%) to very steep (slope >35%) with dominant classes greater than 18%. Soil depth ranges from shallow (depth <30 cm) to very deep (depth >150 cm). Soils formed on marl, conglomerates, and alluvial deposits are relatively deep (soil depth >75 cm), while soils formed on shale and limestone are shallow to moderately deep (depth 15-120 cm). Based on the meteorological station of Souda, the average annual rainfall is 627 mm for the area increasing by about 30% in the higher altitudes. The average air temperature of the area is 18.7 ^{o}C decreasing in the upper region by about 2 degrees.

Soil erosion rates presented in Fig. 2 corresponds to the meteorological data of the year 2000. The erosion rates estimated by the application of the PESERA model are relatively high under the existing land management practices. The dominant class of soil erosion was 2-5 t ha^{-1} yr^{-1} covering 21.1% of the total area (Table 1). Such soils are located in areas with relatively steep slopes (slope gradient >25%), formed mainly on shale or conglomerates, partially covered with perennial or annual vegetation.

Figure 1. Location of pilot areas (a) Chania-Crete and (b) Philippi-Macedonia in Greece

Table 1 Distribution of soil erosion rates for Chania

Erosion rate (t/ha/year)	<0.5	0.5-1	1-2	2-5	5-10	10-20	20-50	>50
Area (%)	20.1	16.4	17.8	21.1	11.9	5.1	3.7	3.9

(Estimated by the PESERA model using meteorological data for the year 2000)

The following important classes of soil erosion are 1-2 t ha^{-1} yr^{-1} and 0.5-1 t ha^{-1}yr^{-1} covering 17.8% and 16.4%, respectively. Such areas are mainly located in the northern and central part of the pilot area with relatively steep slopes (slope gradient >12%), and soils formed mainly on shale or marl deposits. Areas with erosion rates 5-10 t ha^{-1} yr^{-1}) cover relatively smaller areas (11.9% of the total area). Such soils are mainly located in the south and central part of the study area with very steep slopes (slope gradient >35%), formed mainly on shale or conglomerates, and vegetation is mixed olive groves with shrubs or unmixed shrubs. Areas under very high erosion rates with classes 10-20 t ha^{-1} yr^{-1}, 20-50 t ha^{-1} yr^{-1}, >50 t ha^{-1} yr^{-1} covering 5.1%, 3.7% and 3.9%, respectively, are characterized with very steep slopes, low plant cover (new olive plantations, bare land, degraded pastures) and shallow soils. Plain areas or slightly sloping areas (slope gradient <6%) well vegetated are characterized al low erosion risk. These areas are characterized as having less than 0.5 t ha $^{-1}$ yr^{-1}, and cover 20.1% of the area.

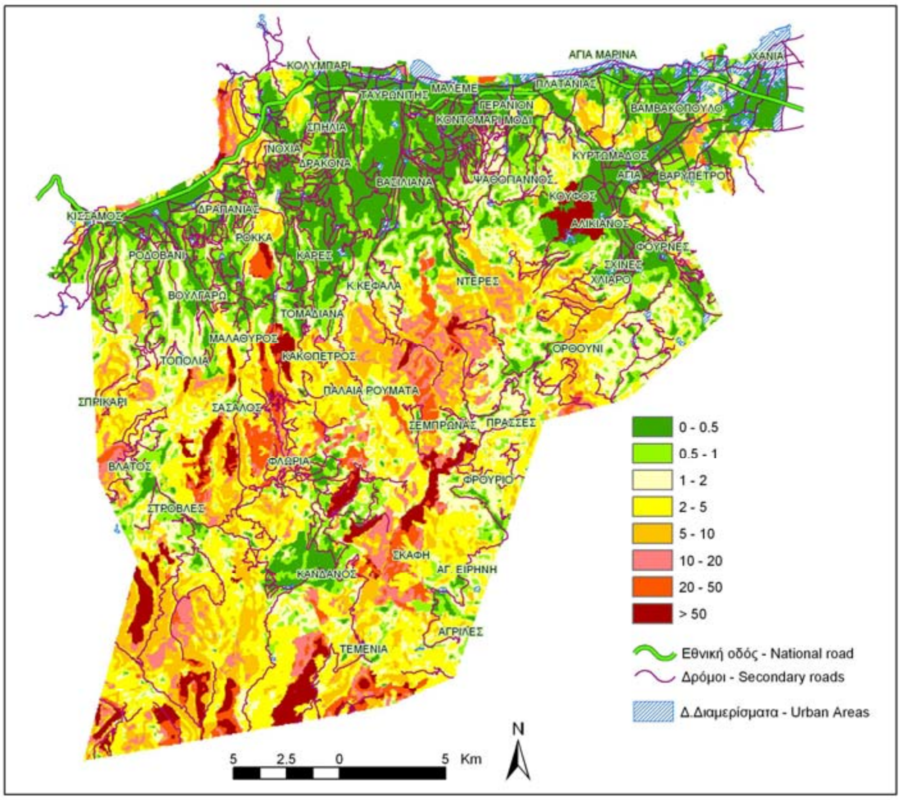

Figure 2. Soil erosion rates estimated by the application of the PESERA model for the Chania pilot area (year 2000)

The Philippi-Macedonia area

is located in northern Greece, eastern Macedonia covering an area of 23.068 hectares (Fig. 1). A great proportion (70.3%) of the area is characterized as hilly with slopes ranging from moderate sloping (slope 6-12%) to very steep (slope >35%). The lower part of the area is a bottom valley where organic soils have been formed. The upper part of the area (47.3% of the total area) is covered with natural vegetation (shrubs, pines, etc) while the lower part is cultivated with annual or perennial crops. Soil formed on marble or shale parent materials are shallow to moderately deep while soils formed on alluvial deposits are very deep. Based on the meteorological station of Drama, the annual rainfall is 591 mm and the average air temperature 15.6^{o}C.

The main process of land degradation in the hilly part of the area is soil erosion. As it is estimated by the application of the PESERA model, the dominant classes of soil erosion rates are 5-10 t ha^{-1} yr^{-1}, and 10-20 t ha^{-1} yr^{-1} (Fig. 3) covering 18.4% and 18.1%, respectively. These areas are characterized by steep slopes (slope gradient >35%), shrubby vegetation with plant cover >75% and moderately deep soils (soil depth >50 cm). Classes of high erosion rates 20-50 t ha^{-1} yr^{-1}, and >50 t ha^{-1} yr^{-1} have been estimated in a significant area covering 10% and 8.8%, respectively (Table 2). These areas are characterized by steep slopes (slope gradient >35%), shallow soils, (soil depth 5-30 cm), moderate plant cover (usually less than 75%), and intensive grazing.

Classes of slight erosion rates (<2 t ha^{-1} yr^{-1}) have been estimated in agricultural areas, in foot slopes with slope gradient less than 6%. These erosion rates are estimated in 5.5% of the total area (Table 2). Plain areas, covering 26.7%, are subjected to deposition of soil materials transported from the upper hilly areas.

Table 2. Distribution of soil erosion rates for Philippi-Macedonia estimated by the PESERA model using the meteorological data of the year 2001

Erosion rate (t ha year^{-1})	<0.5	0.5-1	1-2	2-5	5-10	10-20	20-50	>50
Area (%)	26.7	0.9	4.6	12.5	18.4	18.1	10.0	8.8

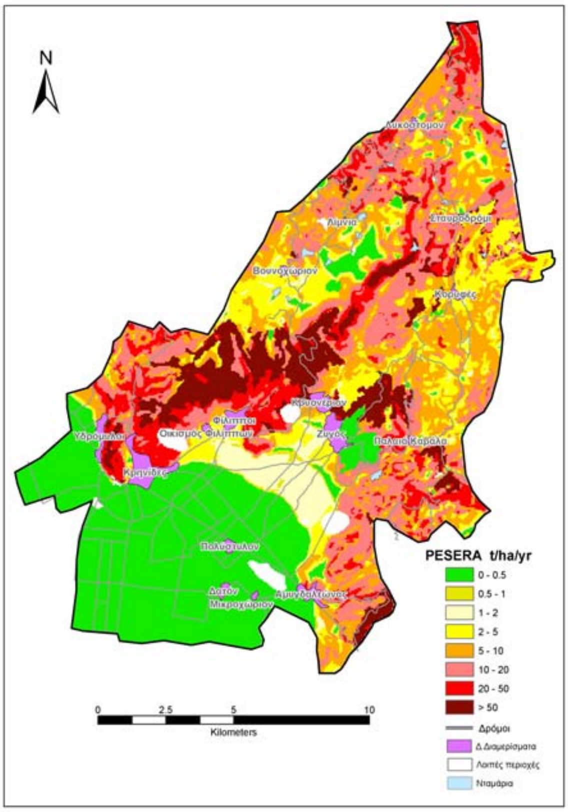

Figure 3. Soil erosion map of Philippi-Macedonia area estimated by the application of the PESERA model

Data

Sampling design

The data used to assess soil erosion were collected by conducting a regular soil and vegetation semi-detailed survey (1:30.000). The following parameters were described related to soil: soil texture of the surface horizon, drainage conditions, presence of rock fragments, depth to bedrock, degree and direction of soil development, slope gradient, slope aspect, and parent material. These land parameters were studied in a dense network of field observations and were recorded on each mapping unit. The boundaries of the mapping units were drawn on ortho-photo maps.

Vegetation was mapped on the basis of the dominant species such as olives, vines, citrus, annuals, shrubs, pines, deciduous oak, kastanea, bare land, etc. The type of land use and the percentage cover by each type of vegetation was defined in classes by aerial ortho-photo-interpretation and field survey at a scale of 1:30,000. Each vegetation unit, presenting in the corresponding mapping unit, usually includes more than one of the dominant species mentioned above.

Data description and standards

Soil data were described using existing systems of classification. In particular, the soil textural classes were defined according the USDA system (Soil Survey Staff, 1975), and were grouped into the following textural classes: very coarse (S, LS), coarse (SL), medium (L, SiL, Si), moderately fine (SCL, CL, SiCL) and fine (SC, C, SiC). The parent material was defined according to the geological map of the area (scale 1:50,000) supplied by the Greek National Institute of Geology and Mineral Exploitation (IGME). The main parent materials mapped in the study areas were marl, shale, limestone, conglomerates, and alluvial deposits. Soil depth to unconsolidated bedrock was measured in auger holes or in cuts. The following classes were used: very shallow (depth 0-15 cm), shallow (15-30 cm), moderately shallow (30-60 cm), moderately deep (60-100), deep (100-150 cm) and very deep (>150 cm). Slope gradient was described using the topographic maps. The soils were classified according to the Soil Taxonomy (Soil Survey Staff, 1975) into broad categories (Soil Orders), viz. Entisols, Inceptisols, Histosols, and Alfisols.

Vegetation was described on the basis of: (a) land use type, and (b) pant cover. Land use types were described using the FAO classification system. Plant cover was described using the following classes: <25%, 25-50%, 50-75% and >75.

Long term climatic data (period of 40 years) for the study areas were available from the meteorological stations located in or nearby of the study areas. The following data were used rainfall, minimum and maximum air temperature, air humidity, wind speed, sunshine duration. Rainfall data were used on a year and on a long term basis.

Methodology used for calculations / estimations of parameters and indicator

Soil erosion rates due to overland surface water runoff were estimated estimated by the PESERA model. PESERA is a physically based soil erosion model built around conceptual separation of precipitation into overland flow runoff generation and infiltration, with a runoff threshold depending primarily on soil and vegetation properties. Sediment transport is estimated from runoff totals in each storm, and represents the processes of sheet wash and rill wash, which are the dominant processes in severe soil erosion loss. Other active processes, including tillage erosion and rain-splash, are not considered in the model. Specifically, the input data required by the PESERA model are the following:

- Soil textural class (soil erodibility)
- Soil water storage capacity
- Soil crusting
- Initial surface water storage
- Roughness reduction
- Scale depth or increment of soil depth
- Land cover type
- Plant cover
- Standard deviation of elevation
- Monthly rainfall
- Monthly temperature
- Monthly temperature range
- Coefficient of variation of rainfall per rain day for each month
- Mean rain per rain day for each month
- Monthly potential evapotranspiration (ETo).

<u>Soil textural class</u> corresponds to the texture of the surface horizon defined by the USDA soil textural triangle. It is used for defining soil erodibility by the PESERA model. If experimental data are available for soil erodibility, then these values are used.

<u>Soil water storage capacity</u> was measured for the existing soil mapping units. In case that such data are not available, the PESERA model estimtes it.

Soil crusting corresponds mainly for cultivated soils. It is estimated by the model using soil texture and land cover type.

Initial surface water storage is affected by: (a) soil roughness, and (b) soil texture and soil porosity. Soil rougness is distinguished by the model in two categories: (a) soil roughness under vegetative cover (cover storage), and (b) soil roughness formed after plowing the soil (bare storage). This can be caluclated by the model based on the land cover type and soil characterisitcs.

Scale depth corresponds to the increment of soil depth ranging from 5 mm to 30 mm.

Land cover type was related to the type of vegetation or type of land use which determines the percentage plant cover during a certain period, as well as initial roughness water storage and change with time, and plant root depth. The user can select it based on the CORINE classification system.

Plant cover was defined per each month and land cover type in percentage.

Standard deviation of elevation was estimated from DEM using spatial analyst (ARC-GIS).

Monthly rainfall in mm was defined for each grid and for 12 months using monthly values.

Monthly temperature in ^{o}C was defined for each grid for 12 months using monthly values.

Monthly temperature range in ^{o}C was defined for each grid for 12 months using monthly average ranges.

Coefficient of variation of rainfall was defined per rain day for each month and each grid.

Mean rain per rain day was defined as the total rain per month divided by the number of rainy days for each month.

Monthly potential evapotranspiration (ETo) in mm per each month was calculated by an existing methodology of calculation such as Penman- Monteith equation.

Commentary on original data

ENVASSO protocols are applied in the pilot areas but some data required are not provided by the existing data basis. ENVASSO data basis has been created based on soil profiles. The assessment of soil erosion rates for a specific field site can be estimated using the ENVASSO data basis but this can not be achieved for a region. The assessment of soil erosion and land desertification requires the use of detailed or semi-detailed soil, vegetation and land management maps. The assessment is based on a mapping unit and not on a soil profile data.

Pilot method

Compilation of layers (maps) for the pilot area

A full set of 93 input data layers are required in ArcGrid format to execute the model. The grid size for both pilot areas was defined in 50 meters. The data layers required by the model are listed in Table 5. An Arc Macro Language (AML) module extracts local areas or complete areas to ASCII format. The ASCII files are combined into one data file on which the PESERA_GRID code operates. Final model output is written back to ArcGrid format for visualization Output grids of erosion estimates are considered the ‘primary’ output and are derived from asci files as a series of monthly surfaces from which risk maps can be produced. Other significant outputs are the monthly runoff estimates and soil water deficits. All the raster layers must be transformed to match the projection and coordinate system of the INRA data (*Lambert-Azimuthal*).

Table 3. Data in grid format prepared for application of the PESERA model

Data Source	Initial Grid name	No of layers	Description
Vegetation data	Rootdepth	1	Root depth in cm
	Rough0	1	Initial surface storage (cm)
	Rough_red	1	Roughness reduction (%)
	Use	1	Land use characteristic
	Cov_jan – cov_dec	12	Ground cover (for each month) (%)
Climate data	Meanrf1301-meanrf13012	12	Monthly rainfall (for each month) (mm)
	Mtmean1- mtmean12	12	Mean temperature (for each month) (^oC)
	Mtrange1- mtrange12	12	Mean temperature range (for each month) (^oC)
	Cvrf21 – cvrf212	12	Coefficient of variation of rain per rain day (for each month). Coefficient of variation of rainfall is calculated for all rain days of the month
	Meanrf21-meanrf212	12	Mean rain per rain day (for each month) (mm). Divide the monthly rain in mm by the rain days
	Meanpet301- meanpet3012	12	Potential Evapo-Transpiration (Eto) (for each month)
Soil data (soil texture)	Soil_stor	1	Soil water storage (mm)
	Crust_0702	1	Crusting (calculated by the PESERA model)
	Erod_0702	1	Erodibility (it can be estimated by the PESERA model)
	Zm	1	Scale depth (range 5-30mm)
INRA	Std_eudem2	1	Standard deviation of elevation

Methodology used for calculations / estimations of parameters and indicators

The model estimates erosion by identifying three components respectively derived from climate and vegetation, topography and soil factors. For each of these components widely available data are used in order to make regional forecasts. Because climate and land use are explicit drivers in the model, PESERA may also be used to assess sensitivity to change conditions.

The amount of sediments transported after each rainfall event is estimated as a mean soil loss in t ha^{-1}, obtained as a product of the three components for climate and, vegetation, topography and soil given by the equation (Kirkby 1999, Kirkby *et al.*, 2000):

$$\boldsymbol{S} = \boldsymbol{kq}^2\Lambda \qquad (1)$$

where **q** is estimated from the equations

$$q = jx = px(r-h) \qquad (2)$$

where: ***k*** is soil erodibility
q is overland flow discharge per unit width
Λ is local slope gradient
j is storm runoff (storm depth per unit area)
x is distance (or area drained per unit contour width) from divide
h is the runoff threshold
and ***p*** is the runoff coefficient ($0 \le p \le 1$)

Sediment transport is estimated at the slope base (***x=L***), for which the average storm sediment loss , ***Y***, combining equations (1) and (2) above, is:

$$Y = \frac{S}{L} = k\left[pL(r-h)\right]^2 \frac{\Lambda}{L} = kp^2\left(r-h\right)^2.L\Lambda = k'p^2\left(r-h\right)^2 R \qquad (3)$$

where ***R*** is the hillslope relief
and ***k'*** is the erodibility corrected for slope form = ***k LΛ/R.***

This expression is then summed over the frequency distribution of storm rainfalls, which is estimated as the distribution of daily rainfalls, giving the total average sediment yield as:

$$\overline{Y} = k'\ R\ p^2 \sum_r \varphi(r).(r-h)^2 \qquad (4)$$

where $\varphi(r)$ is the frequency of daily rainfalls of ***r***.

Soil erosion is estimated from equation (4), using data on daily climate, soils, topography and land use which are combined in a physically based model. The first term, ***k'*** , is based on properties derived from soil mapping. The second term, for relief, is estimated as the standard deviation of elevation within a given radius (1.5 km) from a DEM of the topography. This measure has been shown to be sensibly independent of DEM resolution provided that the radius is held constant. The third term is computed from climate (to give the rainfall distribution), vegetation cover or land use and soils (to give the runoff threshold)

Evaluation of pilot results

Feasibility and experience of applying ENVASSO procedures and protocols

Soil erosion assessment using the PESERA model can be satisfactory if detailed soil, vegetation, climate and management data are available. The application of the model in a region requires the preparation of a large number of raster layers (103 layers) which can be made by an expert on ArcGIS. PESERA model is a valuable tool for assessing soil erosion rates under various land use types and management practices. Soil erosion rates can be predicted also under various climatic scenarios.

The application of the model can be achieved by using ENVASSO protocols for part of the data required. For example data such as: soil texture of surface layer, soil depth, soil water storage capacity, slope gradient, rainfall, land use type, plant cover can be extracted from the ENVASSO data basis. In the opposite, data such as: soil crusting, initial surface water storage, roughness reduction must be estimated from the data basis available from the PESERA model.

Output performance of applying ENVASSO procedures and protocols

Soil erosion performance assessment by the PESERA model has been tested previously in Greece during the execution of the PESERA project using exiting soil erosion data collected under various climatic, soil, and vegetation characteristics (Tsara *et al*., 2005). The comparison between the data obtained by the PESERA model and the measured values in the various soil erosion plots generally showed a satisfactory performance of the model. Rates of soil erosion were better predicted for abandoned bare land with a maximum error (MAX) equal to 0.65 t ha^{-1} $year^{-1}$. The greater maximum error (1.49 t ha^{-1} $year^{-1}$) was found for the vineyard plots. The model overestimated soil erosion rates for wheat field. However, the erosion rates predicted by the model are relatively low (lower than 1.16 t ha^{-1} $year^{-1}$) which are close to measured values (zero or almost zero). However, as Fig. 4 shows, the overall predictions of the PESERA model seems to be in acceptable agreement with the measured values of soil erosion. The application of the model to a small watershed for a period of two months predicted a sediment of 0.24 tones while the measured value was 0.18 tonnes.

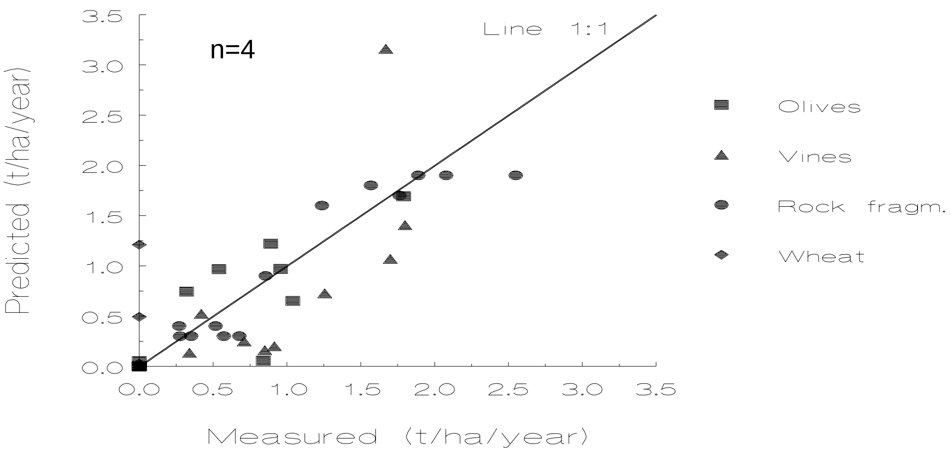

Figure 4. Measured and predicted soil erosion rates by the PESERA model in various experiments in Greece (Tsara et al., 2005)

Identified strengths and weaknesses of the estimation of indicator values

Soil erosion can be easily estimated by the PESERA model for a hillslope using the two dimension MS Excel version. ENVASSO protocol can provide all the necessary data for running this version of the model. In the opposite, the three dimension version of the PESERA model, which can be applied at regional level, requires simplification. It can be applied after few hours training by an expert. ENVASSO protocol can be partly used for this form of the model. The model before application requires calibration and validation using experimental soil erosion data. The application of the model in Greece after calibration gave reliable results in many cases.

Identified *strengths* and weaknesses of the interpretation of indicator values

Soil erosion rates estimated by the PESERA model can be easily interpreted. Specific classes of soil erosion rates can be identified based on the vulnerability of the land for degradation. Furthermore, differences in soil erosion rates due to land use change can be analyzed. The model can be used as a tool for assessing best land management practices for soil erosion protection.

Conclusions and recommendations

ENVASSO program make an excellent effort in organizing the soil data basis and identifying the best methodologies for assessing various soil threats using indicators. ENVASSO system must be further improved in relation to the data availability by: (a) introducing more data on the existing data basis, (b) including new data related to vegetation, climate, and land management. The data basis has to be organized in such a way that can be easily used by the recommended methodologies for assessing soil treats. The PESERA model requires more user friendly documentation.

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Kirkby, M. 1999. Regional desertification indicators (RDI's). In: The Medalus Project, Mediterranean Desertification and Land Use-Manual on Key Indicators of Desertification and Mapping Environmentally Sensitive Areas to Desertification, eds C Kosmas M Kirkby & N Geeson, European Commission, EUR 18882, pp 48-65.

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Tsara, M., Kosmas, C., Kirkby, M.J., Kosmas, D., and Yassoglou, N. 2005. An evaluation of the PESERA soil erosion model and its application to a case study in Zakynthos, Greece. Soil Use and Management, 21:377-385.

Pilot area: North Valencia transect, Spain

Lead Partner: CSIC
J.L. Rubio
V. Andreu
J.A. Pascual

North Valencia transect, Spain

Name of pilot area		Transect North of Valencia, Spain
Names of participating partners	**Lead partner**	**J.L. Rubio**
	Partner A	J.L. Rubio
	Partner B	V. Andreu
	Partner C	J.A. Pascual
Location and description	Member State(s)	Spain
	Coordinates	682720-0º 52' 4" W / 4400382-39º 43' 59" N
	Area of pilot area (km^2)	3011
	Climate	Sub-humid toSemi-arid
	Mean temperature (FAO 2006*)	16.54 ^{o}C
	Average Annual Precipitation (FAO 2006)	471.30 mm
	Outline description of topography	From coastal plain to highly mountainous
	Elevation (m)	601 on average 1836 highest peak
	Vegetation (FAO 2006)	Mediterranean woodland, xeromorphic shrubland
	Major Land Use (FAO 2006)	Natural and reforested woodland, irrigated and non-irrigated cultivation
	Major soils (WRB 2006 RGs)	Calcisols, Luvisols, Cambisols, Fluvisols, Anthrosols, Regosols, Leptosols, Phaeozems, Kastanozems

Threat and related indicator(s) evaluated in pilot area

Threat	Erosion
Indicator 1	ER01 Soil erosion
Indicator 2	
Indicator 3	

Rationale for selection of the pilot area

This pilot area has been selected because it combines different, natural and land use characteristics, which allows us to observe and test different conditions of uses, vegetation, lithologies, topography, climatic conditions and soils. Its interest is increased by the diverse history of human pressure and socio-economic development that shows.

The geographical transect that constitutes the selected area covers from interior environments, with a mountainous morphology, almost continental climate and reduced human pressure, to a coastal zone highly populated and transformed (urban development, communication infrastructures, industrial areas and tourism facilities), with a alluvial plain morphology and intensively cultivated with irrigated crops.

The area also presents a transition zone, which occupies the central part of the transect, with particular characteristics reflecting a gradual hardening in the environmental conditions towards the inner zone. In this zone, the irrigated land diminishes and dry-farmed crops become the more representatives.

The different aspects covered by this pilot area, from the inner zones to the coastal plain, are representatives of the consequences and circumstances produced by the human development in Europe, and mainly in the Mediterranean regions, along history under different landscape and environmental conditions. These facts made this area very valuable to apply the methodologies included and developed in the ENVASSO project.

Indicator Evaluation

Indicator

The applied in this case to the selected pilot area is land desertification, being assessed according the methodology of environmentally sensitive areas defined in the MEDALUS III research project.

Description of the study area

The selected pilot area covers five administrative regions (comarcas) inside the province of Valencia (Figure 1): Camp de Morvedre, L'Horta Nord, Camp de Túria, Els Serrans and racó d'Ademuz. It is representative of large areas of the Mediterranean Europe, including different aspects:

- The agricultural irrigated zone of the coastal plain (Camp de Morvedre and L'Horta Nord regions)
- The agricultural non-irrigated zone, which is a transition towards the inland mountainous zones, and shows a patchy structure of dry farming, rangelands and open forest (Camp de Túria and Els Serrans regions)
- The mountainous zone of the interior areas with abrupt topography, but also including areas of dry farming and marginal crops (Racó d'Ademuz)

The agricultural irrigated zone constitutes a wide coastal plain modelled by the alluvial contributions of rivers and torrents. The surface deposits are up to 100 meters thick. Near the coast, marshy zones seasonal or permanently flooded appear due to the proximity of the water table. Parts of these zones have been transformed for agriculture by drainage and soil filling.

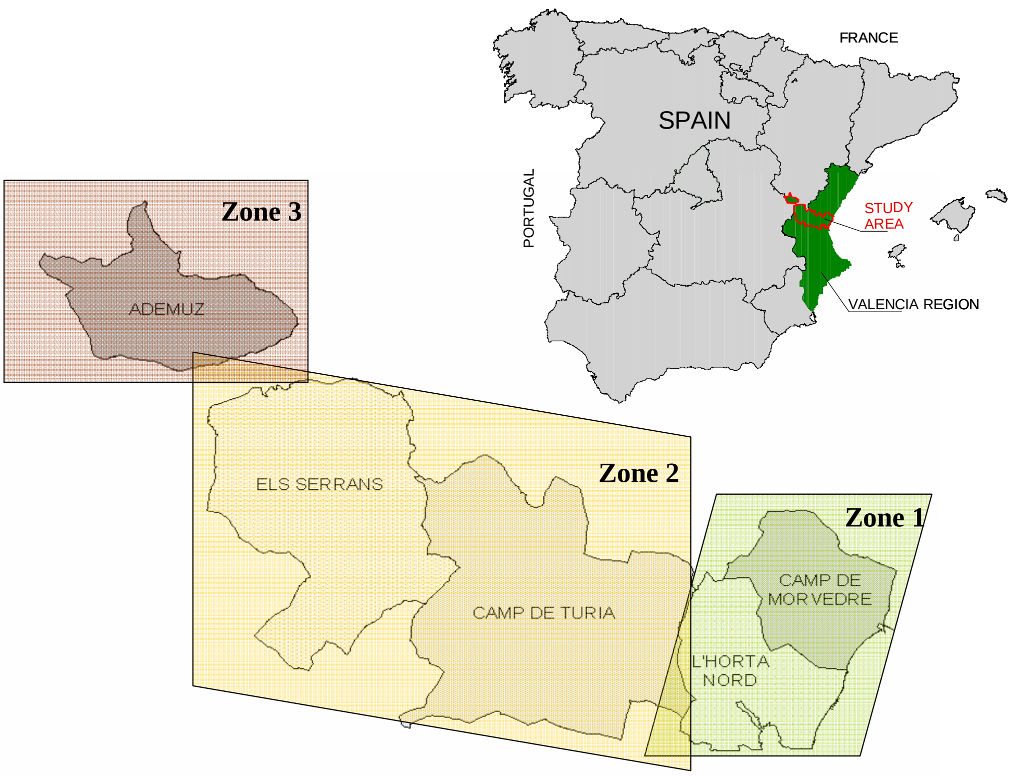

Figure 1. Location of the Pilot area and differentiation of the zones.

In the coastal zone there is a small littoral strip with dunes. These dunes are partly stabilised and the others are strongly degraded by tourism and urban expansion.

The transition zone is dominated by dry farming, abandoned agricultural land and forest zones (mainly pines). Together with relatively small villages, the zone is populated with some second residence constructions. Large forest fires have damaged some parts of this zone in the past years.

The inner mountainous zones are dominated by forests and marginal dry farming, all influenced by the abrupt topography. The agricultural areas, of little extension, support a low population density. In this sense population is one of the differential aspects between the three zones going from 8.11 inhabitants km^{-2} in Racó d'Ademuz (zone 3) to 1439.56 inhabitants km^{-2} in L'Horta Nord (zone 1).

There is a great topographic variability along the pilot area (Figure 2). In the southern coastal zone there is a large plain area, around the Túria River. This corresponds to the L'Horta Nord and Camp de Túria regions. This valley extends to the North and links to the coastal zones of Camp de Morvedre, in the catchment of the Palancia River. It then extends to the west covering most of the Camp de Túria region. A Mountainous range appears around the boundary of Camp de Túria. The mountains lead to a small plateau in the middle of Els Serrans, where there is abundance of plain zones with high altitude, surrounded by steep areas in the western and northern boundaries of this region. The most abrupt area in the transect corresponds to the East of Racó d'Ademuz, where there steep landscape stretches through a wide area. The West of this region becomes gradually less abrupt. A different pattern from that of the surroundings of the Túria River is observed in the catchment of the Palancia River, in the West of Camp de Morvedre region, where mountains appear near the sea.

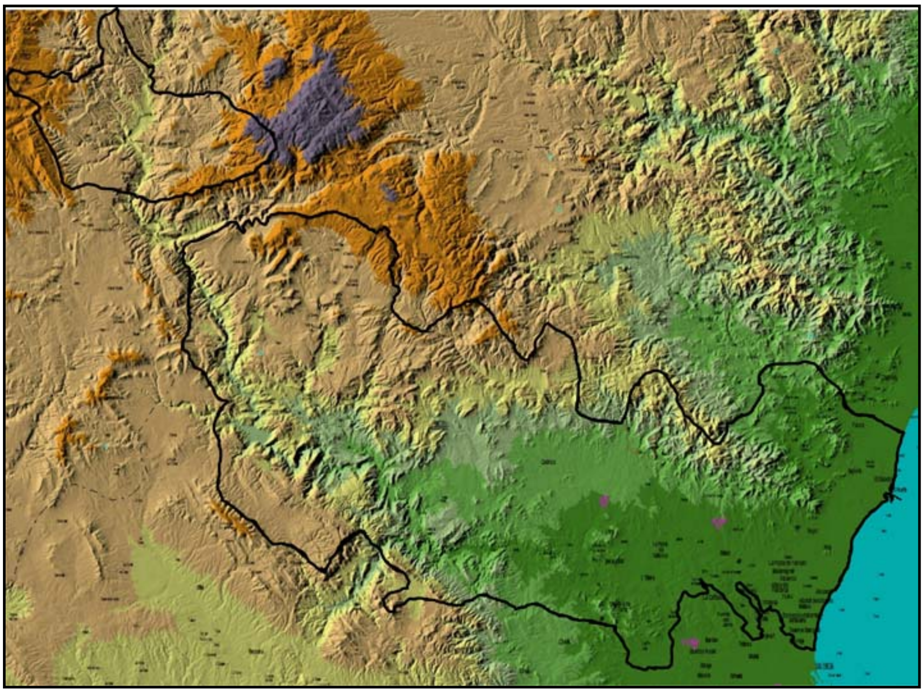

Figure 2. Morphological configuration of the pilot area.

Lithology

The geology of the pilot area is based on materials mainly of two eras:

- The mountainous zones: these zones were formed in the Mesozoic (Triassic, Jurassic and Cretacic), and are mainly of carbonate nature.

- The coastal zones, together with depressions and interior valleys: the materials of these zones are constituted by Tertiary and Quaternary rocks, including consolidated materials and sediments of different textures.

The main lithological characteristic of the pilot area is the abundance of sedimentary rocks. Among them, limestone (calcite, dolomite) are the dominant ones. These were originated in the Mesozoic and are abundant in the interior of the pilot area (Ademuz, Els Serrans, and Camp de Túria). In the coastal zones, the detritic rocks are dominant, either loose (clay, silt, sand or gravel), or compacted (sandstone, conglomerate, limestone, etc.). There are important outcrops of sandstone in Camp de Túria. The evaporitic rocks (gypsum and others salts) appear in some local areas, originated by large salty continental wetlands or silty coastal marshes. Finally, there is a zone of materials of organic nature (peat bogs) near the sea in L'Horta Nord and Camp de Morvedre.

Climate

In the pilot area a great climatic contrast between the coastal zones and the interior areas could be observed. These differences are produced by several factors:

- The influence of the sea, which soften the thermal changes in the coastal zones. Therefore, there is a great thermal contrast with the interior of the transect.
- The effect of orography, is reflected by the strong differentiation of climates between zones. The existence of mountain ranges near the coast (Figure 2) diminishes the influence of the sea, increasing the continentality of the inner zones. In addition, the altitude increases towards the interior reaching more than 1800 m. This greater altitude tends to diminish the temperature and slightly increases precipitations.
- The variations in exposure, caused by the orientation of the slopes, produce intense changes in short distances. Moreover, the contrast between northern (more humid) and southern (more dry) slopes have also an important sea influence. The slopes exposed to the winds coming from the sea receive more rain than the west facing slopes. This explains the important variations in soil type and vegetative cover that can be appreciated between different slopes of the same mountainous range.

All these factors favour the existing great variability, in short distances, of precipitation and temperature. The mean temperature varies in the selected transect from below 11°C to 17-19°C, from the interior to the coast. Similarly, mean precipitation varies from under 400 mm, in the non-irrigated plain of Camp de Túria, to 600-800 mm in the mountainous zones of Racó d’Ademuz and Els Serrans (Figure 3).

In summer, the shift of the subtropical Atlantic anticyclone deviates towards the North the precipitation coming from the wet fronts of the Atlantic Ocean. In winter, the Atlantic winds also dominate the region but, again, the precipitations are reduced because the Iberian Mountainous range acts as a barrier to the Atlantic humid fronts, and because a cold anticyclone is formed in the Centre of Spain in this season also acts as a barrier to Atlantic storms. Consequently, the most important rainfalls occur as a consequence of winds that come from the Mediterranean, and it is strongly seasonal.

The low rainfall volumes and its variability is one of the factors that make this area sensitive to desertification process. The majority of this area is classified as semi-arid, dry or dry sub-humid, and there is only a small part in the mountainous zones of the selected transect that is classified as sub-humid. Except for this small zone, the rest of the pilot area can be considered sensitive to desertification processes according to the definition of the United Nations Conference to Combat Desertification (UNCED, 1994).

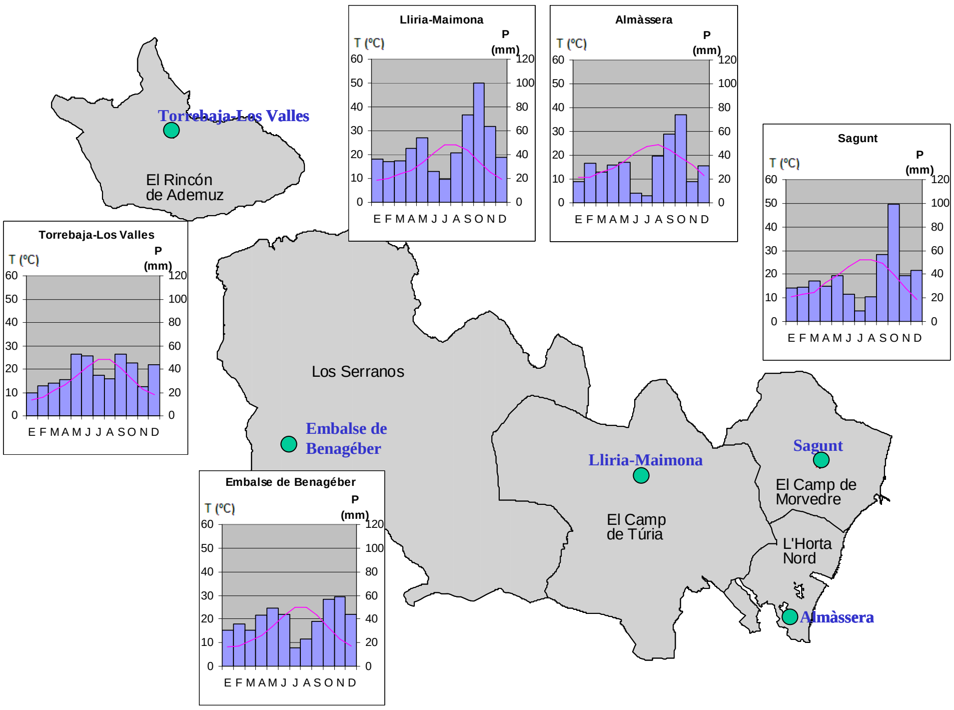

Figure 3. Climatic variations characteristic of the pilot area, through its more representative climatological stations

Land Use and Land Cover

Land use changes are significantly along the transect. In the coastal plain the cultivation of citrus species is the dominant agricultural activity. These citrus species occupy to 90% of the irrigated surface. Vegetables and other fruits (pears, medlar) are the other, less important, crops. In the transition zone there is abundance of dry farming (olive trees, vineyards, carob trees, almond trees, plum trees, etc.), together with abandoned agricultural land and forest zones (pines). The inland area is mainly covered by pine forest and rangeland. This abundance of single forest species, and pine in particular, is an important factor which increases the risk of fires, which have led us to develop new policies for the diversification in the Mediterranean forests. Inside the forest zones there are isolated agricultural areas of marginal dry farming (cereals, walnuts, etc.), and grazing.

Soils

The pilot area is also representative of many different soil types. The major soil groups existing in the area are (FAO 1988 legend): Regosols, Leptosols, Calcisols, Cambisols, Luvisols and Fluvisols.

In the coastal plain Calcic Gleysols are frequent due to the presence of a groundwater table near surface as well as soils affected by salts due to marine intrusion (Gleyic Solonchaks).

Haplic Regosols (Calcic), Haplic Calcisols and Petric Calcisols are the most common soils encountered in dry farming areas. These are highly erodible soils, characterised by high calcium carbonate and low organic matter contents.

In forest areas, Lithic and Rendzic Leptosols are the dominant soils. They are limited in depth, mainly by limestones, within 10 or 30 cm of the surface, respectively. Leptic Regosols are also present.

Isohumic soils are only present in some few areas where there is a well preserved vegetation cover (mountainous areas mainly). They are characterised by a mollic horizon in surface with high organic matter content and water retention capacity. Rendzic Leptosols, Calcic and Haplic Kastanozems and Calcic Phaeozems are typical of these areas.

Pilot area Methodology

The description and spatial distribution of erosion rates due to surface runoff have been assessed by the application of the Pan-European Soil Erosion Risk Assessment (PESERA) model. All data used have been handled and distributed according the requirements of the different routines of this model. The sequence of implementation of the different parts of the model, and the sources of data used, has been made according the thematic compartments or groups (Table 1). The followed sequence has been:

STEP 1: Elaboration of the digital layers related to Climate Parameters.

Data used were obtained from those available in the existing reports and publications from the National Meteorological Institute. The layers prepared were:

- Meanrf130 to Meanrf3012 (monthly rainfall in mm, defined for each grid and for the 12 months using monthly values).
- Meanrf21 to Meanrf212 (mean daily rain, which is the total rain per month divided by the number of rainy days for each month).
- Cvrf21 to C212 (coefficient of variation of rainfall per rain day, for each month and grid)
- Mtmean1 to Mtmean12 (monthly temperature in ^{o}C, calculated using monthly values for each grid for 12 months).
- Mtrange1 to Mtrange12_ (mean temperature for each month)
- Meanpet301 to Meanpet3012 (monthly mean potential Evapo-Transpiration)
- Newtemp_ (predicted future temperature)
- Newrf130_ (predicted future rainfall)

The data treatment process was:

1. Pre-processing and interpolation
2. Interpolation of data using ArcGIS functions (Kriging)
3. Parameter assignation according the PESERA Methodology

STEP 2: Elaboration of the layers related to Land Cover and Vegetation Parameters.

Data used were obtained from the CORINE land Cover 2000, and the layers prepared were:

- Use (land cover type or management)
- eu12crop1 (dominant arable crop)
- maize_210c (maize crop)
- eu12crop2 (Second dominant arable crop)
- itill_crop1 (planting month of the dominant arable crop)
- itill_maize (planting month of maize)
- itill_crop2 (planting month of the second dominant arable crop)
- mitill_1 (planting marker of the dominant arable crop)
- mitill_m (planting marker of maize)
- mitill_2 (planting marker of the second dominant arable crop)
- cov_ (initial ground cover)
- Cov_jan to Coc_dec (ground cover in % for each month)
- rough0 (initial surface storage)
- rough_red (roughness reduction)
- rootdepth (root depth)

The actions performed with the data were:

1. Revision of the Legend
2. Parameter assignation according the PESERA Methodology

STEP 3: Preparation of the layers related to Soil Parameters.

The layers elaborated and the sources of information were:

- Crusting (crust storage)
- zm (scale depth in the range 5-30 mm)

The Soil Geographical database for Eurasia as source of information, and the data treatment was:

1. Integration into the GIS structure
2. Parameter assignation from the PESERA Methodology

- Erodibility (sensitivity to erosion)

This layer was based on the k factor units of the published digital map of the Consejería de Obras Públicas, Urbanismo y Transportes (COPUT) of the Valencian Community, at 1:50,000 scale. The data treatment applied was the same as for the two previous layers.

- swsc_eff_2 (effective soil water storage capacity)
- plxswap1 (soil water available to plants in top 300 mm)
- p2xswap2 (soil water available to plants at 300 and 1000 mm depth)

The data source for these three layers were the LUCDEME Project soil maps at 1:1000,000 scale. These data were treated by:

1. Digitising of soil units from the original paper map
2. Statistical analysis of the reference soil profiles for moisture and water content map units identification
3. Parameter assignation from the PESERA methodology

STEP 4: Elaboration of layers related to Topography Parameters.

The prepared layer was STD_eudem2 (Standard deviation of elevation) obtained from the published digital maps with 20 m contour lines from the COPUT at 1:50,000 escale, by:

1. Elaboration of the Digital Elevation Model
2. Parameter assignation according the PESERA methodology

All the process applied are reflected in Table 1.

Evaluation of pilot area results

Soil erosion rates obtained by the application of the PESERA model, are reflected in Table 1, and its graphical representation is shown in Figure 4. The dominant range on soil erosion by the application of the model lies on 0-0.8 t/ha/yr that corresponds to the 69.4% of the total area. It is far from the real data consulted in different reports, underestimating the possible erosion losses. It is more marked in the central zone of the transect, with traditional agricultural systems and that represents the transition zone from the irrigated agriculture of the coastal plain to the dry farming, which is mainly dominated by moderate slopes. And, in the western part of the transect (Els Serrans and Racó d'Ademuz regions), occurs similar trends in the valleys and in the banks of the Turia river.

Table 1. Course of the methodology applied according to the PESERA erosion model protocols.

GROUP	Model parameter	Source	Data Treatment
STEP 1: Layers related to Climate Parameters			
CLIMATE	meanrf130_ meanrf2_ Cvrf2_ mtmean_ mtrange_ meanpet30_ newtemp_ newrf130_	Data available in existing reports an publications from the National Meteorological Institute	1. Data pre-processing for interpolation 2. Interpolation of data using ArcGIS functions (Kriging) 3. Parameter assignation from the PESERA methodology
STEP 2: Layers related to Land Cover and Vegetation Parameters			
VEGETATION/LANC COVER	use eu12crop1 maize_210c eu12crop2 itill_crop1 itill_maize itill_crop2 mitill_1 mitill_m mitill_2 cov_ rough0 rough_red rootdepth	CORINE LAND COVER 2000	1. Revision of the Legend 2. Parameter assignation from the PESERA methodology
STEP 3: Layers related to Soil Parameters			
SOIL	crusting zm	Soil Geographic Database of Eurasia	1. Integration into the GIS structure 2. Parameter assignation from the PESERA methodology
	erodibility	Published digital map (COPUT) with k factor units (1:50000 scale)	1. Integration into the GIS structure 2. Parameter assignation from the PESERA methodology
	swsc_eff_2 p1xswap1 p2xswap2	LUCDEME Project Soil maps (1:100000 scale)	1. Digitising of soil units from the original paper map 2. Statistical analysis of reference soil profile for moisture and water content map units identification 3. Parameter assignation from the PESERA methodology
STEP 4: Layers related to Topograhy Parameters			
ELEVATION	Std_eudem2	Digital maps with 20 m contour lines from the COPUT at 1:50000	1. Elaboration of a Digital Elevation Model 2. Parameter assignation from the PESERA methodology

Table 2. Area covered by the different erosion ranges in the North Valencia transect, obtained by the application of the PESERA model..

Erosion (t ha^{-1}yr^{-1})	Area (km^2)	Area (%)
0-0.5	207200.0	69.4
0.5-1	26943.8	9.0
1-2	19443.8	6.5
2-5	17931.3	6.0
5-10	11000.0	3.7
10-20	7931.3	2.7
20-50	4562.5	1.5
>50	3675.0	1.2

In general, the remainder erosion ranges fits fairly well with the observations made. Probably, the 0.5-1 and 1-2 t/ha/yr would be the ranges that need to be increased in the area mapping. These two ranges occupy the 15.5% of the total area, with 9.0 and 6.5%, respectively. They correspond to the hillsides of the mountainous ranges and Sierras that conserve the forest stands altered by the impact of recurrent fires. The losses from 2 to 5 t/ha/yr are located in the mountainous zones with more steep slopes, which concentrate, in many cases, marginal farming and abandoned fields.

Areas described with losses higher than 5 t/ha/yr covers the 9.1% of the transect corresponding to the mountainous zones with less favourable conditions and that show the more degraded vegetation cover.

These results have been also compared with those produced by the application of the USLE model (Figure 5), based on data at 1:50,000 scale and in environmental units. We consider that the PESERA application gives more realistic results than USLE, as it is commented in the next section, although considering the previous remarks.

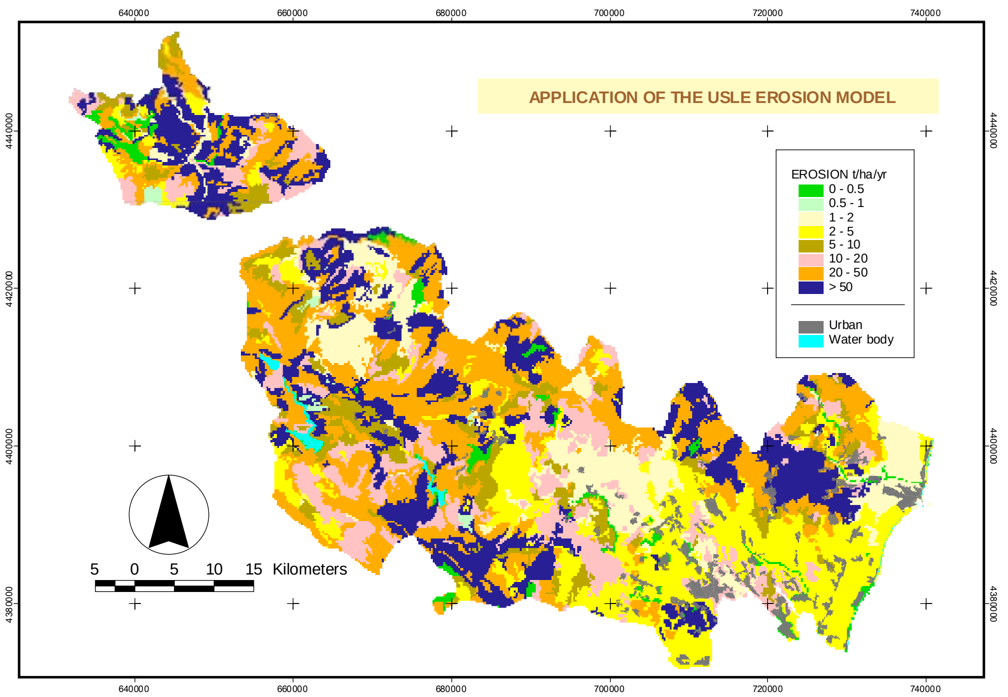

Figure 4. Map of the distribution of the different ranges of erosion, based on the application of the PESERA methodology, in the North Valencia transect.

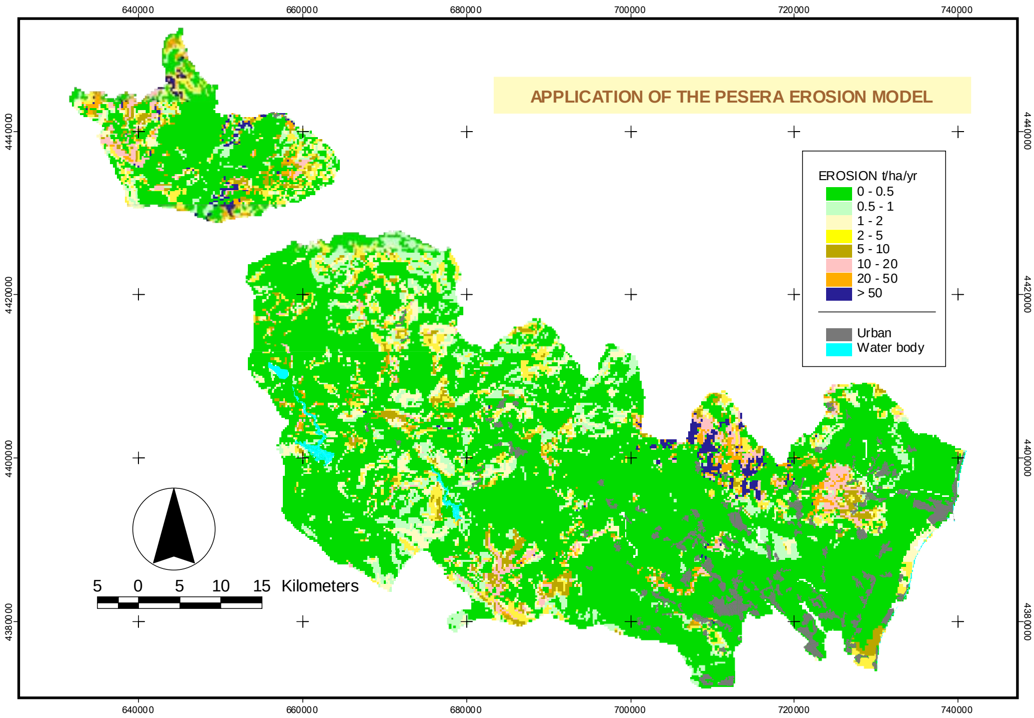

Figure 5. Map of soil erosion rates by application of the USLE model to the North Valencia transect.

Conclusions and recommendations

The different observations made by the application of the PESERA model can be summarized firstly according the different group of parameters that constituted the layers of this methodology:

1. Soil Information:
    - The LUCDEME map, used for the elaboration of the water related layers, associated to the soil profiles database, gives a non detailed distribution of the various water content parameters. Further work should be done to obtain more specific information on such attributes that would allow a better spatial distribution of the parameters.
    - **Crusting** and **zm layers** have been obtained from a not enough detailed information source (Soil Geographic Database of Eurasia), reinforcing the coarse and non detailed distribution of the parameters.
    - In all layers, different data sources have been used to obtain specific soil parameters. Apart from cartographic scale, methodologies to obtain environmental (mapping) units will introduce mismatching of parameters.
    - It is highly recommended that, for soil parameter characterisation, the use of a unique soil map layer. Also, soil mapping should incorporate more specific information related to erosion and hydrologic models.

2. Climate Information:
    - Parameters are derived from existing data, based on the conventional meteorological network, which once interpolated give a coarse distribution of the climatic parameters.
    - Particularly for Mediterranean areas, more specific information on rainfall intensity (e.g. concentration of rainfall in 24 hours or shorter time span; ratio between total amounts of rainfall an hours of precipitation) would probably enhance the quality of the data.

3. Vegetation/Land Cover:

- Vegetation parameters have been derived using the CORINE LAND COVER map, which could be a too coarse source of information to describe the complexity of some Mediterranean vegetation patterns.
- Although this is a very demanding task if not available, the use of better-more detailed vegetation maps (scale 1:50000) should be recommended.

The performance of the model gives a distribution of erosion mainly related with major trends, were topography plays an important role. The obtained graphical representation seems to be quite realistic in the general trends. To test its performance it has been compared, as it has been indicated above, with an erosion map calculated using the USLE methodology and based on the concept of environmental units (or equal response units). Although the methodological procedure and the working scale are different, results are similar in the representation of sectors with different rates of erosion. The quantification of erosion in both maps is distinct. The USLE based methodology overestimates with higher amounts, while the PESERA methodology underestimates the values as a general trend. This is, provably, not only a question of the internal calculations of the PESERA model but also of the coarseness of the data sources used, and the need of more detailed parameters that could represent properly the reality and singularities of local areas.

Thus, a critical and deep revision of the different model components and incorporation of more specific parameters are needed to advance in the refinement of the PESERA final results.

Pilot area: Hungary

Lead partner: SIU
I. Waltner,
E. Micheli

R. Jones (CU)

Description of the Pilot Area, Hungary

Name of pilot area		**Hungary**
Names of participating partners	**Lead partner**	**Szent Istvan University, (I. Waltner, E. Micheli)**
	Partner A	Cranfield University (R. Jones)
	Partner B	
	Partner C	
Location and description	Member State(s)	Hungary
	Coordinates	45°44', 48°35' N 16°07', 22°54' E
	Area of pilot area (km^2)	90,030
	Climate	Temperate
	Mean temperature (FAO 2006*)	9.7 °C
	Average Annual Precipitation (FAO 2006	600-650 mm
	Outline description of topography	Approx. 3/4 is low plain,1/5 is hilly and 5% is mountainous
	Elevation (m)	78 to 1014 m
	Vegetation (FAO 2006)	Various
	Major Land Use (FAO 2006)	Various
	Major soils (WRB 2006 RGs**)	Arenosol, Chernozem, Cambisol, Fluvisol, Histosol, Leptosol, Luvisol, Phaeozem, Regosol, Solonchak, Solonetz

Threat and related indicator(s) evaluated in pilot area

Threat	**Soil erosion**
Indicator 1	ER01 Estimated soil erosion by rill, inter-rill & sheet water
Indicator 2	
Indicator 3	

Rationale for selection of pilot areas

Water erosion affects more than one-third of total agricultural land in Hungary. Although erosion research has been ongoing for several decades, with many estimations of soil loss, the only map (with a scale of 1:75,000) of erosion based on field data was released in 1964, and even that provided data only for certain areas of the country, with no numeric predictions of actual soil loss.

The Grid version of the PESERA model has the potential for application at different resolutions – 100m, 250m, 1km, 2km etc and the capability to estimate the effects of different scenarios of climate and land use. Existing databases in Hungary provided data more accurate and higher resolution data than were available for previous application of the PESERA Grid model e.g. at European scale (1km resolution). Data from the national AGROTOPO database was used to provide a higher resolution soil texture data, and Corine Land Cover 2000 and SRTM data were used to improve the input data for topography and land cover at Hungarian scale.

Indicator Evaluation

Indicator: ER01 Estimated soil erosion by water runoff

Description of the pilot area

Spatial extent

The pilot area includes the whole of Hungary. It is situated in the Carpathian Basin, surrounded by Austria, Serbia, Croatia, Slovenia, Romania, Ukraine and Slovakia. Hungary covers 90,030 km^2 and extends about 250 km from north to south and 524 km from east to west, with boundaries 2,258 km in length.

Soil erosion estimation

Using data from the Hungarian AGROTOPO database and from Corine Land Cover 2000, two updated soil erosion maps were created, one with a 1km x 1km (Figure 1), and one with a 250m x 250m grid size.

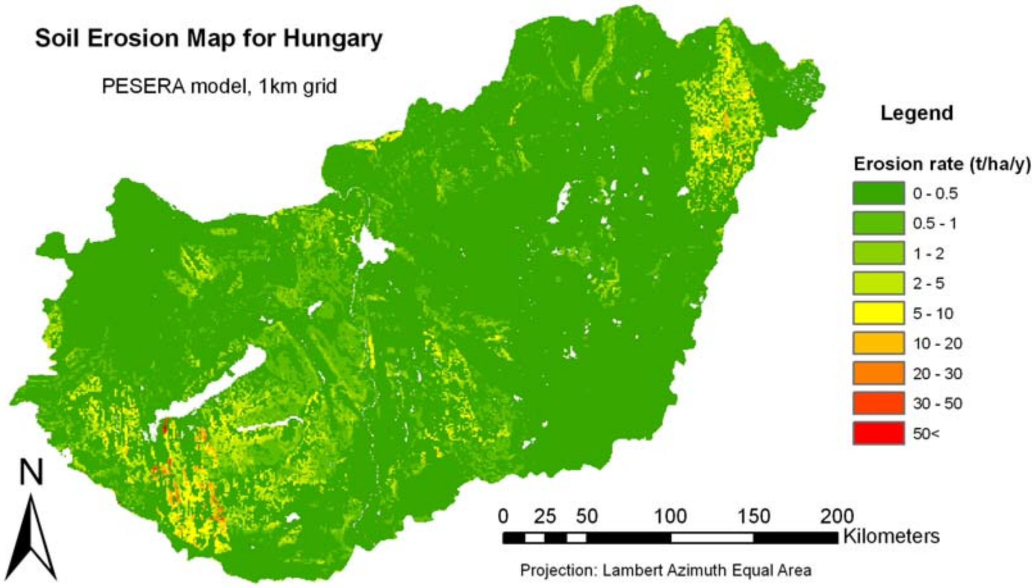

Figure 1. Soil erosion map for Hungary.

The application of the 250m grid did not greatly affect the spatial distribution of estimates erosion rates compared with the 1km estimates. The PESERA erosion estimates are broadly comparable with existing national maps of erosion risk. The main differences are in the mountainous regions in the northern areas of the country. This might be caused by changes in land use or the fact that the nationally sourced maps show classes of soil erosion whereas PESERA provides discrete unique values of soil loss for each 1km grid cell. Thus the only way to properly validate the Pesera model estimates would be to conduct a nation-wide study to measure soil erosion directly from different landscapes and soil types. To date this has not been done and until soil erosion measurements become available, we are unfortunately only able to conclude that the PESERA results are no more or less valid than previous erosion estimates for Hungary. Without sufficient measured data it is difficult to establish which of the two maps is the more accurate, but conventional wisdom would suggest that higher resolution map data (on 250m grid) should be more precise than data on the 1km grid.

Pilot area: Chemnitz, Germany and Czech Republic

Lead Partners:BGR, CUA
Rainer Baritz
Jan Willer
Einar Eberhardt

Josef Kozak
Vit Penizek CUA)

Heiner Heilmann (LfUG)
Ronald Symmangk
Anna Böhm

Chemnitz, Germany and Czech Republic

Name of pilot area:		**Pilot area 1:250,000 Sheet Chemnitz (Germany-CZ)**
Names of participating partners	**Lead partner**	**Rainer Baritz, Jan Willer, Einar Eberhardt (BGR)**
	Partner Saxony	Heiner Heilmann, Ronald Symmangk, Anna Böhm (LfUG)
	Partner Czech Republic	Josef Kozak, Vit Penizek (CUA)
Location and description	Member State(s)	CZ and Germany (mainly parts of Saxony, smaller area of Thuringia and Bavaria)
	Coordinates	coordinates (map corners, WGS84) X Y NW 12° 0' 0"E 51° 0' 0"N NE 14° 0' 0"E 51° 0' 0"N SW 12° 0' 0"E 50° 0' 0"N SE 14° 0' 0"E 50° 0' 0"N
	Area of pilot area (km^2)	appr. 15,753 km²
	Climate	temperate suboceanic to temperate-subcontinental (acc. to soil regions vers. 2.0)
	Mean temperature (FAO 2006)	annual mean temp.: 5.2-8.2°C
	Average Annual Precipitation (FAO 2006	annual average: 600-1500 m
	Outline description of topography	level land, sloping land
	Elevation (m)	666-1011 mm
	Vegetation (FAO 2006)	Herbaceous, Woodland, …
	Major Land Use (FAO 2006)	cropland (36%), forest (30%), grassland (8%), urban (9%), heterogeneous agricultural land (10%), Scrubs (5%)
	Major soils (WRB 2006 RSGs)	Cambisols, Luvisols, Albeluvisols, Podzols, Chernozems, Andosols

Threat and related indicator(s) evaluated in pilot area

Threat	**Soil erosion**
Indicator 1	ER01 erosion by water

Rationale for selection of pilot area

Questions regarding land use and soil require harmonized and accurate information and data across political borders. The existing low-resolution soil data, such as those for the scale 1:1,000,000 are usually derived from auxiliary data (geology, land use, relief, climate) in a so-called "top-down" manner, rather than aggregated from field assessments. Such maps are lacking accuracy, and often only allow rough estimates of the distribution of soils and soil properties in the landscape. Therefore, many countries have decided to pursue high resolution overview maps, such as the 1:250,000. Experts of the European Soil Bureau Network (ESBN) have thus developed a mapping guide to support the harmonized 1:250,000 inventory (Manual of Procedures). Within the scope of ENVASSO, therefore, testing should include this target scale, because it represents a realistic future resolution of harmonized soil information across Europe. The sheet Chemnitz is one of the official 1:250,000 test areas of the ESBN, for which we have partnership in ENVASSO.

Indicator Evaluation

Indicator: ER01 Estimated soil loss by rill, inter-rill and sheet erosion

Erosion causes damages on cultivated soils: sediment transport and off-site problems such as diffuse pollution are consequences. Erosion is caused when water cannot infiltrate into the soil. This is followed by surface runoff, then creating features such as sheet, rill or gully erosion. Four main factors are to be considered when assessing erosion risk: soil, topography, land cover and climate. Rill and inter-rill erosion is not distinguished by PESERA, because the erodibility parameters are based on coarse empirical calibration parameters specifically developed for the 1:1,000,000 European soil database. More precisely, PESERA considers hillslope erosion (or: overland run-off) and excludes channel processes. Therefore, applying this method, the final estimate can only be interpreted at broad regional scales.

Description of the pilot area

Spatial extent

The sheet covers the area starting from Thuringia in the north-west (city of Gotha), and a small area of Bavaria in the south-east (next to the city of Marktretwitz), and reaches almost to the city of Dresden in the north-east and to Prague in the south-eastern part. The area of the sheet Chemnitz has a high proportion of mining and industrial land (especially foothills of the Ore Mountains around the larger cities, especially Freiberg). Agricultural land dominates although the Ore Mountains, oriented WSW to ENE throughout almost the entire sheet, are dominated by forest vegetation. It can be expected that the susceptibility for erosion by water is quite high for the loess area in the northern part of the pilot area and for the Prague basin (which is included in the central- and south-eastern part of the map).

Data sources

The objective of testing ER01 (water erosion) is to apply PESERA using the spatial approach, which requires mapped (rasterised) data for the pilot area. As for the soil data base, data for soil profiles are needed which are typical for the corresponding mapping units.

The following data are available:

Original map Sheet Chemnitz

	geometries, harmonized along the country border to CZ and to Bavaria and Thuringia	– WRB 1998, soil body and soil attribute table acc. to Manual of Procedures, including report, how these data were derived – soil mapping units n=104

New data from partners LfUG (Saxony) and CUA (CZ)

Saxony	soil profiles n=59, representative for the resp. mapping units (imported into SoDa by LfUG)	– coordinates of the profile within a mapping unit; data classes and codes acc. to Manual of Procedures – elevation, slope, slope orientation, major landform, horizontal slope form – WRB 2006 RSG, soil region (version 1.0), STU (dom. soil type + parent material, humus form, German *Bodenform* – type of erosion, drainage class, rootable depth – vegetation and land use (FAO 2006), – n=325 horizons with designation and descriptions acc. to German guideline, colour (Munsell), humus content (class), soil moisture, packing density, texture class, decomposition class (peat), soil volume, stones, geogenesis and parent material composition – pH($CaCl_2$), C-tot, N-tot, P-tot, sand/silt/clay and sub-fractions – additional mandatory data (ENVASSO WP5 in progress, e.g. some avg. climatic data, cropping, min/max depth to water table)
CZ	– new geometries from the national 1:250,000 SOTER map	– parent material (national nomenclature), WRB 1998 and 2006 for n=1963 polygons
	– soil data (as shape file attribute table)	– data for n=1636 out of n=1963 polygons: – horizon designation, upper and lower boundary,

		$CaCO_3$, humus content, pH(KCl), base saturation, CEC, sand/silt/clay-fractions
	– soil profiles	– ID for n=295 sites, WRB 2006, parent material (national nomenclature) – horizon designations – CaCo3, humus content, pH(H_2O), pH(KCl), base saturation, CEC, stones (n=4 sites), sand/silt/clay-fractions, bulk density (n=14 sites)

All data are imported into **SoDa**. For PESERA, the required texture class could be derived. The main step was now to prepare the geometries - a map sheet with the new CZ polygons. Given that the data from CZ did not fulfil the criteria set by the Manual of Procedures, this turned out to be difficult.

The **original map** resulted from an earlier project between LfUG and the CZ Geological Service with the objective to produce and harmonize a cross-border pilot mapping sheet 1:250,000 (pilot area for the Georeferenced Soil Database of Europe). The geometry was completed for the whole area (N=104 mapping units) including the soil attribute and soil body tables. The mapping units are described according to WRB (FAO 1998; reference soil group with 1-2 qualifiers). Information for the parent material, rooting depth and texture (5 classes) was compiled according to the Manual of Procedures (Finke et al. 1998).
Original map projection: Gauss Krüger, central median 12° (zone 4), Datum Rauenberg (Potsdam).

In the meantime, the Czech University of Agriculture, Prague, has produced a new country-wide 1:250,000 SOTER map (Soil and Terrain Database). Since this product has now become the official CZ 1:250,000, the **new CZ version** had to be built into the original database. It was found that the geometries do not fit at the borders. The following frame conditions added up to make this step time consuming, thus only preliminary without further validation:

- lack of soil body and soil attribute tables according to Manual of Procedures
- lack of a map legend and stratification according to soil regions
- lack of a unique identifier which connects the additionally provided soil profile data and the attribute data with the geometries (mapping units)

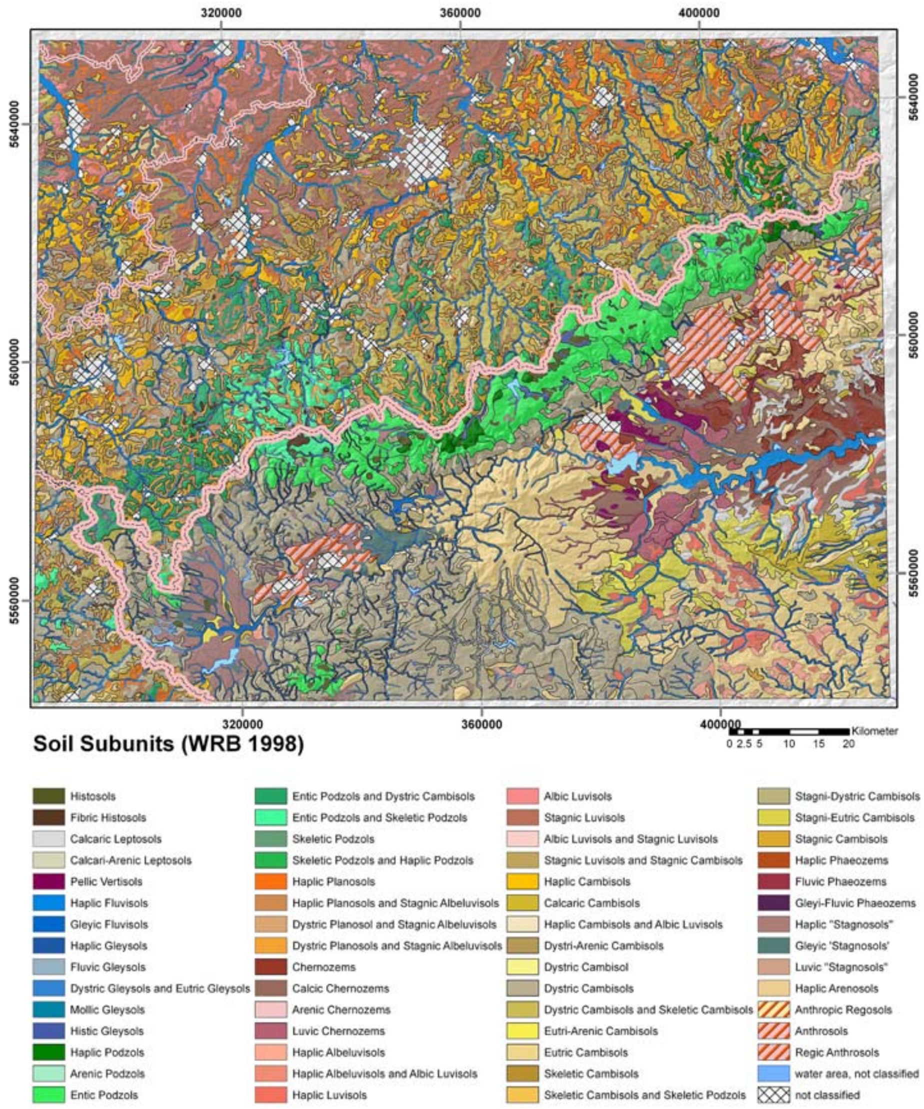

Figure 1. Polygon map 1:250,000 sheet Chemnitz

To incorporate this new version, the following **working steps** were then applied:

i) Development of a generic identifier (ID ' pol_id_cz'); added to the soil map, but also to the supplied texture und humus geometries; the data sets could then be combined (spatial join). The basis for this ID was the polygon_id of the soil map geometries. While the profile information could be joined to the geometries, the ID was not able to compensate for some redundancies because a generic mapping unit was not defined.
ii) Development of soil attribute tables for PESERA (not fully conform with the Manual of Procedures): the data from the various shape files were exported into seperate tables (tbl_soil_data_czech.dbf, tbl_texture.dbf and tbl_humus.dbf). The tables were then grouped in order to identify redundant information.
iii) Introduction of the common map projection ETRS 89, UTM Zone 33N
iv) Comparison and harmonization of CZ parent material classes

– Joining of the polygon maps (original Saxon part, new CZ part) by comparing old and new polygons in order to utilize the former map ID for the new CZ part (to identify the mapping units); parent material and soil type were also viewed to support the polygon identification; advantage of the procedure: the border harmonization and map unit ID of the original project could be utilized, because not enough soil data are available to generate a new map legend; the validation of this step, and the structuring of the map legend require the soil regions to be considered

For working PESERA, the following PESERA input grids were prepared:

– primary grids: soil texture classes, depth to rock (taking obstacle for rooting and/or lower boundary of the deepest horizon), soil type and parent material
– secondary, derived grids: erodibility, crusting, top soil and subsoil available water capacity, soil water storage capacity (see also Annex 1 and Figure 2)

Figure 1 presents the current status of the map sheet Chemnitz.

Figure 2 presents the input grids for erodibility and crusting. It allows comparison between the two resolutions, 1:1Mio and 1:250,000.

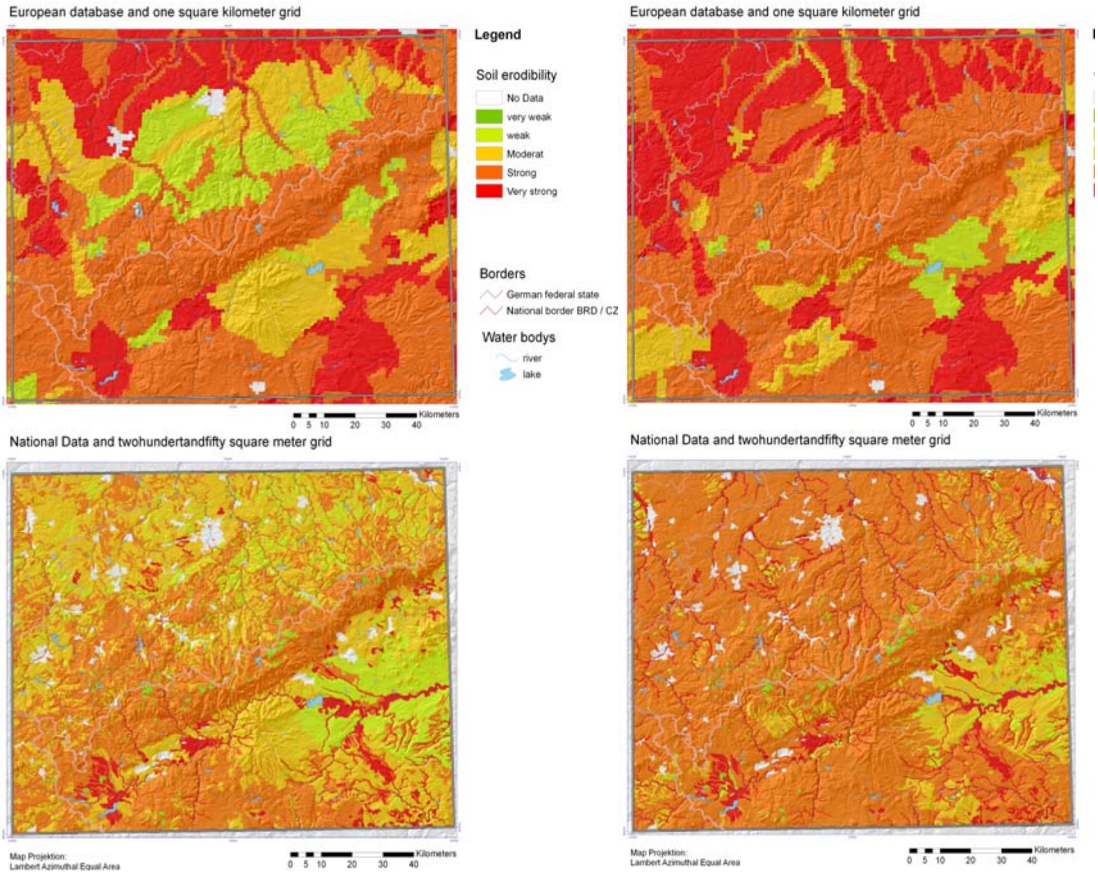

Figure 2. PESERA input grids

(left: soil erodibility, right: soil crusting (top: 1:1Mio, bottom: 1.250,000)

Climate

The spatial data is needed at comparable resolutions. For the scale 1:250,000, we agreed to use 250 m cell size. While deriving this resolution is easy for the soil information, difficulties arise for the climatic data. We have therefore contacted University of Hamburg (see also Boehner 2004) to regionalize data from weather stations, provided by the German Weather Service (DWD). Data for CZ are purchased from ČHMÚ (CZ Hydrometeorological Institute). We expect that the relief-based regionalization method to upscale the weather station data is very suitable for the PESERA modeling because we will use the SRTM model to receive climate variables interpretable as relief-modified meso-climate.

For PESERA, the following basic climate data are needed.

– daily potential evapotranspiration (reference ETP for grass crop; Penman-Monteith is proposed)
– daily global radiation (either acc. to Ångström, Supit, or Hargraeves; additionally requires sunshine hours/day, or vice versa: cloud cover)
– daily rainfall (in mm)
– daily temperature (mean, min, max, range, days below 0°C)
– total number of rain days per month

In addition, some integrated weather parameters have to be derived, e.g. proportion of daily freezing, standard deviation of daily rainfall per rain day, monthly mean of daily rainfall per rain day. Snowfall is generated by PESERA, based on precipitation on days < 0°C (snowmelt vice versa). All data are prepared as (mean) **monthly** layers.

CORINE Land Cover

The 100 und 250 m raster data for Europe were used (lceugr100_00.tif und lceugr250_00.tif).
Projection: Lambert Azimuthal Equal Area, Kartendatum ETRS89,

In contrast to the PESERA plot model, only few components of a dynamic growth model are considered: for crop groups in Europe:

– planting dates (plant growth parameters data base, „ GfG-KULeuven” database),
– water balance (water-use efficiency look-up table)
– plant cover (plant cover look-up table)
– spatialized agricultral land use and dominant arable crops (re-classified CORINE)

Data preparations:

- to clip the data to the area extent of the pilot area
- to adjust the projections of the grids to the target projection of the pilot area (ETRS 89, UTM Zone 33N) using the ArcGIS routine ETRS_to_DHN_7
- to reclassify the CORINE land cover classes according to the PESREA Manual (using the programme SAGA-GIS).

Digital Elevation Model (DEM)

The data from the **Shuttle Radar Topography Mission (SRTM)** was used. SRTM is an international project led by NGA (National Geospatial-Intelligence Agency) and NASA (International Aeronautics and Space Administration).

Data preparations:

- to clip the extend of SRTM to the pilot area including a buffer zone to the adjacent area in order to substract calculaton errors along the edges of the DEM
- to adjust the projection DEM (ETRS 89, UTM Zone 33N) in ArcGIS
- to fill nodata pixels using adjacent pixels (using the SAGA fill gaps module)
- to filter the DEM for reducting noise coming from the satelitte data (using the SAGA multidirectional Lee Filter)
- to implement a hydrological correction of the DEM by filling canyons lacking a natural drainage (algorithmus according to Planchon and Darboux (2001), implemented in SAGA)

For PESERA, altitude in m, slope intensity, and 3x3 km window relief index (standard deviation for elevation of the neighboring cells) are prepared.

Data from the PESERA project 1:1,000,000
In order to make sure that the programme can successfully complete the operations with the new 250 m data from the pilot map sheet, data from PESERA were clipped to the pilot area. Another important reason for including these data is to compare the effect of resolution on the model results. The data were kindly provided by Cranfield University.

Pilot methodology

The data were prepared according to the following materials:

- PESERA deliverable 5 (Kirkby et al. 2003)
- PESERA deliverable 15 (Irvine and Cosmas 2003)
- PESERA deliverable 17 (Gobin et al. 2003)
- PESERA Dictionary (Daroussin 2003)
- Le Bissonnais et al. (2005)
- Pedo-transfer rules 1, 611, 612, 613, 621, 623 from the European Soil Data Base

The model builds on a chain of coupled pedotransfer rules specifically developed to utilize the European Soil Database 1:1,000,000. Soil crusting susceptibility is additionally considered in PESERA though missing in USLE and other erosion models. A basic assumption for the exploitation of existing soil map data is the information provided by the soil nomenclature, thus the soil name combined with textural information is used as key information source. A soil physico-chemical factor combines parameters such as SOM, Na and carbonates, Fe- and Al-oxides, which are assumed to influence aggregate stability. The principle of the model is based on assumptions regarding aggregate breakdown by rainfall and soil shear strength resistance to run-off.

The model results give an estimate of the sediment transport provided as a mean soil loss [tonnes per hectare].

The following scheme (Fig. 3) provides an overview of the basic thematic soil data layers which have to be produced (see Annex 1 for the corresponding input data and processing scheme for the soil hydrological layers):

The crucial terms and rational for PESERA modelling are described in Annex 2. Data on soil hydrological status, climate and vegetation cover are used to assess the threshold daily rainfall beyond which run-off and erosion occur.

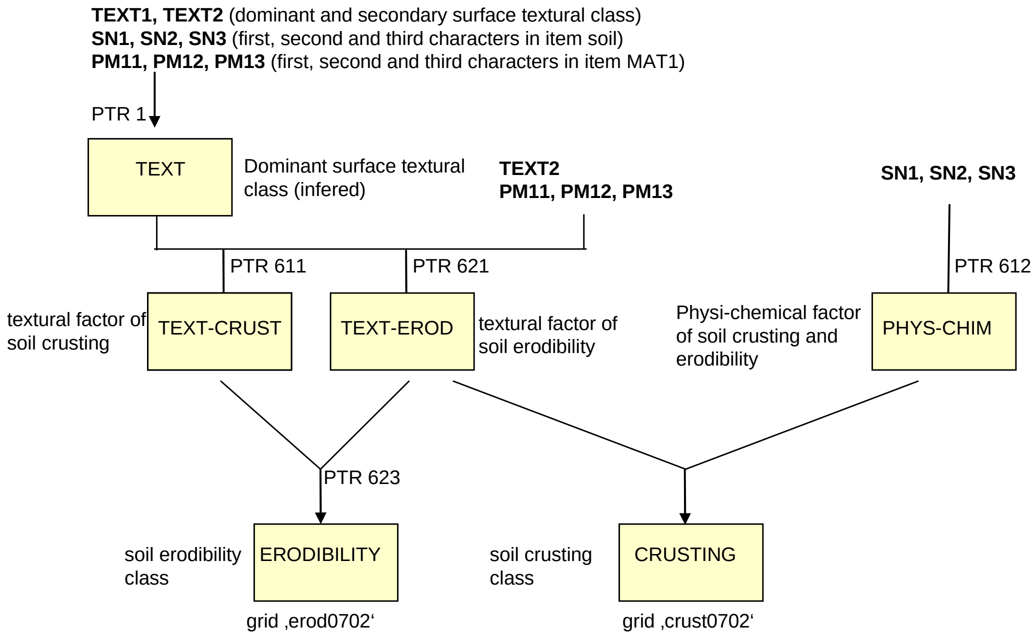

Figure 3. Structure of the required soil property data for PESERA

(input data, coding and classes are developed on the basis of specifications and definitions coming from the European Soil Database 1:1,000,000)

Evaluation of pilot results

Considering the multiple tasks of this pilot, the following results were received:

a)Development of a 1:250,000 soil data base, harmonized along the D-CZ country borders The original map legend with n=104 mapping units was maintained. Some harmonization efforts remain to be completed:

- comparison of the parent material: connectivity to mapping units on the CZ side, reduction of the refined assessment of periglacial layers on the German side.
- check of the WRB classification, and consideration of WRB 2006 (similar mapping units are classified differently)
- integration of soil regions

clear orientation of horizon data and mapping units (CZ)

Parent material classification, soil classification, texture classes, profile descriptions, analytical methods are extremely difficult to harmonize after data submission without local expert knowledge and large amounts of auxiliary data. For example, texture in CZ is defined as clay < 1 µm, Sand 50-2000 µm; in Germany: clay < 2 µm, Sand 63-2000 µm. On the other hand, the definitions, stratification and amount of mapping units must be harmonized for each mapping area. For example, just for this one sheet, we received 104 combinations of soil type and parent material for the CZ side,; adding soil horizons, we received 247 soil-parent material-horizon combinations. On the other hand, about ≤ 100 mapping units can be handled for one 1:250,000 map sheet in order to keep control over a national, and even more so international, 1:250,000 map legend (given that a basic stratification such as soil regions are implemented).

The Manual of Procedures, developed to facilitate harmonized 1:250,000 soil data assessments, needs to be evaluated on the basis of mapping examples and experience, and then extended to become more operational (to be included in the national projects). Such a guideline as well as the WRB classification must be incorporated into the national data assessment and management.

b) Common data management strategy

The data received were imported into SoDa. Thus the data will be able to easily communicate into larger 1:250,000 data bases. Such a data management will easily allow further application of all the data using specific indicator methods, where results are needed over larger areas (this requires data exchange, harmonization and integration).

c) Indicator monitoring: application using PESERA
- different soil input data resolutions
- new climate data

At this point of the project, full model results were only received for the 1:1,000,000 data base. Figure 4 presents the maps for the month December (the months April and August are presented in Annex 3). When comparing the input data grids (1:1Mio vs. 1:250,000), major differences appear. It can be expected that the very coarse resolution of the “top down” 1:1Mio data base will cause high regional over- and/or underestimations if applied. In addition, it seems that the bottom-up approach on the Saxonian side (using 1:50,000 as the basis for the 1:250,000 mapping), the Sheet Chemnitz incorporated refined knowledge of the distribution and location of specific soil associations. In the northern part of sheet Chemnitz, upland Luvisols and Cambisols dominate, while stagnic soils with pronounced hydromorphic properties dominate in the 1:1Mio data base. Because the PTR-based approach for PESERA still excludes soil properties, the straight-forward classification of crusting and erodibility classes according to soil name is then responsible for this difference between the two resolutions.

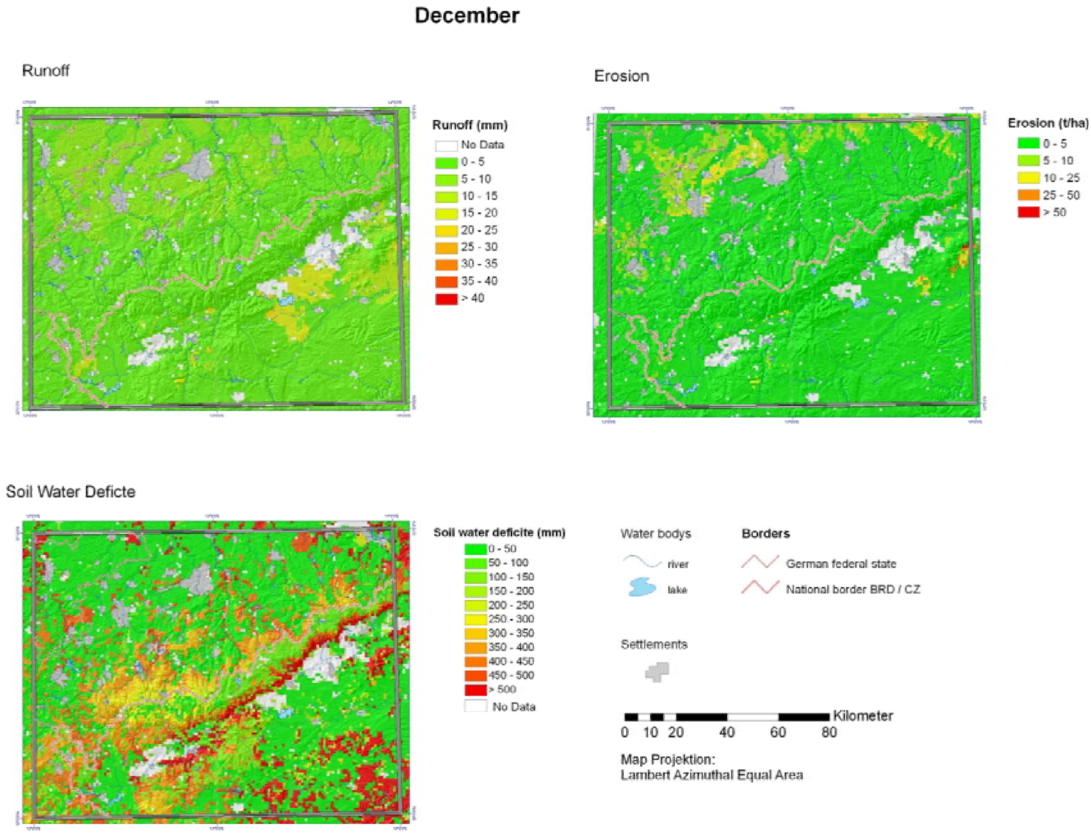

Figure 4. PESERA results (December, database 1:1,000,000)

Conclusions and recommendations

The objective of this pilot is to investigate the role of improved 1:250,000 soil data in soil protection policy in Europe. Mapping (ER01) as well-as point-derived monitoring data (CO01) were stored in SoDa, and can be used to develop integrated evaluation schemes. This pilot has developed and tested the technical implementation of the data management, but also of the indicator methods.

Modelling ER01

Required input data

- It has been demonstrated that 1:1Mio data are very coarse, since top down is in some areas even not valid when compared to data which were at least partially produced in a bottom-up manner.
- The new climate layers will add further reliability to the results
- The input data classes from the 1:1Mio data base are too coarse
- The expert-based PTR must be urgently become refined and validated.

<u>ENVASSO method acc. to fact sheet</u>
Due to the difficulty for receiving real data on water erosion, the model approach seems to be the only way forward. The expected result can be produced. However, its accuracy and reliability is unknown. Validation, cross-checking with another approach (model) at least in some pilots across Europe is necessary. With the new 1:250,000 input data (estimated and measured profiles), uncertainties of the input data can be determined, but has not yet been investigated.

<u>Baseline and Threshold</u>
Information about baselines and thresholds is needed in order to evaluate the model results. Values for baselines and thresholds are not yet available in the case of ER01. Most likely, knowledge for that is available at the regional level as expert judgement.

Model handling

The implementation of ER01 is based on modelling soil loss under current management and climate using the model PESERA. Here, we used the PESERA-grid derivate.

The PESERA authors have developed a data generation approach building on existing Europe-wide data with the frame conditions that important soil properties can only be approximated using a chain of pedotransfer rules. The following limitations were observed:

<u>Documentation</u>
- Deliverable 5 (Kirkby et al. 2003) gives an extensive overview of some of the rationale behind PESERA, even though some of the information has to be extracted from different sources by the user; clarity about what is implemented, and where and how in the model, is missing (e.g. plant growth module; but also the rationale behind the required grids, so that the input data can be improved where available)
- Documentation is missing how the data generation/preparation scheme can be improved with different, more refined input data sets, and how to handle missing data for each required grid
- It is unclear how the SOM module is built; so far, a SOM input data set is not required.
- Documentation of the PTR should be improved.

The general use of PESERA cannot be recommended as a scientifically sound procedure unless these aspects are considered, and additional user-friendly information is provided.

<u>Validation</u>
- Cross-validation with EPIC is proposed
- A quality estimate for the PTR-derived input data is provided, but its reliability is questionable. A Monte Carlo-based approach to assess the combined model errors seems to be highly necessary, especially where higher resolution input data are available.

<u>Limitation of the model</u> (partly already stated by the model authors)

- Lack of the effect of stoniness
- Limitation of the pedotransfer rule method which is not physically-based (not based on soil properties but rather concludes from the expert-based combination of secondary data such as soil type and parent material type).
- The derived single erodibility parameter only serves as a first approximation to assess the effect of the relevant soil properties.
- Currently, a fundamental limitation seems to be the ranking of crusting and erodibility classes based on expert judgment which groups soil types (RSG and basic qualifiers) rather than interpreting soil properties (e.g. all wet soils have medium physical-chemical crusting and erodibility). Are the effects additional water (irrigation, ground and stagnic water) considered (acc. to Deliverable 5: not in the model's plant water balance)?
- Given a clear rationale of all assumptions and conventions, and a manual which describes where the input data are processed and how, the model should consider parameter-based input data directly. The dynamic links between the parameters are not known.

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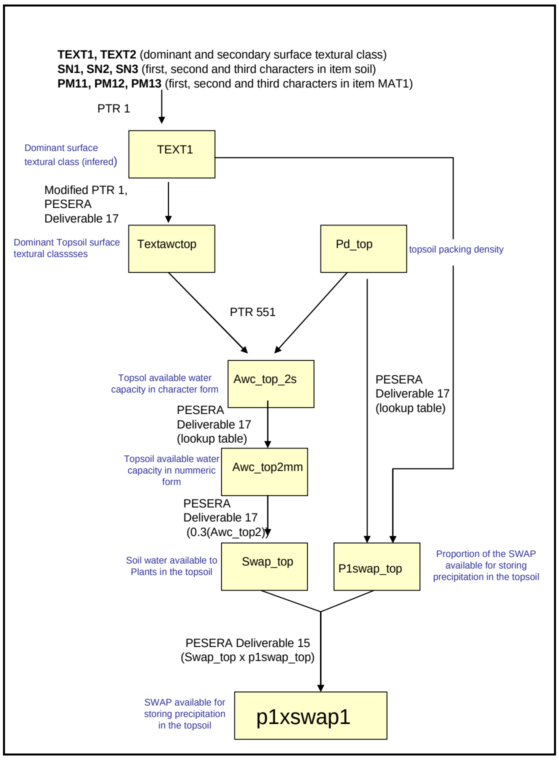
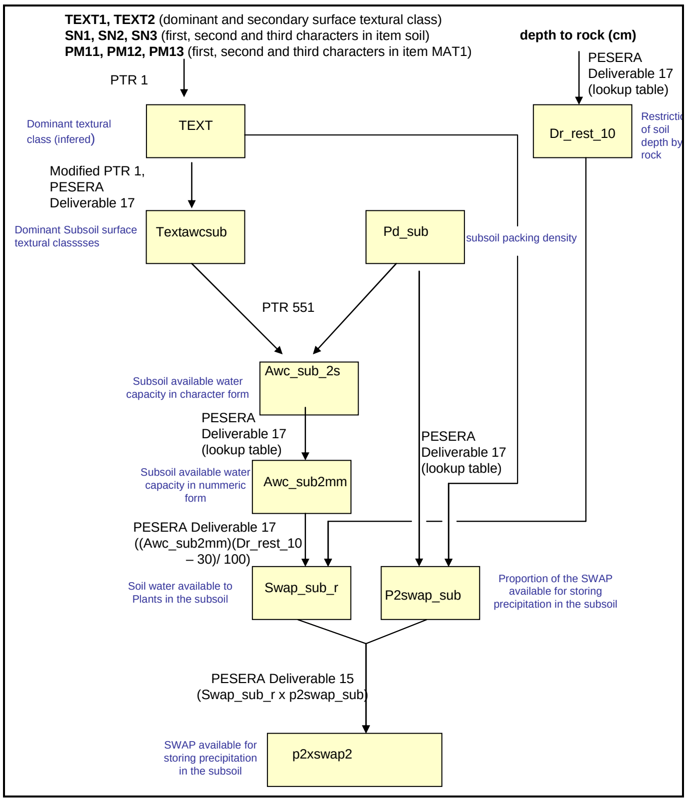
Annex 1: Structure of the required soil hydrological data for PESERA

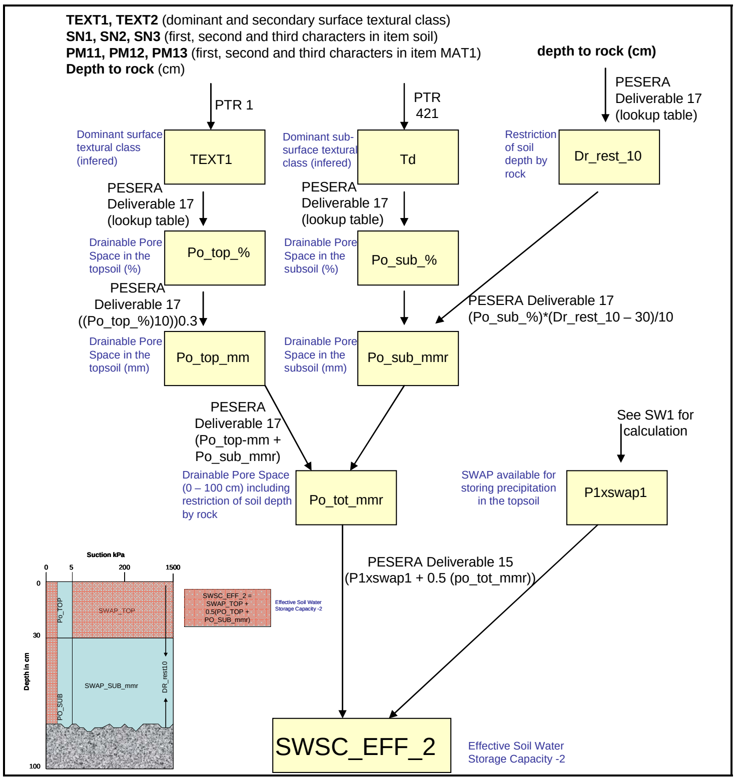
Soil water available to plants in top 300 mm



Soil water available to plants in 300 to 1000 mm depth



Effective Soil Water Storage Capacity



Annex 2: Glossary

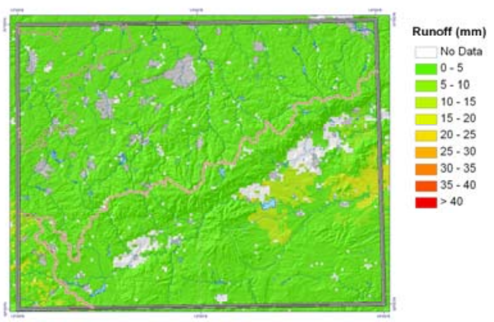
(definitions and abbreviations for PESERA modelling)

AWC	Available water content: moisture content between wilting point and field capacity(large AWC values are expected with silty soils)
erodibility	Key parameter in soil erosion modelling; for PESERA interpreted as an intrinsic property of the soil (because the relevant soil physical parameters are not available in the European soil Database 1:1,000,000) describing the susceptibility of soil material to become detached and transported by raindrop and/or runoff. Erodibility requires the same input parameters as soil crusting, but the relationships differ. There exists dynamic interaction with soil crusting (e.g. soil crusting at one location may increase run-off, which then causes higher erosion at a location beneath)
erosion threshold	Another key parameter in erosion modelling; determines the minimum flow power for erosion to occur
field capacity	Amount of water held against gravity (or, wetness of an initially saturated soil after two days of free drainage (lab: soil water content at a suction of 0.33 m for clay-loam, or 0.1 m for sand)
PO	Drainable pore space: defined as the pore volume with a suction power between 0 and 5 kPa
RD	Rooting depth
PTR	Pedotransfer rules (from the 1:1Mio European Soil Database)
reference evapotranspiration	The evapotranspiration rate from a hypothetical grass crop
run-off threshold	Represents the hydraulic soil properties in erosion modelling; estimated from vegetation and soil properties (e.g. SOM); represents the effects of surface water storage in random roughness and plough furrows, and crusting and moisture storage in upper soil layers
soil crusting	Thin surface layer (few mm to few cm), which is more hard and brittle when dry, than the material beneath it (Bergsma et al. 1996, cited from Le Bissonnais et al. 2005). It decreases hydrological conductivity of the surface, thus reduces rainfall infiltration. One of the main factors controlling runoff and water erosion; it reduces infiltration capacity on cultivated soils, and increases soil erodibility. Soil properties increasing soil crusting: low SOM, high silt or clay content, low aggregate stability.
SOM	Soil organic matter [mg/g, or t/ha]
SWAP	Soil water (storage capacity) available to plants. Defined as the pore volume with a suction power between 5 and 1500 kPa)
SWSC	Soil water storage capacity: including soil water available to plants (SWAP) in the topsoil and a fraction of the drainable pore space (PO)
SWSC_eff, SWAP_eff	Effective Soil Water Storage Capacity, including the restrictions to the soil depth by rocks.
water use efficiency	In PESERA: ratio between actual and potential evapotranspiration
wilting point	Plant-related property indicating the lower limit of water availability (lab: suction of 150 m)

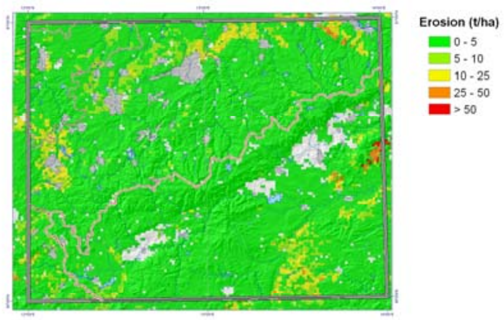
Annex 3: PESERA results 1:1,000,000

April

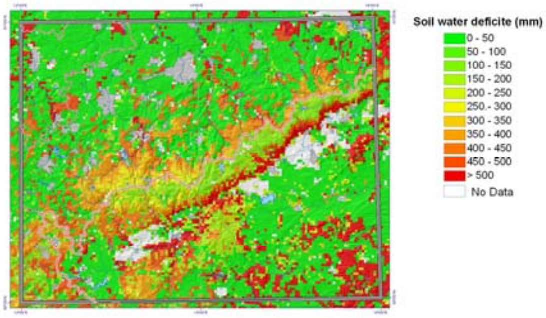
Runoff

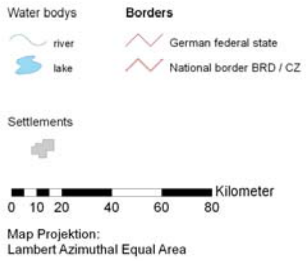


Erosion



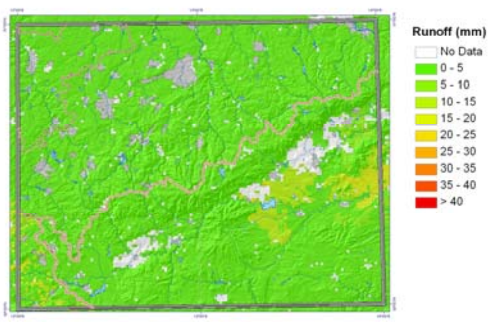
Soil Water Deficte



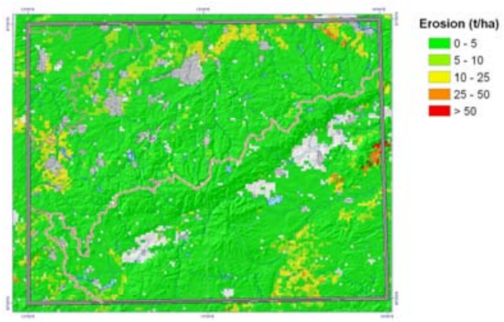


August

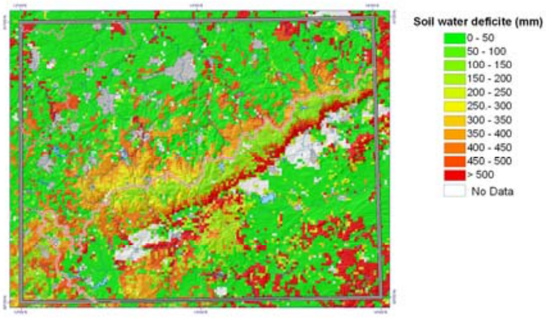
Runoff

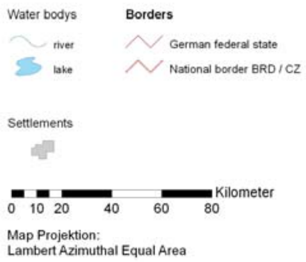


Erosion



Soil Water Deficte





Pilot area: Scotland

Lead Partner: Macaulay Institute
Allan Lilly
Mark Jones
Gordon Hudson

Description of the Pilot Area

Name of pilot area		**Scotland**
Names of participating partners	**Lead partner**	**Allan Lilly Macaulay Institute Aberdeen Scotland**
	Partner A	Mark Jones
	Partner B	Gordon Hudson
	Partner C	
Location and description	Member State(s)	Scotland (UK)
	Coordinates	54.5^o south and 7.5^o west to 60.5^o north and 0.5^o east
	Area of pilot area (km^2)	78 800
	Climate	Temperate Maritime
	Mean temperature (FAO 2006*)	6.2 to 8.3 degrees
	Average Annual Precipitation (FAO 2006	600mm in the East to over 4000mm in the west.
	Outline description of topography	Undulating lowlands and glaciated uplands with deep glacial valleys
	Elevation (m)	Sea level to 1344m
	Vegetation (FAO 2006)	Arable annual cropping (generally rainfed with some sprinkler irrigation), intensive semi-permanent grassland and semi-natural dwarf shrub heaths (mainly evergreen) and rough (Nardus and Molinia) grasslands with moor peat. Little native forest, some coniferous plantation. Tundra-like vegetation on high mountain plateau
	Major Land Use (FAO 2006)	Arable (annual cropping), intensive animal husbandry on grasslands, extensive grazing on dwarf shrub heaths
	Major soils (WRB 2006 RGs**)	Podzols (23.7%), (histosols (22.5%) and stagnosols (20.6%), Cambisols, planosols, arenosols, fluvisols, gleysols and regosols.

Threat and related indicator(s) evaluated in pilot area

Threat	**Soil erosion**
Indicator 1	ER01 Modeled erosion by water
Indicator 2	
Indicator 3	

Rationale for selection of pilot area

The study area is representative of the maritime countries of north-west Europe. Soil erosion is a limited but real threat to soils in Scotland. Soil losses are generally low and localized but off-site impacts on water quality and damage to cultural artifacts are important consequences of erosion. Over 50% of Scottish soils have organic (>35% organic carbon) surface horizons and the loss of this stored carbon by erosion is a contributory factor to global climate change. This will also test the ability of the model to distinguish regional variability if erosion risk for organic soils.

The wide range in amounts of precipitation within a small geographical area (600-4000mm) offers the opportunity to assess the sensitivity of the PESERA model to rainfall amount and variability. Similarly the variable land use (arable field that are ploughed annually intermixed with permanent, improved grassland under intensive grazing) and upland semi-natural dwarf shrub heath and grasslands will test the model sensitivity to land use changes.

Few validation datasets exist though there are long term records of river sediment. Unfortunately these are only for low flow conditions, however, existing modeled sediment losses, some specific erosion studies, observed erosion at 10km grid points and a conceptual soil erosion risk model may be used to partially validate at least the spatial distribution of erosion risk.

Indicator Evaluation

Indicator: ER01 Estimated soil loss by rill, inter-rill & sheet erosion

Description of the pilot area

Spatial extent

Scotland is situated on the north western fringes of Europe (54.5^o south and 7.5^o west to 60.5^o north and 0.5^o east). It is surrounded on three sides by water (Atlantic Ocean and the North Sea) and has a land border with England to the south. The total area of the country is around 78 800 km^2 although there are many inland water bodies (lochs). The land rises from sea level to a height of 1344 m. Politically; Scotland is a component part of the United Kingdom but has its own devolved government and a degree of autonomy. There are three main physiographical regions, The Southern Uplands (which border England), the Midland Valley (an ancient rift valley) and the Highlands. Fault lines to the north and south of the Midland Valley delineate these regions and have a major impact on the underlying geology and soil development. The Southern Uplands comprise mainly Ordovician and Silurian greywackes and shales with some Permian sandstones and some granites. The Midland Valley comprises Carboniferous and Old Red Sandstone age sediments with some basalts while the Highlands are underlain by hard, igneous and metamorphic rocks such as granite, schist, and gneiss.

Data

The input data used in the pilot study included soil data derived from the 1:250 000 scale Soil Map of Scotland completed in 1984 by the Soil survey of Scotland, climate data from the UK Meteorological Office, digital elevation data from the UK Ordnance Survey and land cover/use data from the Centre of Ecology and Hydrology (CEH) Land Cover Map 2000 (LCM2000; Fuller *et al*., 2002) derived from remotely sensed imagery.

The dominant soil in each 1km^2 grid cell was derived from the 1:250 000 scale soil map using a GIS to calculate the proportion of soil map units in each cell and multiply this by the proportion of soils within each map unit. The results were then ranked by areal extent and the most extensive soil selected to represent that grid cell.

An existing attributes dataset (SSKIB) which is linked to the soil spatial dataset was used to derive the required soil input data. SSKIB (Scottish Soils Knowledge and Information Base; Lilly et al, 2004) holds statistical summary data for all Scottish soils delineated on the 1:250 000 soil map of Scotland, including median particle size classes for sand silt and clay contents (FAO/USDA size classes) and horizon designation and thicknesses. These median values were used to derive available water capacities for each soil using established pedotransfer rules (Dunn et al, 2004). The European soil texture classes were derived and used within the PESERA model to derive crusting, erodibility and scale depth parameters (Figure 1).

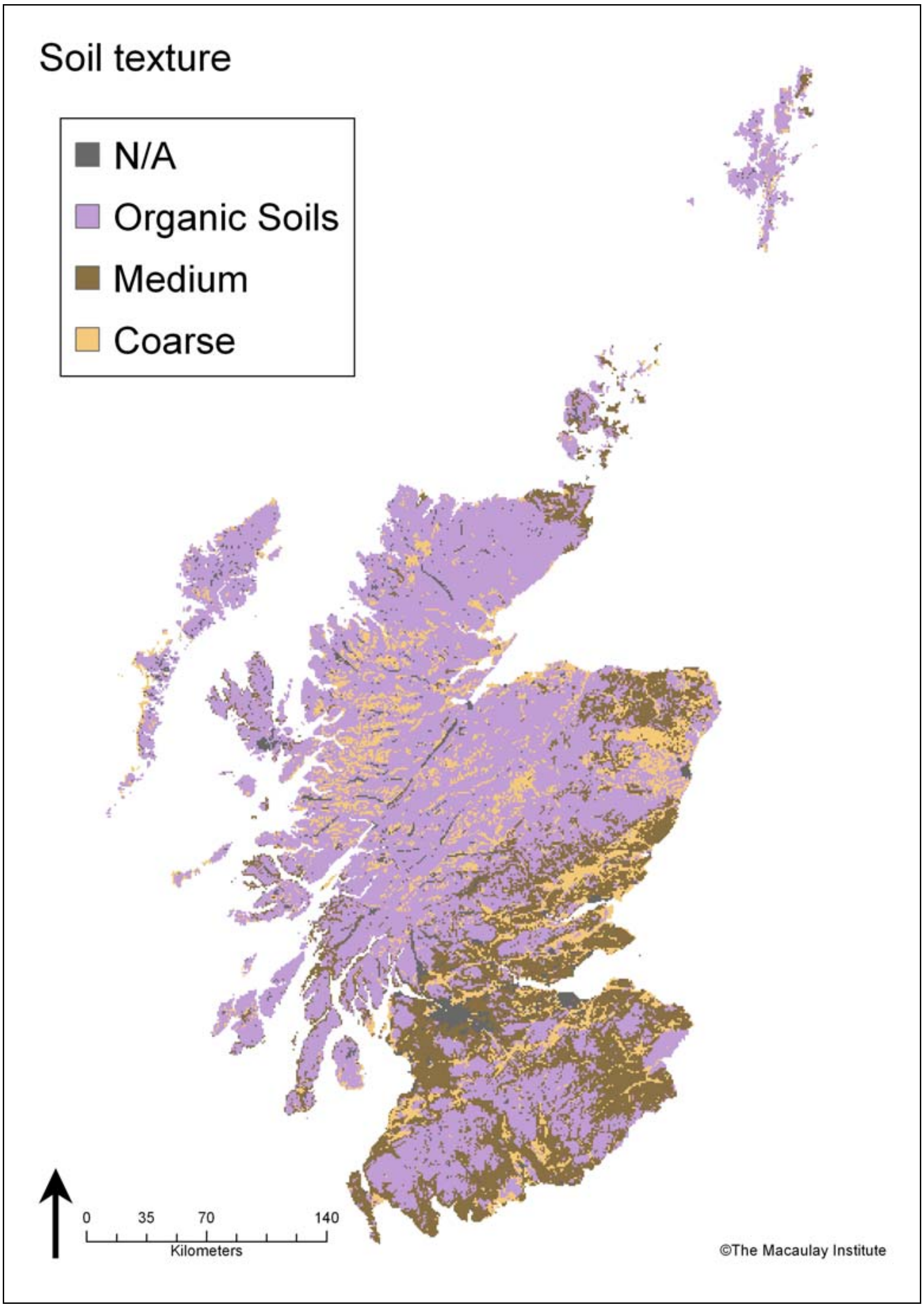


Figure 1. Soil texture class.

The rainfall/precipitation data were originally derived from Meteorological Office rain gauge data but were processed to give mean monthly precipitation for each 1km^2 grid cell as part of an earlier project to predict diffuse pollution loadings to waterbodies (Anthony et al, 2005). This climate dataset also included potential evapotranspiration (5 km^2 grid cell) and temperature. The coefficient of variation of rainfall was taken from the PESERA Europe-wide dataset and data for the Shetland Islands were added from existing daily rainfall data. Digital elevation model at a scale of 50 m was used to derive the topographic input data (relief) for each 1km grid cell (Figure 2).

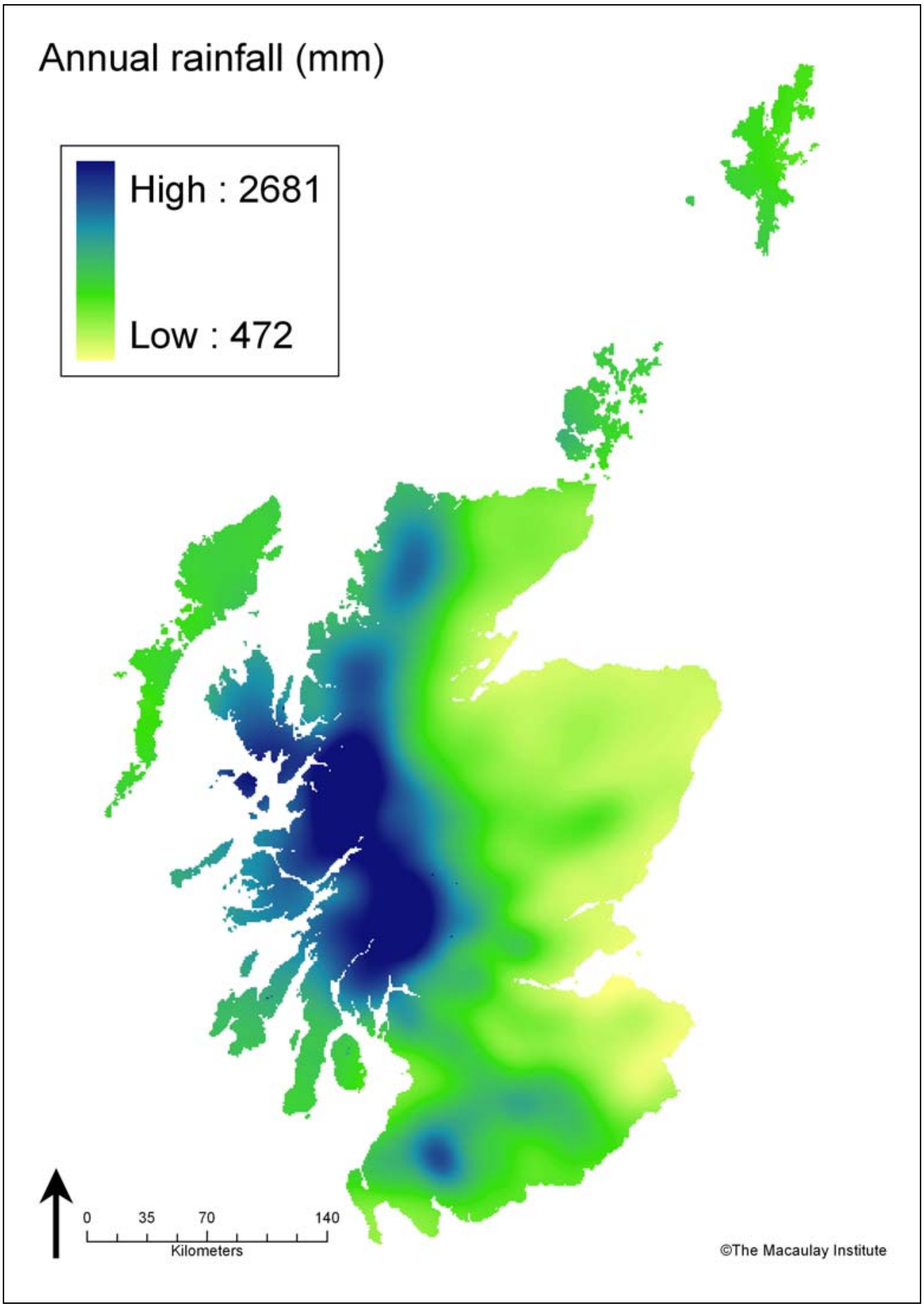


Figure 2. Average annual rainfall

The land cover data from the Land Cover Map 2000 that was derived from remotely sensed imagery was used as the main spatial coverage of land use data. The land cover types were converted to the CORINE classes used by the PESERA model (Table 1 and Figure3). The arable land was subdivided into dominant crop types through the use of the Agricultural and Horticultural Census data that are collected by the Scottish Government on an annual basis and the percentage of crop cover modified to suit local conditions in Scotland.

Table 1. Land cover classes:

LCM2000 land classes	PESERA land cover
Sea and Estuary	Sea and Estuary
Water (Inland)	Water (Inland)
Littoral Rock	rock
Littoral Sediment	water surfaces and wetland
Saltmarsh	water surfaces and wetland
Supra-Littoral Rock	rock
Supra-Littoral Sediment	water surfaces and wetland
Bog (Deep Peat)	scrub
Dense Dwarf Shrub Heath	scrub
Open Dwarf Shrub Heath	scrub
Montane Habitats	scrub
Broadleaved and Mixed Woodland	forest
Coniferous Woodland	forest
Improved Grassland	pastures and grassland
Neutral Grass	scrub
Setaside Grass	pastures and grassland
Bracken	scrub
Calcareous Grass	scrub
Acid Grassland	scrub
Fen, Marsh and Swamp	scrub
Arable Cereals	arable
Arable Horticulture	arable
Arable Non-Rotational	heterogeneous agricultural land
Suburban and Rural Development	artificial land
Continuous Urban	artificial land
Inland Bare Ground	bare land
Unclassified	artificial land

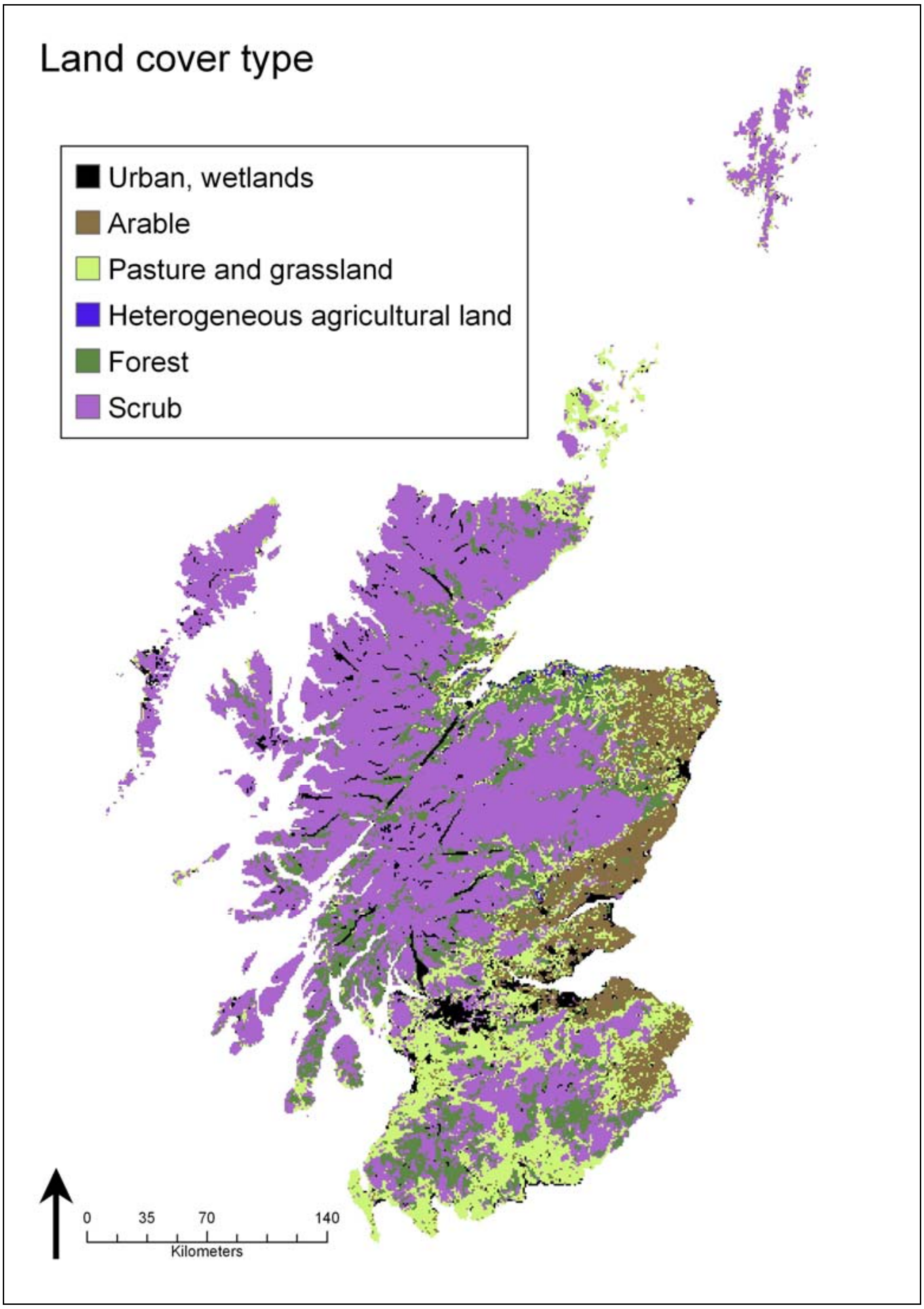


Figure 3. Land cover

Pilot methodology

Country-specific data were used throughout the pilot study where ever possible. The only original dataset that accompanied the PESERA model used was the coefficient of variation of rainfall (though Scotland-specific data can be generated in time). The remaining datasets and input grids used pedotransfer rules (PTRs) or look up tables within PESERA to generate the required data. None of the soil data required as input data by the model were generated by the PTRs derived for the EU-wide application of PESERA as described in the user manual that was revised specifically for the ENVASSO project. These PTRs refer primarily to the European Soil Database (1:1,000,000 scale spatial dataset).

Evaluation of pilot results

Difficulties in fully understanding the required input data from the documentation delayed the implementation of the model and therefore, no validation against existing model output or river sediment data was possible. The model did produce output of sediment losses for each 1km grid cell and therefore meets the criteria set by the ENVASSO indicator for erosion. The model was sufficiently flexible to allow more detailed datasets to be used however, the lack of good quality measured data on erosion rates means that it is difficult to validate the model output.

One major issue was that there was poor discrimination for soils with organic surface layers. The erodibility of these soils vary with the type of organic surface layer and there is scope for deriving a set of parameters specifically for these soil layers.

Conclusions and recommendations

The documentation accompanying the manual needs to be revised and this is already underway. This can be done with the help of the user community and a procedure whereby uncertainties and problems with understanding the model requirements can be reported should be put in place. The physical basis of the model, its relative low input data demands and its ease of application make it a useful tool for assessing soil erosion at a range of scales suitable for monitoring. However, the lack of validation data would suggest that the model would best be used to assess the **relative risk** of erosion rather than absolute sediment losses at this stage.

References:

Anthony, S., Betson, M., Lord, E., Tagg, A., Panzeri, M., Abbott, C., Struve, J., Lilly, A., Dunn, S., DeGroote, J., Towers, W. and Lewis, D. 2005. Provision of a screening tool to identify and characterise diffuse pollution pressures: Phase II. Final Report WFD19 (230/8050. Sniffer).

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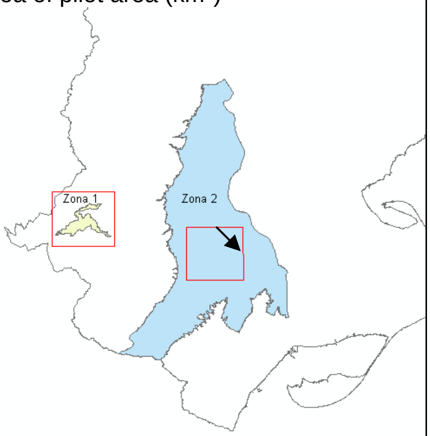
Lilly. A., Towers, W., Malcolm, A. and Paterson, E. 2004. Report on a workshop on the Development of a Scottish Soils Knowledge and Information Base (SSKIB). Macaulay Land Use Research Institute, September 22, 2004. http://www.macaulay.ac.uk/workshop/SSKIB/SSKIBWorkshop_Report.pdf

Pilot area: Terres de l'Ebre, Spain

Lead Partner: SARA
Jaume Boixadera
Iolanda Simó i Josa

Description of the Pilot Area

Name of pilot area		**Terres de l'Ebre**
Names of participating partners	**Lead partner**	**Jaume Boixadera, SARA, Spain**
	Partner A	Iolanda Simó i Josa, SARA, Spain
Location and description	Coordinates	Xmin: 0º 15' 15,21'' Ymin : 40º 34' 57,29'' Xmax: 0º 50' 1,82'' Ymax : 40º 55' 48,76''
	Area of pilot area (km²) 	Has been decided to apply Pesera only in areas where we have enough information. 2 small areas have been chosen: • Zone 1: 8,7 km2 • Zone 2: 49,8 km2
	Climate	Typical Mediterranean (*Csa* according to the Köppen classification)
	Mean temperature Average Annual Precipitation	Zone 2: - Temperature: 16 º C - Precipitation: 413 mm Zone 1: - Temperature: 14 º C - Precipitation: 800 mm
	Outline description of geomorphologic unit	Flood plain and terraces of Ebro river, glacis of Mora and marls and limestone hills.
	Maximum elevation (m)	1300 m
	Vegetation	Evergreen shrub
	Major Land Use	Crop agriculture: Non-irrigated tree crop cultivation, irrigated tree crop cultivation. Natural forest and woodland Nature protection: reserves/park Areas with human influence
	Major soils	Zone 1: Phaeozem, Fluvisol, Cambisol. Zone 2: Fluvisol, Calcisol, Kastanozem, Regosol, Luvisol, Leptosol

Threat and related indicator(s) evaluated in pilot area

Threat	Erosion
Indicator 1	ER01 Modeled erosion by water

Rationale for selection of pilot area

These pilot areas have been selected because they combine differences and it allows observing and testing different conditions of use, vegetation, lithology, topography, climatic conditions and soils. The interest is increased by the diverse history of human pressure and socio-economic development that shows.

We have decided to apply PESERA in 2 different zones in representative of erosion threat in Southern of Catalonia (Spain). It's possible to find various types of soil erosion in these pilot areas and it's available of relevant existing soil data and monitoring systems for both zones.

Pilot area 2 (zone 2) has a high number of hectares of non- irrigated land but it's possible that in a close future, these hectares will be transformed in irrigated land and they will be more susceptible to feel some threats. Soil erosion is associated to shallow soils, hot and dry climatic condition and scarce vegetation lead.

SARA has been studying those pilot areas very good and has elaborated accuracy information during the soil map (scale 1:25.000).

Indicator Evaluation

Indicator: ER01 Estimated soil loss by rill, inter-rill and sheet erosion

Data

Terres de l'Ebre region is located in the southern of Catalonia region where Mediterranean conditions prevail with high temperatures during summer and most of the rainfall concentrated during autumn and spring months. The major soils in the pilot area 1 are Phaeozem, Fluvisol, Cambisol. In zone 2 the dominant soils are Fluvisol, Calcisol, Kastanozem, Regosol, Luvisol, Leptosol, some of them are limited in depth, within 30 or 40 cm of the surface.

The pilot areas selected are representative of the Mediterranean characteristics. In zone 2 could be found various agricultural managements. In some area is present an agricultural irrigated management but the mostly is the non-irrigated management. The main land uses in non-irrigated crop cultivation are olive and almond tree and in irrigated land is citrus.

Zone 1 is a transition towards the inland mountainous zones with abrupt topography, and it shows a patchy structure of dry farming, rangelands and open forest. This area is a protected area.

Pilot methodology

Compilation of soil data and maps for the pilot area.

The soil data used to apply PESERA model is from the Catalan soil survey digital maps (1:25000). These maps describe the soil mapping units and soil phases related to some soil characteristics like depth, pH, drained, texture... Soil analytical data is obtained of the representative soil profiles from the internal database 'SISCAT' of Agricultural Resources and Evaluation Section (SARA).

Location of the pilot areas

Spatial extent

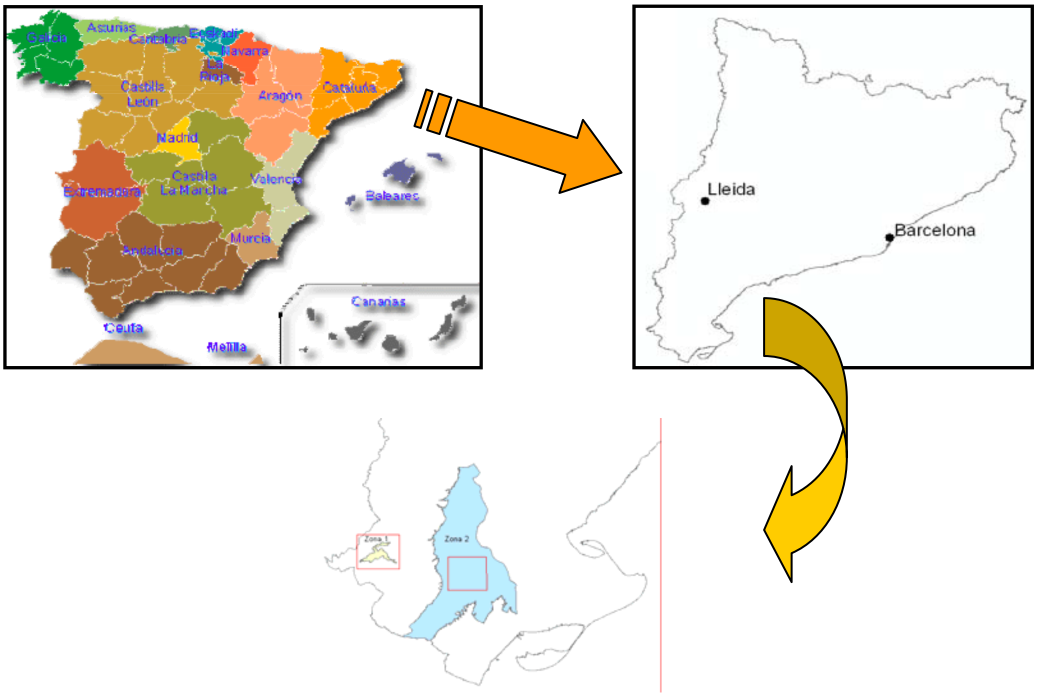


Figure1. Location of 2 pilot areas.

Has been applied PESERA (Pan-European Soil Erosion Risk Assessment) model to calculate the spatial distribution of erosion rates due to surface runoff. This model works according different routines where are needed various resource of data depending or according to thematic compartments or groups.

The following table reflects the sources used and the steps applied:

STEP 1: Layers related to Climate parameters

STEP 2: Layers related to Land Cover and Vegetation parameters

Model parameter	Source	Data Treatment
meanrf130_	In the pilot area “Terres de l'Ebre” there is 15 meteorological stations belonging to the Network of Automatic Weather Stations managed by the Meteorological Service of Catalonia (SMC), and forms part of the Network of Meteorological Equipment of the Generalitat of Catalonia (XEMEC).	Creating Thissen proximal polygons which contain climate data. Parameter assignation from the PESERA methodology. Create grids climate data needed.
meanrf2_		
Cvrf2_		
mtmean_		
mtrange_		
meanpet30_		
newtemp_		
newrf130_		

STEP 3: Layers related to Soil parameters

Model parameter	Source	Data Treatment
use eu12crop1 maize_210c eu12crop2 itill_crop1 itill_maize itill_crop2 mitill_1 mitill_m mitill_2 cov_ rough0 rough_red rootdepth	a. Classification of land use in Catalonia in 2002 in 22 categories. Data in raster format in 30x30m. b. Maps of habitats of community interest in Catalonia drawn up on the cartographic base of the Army Geographic Service on a scale of 1:50,000.	1. Revision of the Legend 2.Parameter assignation from the PESERA methodology
crusting zm erodibility swsc_eff_2 p1xswap1 p2xswap2	Soil Survey Digital maps (1:25000) and data of the internal soil database 'SISCAT'	1.Statistical analysis according to the soil profile for moisture, water content and textural classes of soil map units. 2. Parameter assignation from the PESERA methodology.

STEP 4: Layers related to Topography parameters

Model parameter	Source	Data Treatment
Std_eudem2	Digital Elevation Model (30x30m)	1. Calculated Standard deviation of DEM. 2.Parameter assignation from the PESERA Methodology.

Difficulties during the application of the PESERA Methodology.

- At the beginning, a big pilot area was chosen and we worked with quite detailed data, and we created raster files with a size cell of 30x30 m. It is necessary a high resolution of computer if PESERA model is applied in a quite big area and it works with detailed scale.
- We had some difficulties in harmonisation soil data according to the parameter from PESERA.
- Climate data could be obtained from several ways (climate raster maps, (if they exist), data points from Network of Automatic Weather Stations ...). The methodology could explain more detailed how to calcul this data, because it depens of the scale or detaile that you want to work.
- In the graphical results could show that points where some data is lost they appear like No data, but is it real or the methodology has some black points?

Evaluation of pilot area results

The results obtained, in zone 1 and 2, according to PESERA model are shown in the table 1 and table 2, and its graphical representation are shown in Figure 1 and figure 2. The dominant class in zone 1 is 5-10 t/ha/year where it covers 35.3% of the total area; the second most important class is 10-20 t/ha/year that corresponds to the 26.8% of the total area. These areas are characterized by highest and steepest slope. This area corresponds essentially to the areas where oak tree Mediterranean woodland is. It's a protected area where non agricultural practices are applied.

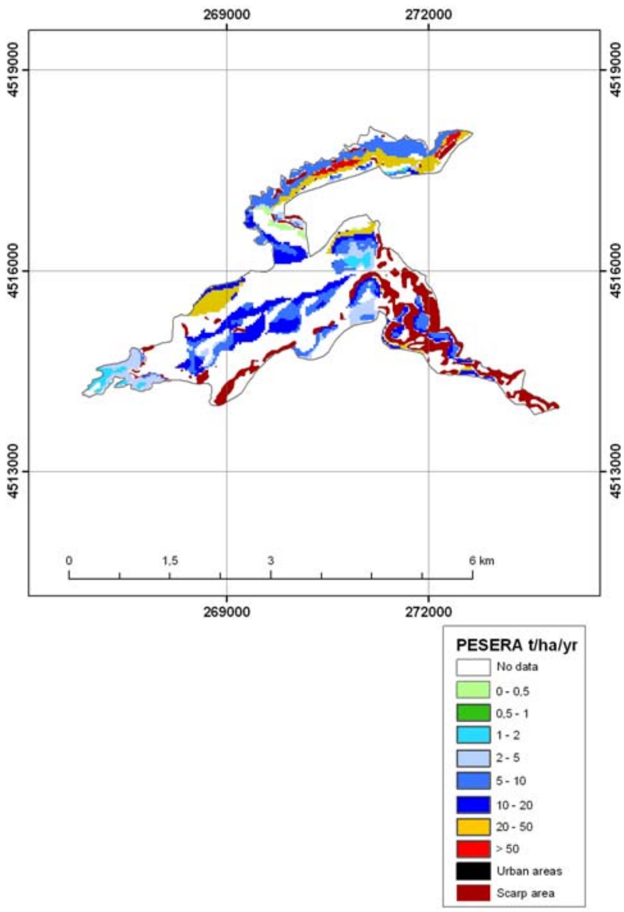


Figure 2. Graphical representation of the results in pilot area-1

Table 1. Results obtained in pilot area 1

Erosion rate (t/ha/year)	<0.5	0.5-1	1-2	2-5	5-10	10-20	20-50	>50
Area (%)	1,64	0,07	4,05	13,68	35,3	26,8	16,22	2,21

In zone 2, the dominant soil erosion rate is 1-2 t/ha/year and 2-5 t/ha/year, covering 61.2% and 21.84%, respectively. This data is not corresponding to real data consulted by this area. This zone is typical traditional agricultural systems and that represents the transitions zone from the dry farming to the irrigation land.

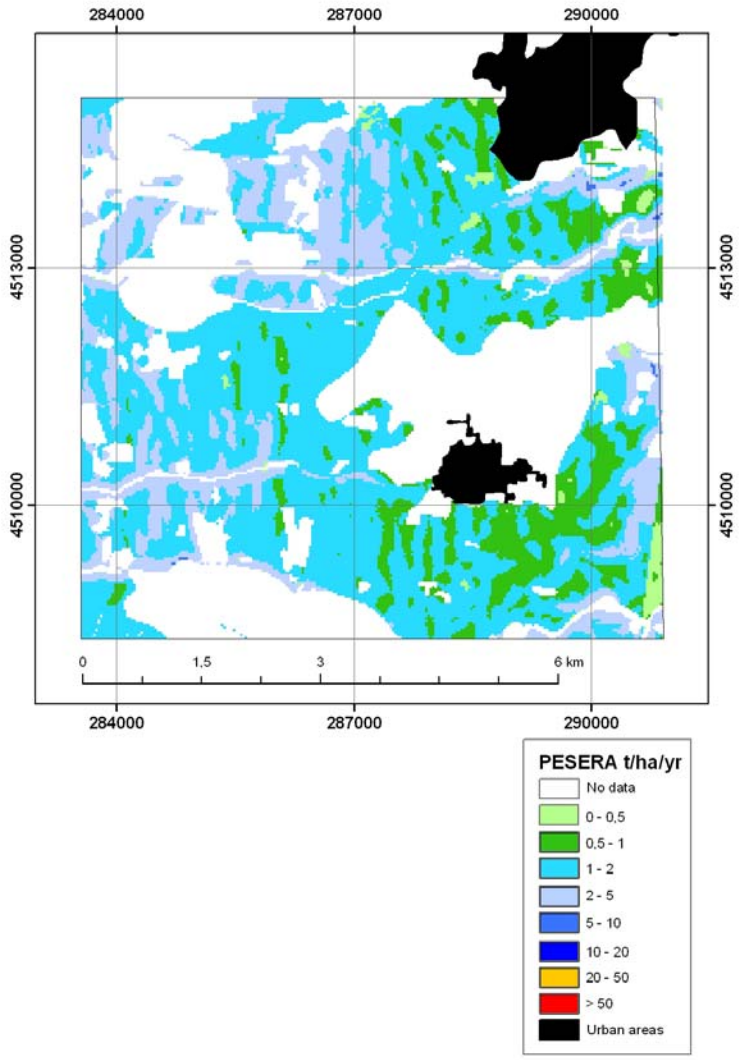


Figure 3. Graphical representation of the results in pilot area-2

Table 2. Results obtained in pilot area 2

Erosion rate (t/ha/year)	<0.5	0.5-1	1-2	2-5	5-10	10-20	20-50	>50
Area (%)	1,7	15,2	61,2	21,84	0,1	0	0	0

Pilot area: Orivesi, Finland

Lead partner: MTT
Harri Lilja

Description of Pilot Area

Name of pilot area		**Orivesi**
Names of participating partners	**Lead partner**	**Harri Lilja, MTT Agrifood Research Finland**
	Partner A	
	Partner B	
Location and description	Member State(s)	Finland
	Coordinates	61⁰ 34' 38" N 24⁰ 00' 00" E 61⁰ 45' 27" N 24⁰ 00' 00" E 61⁰ 45' 18" N 24⁰ 45' 25" E 61⁰ 34' 31" N 24⁰ 45' 12" E
	Area of pilot area (km^2)	800 km²
	Climate	Boreal- Continental
	Mean temperature (FAO 2006*)	3,1 C
	Average Annual Precipitation (FAO 2006	600-700 mm
	Outline description of topography	Western rocky area: Lakes usually 140 -160 m above sea level, highest hills 200 m a.s.l. SE- lake area: Lakes 80-90 m a.s.l and hills 150 -160 m a.s.l.
	Elevation (m)	80 m – 200 m
	Vegetation (FAO 2006)	FC
	Major Land Use (FAO 2006)	FN1
	Major soils (WRB 2006 RGs**)	Leptosols, Regosols, Arenosols, Podzols

* ftp://ftp.fao.org/agl/agll/docs/guidel_soil_descr.pdf
**ftp://ftp.fao.org/agl/agll/docs/wsrr103e.pdf

The Orivesi area is located in the southwestern part of central Finland. (see figure 1).

It is mainly a subaquatic area, where the highest marine marine point is about 160 m above sea level. The area is characterized by extensive rocky stretches (35 %) and till deposits (26%). Fine grained deposits cover nearly 20% of area and peat deposits about 8%. The most significant Quaternary feature is so called Näsijärvi ice-marginal formation with its vast outwash plain and delta deposits.

The ground water resources of the area are abundant and the quality of water is good. The reserves of arable land are large, about 10 000 ha, where as the reserves of horticultural and fuel peat are scarce. The voluminous sand and gravel resources (108,5 million cubic metres) are concentrated in the northwestern part of area.

In the area is located the Lakkasuo mire 116 ha, where has been made long term measurements of carbon dioxide emissions and other measurements concerning OM

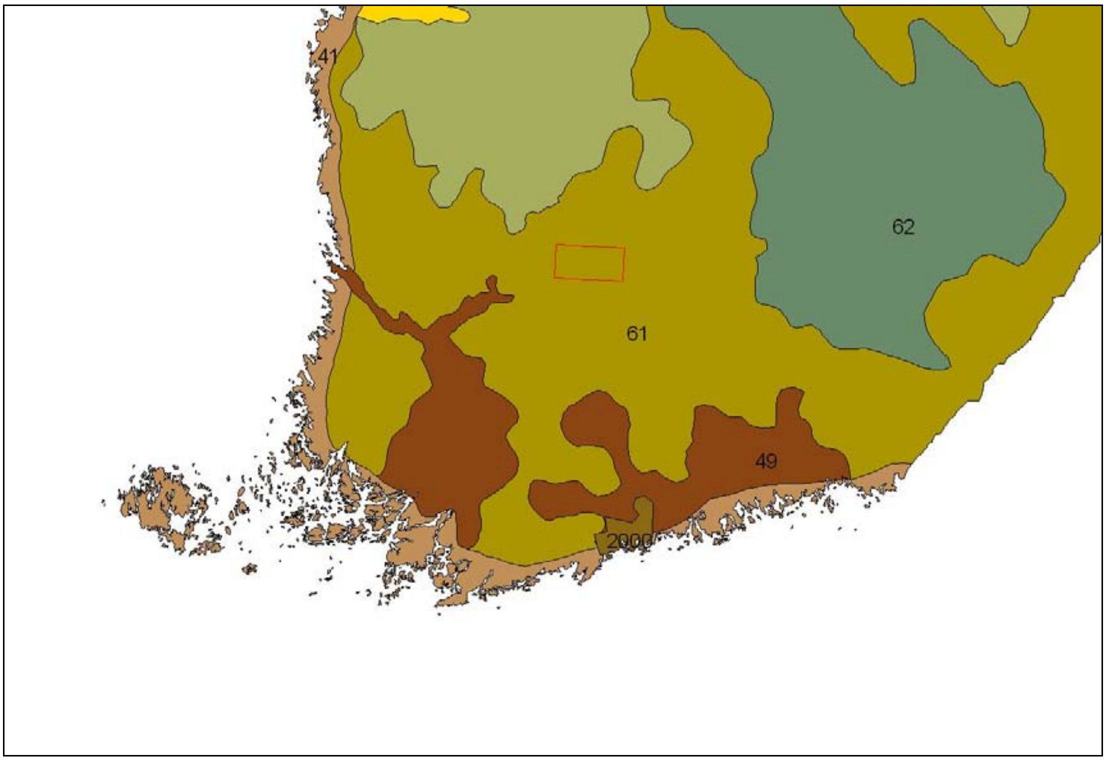


Figure 1. Location of the Pilot Area (rectangle) and Soil Regions map

Threat and related indicator(s) evaluated in pilot area

Threat	Decline in OM
Indicator 1	
Indicator 2	
Indicator 3	OM03 Peat stock (change in land use of peatlands)

In the PA, one of top 3 indicators defined by WP1 was analyzed

Rationale for selection of pilot area

Represents Northern peat areas of Europe. Area/depth of peat is changing due to changes in land use. There are three different scale Soil maps available from the area in electronic format (vector) Soildatabase 1:250 000, made according to the manual of procedures, covers 85 % of area (Soilbody and Soilscape geometries) and map of surficial deposits in scale 1:20K. All these products base on 1:20K mapping made in 1981. Thickness of peat lands can be determined (divided in different soil classes). Combined with field cadastral data the amount of peat lands in agricultural use can be calculated.

Calculations made about peatlands in 1:20K mapping project: 1) Area in Ha, 2) Total area, 3) Area over one meter deep, 4) Area over two meters deep, 5) Average depth, 6) Average degree of humification 7) Quantity of peat (millions of m^3) including whole peat deposit, less humified surface layer, more humified bottom layer, drainage situation, peat species, OM matter content measured, 230 points, peatlands and forest.

Indicator evaluation

This part provides a description of the indicator OM03. (Peat stock), but also explains how the sampling area is defined and prepared. Actually this evaluation could be better treated as evaluation of indicator nro 5, land use change.

Spatial extent and sampling design for the indicator

There were two options to select how to monitor land use change of peat lands in PA: Regular grid or area based (vector). Because majority of the data was in vector format the area based method was selected. A soilscape (150 ha) was selected as an area, where using free GDAL spatial libraries and own analysis tools, polygons in polygon analysis were made.

The second reason that supports area-based method is the design of 1:250K Soil Database structure. In the manual of procedures it is said that the consistency of a soilscape could be evaluated by determining its Soil Body (soil topological unit) composition. The results of evaluation are stored in Soil Body Pattern table (topological dataset). The land use composition could be evaluated with similar procedure.

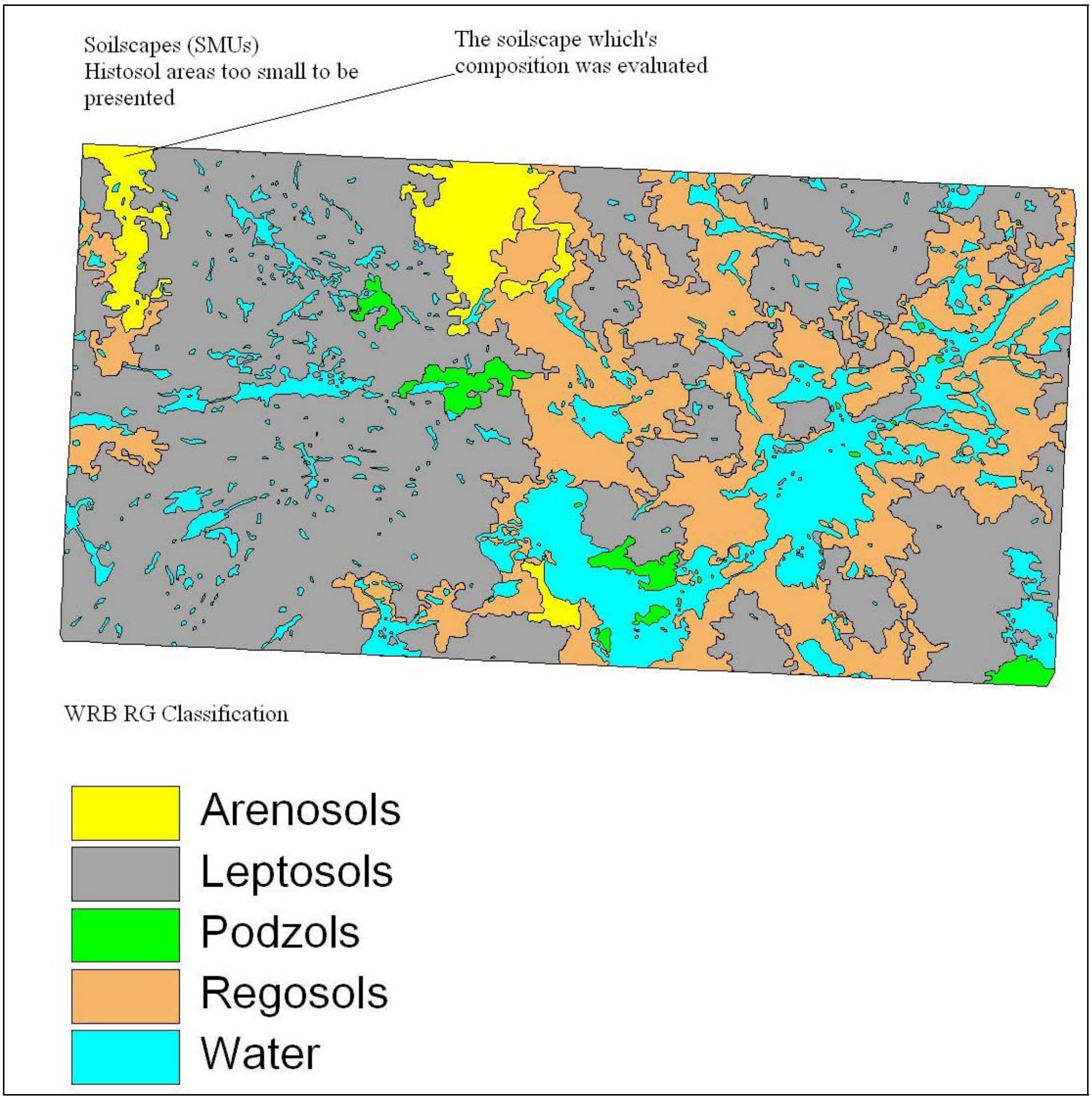


Figure 2. Soilscapes of PA, analyzed polygon in upper left corner

Indicator Evaluation: OM 03 – Peat Stock

Pilot description

Testing

One soilscape unit (soil mapping unit) was selected to analyzed. Vector geometries of 1:20K map of quaternary deposits, soilbody , CLC 2000 level3 and level 4 were clipped out with this polygon. After that the GDAL-based first version of polygon in polygon analysis tool was used to make percentage analysis of soilscape composition.

Data description and standards

Soilscape and soilbody geometries are part of Finnish Soil Database 1:250K and made by MTT. The CLC2000-data was obtained from Finnish Environmental Ministry without charge and 1:20K Maps of quaternary deposits was got for free as well. .

Baseline definition

No baseline defined within WP1.

Threshold definition

No baseline defined within WP1.

Commentary on original data

Pilot methodology

Standard GIS based statistical analysis based on polygons in polygon analysis. The special tool to make polygons in polygons analysis was developed by using GDAL free spatial libraries.

Compilation of soil data and maps for the pilot area

No need to compile, already existing in different scales

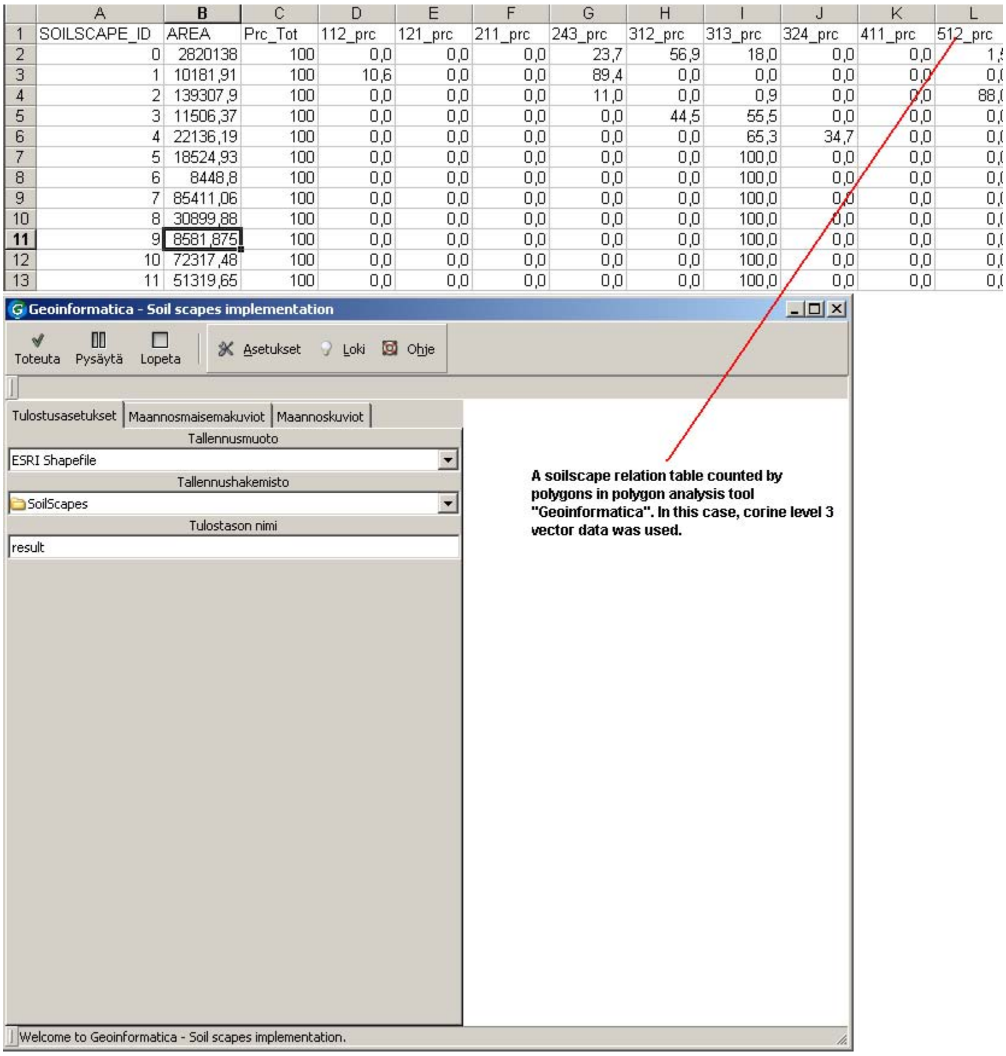
Method development and application

Table 2 presents methods used make GIS-based analysis of land use change of Soilscape (mapping unit)

Table 1. Procedure to evaluate land use change in soilscape

Step	Procedure
1. projecting the data	All data was projected to Finnish YKJ-coordinate system
2. Raster to vector conversion	CLC 2000 raster data (level 4) was vectorized
3.Clipping all data with a single soilscape	- CLC 2000 (level 3 and 4), 1:20K map of Quaternary deposits and Soilbody geometries were clipped out from original data
4. Developing polygon in polygon analysis tool	- Programming application with C++ by using GDAL spatial libraries
5. Polygon in polygon analysis	- Polygons in polygon analysis tool were used to calculate consistency of a soilsape with mentioned three datasets. Results were stored in attribute table of the soilscape

Statistical and spatial analysis



	A	B	C	D	E	F	G	H	I	J	K	L
1	SOILSCAPE_ID	AREA	Prc_Tot	112_prc	121_prc	211_prc	243_prc	312_prc	313_prc	324_prc	411_prc	512_prc
2	0	2820138	100	0,0	0,0	0,0	23,7	56,9	18,0	0,0	0,0	1,!
3	1	10181,91	100	10,6	0,0	0,0	89,4	0,0	0,0	0,0	0,0	0,(
4	2	139307,9	100	0,0	0,0	0,0	11,0	0,0	0,9	0,0	0,0	88,(
5	3	11506,37	100	0,0	0,0	0,0	0,0	44,5	55,5	0,0	0,0	0,(
6	4	22136,19	100	0,0	0,0	0,0	0,0	0,0	65,3	34,7	0,0	0,(
7	5	18524,93	100	0,0	0,0	0,0	0,0	0,0	100,0	0,0	0,0	0,(
8	6	8448,8	100	0,0	0,0	0,0	0,0	0,0	100,0	0,0	0,0	0,(
9	7	85411,06	100	0,0	0,0	0,0	0,0	0,0	100,0	0,0	0,0	0,(
10	8	30899,88	100	0,0	0,0	0,0	0,0	0,0	100,0	0,0	0,0	0,(
11	9	8581,875	100	0,0	0,0	0,0	0,0	0,0	100,0	0,0	0,0	0,(
12	10	72317,48	100	0,0	0,0	0,0	0,0	0,0	100,0	0,0	0,0	0,(
13	11	51319,65	100	0,0	0,0	0,0	0,0	0,0	100,0	0,0	0,0	0,(

Figure 3. Corine level 3 compostion of soilscapes of PA, analyzed by ”Geoinformatica” polygons in polygon analysis tool
[Results were presented in separate file]

Methodology used for calculation/estimation of parameters and indicators

The following parameter and indicator was measured or calculated:

Relative change in peat areas inside a soilscape based on three different datasets.

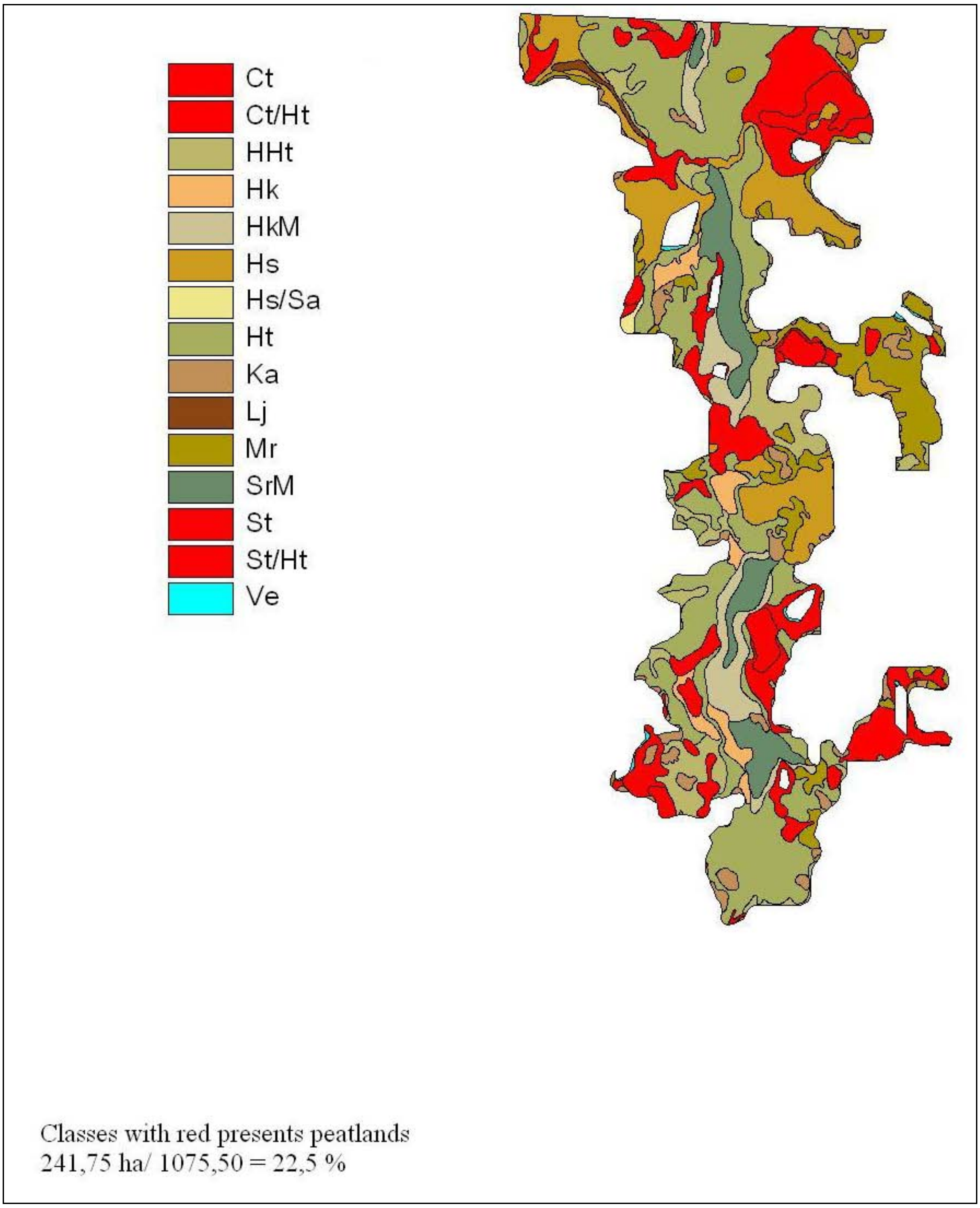


Figure 4. Soilscape composition with 1:20K sufacial deposits map, Finnish classification

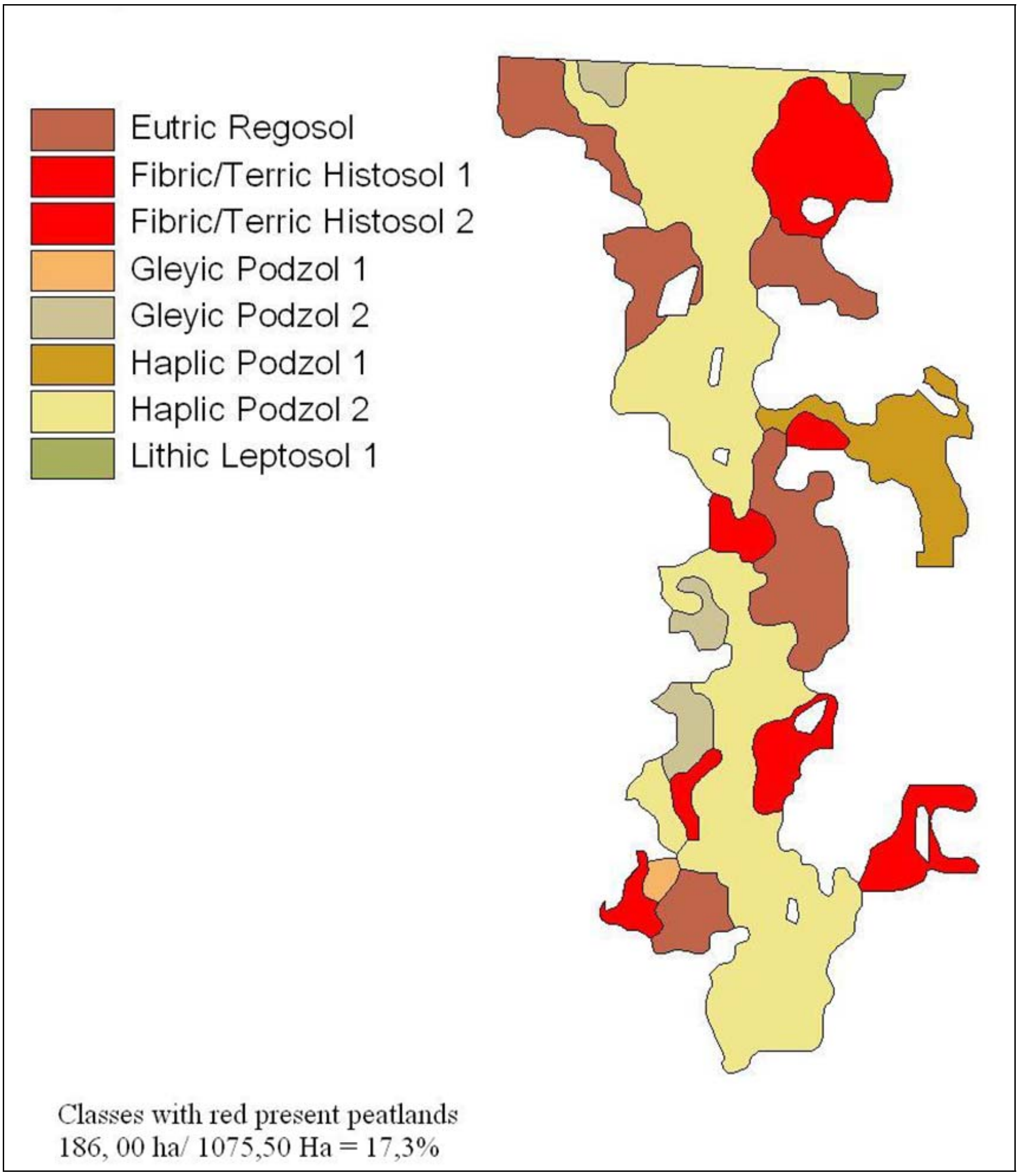


Figure 5. Soilscape composition with Soil Body, FAO/WRB classification

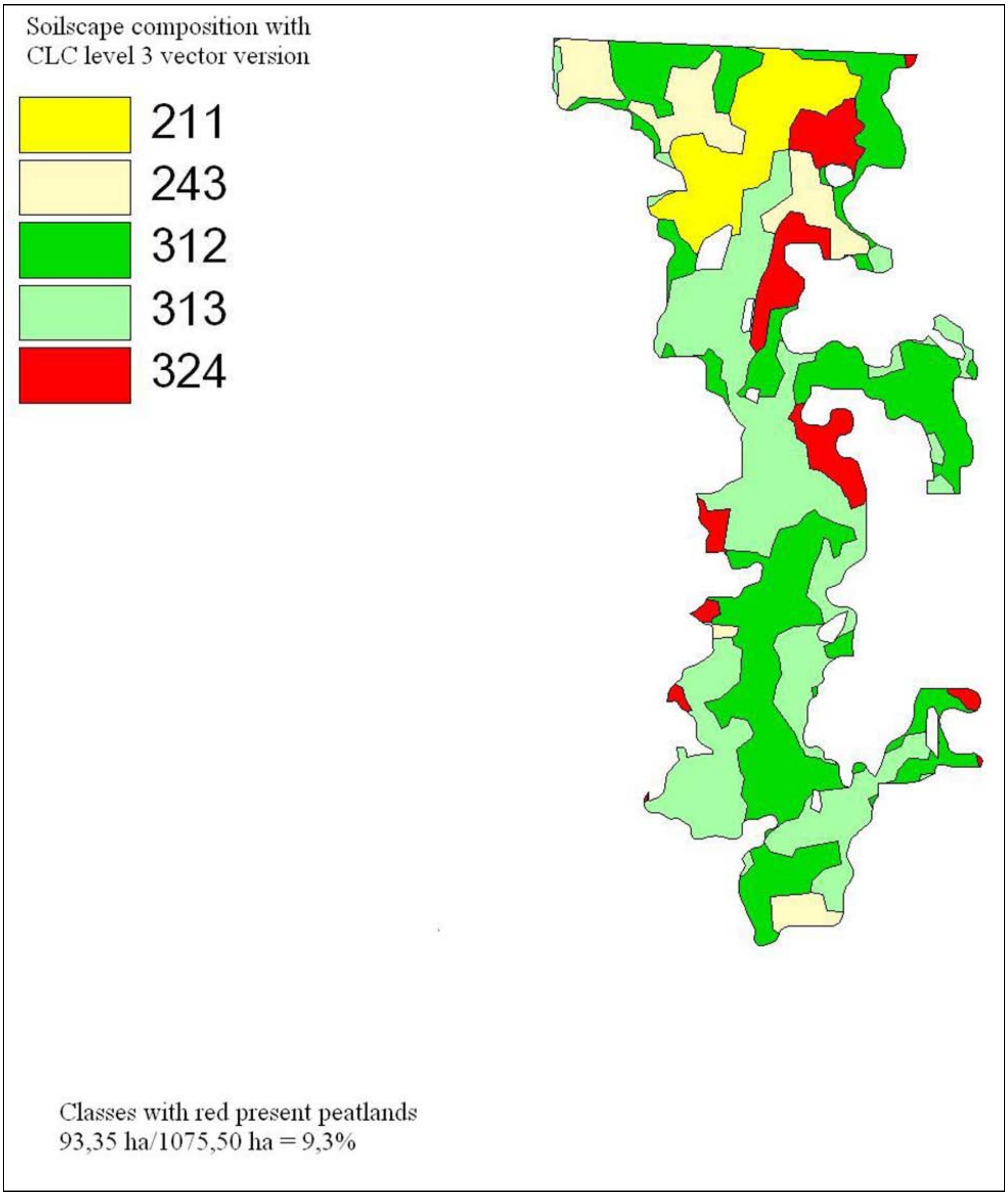


Figure 6. Soilscape composition with CLC level 3 vector version

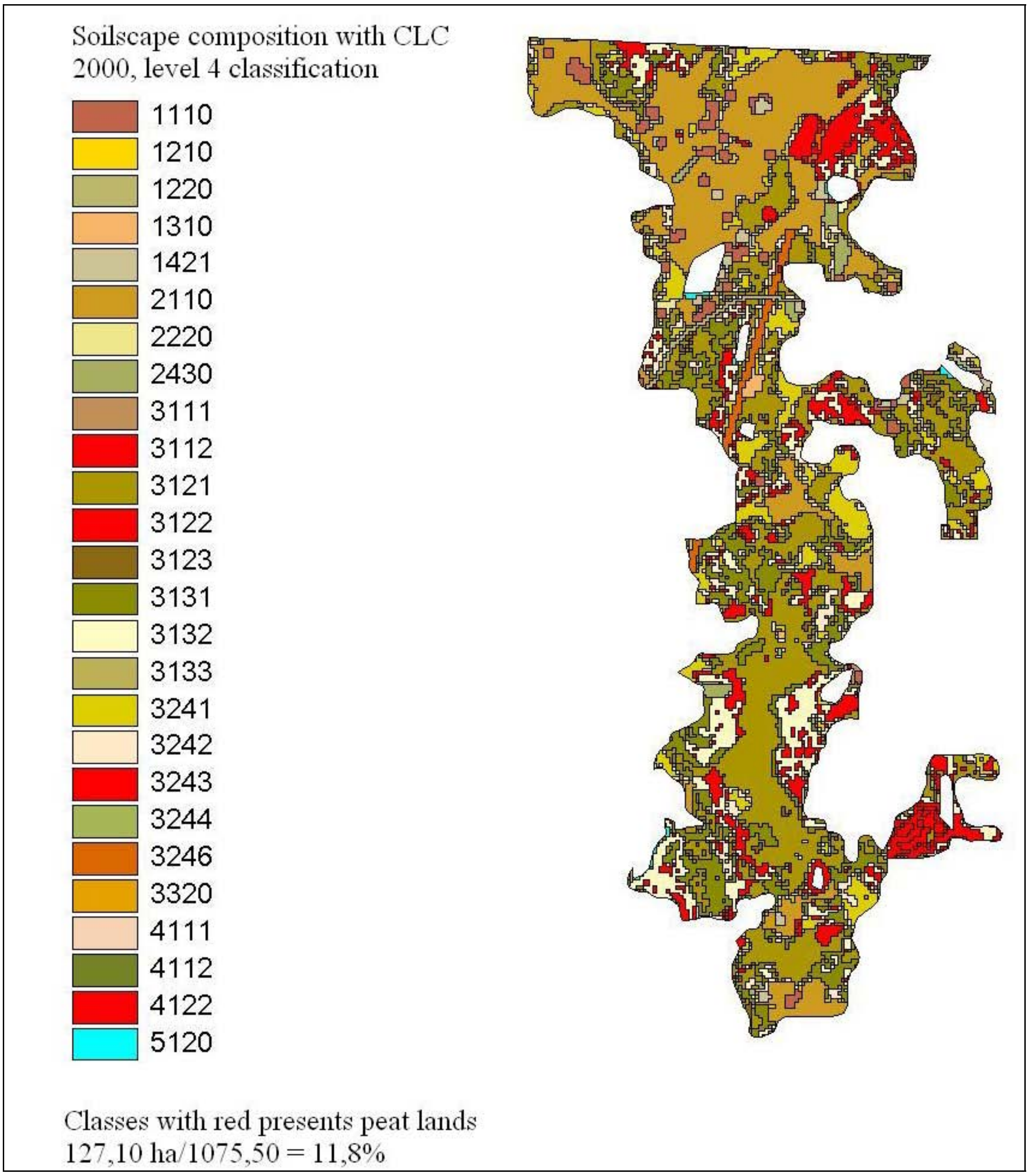


Figure 7. Soilscape composition with CLC 2000 level 4 classification

Definition of baselines

It may be possible to start the definition of baseline values according to CLC-2000, which could be used as level zero.

Definition and application of threshold

Values or percentage can be threshold values (compared to the baseline ones).

Evaluation of pilot results

Feasibility and experience of applying ENVASSO procedures and protocols

The protocol is simple to apply but results are under question

Output performance, e.g. Minimum Detectable Change, achievable and comparison with requirements specified in Volume I;

Definition of baselines and application of thresholds:
Not tested, no result available yet.

Identified strengths and weaknesses

a. the estimation of indicator values
   - Strengths: easy to do with existing GIS-data
   - Weaknesses:
     Results not comparable with earlier data/statistics. Problems with classification of peat lands, minimum size of a bog used in statistics varies. Virtual changes in OM easy to achieve! Only working solution seems to be to determine the consistency of soilscape by CLC level 4. For instance CLC_2000, CLC_2010

b. the interpretation of indicator values
   - Strengths: Percentage change is easy to understand
   - Weaknesses: What is significant change in percentages?

Conclusions and recommendations

It is not reasonable to monitor peat stock changes by modelling or using gamma radiometry in Finland. However, it is possible to evaluate changes in peat stock by monitoring land use changes in certain area => more close to indicator 5. But all datasets are not comparable. CLC 2000-2010 data could be compared, because they production methods have been well standardized and documented. CLC 1990- 2000 probably not.

One crucial point is the level issue. Based on Finnish experiences Corine level 4 should be used (level 3 =1:100K scale level 4=1:50K scale) to detect changes in land use of peat lands. The changes are rarely so massive that they would be visible on level 3 but can be significant as total; the changes appear “in stealth”.

Consequences of the two different MMUs

The MMU in CLC90 and CLC2000 is 25 ha. The similar parameter for CLC-Changes is 5 ha. Understandably, decision makers are interested in changes smaller than the 25 ha limit of CLC. However, the change mapping instruction saying: "a change inside a polygon of an area between 5 and 25 ha will not be recorded as change” will result in a biased change database in the size range of 5-25 ha. Changes between 5 and 25 ha will be mapped only if they are increments or decrements of an existing polygon. Isolated changes will be mapped only if larger than 25 ha.

E.g. a new industry of 20 ha will be mapped as a change if it is an increment of an existing industry polygon in CLC90, but will not be mapped as a change if it is built isolated inside an arable land polygon. The severity of this bias depends on the typical size and distribution of changes in the country.

Pilot area: Republic of Ireland

Lead Partner: TEAGASC
Marta Fuchs

University College Cork
University College Dublin
Cranfield University

Description of the Pilot Area

Name of pilot area		**Republic of Ireland**
Names of participating partners	**Lead partner**	**TEAGASC Ireland**
	Partner A	University College Cork
	Partner B	University College Dublin
	Partner C	Cranfield University
Location and description	Member State(s)	Republic of Ireland
	Coordinates	53° N 8° W
	Area of pilot area (km^2)	69 902
	Climate	Temperate maritime
	Mean temperature (FAO 2006*)	East: 9 °C West: 10,5 °C
	Average Annual Precipitation (FAO 2006)	East: 750-1000 mm West: 1000-1250 mm
	Outline description of topography	36% of the area is „Flat to Undulating Lowland", mostly below 100 m, with slopes less then 3°. 31% of the area is „Rolling Lowland" mainly below 150 m, with slopes ranging between 2 and 6°. „Mountain and Hill" covers 15%, occurs mostly above 500 m, with very steep (16-23°) and steep (12-16°) slopes. 11% is „Drumlins", and 6% is „Hill" –elevation is between 150-365 m, with slopes usually less then 12°.
	Elevation (m)	0 – 1041 m
Location and description	Vegetation (FAO 2006)	Medium grassland (HM), Rainwater-fed bog peat (M), Deciduous forest (FD), Coniferous forest (FC)
	Major Land Use (FAO 2006)	Non-irrigated cultivation (AP1), Animal production (HI1), Extensive grazing (HE), Plantation forestry (FP), Not used and not managed (U)
	Major soils (WRB 2006 RGs**)	Histosols (HS), Gleysols (GL), Luvisols (LV), Podzols (PZ), Cambisols (CM), Leptosols (LP)

You can download the related info from:
* ftp://ftp.fao.org/agl/agll/docs/guidel_soil_descr.pdf
**ftp://ftp.fao.org/agl/agll/docs/wsrr103e.pdf

Ireland is an island in northwest Europe in the North Atlantic Ocean. Its main geographical features are low central plains surrounded by a ring of coastal mountains.

The large central lowland is of limestone covered with glacial deposits of clay and sand, with widespread bogs and lakes. The coastal mountains vary greatly in geological structure. In the south, the mountains are composed of old red sandstone with limestone river valleys. In Galway, Mayo, Donegal, Down and Wicklow, the mountains are mainly granite, while much of the north-east of the country is a basalt plateau.

The soils of the north and west tend to be poorly drained Histosols and Gleysols, including peaty Podzols. In contrast, in the south and east the soils are free-draining Cambisols, Luvisols and Podzols. This is reflected in the rainfall distribution on the island, with the poorly-drained regions being those with the highest rainfall.

4.3 million ha (62%) of the 6.9 million ha country is used for agriculture: 3.4 million ha (49%9 is in grass, hay and silage, 0.5 million ha (7,2%) is in rough grazing, and 0.4 million (5.8%) is in crop production. Forests represent 710,000 ha, 10,3%.

Threat and related indicator(s) evaluated in pilot area

Soil organic matter plays a major role in maintaining soil functions. It is influencing cation exchange capacity, water retention, soil structure and stability, soil ecology and biodiversity, and serves as a source of plant nutrients.

Carbon is major component of soil organic matter, which in turn plays a major role in the global carbon cycle. Therefore, the rising concentrations of atmospheric CO_2 and the stocks of soil organic carbon (SOC) receive more attention.

The threat to soil “Decline in soil organic matter” is defined in the ENVASSO context as “a negative imbalance to an overall decline in soil organic matter contents and/or quality, causing a deterioration or loss of one or more soil functions”.

For the harmonized inventory and monitoring of the decline in soil organic matter the following key issues and questions and related indicators were selected in the project:

Threat	**Decline of SOM**
Indicator 1	OM01 Soil organic matter content in topsoil (measured)
Indicator 2	OM02 Topsoil organic carbon stocks (measured)
Indicator 3	OM03 Peat stock (calculated or modeled)

Rational for selection of pilot area

Ireland is representative of the temperate maritime areas of Europe. In order to evaluate the decline in soil organic matter in this region it is necessary to include the major soil type / land use combinations. Given the large variation in climatic and soil conditions throughout the country it was decided that pilot area should include the entire country.

The pilot area contains 60 sites (50 mineral soil sites and 10 peat sites, 0 to 50 cm depth) which are representative of the major land uses and soil types of Ireland, and have a geographic spread. These 60 sites were selected by the “SoilC” (“Measurement and modelling of soil carbon stocks and stock changes in Irish soils”) and “CréBeo” (“A national project on soil biodiversity”) projects and were sampled in 2006.

The SoilC project is based on the sites of the Irish National Soil Database (NSD), containing 1310 sites in all land uses. All NSD sites were sampled once (the south eastern region in 1995-96, the other areas of the country in 2002), to a depth of 10 cm, on a predetermined defined positions on the national grid (two samples per 100 km^2). All 1310 samples were analysed for a number of chemical parameters a list of which can be found in Table 1. The results were used to generate a national soil geochemical database.

The 60 sites for the pilot study were selected from the dominant soil type/land use combinations of the NSD. Finally the 60 sites are within 15 different categories of land-use/soil-type combinations, with a minimum of three sites in the selected soil type/ land use combination. The sites are a random selection from the NSD sites.

Using the background data of NSD, and the new, more detailed data from the SoilC project, it was convenient to follow the changes and decline in soil organic matter content, carbon and peat stock in Ireland, and extend our knowledge from its current depth of at 0 to 10 cm to greater depth at 0 to 50cm.

Table 1. List of parameters measured for NSD sites with associated abbreviations

Al	aluminium	Nb	niobium
As	arsenic	Ni	nickel
Avail_K	available potassium	P	phosphorus
Avail_Mg	available magnesium	pH	soil acidity
Avail_P	available phosphorous	Pb	lead
Ba	barium	Rb	rubidium
Ca	calcium	S	sulphur
Cd	cadmium	Sb	antimony
Ce	cerium	Sc	scandium
Co	cobalt	Se	selenium
Cr	chromium	SOC	soil organic carbon
Cu	copper	Sn	tin
Fe	iron	Sr	strontium
Ga	gallium	Ta	tantalum
Ge	germanium	Th	thorium
Hg	mercury	Ti	titanium
K	potassium	Tl	thallium
La	lanthanum	U	uranium
Li	lithium	V	vanadium
Mg	magnesium	W	tungsten
Mn	manganese	Y	yttrium
Mo	molybdenum	Zn	zinc
Na	sodium		

Indicator Evaluation: OM01 Soil organic matter content in topsoil

Indicator

Soil organic matter plays a major role in maintaining soil functions. It is influencing cation exchange capacity, water retention, soil structure and stability, soil ecology and biodiversity, and serves as a source of plant nutrients.

Carbon is a major component of soil organic matter, which in turn plays a major role in the global carbon cycle. Therefore, the rising concentrations of atmospheric CO_2 and and the stocks of soil organic carbon (SOC) receives more attention.

The threat to soil 'decline in soil organic matter' is defined in the ENVASSO context as "a negative imbalance between the build-up of soil organic matter and rates of decomposition leading to an overall decline in soil organic matter contents and/or quality, causing a deterioration or loss of one or more soil functions".

Pilot description

Spatial extent

Pilot area and the 60 sampling sites are shown in Figure 1.

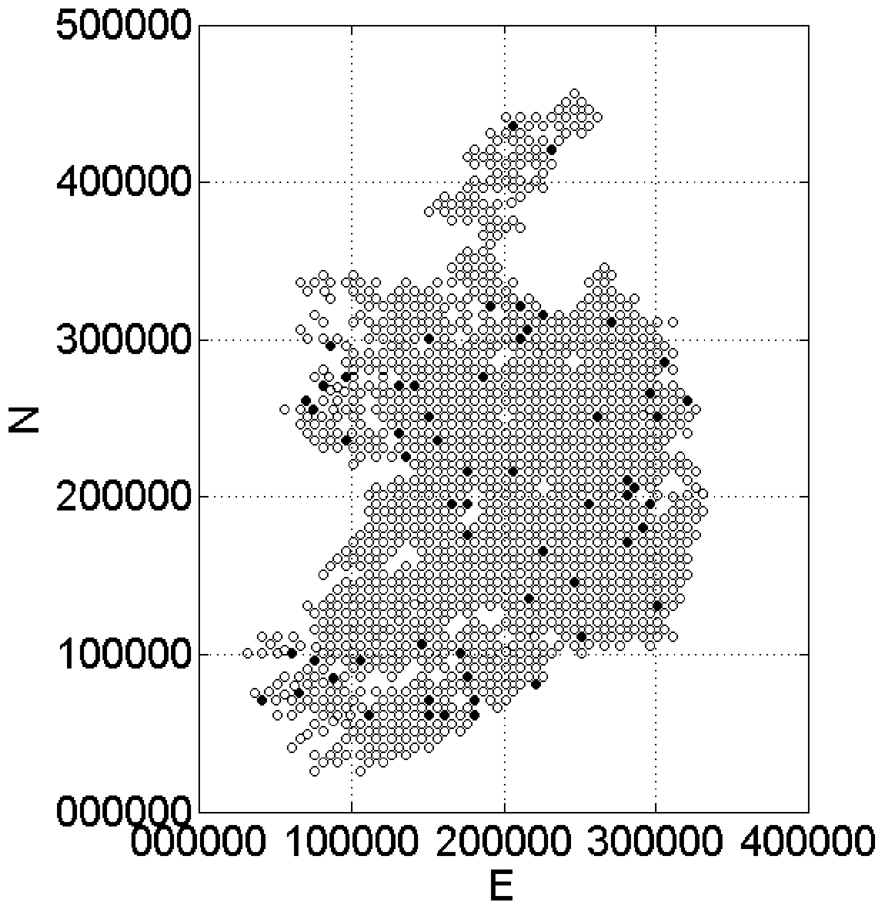


Figure 1. The 60 representative site of the pilot study from the NSD sites

Data

Sampling design

The following sampling design was followed (Figure 2. and 3.):

- At each of the 60 sites, 20x20 m sampling grid was laid out (the same as at NSD sites), and samples were taken with augering at 10 m intervals, giving a total of 9 points.
- Samples were collected from 3 fixed depths: 0 to 10 cm, 10 to 25 cm, 25 to 50 cm, at the each of the nine points. The 9 samples from each depth level were combined into composite samples, giving 3 samples for organic carbon (OC) analysis per site.

Bulk density (BD) samples were collected using Eijkelkamp sampling rings from 5 of the 9 points (the central point, and the four corner points), at the same 3 fixed depths, giving 15 samples for BD analysis per site.

OC and BD sampling in peats were like in the mineral soils –except in cases of high water content, where 50*50*50 cm cubes were cut for BD determination.
The peat depth was probed at several locations with ranging rod.

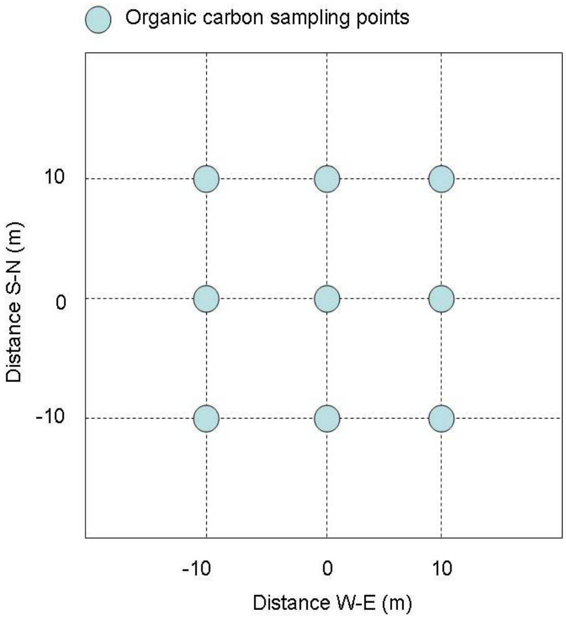


Figure 2. Sampling designed of organic carbon (OC) on a 20x20 m sampling grid

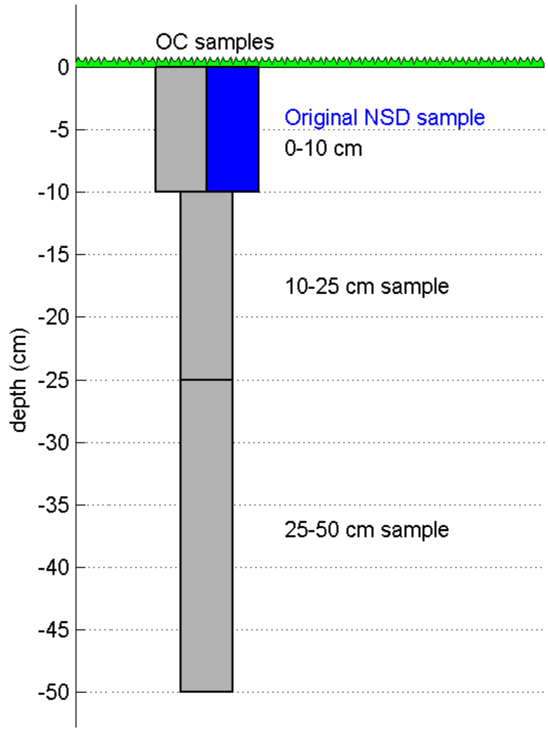


Figure 3. Sampling depths of organic carbon (OC) at the sampling sites

Testing
Sampling is made according to the WP4 procedures and protocols, with advances: deeper soil depth is studied, 0-50 cm instead of 0-30 cm in procedures and protocols.

Data description and standards

Soil data
Archived soil physico-chemical data are provided by the Irish National Soil Database (NSD), and new data will be obtained from the SoilC Project.
Irish soil classification data is obtained from the "General Soil Map of Ireland" (second edition) at a scale 1:575000 (Gardiner and Radford, 1980). On the map 10 Great Soil Groups are identified and are represented in the form of soil associations -which are not suited for correlation with WRB. Detailed soil survey (AFT County maps at soil series level, at scale of 1:126,720) is available just for 44% of the country.

Expert judgment may be possible in possession of SoilC data at Reference Soil Group level.

Described and correlated WRB classification will be available from a new project of „Digital Soil Database at 1:250000 scale for Ireland" by 2009.

Map data
Land use, land cover, and soil type maps published by the Environmental Protection Agency (EPA), Ireland, 2007 were used.

These information will be used to produce maps and any relevant information on the area.
The data set will be integrated into the SoDa base.

Methodology used for calculations / estimations of parameters and indicators

Classical additive approaches and basic statistical analyses will be used to bring out differences in soil indicators depending on soil types, and land uses.

Baseline definition

The baseline will be the first available data from SoilC Project (the present status of SOC content) -because the archived NSD data do not satisfy the depth criteria of the ENVASSO Project (0-10 cm instead of 0-30 cm).

Threshold definition

Zero change according to baseline value

Commentary on original data

There are not any available repeated sampling and testing for OM01 (Soil organic matter content in topsoil) indicator.

Pilot methodology

All the sites were sampled. Laboratory analysis has been initiated and results (or part of the results) will be available in 2008.

Compilation of soil data and maps for the pilot area
The compilation will be done with results.

Method development and application (i.e. changes to WP4 procedures and protocols)
Steps according to the "ENVASSO Procedures and Protocols" were followed:

- Step 1: Take topsoil samples (see figure 2 and 3)
- Step 2: Perform sample pre-treatment
- Step 3: Perform SOC analysis by the indirect determination of the dry combustion method (removal of carbonates prior to analysis)

Statistical and geo-statistical analysis (to be completed with results)

Data was stored in MS Excel and loaded for statistics in SPSS. ANOVA, LSD Post Hoc tests and linear regressions will be carried out.

Methodology used for calculations / estimations of parameters and indicators, including interpolations. Minimum detectable change (?) etc (to be completed with results)
The following parameter will be measured or calculated:
SOM content (%)

Definition of baselines
The definition of baselines: the first measurement of these parameters (the present status of SOC content).

Definition and application of thresholds
Zero change according to baseline value

Evaluation of pilot results

ENVASSO procedures and protocols proved simple and easy to apply; baselines and thresholds are more difficult to define.

Output performance e.g Minimum Detectable Change achievable and comparison with WP1 requirements: Not tested yet.

References:

Gardiner, M. J. and Radford, T., 1980: Soil Associations of Ireland and Their Land Use Potential. Explanatory Bulletin to Soil Map of Ireland 1980. National Soil Survey of Ireland, Dublin.

Mitchell, F. and Ryan, M., 1998: Reading the Irish landscape. ISBN: 1860590551

National Soil Survey of Ireland, 1980: Second Edition of the General Soil Map of Ireland (scale 1:575000). National Soil Survey of Ireland, Dublin.

Indicator evaluation: OM02 Topsoil organic carbon stock

Soil organic matter plays a major role in maintaining soil functions. It is influencing cation exchange capacity, water retention, soil structure and stability, soil ecology and biodiversity, and serves as a source of plant nutrients.

Carbon is a major component of soil organic matter, which in turn plays a major role in the global carbon cycle. Therefore, the rising concentrations of atmospheric CO_2 and and the stocks of soil organic carbon (SOC) receives more attention.

The threat to soil ‘decline in soil organic matter’ is defined in the ENVASSO context as “a negative imbalance between the build-up of soil organic matter and rates of decomposition leading to an overall decline in soil organic matter contents and/or quality, causing a deterioration or loss of one or more soil functions”.

Pilot description

Spatial extent

Pilot area and the 60 sampling sites are shown in Figure 1.

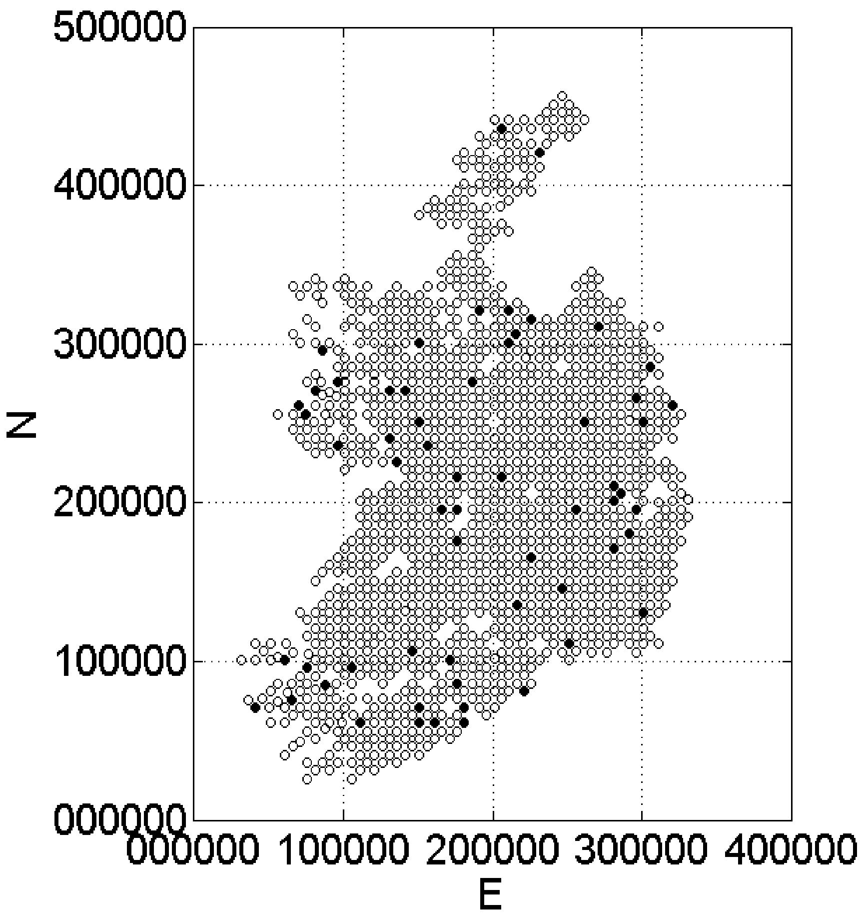


Figure 1. The 60 representative site of the pilot study from the NSD sites

Data

Sampling design

The following sampling design was used (Figure 2. and 3.):

At each of the 60 sites, 20x20 m sampling grid was laid out (the same as at NSD sites), and samples were taken with augering at 10 m intervals, giving a total of 9 points.

Samples were collected from 3 fixed depths: 0 to 10 cm, 10 to 25 cm, 25 to 50 cm, at the each of the nine points. The 9 samples from each depth level were combined into composite samples, so finally it's giving 3 samples for organic carbon (OC) analysis per site.

Bulk density (BD) samples were collected using Eijkelkamp sampling rings from 5 of the 9 points (the central point, and the four corner points), at the same 3 fixed depths, giving 15 samples for BD analyzis per site.

OC and BD sampling in peats were like in the mineral soils –except in case of high water content, where 50*50*50 cm cubes were cut for BD determination.
The peat depth was probed at several locations with ranging rod.

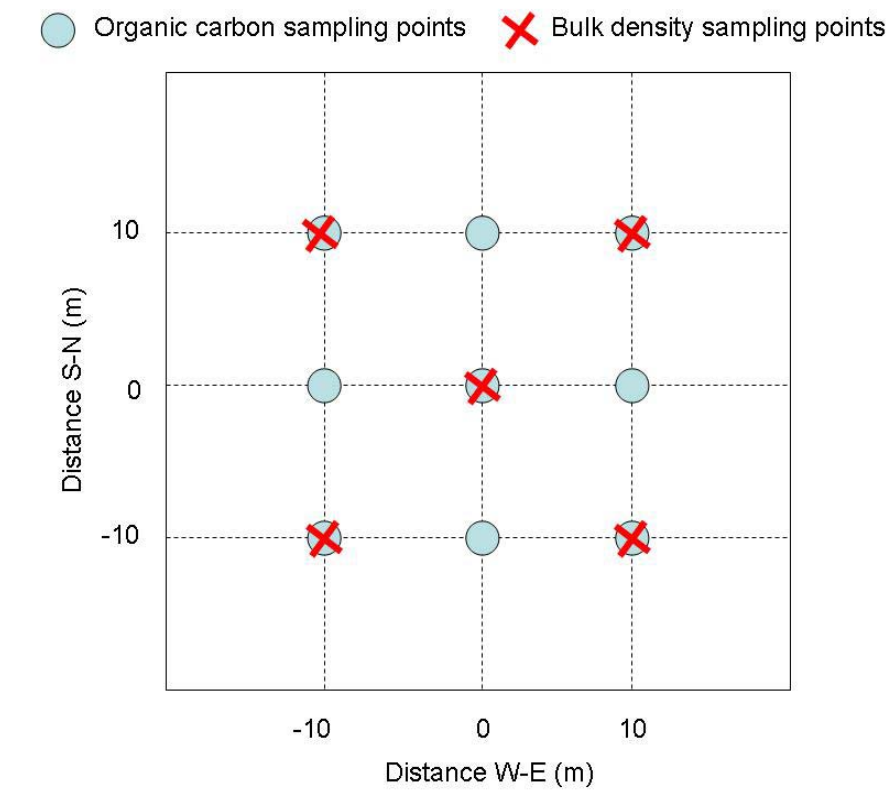


Figure 2. Sampling design of organic carbon and bulk density on a 20x20 m sampling grid

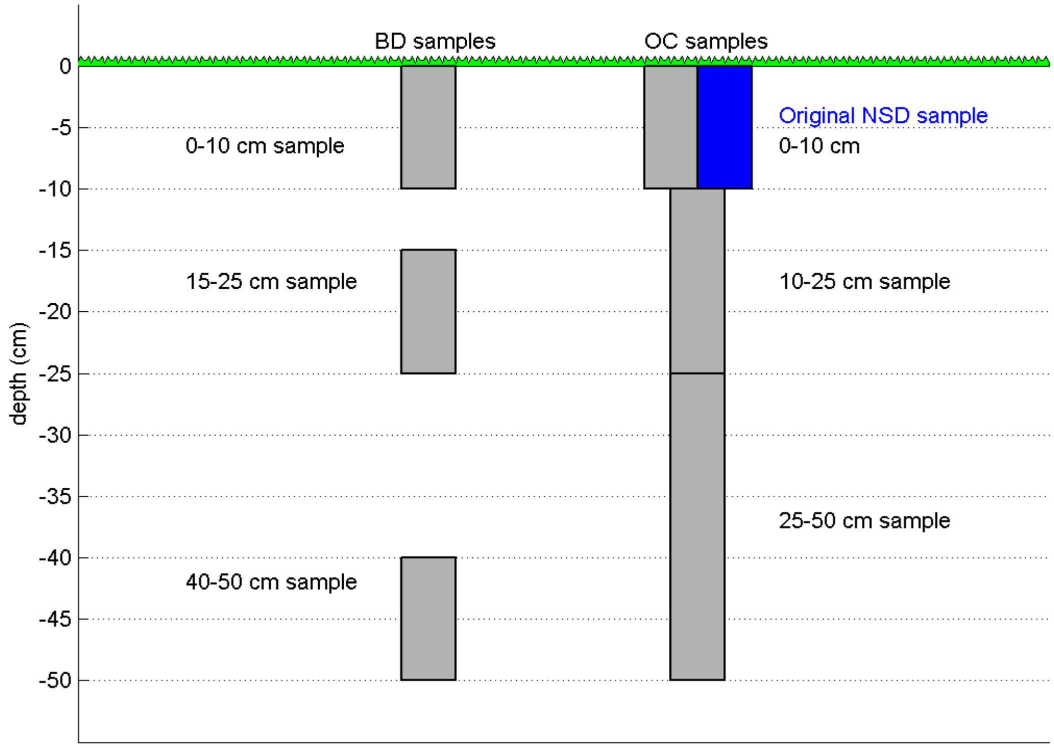


Figure 3. Sampling depths of bulk density (BD) and organic carbon (OC) at the sampling sites

Testing

Sampling is made according to the WP4 procedures and protocols, with advances: deeper soil depth is studied, 0-50 cm instead of 0-30 cm in procedures and protocols.
Detailes of the sampling procedure is showed in figure 2 and 3.

Data description and standards

Soil data
Archieved soil physico-chemical data are provided by the Irish National Soil Database (NSD), and new data will be obtained from the SoilC Project.

Irish soil classification data is obtained from the “General Soil Map of Ireland” (second edition) at a scale 1:575000 (Gardiner and Radford, 1980). On the map 10 Great Soil Groups are identified and are represented in the form of soil associations -which are not suited for correlation with WRB. Detailed soil survey (AFT County maps at soil series level, at scale of 1:126,720) is available just for 44% of the country.

Expert judgement may be possible in possession of SoilC data at Reference Soil Group level.

Described and correlated WRB classification will be available from a new project of „Digital Soil Database at 1:250000 scale for Ireland” by 2009.

Map data
Land use, land cover, and soil type maps published by the Environmental Protection Agency (EPA), Ireland, 2007 were used.

ThIS information will be used to produce maps and any relevant information on the area.
The data set will be integrated into the SoDa base.

Methodology used for calculations / estimations of parameters and indicators
Classical additive approaches and basic statistical analyses will be used to bring out differences in soil indicators depending on soil types, and land uses.

Baseline definition
The baseline will be the first available data (the current stock) from SoilC Project -because the archieved NSD data are not satisfied the depth criteria of the ENVASSO Project (0-10 cm instead of 0-30 cm).

Threshold definition
Zero change according to baseline value

Commentary on original data
There are not any available repeated sampling and testing for OM02 (Topsoil organic carbon stocks) indicator.

Pilot methodology

All the sites were sampled. Laboratory analysis underway, results (or part of the results) will be available in 2008.

Compilation of soil data and maps for the pilot area
The compilation will be done with results.

Method development and application (i.e. changes to WP4 procedures and protocols)
Steps according to the “ENVASSO Procedures and Protocols” were followed:

- Step 1: Take bulk density samples (see figure 2 and 3)

- Step 2: Determine bulk density value

- Step 3: Retrieve value for OM01 for this site

- Step 4: Determine topsoil OC stock

Perform equation:

$SOC_{stock} = D_b * SOC_{content} * 0,1 * D$

Where:

SOC_{stock} in t ha^{-1}
Db (bulk density) in t m^3
$SOC_{content}$ in g kg^{-1}
D (depth of topsoil) in m.

- Step 5: Express indicator value:

SOC_{stock} of 0-30 cm soil depth (t ha^{-1})

SOC_{stock} of 0-50 cm soil depth (t ha^{-1})

Statistical and geo-statistical analysis (to be completed with results)
Data was stored in MS Excel and loaded for statistics in SPSS. ANOVA, LSD Post Hoc tests and linear regressions will be carried out.

Methodology used for calculations / estimations of parameters and indicators, including interpolations.
The following parameters and indicators will be measured or calculated:

Topsoil OC content (%)
Topsoil bulk density (t/m^3)
Topsoil stone content (t/m^3)

Definition of baselines
The definition of baselines: the first measurement of these parameters.

Definition and application of thresholds
Zero change according to baseline value

Evaluation of pilot results

ENVASSO procedures and protocols proved simple and easy to apply; baselines and thresholds are more difficult to define.

Output performance e.g Minimum Detectable Change achievable and comparison with WP1 requirements: Not tested yet.

References:

Gardiner, M. J. and Radford, T., 1980: Soil Associations of Ireland and Their Land Use Potential. Explanatory Bulletin to Soil Map of Ireland 1980. National Soil Survey of Ireland, Dublin.

Mitchell, F. and Ryan, M., 1998: Reading the Irish landscape. ISBN: 1860590551

National Soil Survey of Ireland, 1980: Second Edition of the General Soil Map of Ireland (scale 1:575000). National Soil Survey of Ireland, Dublin.

Indicator Evaluation: OM03 Peat stock

Ireland is representative for peat areas of Northern Europe.

The soil carbon stock of the Republic of Ireland is estimated to have been 2048 Mt in 1990, and 2021 Mt in 2000, from which peats hold around 57% (Tomlinson, 2005).

Although peatlands originally covered more than 17% (1,178,798 ha) of the land surface in the Republic of Ireland (Hammond, 1979), the large-scale, mechanised turf extraction schemes, afforestation programmes, intensification of agriculture and land reclamation have seriously depleted the area of peatland. Today only 19% (220,902 ha) of the peatland resource remains in a relatively intact condition. Within the Atlantic Biogeographic Region of Europe, Ireland still possesses 51% of the raised bogs and 50% of the blanket bogs of conservation importance remaining in the region (IPCC, 1996).

The Environmental Protection Agency of Ireland (EPA) has initiated a large-scale 3-year project called "BOGLAND" running from 2005 to 2008 on sustainable peatland management in Ireland. The objectives are to review and synthesise current information on environmental, social, economic and institutional aspects of peatland utilisation and management, and to address some of the gaps identified by conducting research on carefully selected sites.

The work will focus on three areas: biodiversity, characterisation of the physical peatland resource and its use, and socio-cultural, economic & institutional/policy.

The Work Package 3 "Physical peatland resources" is being led by University College Dublin (UCD) with partners in Trinity College Dublin (TCD), National University of Ireland Galway (NUIG), University of Limrick (UL) and Teagasc. WP3.1 is dealing with "Estimation of peat depth, volume and carbon content of Ireland".

The objectives are:
Find rules and develop a model that will permit the prediction of peat depth and carbon for various peatlands:

- Rules based on vegetation cover
- Rules based on existing mapping legends
- Rules based on spatial extent of bogs (including topography)
- Produce a map based on calibration and test areas that will indicate the volume and carbon content of peat (with different reliability for the different areas), of various types, found in Ireland.

Indicator

Globally, peatlands cover an estimated 4 million km2, approximately 3% world's land surface. Due to their anaerobic character causing partial decomposition of organic matter, peatlands store large amounts of carbon, and are very important, dynamic, global C pool (Gorham, 1991). When these peatlands are lost or degraded, CO_2 and other greenhouse gases are released into the atmosphere in large quantities.

Wetlands are under continual threat of degradation due to mainly human activities – mining, conversion to agricultural land and other uses, making the conservation of wetlands a potentially important strategy to prevent increases in greenhouse gas emissions (GACGC, 1998).

Pilot description

Spatial extent

The pilot area includes the entire country of the Republic of Ireland.

Data

1. Sampling design
2. Testing

Testing of the Derived Irish Peat Map (DIPM):

Field testing of the spatial extent of contemporary peatlands was performed in three selected areas along an east-west gradient from County Mayo in the west of Ireland (Study site 1) through County Offaly (Study site 2) to the Wicklow Mountains in the east (Study site 3). The areas were selected to be representative of low-level Atlantic (LLA), high-level montane (HLM) blanket bogs, and raised bogs (RB).

One hundred sampling points were allocated to each of the three sites, with several attributes recorded, including peat depth, vegetation type, land use, anthropogenic influence and overall disturbance.

Testing of the peat depth and disturbance:

New field campaign will be started 2007 autumn at the same sampling sites (Study site 1, 2, 3) for measuring peat depth and collecting samples for carbon content.

Data description and standards

Map data

Peat Map of Ireland (Hammond, 1979)
General Soil Map of Ireland (Gardiner and Radford, 1980b)
CORINE (O'Sullivan, 1994), CORINE 2000
Digital soil map of Ireland

Methodology used for calculations / estimations of parameters and indicators

The Derived Irish Peat Map was produced by using rule-based methodology through four steps (Figure 1.):

Step 1: Digital data sources and pre-processing
Step 2: Rule-based decision tree and the resulting derived peat map
Step 3: Ground truth data and testing of the decision tree rules
Step 4: Peatland classification

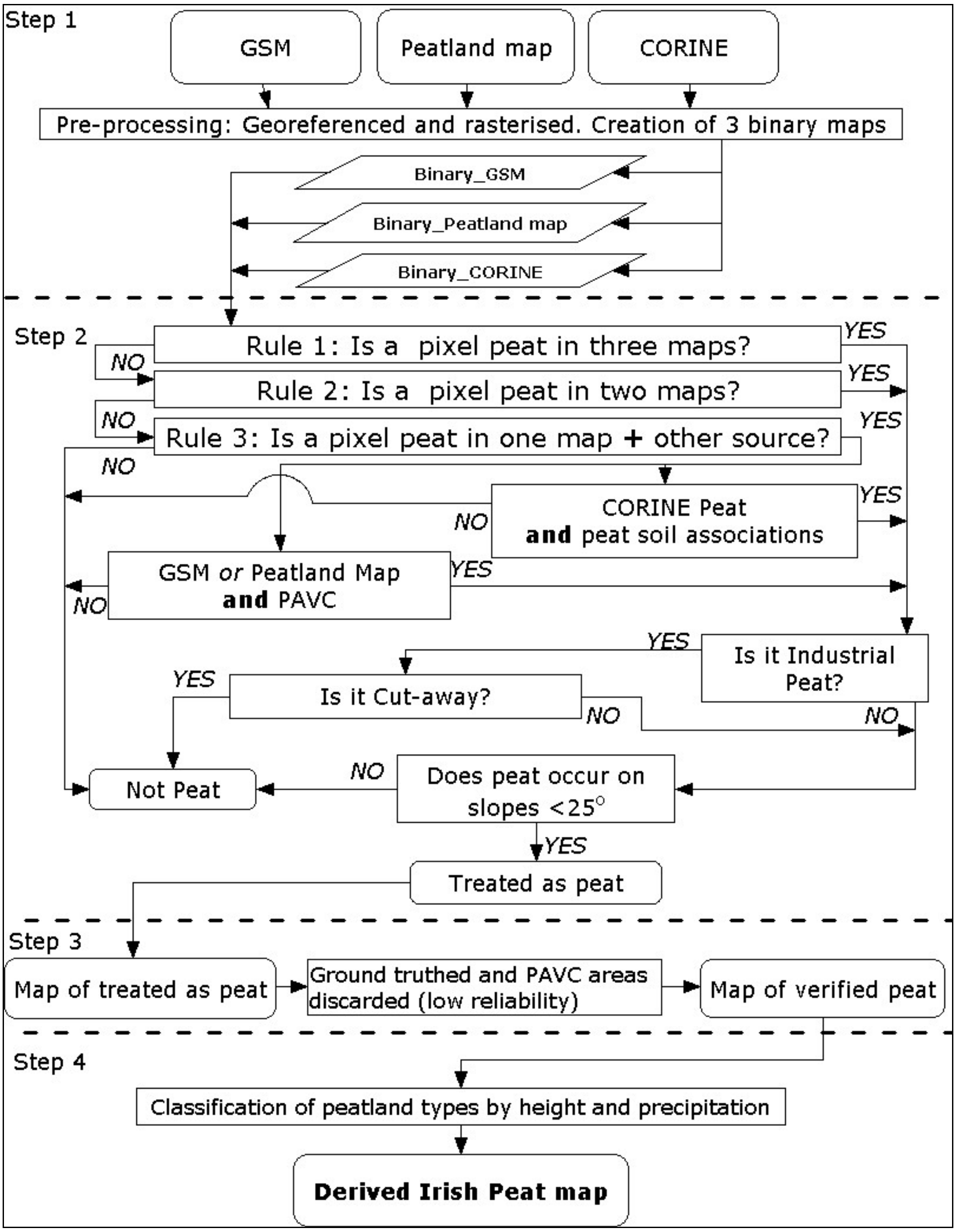


Figure 1. Rule-based methodology steps (GSM=General Soil Map, PAVC=Peat-associated vegetation class) (Connolly et al., 2007)

Baseline definition
No baseline defined within WP1.
The stock based on the new (revised) Derived Irish Peat Map (DIPM)

Threshold definition
No threshold defined within WP1.
Net Zero change.

Commentary on original data

Pilot methodology

The spatial extent of contemporary peatlands was estimated by using rule-based methodology implemented as a series of hierarchical rules in ArcGIS from digital data of available soil and land cover maps: Peat Map of Ireland, General Soil Map of Ireland, and CORINE. The Derived Irish Peat Map (DIPM) was produced at a pixel resolution of 100 m.
To get better reliability, DIPM has been updated using newer data sources such us CORINE 2000 and the Digital soil map of Ireland.

Previous field work collecting peat depth estimates indicated that peat depth is predictable (at least within classes) based on the vegetation mapped by CORINE and the legend of the Peatland Map of Ireland. Existing map legends and soil survey field descriptions also provide evidence for peat depth at specific points. In addition there are models that relate bog size and shape to depth based on the physical properties of peat. A model will be developed that will utilize this series of rules (forming a decision tree) will be devised to predict peat depth and carbon content for each mapped area of peatland in Ireland.

A field sampling regime will be then implemented to test the peat depth and carbon content predictions (including correlation with topography). GIS maps for each rule in the decision tree will be used to devise a layered sampling strategy and the results will be analysed for prediction accuracy. Sampling will aim to visit at least 500 sites (with more blanket peatland sites) to make peat depth measurements or estimates (in addition to the 300+ already available). The field data will be used to re-evaluate the rules and the analysis will reveal which rules are most important and which contribute last. If necessary a revised set of rules will be formulated.

A final, independent data set will be collected (300 samples) that will be used to test the fine tuning of the depth prediction rules. Using all available data (1100+ samples plus any literature / National soil database of Ireland, Bord na Móna, Airtricity, Dúchas data available) the peat depth and carbon content prediction model will be tested to derive prediction accuracy.

A three-dimensional map of peatland depth and peatland carbon (mass per unit depth) in Ireland will be produced.

Further objectives:

- Integration of the peat volume map with the peat carbon map.
- Integration with other physical and biological results to identify area of peatland susceptible to change with respect to the carbon reservoir.

Compilation of soil data and maps for the pilot area

The Derived Irish Peat Map (DIPM) is available.
Peat volume estimation and testing will be finished until February 2008.
The compilation will be completed with results.

Method development and application (i.e. changes to WP4 procedures and protocols)

Steps according to the “ENVASSO Procedures and Protocols” is followed:

Step 1: Determine area of peat
“Derived Irish Peat Map” (DIPM) was produced using a rule-based methodology and digital data at a pixel resolution of 100 m (Connolly et al., 2007), and has been updated using newer data sources to get better reliability.
Step 2: Determine depth of peat
A model will be developed and tested to predict peat depth (for details see “Pilot method” chapter).
Step 3: Estimate bulk density
Bulk density of peats will be estimated based on available literature data.
Step 4: Determine peat stock
Perform equation:

PS = PA * PD * 10-4 * Db

Where:
PS is peat stock in Mt
PA is peat area in km2
PD is peat depth in m
Db (bulk density) in t m3

Statistical and geo-statistical analysis (to be completed with results)

Methodology used for calculations / estimations of parameters and indicators, including interpolations. Minimum detectable change (?) etc (to be completed with results)

The following parameters and indicators will be measured or calculated:

Depth of peat (m)
Area of peat (m2)
Bulk density of peat (t/m3)
Carbon content of peat (%)

Definition of baselines

The stock will be based on the new (revised) Derived Irish Peat Map (DIPM)

Definition and application of thresholds: Net Zero change

Evaluation of pilot results

ENVASSO procedures and protocols proved simple and easy to apply; baselines and thresholds are more difficult to define.

Output performance e.g Minimum Detectable Change achievable and comparison with WP1 requirements: Not tested yet.

References:

Connolly, J., Holden, N.M. and Ward, S.M., 2007: Mapping peatlands in Ireland using a rule-based methodology and digital data. Soil Science Society of America Journal 71(2): 492-499.

GACGC, 1998: The accounting of biological sinks and sources under the Kyoto Protocol: A step forwards or backwards for Global Environmental Protection? German Advisory Council on Global Change, Special Report, Bremerhaven, 75 p.

Gardiner, M. J. and Radford, T., 1980a: Soil Associations of Ireland and Their Land Use Potential. Explanatory Bulletin to Soil Map of Ireland 1980. Soil Survey Bulletin No. 36. An Foras Talúntais, Dublin, Ireland.

Gardiner, M. J. and Radford, T., 1980b: General Soil Map. Soil Survey Bulletin No. 36. An Foras Talúntais, Dublin, Ireland.

Gorham, E., 1991: Northern peatlands: Role in the carbon cycle and probable responses to climatic warning. Ecol. Appl. 1:182-192.

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IPPC, 1996: Action for bogs and wildlife. Information sheets. Irish Peatland Conservation Council, Ireland.

O'Sullivan, G. (ed.) 1994: CORINE land cover project Ireland. Project report.Ordnance Survey of Ireland, Dublin.

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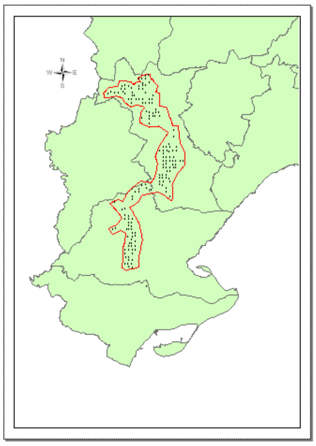
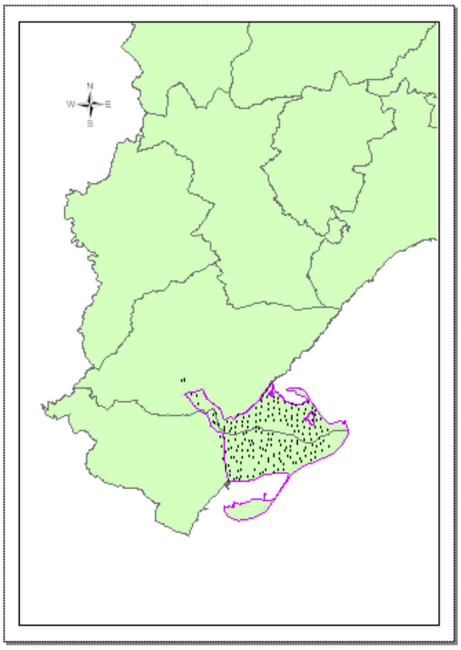
Pilot area: Terres de l'Ebre, Spain

Lead Partner: SARA, Spain.
Jaume Boixadera
Iolanda Simó i Josa

Description of the pilot areas

Names of participating partners	**Lead partner**	**Jaume Boixadera, SARA, Spain**
	Partner	Iolanda Simó i Josa, SARA, Spain
Introduction	It has been decided to use 2 different pilot areas to apply indicators of the threat: Soil organic matter decline. These areas have been chosen because one, Terres de l'Ebre, is quite representative of land uses, soils, climate of Catalonia and the Mediterranean area and the other one, Ebro delta is an important delta of Catalonia and it is a protected area, where agroenvironmental measures are applied (Ramsar conservation area) and it's a bird protected area (ZEPA). Ebro delta is considered one of most important part of fluvial ecosystem in the Ebro Basin.	
A.1. Pilot area C_1: Terres de l'Ebre		
Name of pilot area		Terres de l'Ebre
Location and description	Member State(s)	Catalonia (Spain)
	Coordinates	Xmin: 0º 24' 21'' Ymin : 40º 46'15.9'' Xmax: 0º 39' 57'' Ymax : 41º 18' 33''
	Area of pilot area A (km^2) 	More or less 400 km^2
	Climate	Typical Mediterranean (Csa, according to the Köppen classification)
	Mean annual temperature Average annual precipitation	- Temperature: 16 º C - Precipitation: 413 mm
	Outline description of geomorphological unit	Flood plain and terraces of Ebro river, glacis of Mora and marls and limestone hills.
	Maximum elevation (m)	500 m see level
	Potencial vegetation	Evergreen shrub
	Actual vegetation	Evergreen shrub
	Major land uses	Non irrigated: Olive tree, cereal crops and vineyard Irrigated land: Fruit-trees, citrus and vegetables.
	Major soils (WRB, 2006)	Most important soils are Fluvisol, Calcisol, Kastanozem, Regosol, Luvisol, Leptosol, and Cambisol. All of them are highly calcareous. A significant part of them have Leptic characteristics. An other group (specially Kastanozems, Clacisols and Luvisols) contain a large amount (up to 60%) of coarse fragment (ϴ> 2 mm)

A.2. Pilot Area C_2: Ebro Delta

Name of pilot area		Ebro delta
Location and description	**Member State(s)**	**Catalonia (Spain)**
	Coordinates	Xmin: 0º 28' 58'' Ymin : 40º 32' 12'' Xmax: 0º 52' 34'' Ymax : 40º 48' 51''
	Area of pilot area B (km^2) 	More or less 350 km2
	Climate	Typical Mediterranean (Csa, according to the Köppen classification).
	Mean annual temperature Average annual precipitation	Temperature: 17º C - Precipitation: 530 mm
	Outline description of geomorphological unit	Ebro delta in the Mediterranean sea
	Maximum elevation (m)	4.5 m sea level
	Potencial vegetation	The helophytic communities of the Ebro delta are notably rich due to the surface area they cover and the high spatial variability of the main ecological parameters (salinity and water regime)
	Actual vegetation	In the Ebro delta the dominant natural vegetation is reed (Phragmites Australis).
	Major land Uses	Dominant land use is Paddy rice but it is able to find some vegetable.
	Major soils (WRB, 2006)	Most important soils are Fluvisol, Arenosol, Calcisol, Histosols and Solonchanks. All of them are highly calcareous.

Threat and related indicator(s) evaluated in pilot areas

Threat	**Decline is soil organic matter inventory**

Indicator 1	Topsoil organic carbon content
Indicator 2	Topsoil organic carbon stock

Rationale for selection of pilot areas

These areas have typical Mediterranean characteristics like climate or land use. It is an important and typical agriculture area. SARA has been studying those pilot areas since some years ago and has been colleting SOM data in those pilot areas. This data is available to use in ENVASSO which could be linked with other chemical and physical soil properties.

The annual rate of loss of organic matter can vary greatly, depending on land use practices, the type of plant/crop cover, drainage status of the soil and whether conditions. We can compare what happen with SOM in these areas according to different land uses or soil textures.

In pilot area C1, Terres de l'Ebre, the majority of the studied area (59 % of the area) is irrigated land, crops and fruit trees represents 24.81 % and 27.41 % respectively. About 6.746 ha are cultivated by irrigated tree crops but this area would be bigger in a close future. Approximately, 41% is non irrigated land being the most important crops olive trees, almond trees and vineyard. In this area is possible to find some threats soils like soil erosion, soil salinisation and desertification, and could be a good area to study the content of soil organic matter.

In that area is able to find differences between land use practices depending of the crop production and various land use are present. There are heterogeneity of soil substrates associated to various land uses and land managements.

On the other hand in pilot area B, Ebro delta, the most important land use is paddy rice. Soils are flooded most part of the year, also because agroenvironmental measures (Ramsar Conservation area) and that influences directly to the OM mineralization.

Majority of Catalan soils have high levels of carbonates. Carbonates mean, in both pilot areas, is around 36.20 % of carbonates in pilot area C_1 and 33.37 % of carbonates in pilot area C_2.

Indicator Evaluation

Indicators

OM01: Topsoil organic carbon content
OM02: Topsoil organic carbon stock

Pilot description

Spatial extent

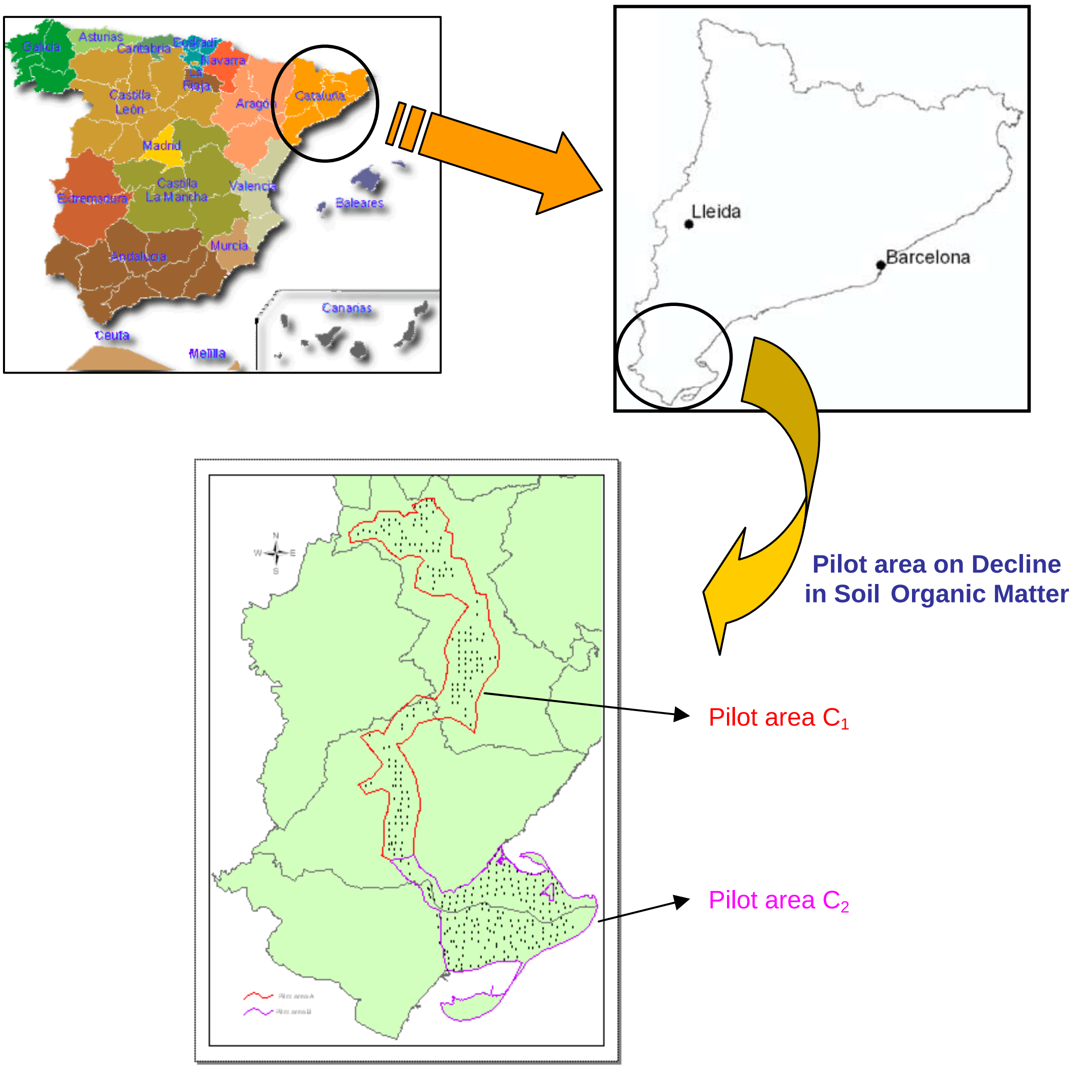


Figure 1. Location of 2 pilot areas.

The pilot area covers the agriculture land of the low valley of Ebro river.

Data

OM01: Topsoil organic carbon content

Detailed description of data:

Compilation of soil data and maps for the pilot area:

Pilot area C_1 used systematic sampling. The sampling was undertaken in May in 2005. The protocol established in that area is detailed below. The field working group has described the land use of each plot sampled and we used that information to develop some statistics, besides, have been used some analytical data like chemical measurements: SOM (%) or texture of topsoil to make some other statistics.

Soil map of pilot area C_1 was created in 1997-1998 to scale 1:50.000. Pedotransfer rules were used as input data obtained from the soil map (i.e topsoil texture), using data available from the soil profile data base.

Historical data (2003-2006) from national monitoring system and new measured data (2007) of pilot area C_2. In pilot area C_2 has been developed a systematic sampling. Most plots are paddy rice. Samples have been analysed to the laboratory and some chemical measurements have been obtained like SOM (%).

Methodology used for calculations / estimations of parameters and indicators, including interpolations.

Calculations:

$$OC\ (\%) = OM\ (\%) \cdot \text{conversion factor}$$

Table 1. Factor conversion of organic matter to organic carbon

Conditions	Factor
OM < 10	1/1.72

(Porta *et al*. 1986)

Analysis:

- Determination of carbonate content in soils. Volumetric method using Bernard calcimeter (UNE 103200).

- Soil texture determination with discontinuous sedimentation (Pipette method).

This method is based in the fact that the sedimentation eliminates in a zone with “d” deep, and in “t” time, all the particles with sedimentation velocity bigger than d/t. If these particles have a sedimentation velocity smaller than “d/t”, they remain in this zone with the original concentration.

A little volume sampling in the “d” deep suspension after a “t” time gives a sample where all the particles with a diameter bigger than “x” (as such the Stokes equation determines) have been eliminated while the thinnest particles remain with the same concentration that in the original suspension.

The sample taken in d deep has been “sieved” by sedimentation, thus the ratio of the weight “W” of the particles present in the sample after a “t” sedimentation time, divided by the weight “W0” of the particles present in the same initially suspension volume, it’s “P/100” where P is the percentage of particles in weight, with a diameter smaller than “x”.

The relation “W/W0” always could be described like the ratio of concentrations “c/C0”, being “c/C0“= “P/100”. This equation connects the concentration “c” in the sample, expressed in g/l, with “P” parameter, being “C0“ the weight of all particles in the original suspension divided by its volume.

OM02: Topsoil organic carbon stock

Detailed description of data:

Compilation of soil data and maps for the pilot area:

Systematic SOM sampling to set topsoil organic carbon stock like the indicator before.
Have been used the same protocols (C_1 and C_2) to set SOM (Topsoil organic carbon content).

Only in the topsoil:
Chemical measurements: SOM (%)
Physical measurements: Bulk density (core method and clod method) (Db) ($g \cdot cm^{-3}$) ($t \cdot m^{-3}$)
Has been used bulk density from soil mapping and it has been related to topsoil texture. With these data could be able to define bulk density in each sampled point.

Methodology used for calculations / estimations of parameters and indicators, including interpolations.

Calculations:

SCO stock (t/ha) = Db * SOC content * D * 0.1

Where: Db (Bulk density) in $t \cdot m^{-3}$
SOC content in $g\ kg^{-1}$
SOC stock in $t \cdot ha^{-2}$
D (depth of topsoil) in m

Definition of baselines

It is unsound to define a single baseline for soil organic carbon in all topsoil.The SOC and SOM contents depend strongly on geo-climatic factors (Jones et al., 2005), on land use (McGrath and Loveland, 1992; Arrouays and Pelissier, 1994), on soil type and clay content (Arrouays et al. 2001, 2006), on combinations of clay contents and precipitation (Verheijen et al., 2005), and on management practices (Carter 1992; Soussane et al., 2004). Therefore, baselines values should be area specific. There is also some consensus that there is a well-defined relationship between lower limits for SOC in a soil and its texture.

Definition and application of thresholds

Although the lower threshold of 2% soil organic carbon has been used widely (Kemper and Koch, 1996). It is clear that a large proportion of intensively cultivated soils of Europe have already reached low levels (Arrouays *et a, 2001l).* The majority of soils of Catalonia have less than 2% SOC, there is no conclusive evidence of significant effects on other soil properties and crop yields (crop production and nutrients, available water capacity, aggregate stability, etc.).

Furthermore, we could find a high variability on data in our pilot area because could be affected by analytical laboratory methodology or may be by land management in many land uses.

In Catalonia 1% SOC is considered as threshold for agricultural soils in pilot area C_1 and 2% is considered as threshold for paddy rice in pilot area C_2.

Pilot Methodology

Method development and application

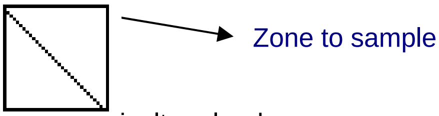
Pilot area C_1

Sampling was done in May of 2005 as follows:

A grid cells (1000 x 1000 m) ≈100 ha was created. The grid was numbered.

With aerial photomaps printed to a scale 1:10.000, we should choose the cells where sample and only in the field plots could be selected to be sampled.

The plot must be bigger than 1000 m^2 but if it is not possible we should make a diagonal to the cell of the grid and choose many plots to sample that belong to the right of the diagonal, i.e:



Sampled plots should be in agriculture land.

A composite sample is taken, obtained from 12 randomly positioned subsampling points and they must not be aligned.

The composite sample is taken of 0-20 cm of depth, with a rotary method, augers Edelman of 7 cm of diameter.

The order of 2 kg of sample is obtained, and it is kept in a plastic bag with the corresponding reference.

Record the location of each plot sampled (composite sample) position with a differential GPS device.

The laboratory to perform SOM uses analysis by wet oxidation with Walkley Black method.

Pilot area C_2

This sampling has been realised on March since 2003-2007.

Aerie photomaps (resolution 1:5.000) were printed to scale 1:10.000 with a grid of 1225x1225m
Sampled plots were selected to each cell of the grid before to go to the field.
Check in field if sample plots selected are able, and they weren't, change them but they could be inside of each cell of the grid.
The composite samples were obtained:

15 subsamples were obtained distributed in a radius of 20 m from a central point.

These 15 subsamples were mixed in a bucket and it was obtained from the order of 2 kg of compound sample.

Depth of sampling is 0-25 cm, with a rotary method: Edelman augers of 5 cm of diameter.

Recorded the location of each plot sampled (composite sample) position with a differential GPS device.

The laboratory to perform SOM uses analysis by wet oxidation with Walkley Black method.

Statistical and geo-statistical analysis

In both pilot areas have been calculated some statistics (mean, max, min, CV) and some relationships between difference parameters (land use, soil textures…) applying statistical analysis like Duncan's Multiple Range Test with SAS software.

Evaluation of pilot areas results:

Feasibility and experience of applying ENVASSO procedures and protocols

The quantitative determination of SOM is made with an organic carbon analysis. The majority of organic carbon analyses are based to oxidize the organic carbon, there are 2 ways:

Dry combustion method.
Analysis by wet oxidation → Walkley Black method.

The analysis by wet oxidation is necessary to reduce OM with Cr^{6+} and later to make an oxidation of OM existent in soil. The valuation of the OM is made with a ferric salt:
$Fe^{2+} \rightarrow Fe^{3+}$

That methodology has some errors or may be the methodology could be interfered by some causes:
Some reduced substances (Mn^{2+} or Fe^{2+}) present in soil could be interfered in the valuation (potassium dichromate)
Some Fe^{3+} could restrain the reaction.
Some chloride ion present in soil could be oxidized and interfere in the valuation with potassium dichromate.

It was decided to use the Walkley Black method because most Catalonian soils have high carbonates content and low SOM level however, we detected some problems in our pilot areas which are explained below.

The main crop in pilot area B is paddy rice and soils are under hidromorphic conditions because most part of the year soils are saturated.

Hidromorphic soil are soil under anaerobic conditions which some could have accumulations of ferric or magnesium concretions. These concretions can affect to the valuation of SOM content with the methodology applied because oxidized and reduced substances (Mn^{2+} or Fe^{2+}) present in soils could be interfered in the valuation with potassium dichromate, and for the that reason appears high values of SOM in Ebro delta.

Furthermore, most soils of Ebro delta are saline, which means high chloride content in soil. Chloride ion is oxidized with soil organic matter and is interfering with the real valuation of SOM.

By another hand, in the procedures and protocols specify how to calculate SOC stock where it does not consider coarse fragments (%), and could be better to consider it.

Output performance:

Results of OM01: Topsoil organic carbon content
Pilot area C_1

Some mean statistics of pilot area C_1 has been calculated and it is summarized in Table 2:

Table 2. Statistics of pilot area C_1

N	SOC Maximum (%)	SOC Mean (%)	SOC Minimum (%)	Median (%)	Std Dev	CV (%)
158	3,87	1,19	0,11	1,04	0,58	49

Some other results have been obtained to apply ANNOVA statistics, Duncan's Multiple Range test (Different letters indicate significant differences in Duncan's test (p=0,05)).

Relationships between soil management (dry land/irrigated land) has been studied using Duncan's test but we did not find any.

Table 3. SOM (%) and land managements

Land Management	Land use	n	SOM Mean (%)	SOC Mean (%)
IRRIGATED LAND		61	2,08	1,2
	Citrus tree	31	2,25	1,3
	Fruit tree	30	1,89	1,09
NON IRRIGATED		93	1,99	1,15
	Almond tree	16	1,98	1,15
	Olive tree	61	1,96	1,13

It is able to see significant differences if all land uses are considered but not if it is compared different land management (irrigated or dry land). The Figure 2 shows that there is not any significant difference between land management. The same happens if it is compared different crops in different managements.

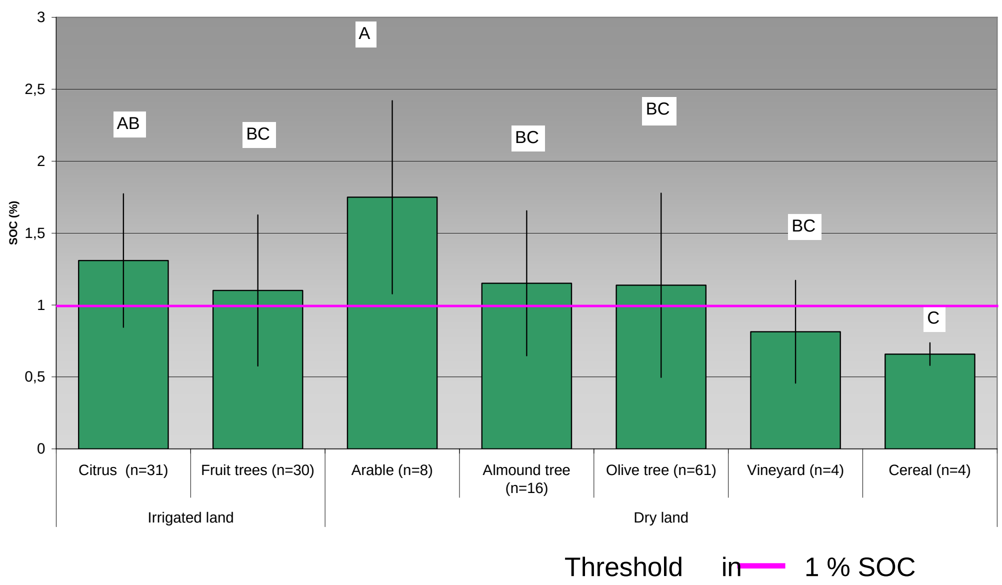


Figure 2. Soil Organic Carbon (%) corresponding to different land use and different managements.

Arable land has a high SOC (%) because receives high doses of animal manure.

If it is considered more sample points, could be able to find more important differences between land uses, because in some cases there is not so much data.

We thought that could be a good idea to study the link with SOC and the most important crops in the same management. In pilot area C_1, the most important crops in irrigated land are citrus tree and fruit tree. ANNOVA has been applied in statistics analysis between crops; almond tree and olive tree and citrus tree and fruit tree but we didn't find any significant difference (table 3).

Soil texture and SOC (%) has a strong relationship with topsoil texture and Figure 3 shows it.

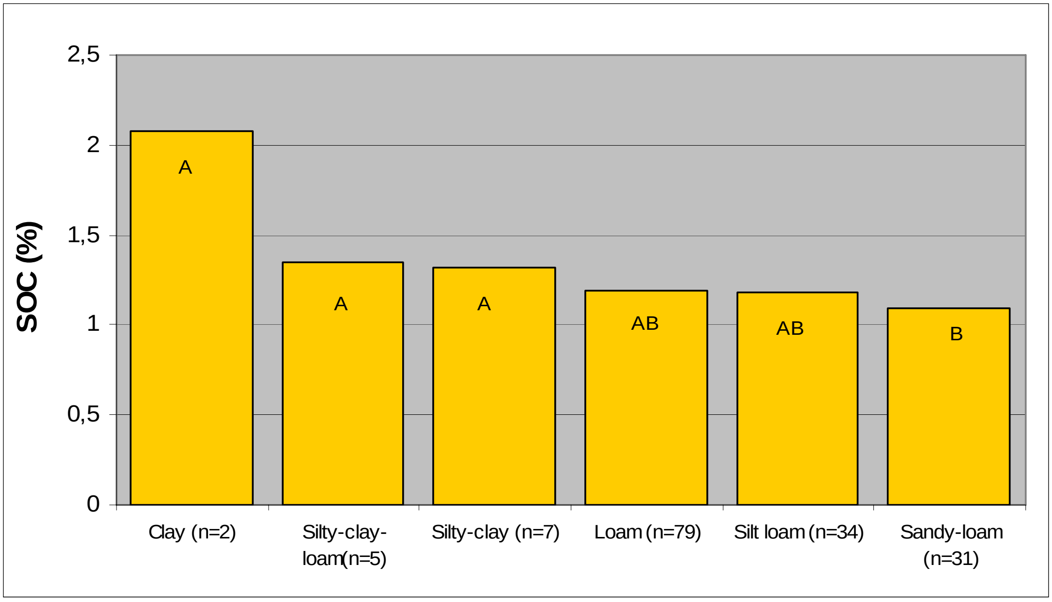


Figure 3. Soil Organic Carbon (%) corresponding to different textures.

Single texture classes are merged in broader texture classes which are better to show significant differences. We used 4 classes:

Coarse: sand, loamy sand.
Moderately coarse: sandy loam, sandy loam fine
Medium: sandy loam very fine, loam, silt loam, silt.
Moderately fine and fine: sandy clay, clay, silty clay, sandy clay loam, clay loam, silty clay loam.

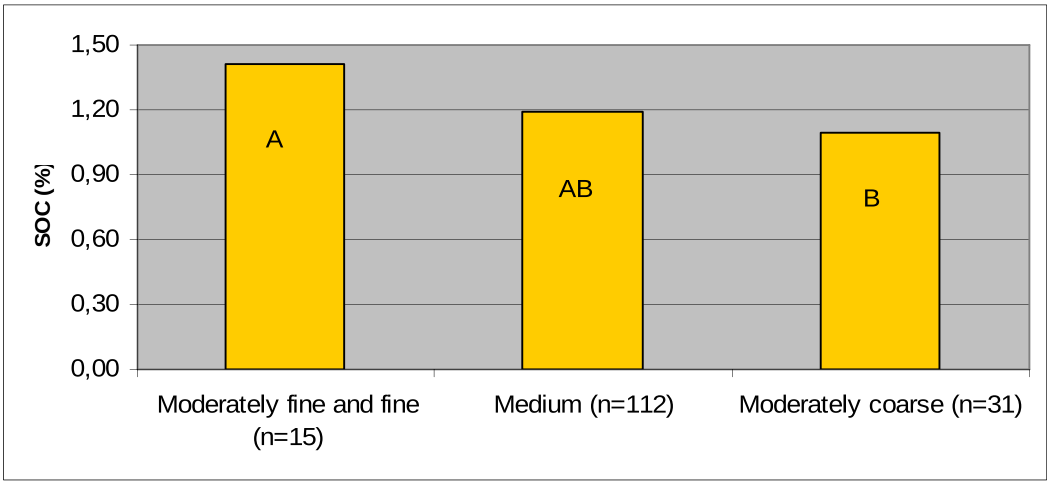


Figure 4. Soil Organic Carbon (%) corresponding to classes of textures.

Pilot area C2

Results of pilot area C_2 has been developed with SAS applying ANNOVA statistics with Duncan's test. The distribution of all data since 2004 to 2007 is showed in the figure 5.

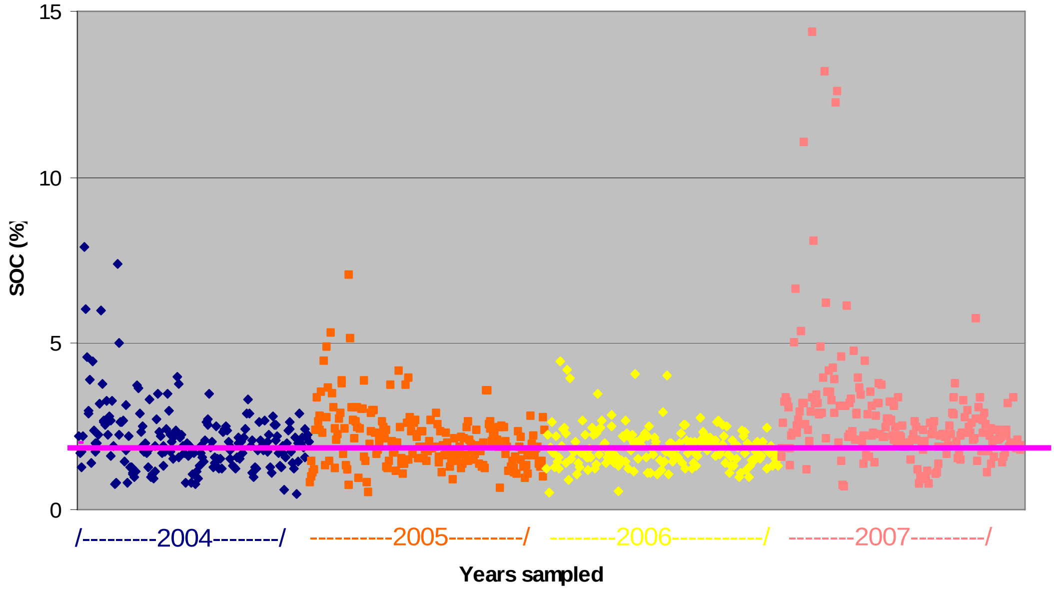


Figure 5. Distribution of soil organic matter content (%) in pilot area B; Ebro delta since 2004-2007.

There are some data that have high levels of SOM (%) because those points are sampled in Histosols or are soils managed with animal manures in this year. The table 4 shows summarized statistics for pilot area B over the study period.

Table 4. It shows the main statistics of SOM (%) by pilot area B since 2004 to 2007:

Year	n	SOC Maximum (%)	SOC Mean (%)	SOC Minimum (%)	Median (%)	Std Dev	CV (%)
2004	197	7,90	2,13	0,46	1,97	1,03	48,3
2005	201	7,03	2,09	0,52	1,92	0,89	42,5
2006	198	4,44	1,86	0,51	1,79	0,58	31,1
2007	205	14,34	2,79	0,68	2,34	1,88	67,3

There is no significant difference between years and figure 6 shows a trend in declining SOM (%) since 2004 to 2006.

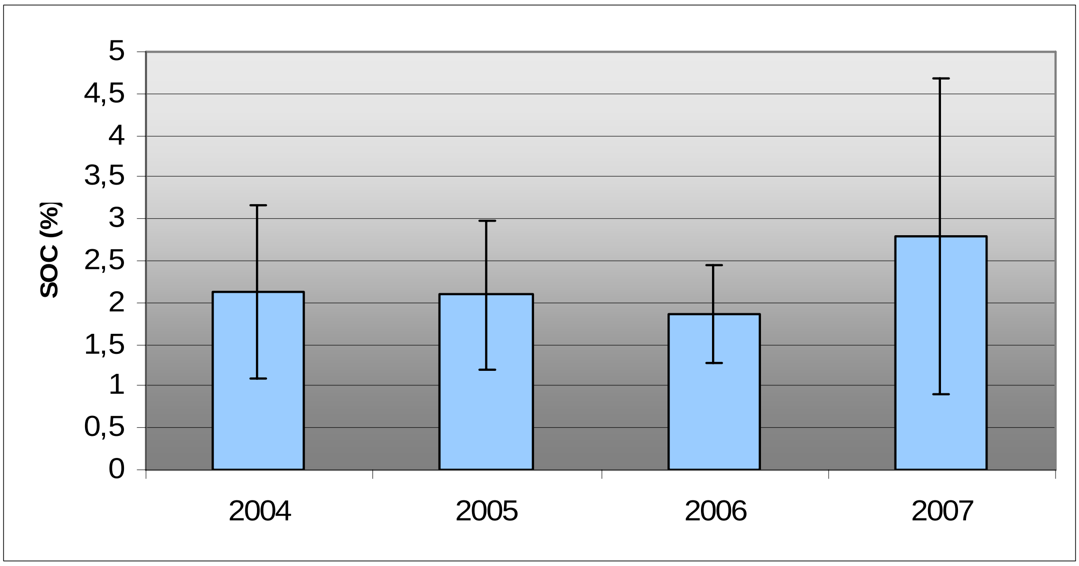


Figure 6. Mean of SOM (%) according to different years studied

The most important crop in Ebro delta is paddy rice. We compared SOM in paddy rice and in natural vegetation and we do not find any significant difference.

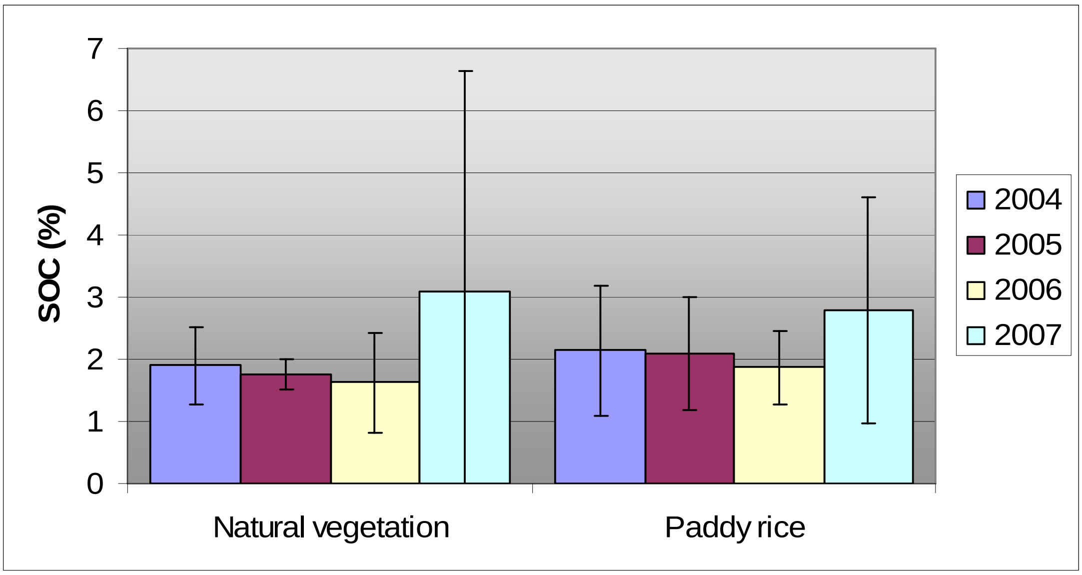


Figure 7. Mean of SOM (%) in different land by each studied year.

In pilot area C_2, Ebro delta, we didn't find any significant differences between textures, only with sand like shows the figure 8. But it is normal find low SOM in sandy soil.

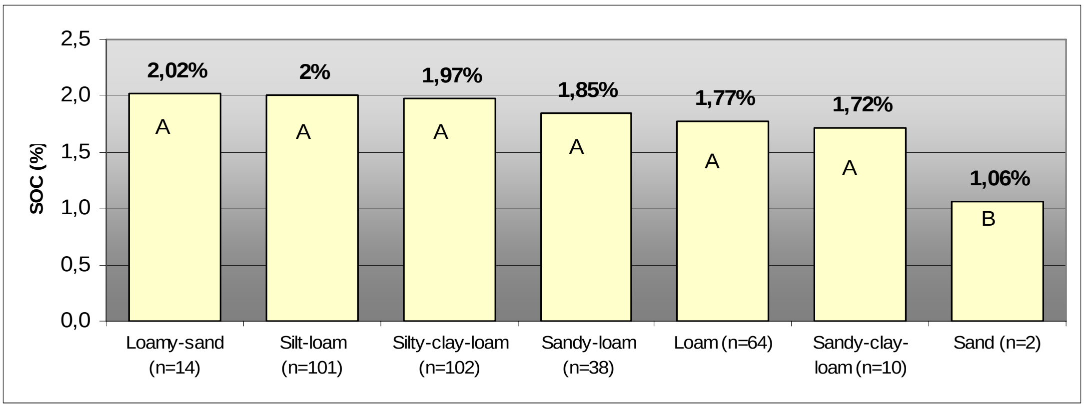


Figure 8. Soil organic matter content (%) corresponding to different textures.

Single texture classes are merged in broader texture classes which are better to show significant differences. We used 4 classes:

- Coarse: sand, loamy sand.
- Moderately coarse: sandy loam, sandy loam fine
- Medium: sandy loam very fine, loam, silt loam, silt.
- Moderately fine and fine: sandy clay, clay, silty clay, sandy clay loam, clay loam, silty clay loam.

Figure 9 shows that there are significant differences between classes in the 2004 sampling but figure 10 shows that in the followings years (2005-2007) there is not the case.

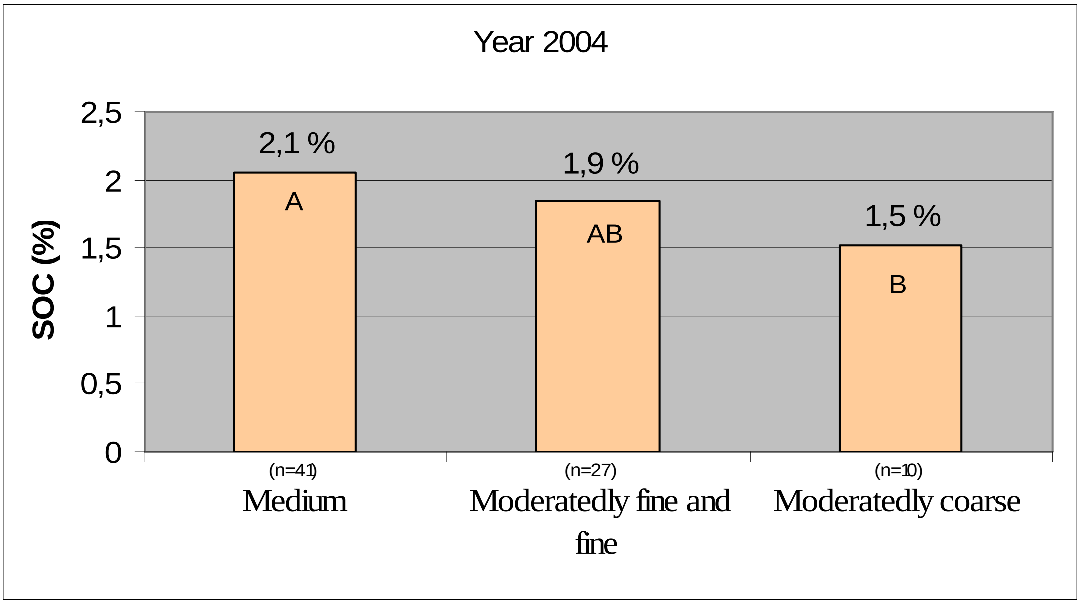


Figure 9. Soil organic matter content (%) corresponding to different textural classes in 2004.

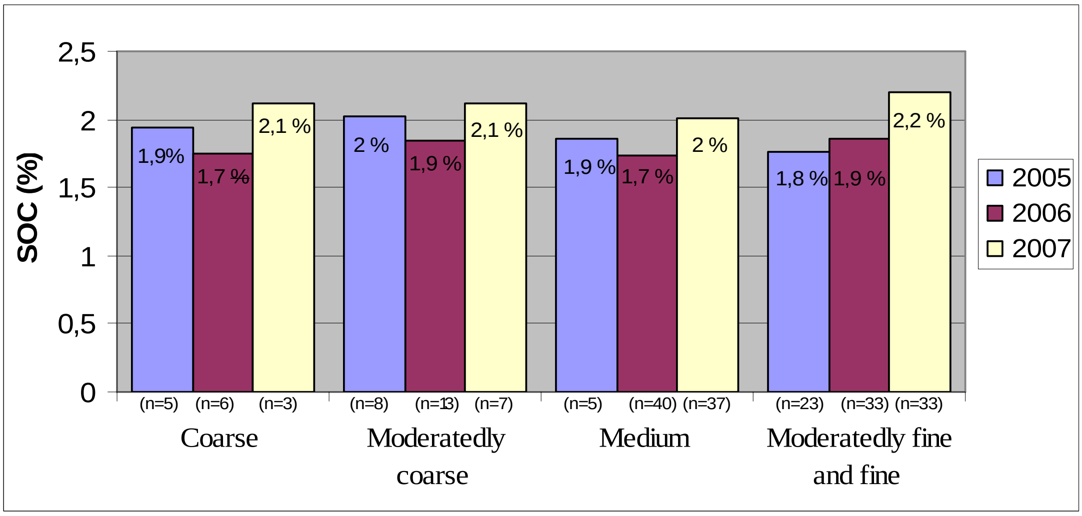


Figure 10. Soil organic matter content (%) corresponding to textural classes from 2005 to 2007.

Results of OM02: Topsoil organic carbon stock

Pilot area C_1

In 1990 pilot area C_1 started to transform some non irrigated land to irrigated land, in 2004 irrigated land got bigger. Figure 11 shows that there are not any significant differences of SOC stocks between land management or major land uses.

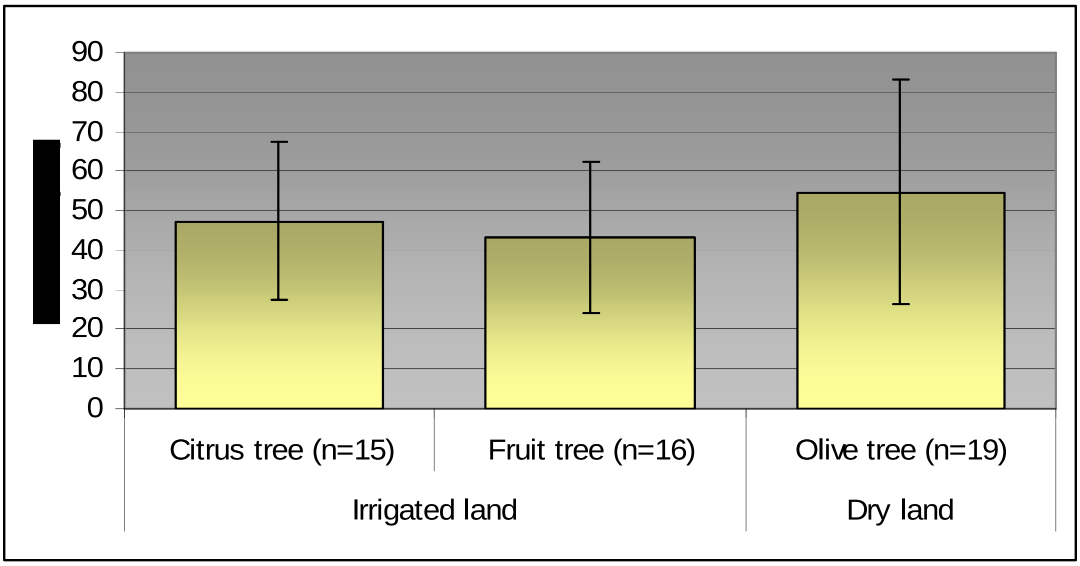


Figure 11. SOC stock in pilot area C1 according to different land managements and land uses.

Pilot area C2

There are significant differences between years of sampling in pilot area C_2 (Fig.12).

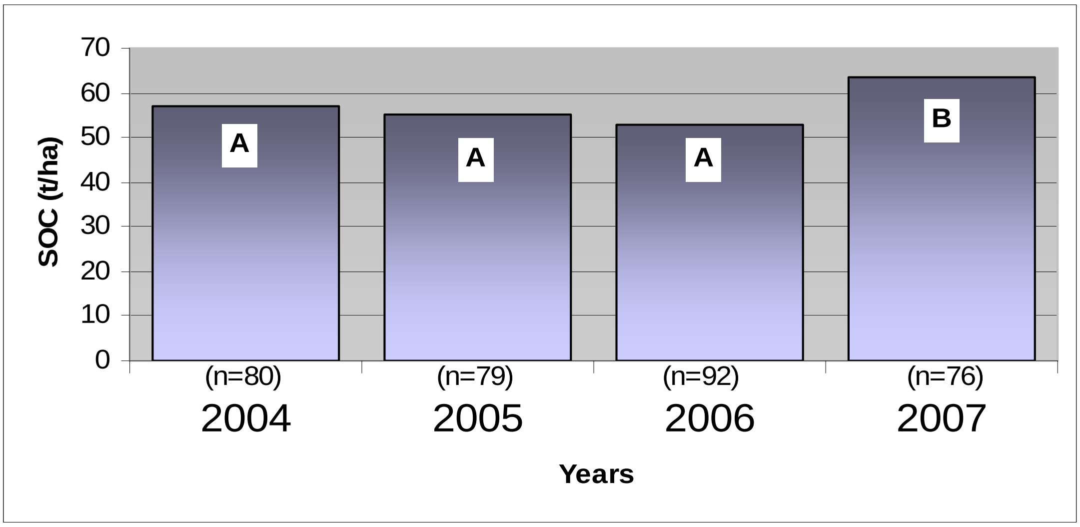


Figure 12. SOC stock in pilot area C2 according to year of sampling.

The main crop in this pilot area is paddy rice. The figure13 shows accord with figure 12.

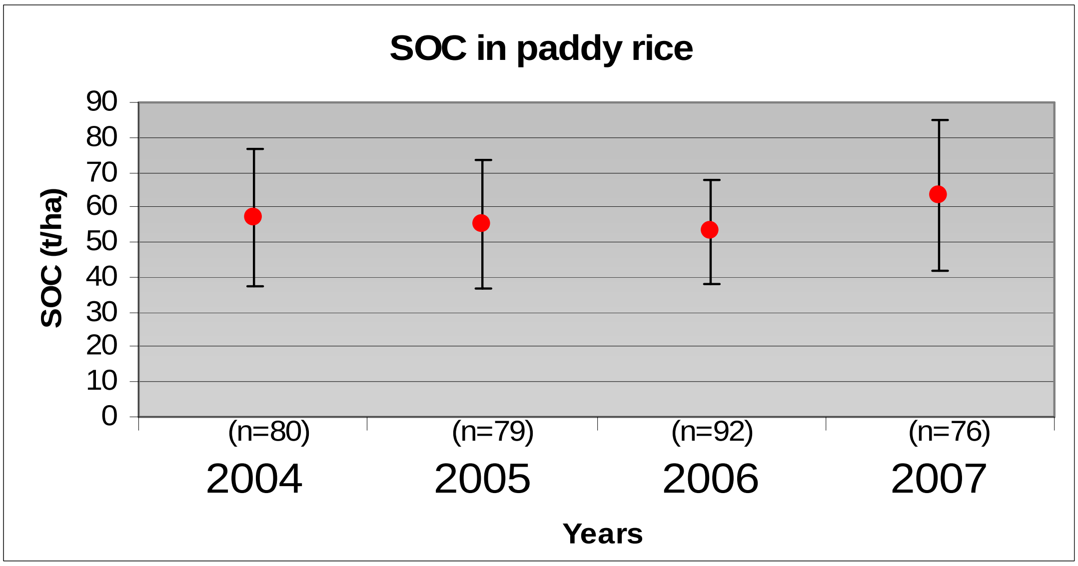


Figure 13. SOC stock in paddy rice.

It's known that SOC has a high relationship with soil texture. Figure 14 and 15 show significant differences between soil textures.

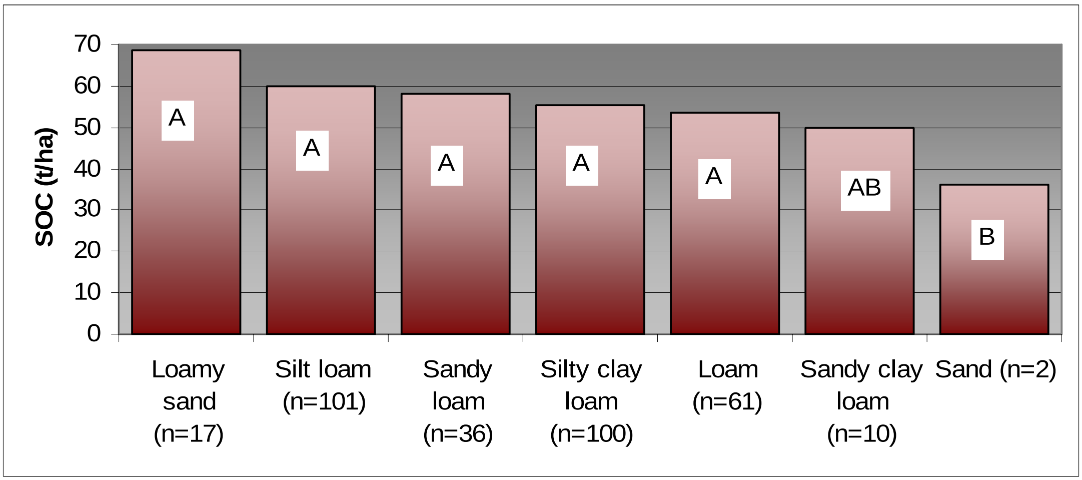


Figure 14. Comparison of SOC stock between soil textures.

Single texture classes are merged in broader texture classes which are better to show significant differences. We used 4 classes:

- Coarse: sand, loamy sand.
- Moderately coarse: sandy loam, sandy loam fine
- Medium: sandy loam very fine, loam, silt loam, silt.
- Moderately fine and fine: sandy clay, clay, silty clay, sandy clay loam, clay loam, silty clay loam.

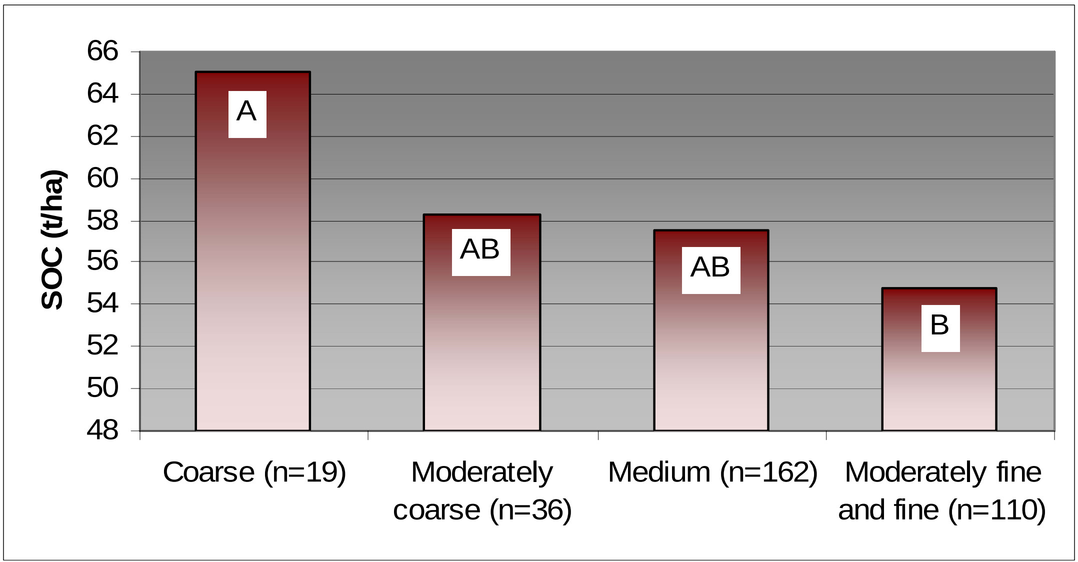


Figure 15. Comparison of SOC stock between soil textures.

Conclusions and recommendations

The literature (FAO) used in this template to define vegetation is not enough detailed.
Baselines used are different according to the pilot area. The baseline in pilot area C_1 is 1% SOC but in pilot area C_2 is 2% SOC.

In Catalonia soils, first procedure proposed to determine SOC is not very suitable because all soil have high levels of carbonates (33.37 %-36.20 %).

The second one procedure (Walkley Black method) has some problem to apply because in Ebro delta there are hydromorphic conditions. There are reduced substances (Mn2+ or Fe2+) which could interfered in the valuation with potassium dichromate and overestimate the real value.

In pilot area C_2, Ebro delta most soils are saline, it means high level in chloride ion. The chloride ion present in soil could be oxidized and interfere in the valuation with potassium dichromate, in Walkley Black method and over estimate the real SOM (%).

It should be clear the depth of the topsoil because the SOM (%) could change depending to the depth. It will be able to define the depth maximum to the topsoil.

It could be interesting to measure the percentage of course fragments because it is and important feature when the topsoil organic carbon stock has to be calculated.

It is necessary to consider course fragments in SOC stock (coarse fragments may amount 60% of soil volume).

References

Métodos oficiales de análisis. Tomo III. 1994. Ministerio de Agricultura, Pesca y Alimentación. Madrid.

Porta, J. Técnicas y experimentos en edafología. 1986. Colegio Oficial d'Enginyers Agrònoms de Catalunya. Barcelona.

Pilot area: Bodrogköz, Hungary and Slovakia

Lead Partner: UNIMIS
Endre Dobos

SIU

SSCRI

Description of the Pilot Area

Name of pilot area		Bodrogköz
Names of participating partners	**Lead partner**	**Unimis**
	Partner A	SIU
	Partner B	SSCRI
	Partner C	
Location and description	Member State(s)	Hungary-Slovakia
	Coordinates	EOV (Hungarian Projection) LLX:821490 LLY:309824 URX:883127 URY:358436
	Area of pilot area (km^2)	1457
	Climate	Temperate
	Mean temperature (FAO 2006*)	
	Average Annual Precipitation (FAO 2006	550-600 mm
	Outline description of topography	Alluvial plain
	Elevation (m)	100-120m
	Vegetation (FAO 2006)	Mainly agriculture, with some forest spots and wet pastures
	Major Land Use (FAO 2006)*	Farmland
	Major soils (WRB 2006 RGs**)	Vertisols, Arenosols, Gleysols, Luvisols, Fluvisols,

Transnational Pilot Area on uniform physiographic units with natural borders of three rivers. Most soils developed on alluvial deposits of different content of clay loam and sand.

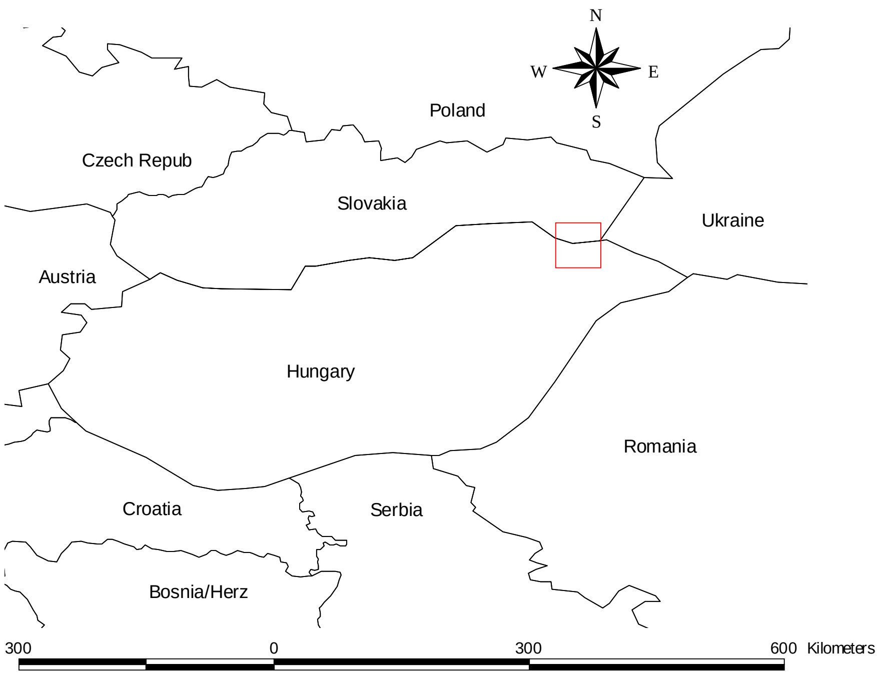


Figure 1. Location of the test area

Threat and related indicator(s) evaluated in pilot area

Threat	Decline in Organic Matter
Indicator 1	OM01 Topsoil organic carbon content (%)
Indicator 2	OM02 Topsoil organic carbon stock (t/ha)

Rationale for selection of pilot area (max 300 words)

The area represents a physiographicaly homogenous landscape, typical for the Pannonian plain. It has 22 official monitoring points, and have a relatively rich soil database behind. Due to its natural setting (lowland plain with high groundwater impact on the soil formation), the pilot area has a wide range of OM rich soils. These soils have been cultivated for over a thousand years, with a strong intensification from the 19th century. Flood protection and drainage systems have been constructed since the second half of the 19th century, which has changed the environmental system dramatically. All these factors had significant impacts on the soil OM content.

Indicator Evaluation

Indicators

OM01 Topsoil organic carbon content
OM02 Topsoil organic carbon stock

Pilot description

Spatial extent

The pilot area covers the Bodrogköz physiographic unit, located between the triangle of the Tisza, Bodrog and Latorica rivers along the Eastern section of the Hungarian-Slovakian border. Coordinates are given above. Figures 1 – 5 provide graphical descriptions of the pilot area.

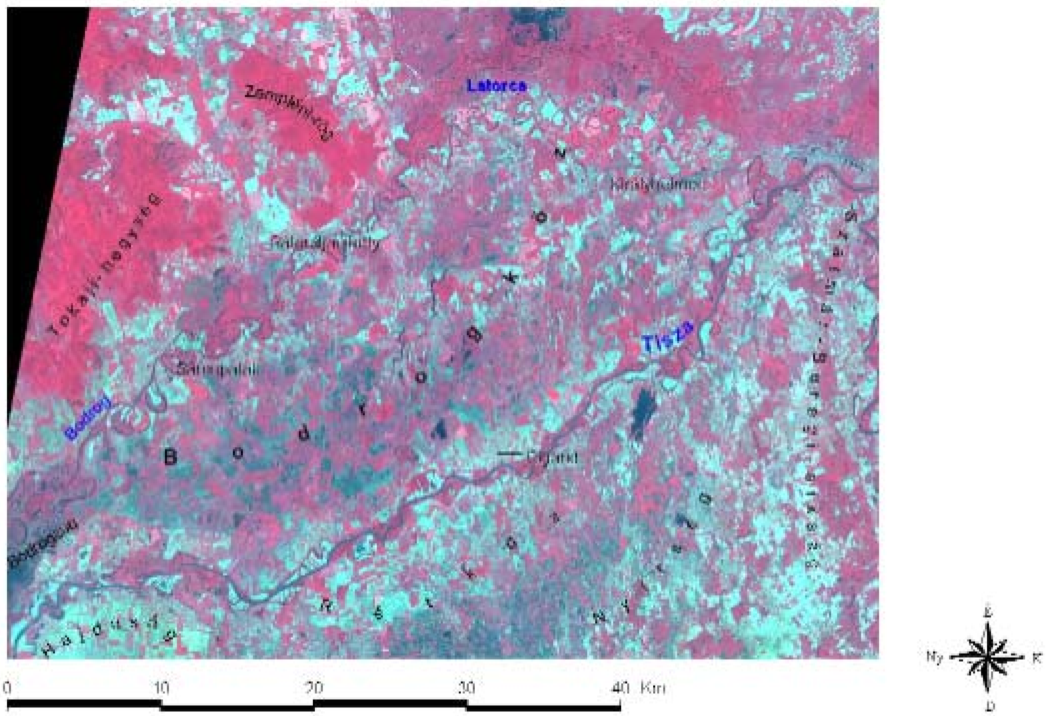


Figure 2. The pilot area on a SPOT image from Sept, 2006

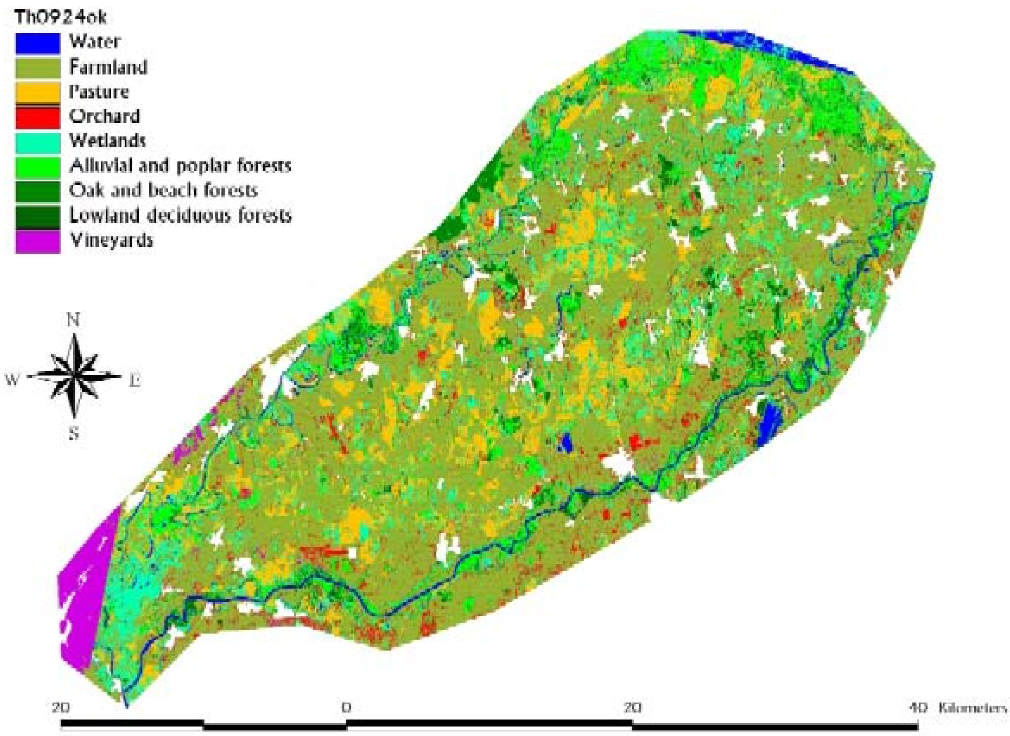


Figure 3. The landuse of the pilot area

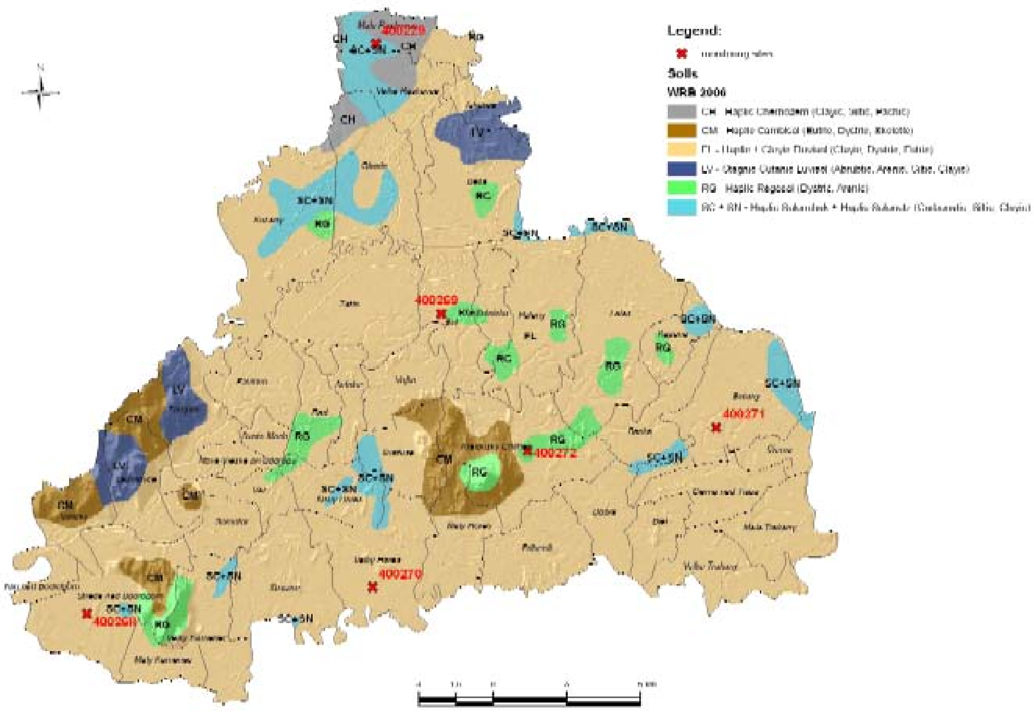


Figure 4. Monitoring sites of the Slovakian side

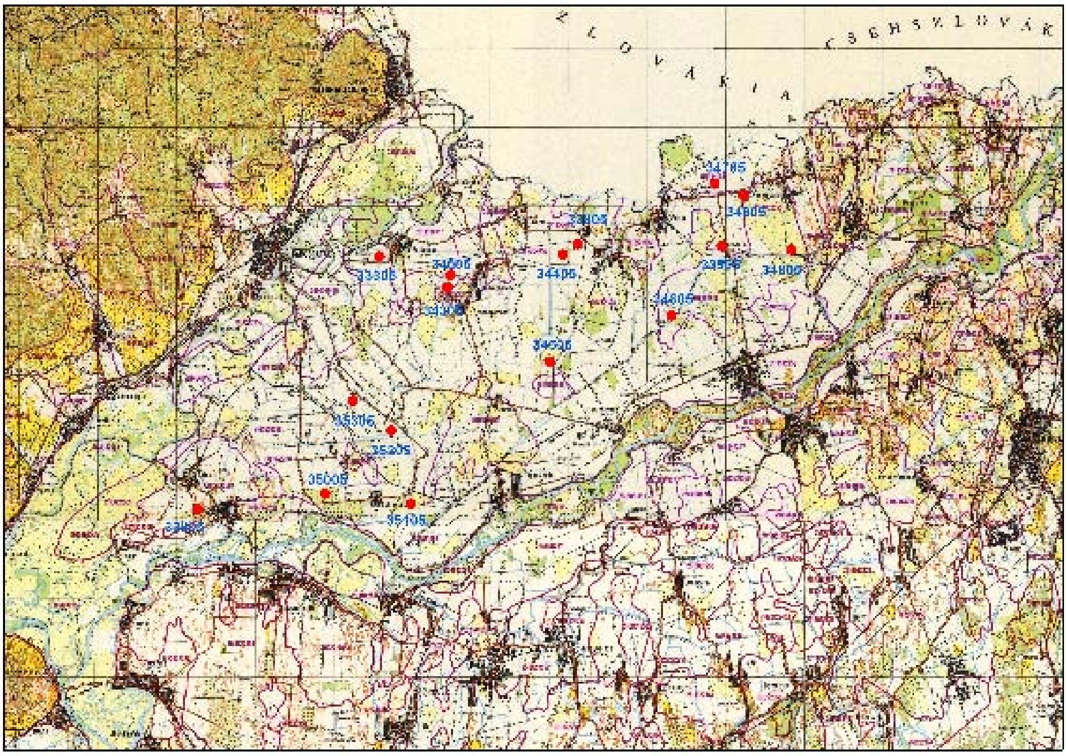


Figure 5. Monitoring sites of the Hungarian side

Data

OM01 Topsoil organic carbon content (%)

Detailed description of data:

Two set of data are available:
a.. Historical data from national (Hungarian and Slovak) monitoring systems.
b.. New measured data based on joint sampling and determination of OM in the same laboratory.

Sampling:
Sampling design of the national monitoring systems:
Hungarian: 0-30, 30-60 cm, 9 composite sample in 30m diameter circle
Slovak: 0-10, 10-20, 20-30 cm depth composite samples

Sampling design of the new OM measurements were strictly following the ENVASSO procedures and protocols (0-30 cm, 6 replicates per

Testing:
Hungarian: Modified Turin Slovak:
Slovak: Dry combustion
Joint: new m measured:

Parameter (= indicator) : SOC (soils organic carbon measured, %, dry combustion)

OM02 Topsoil organic carbon stock (t/ha)
OM02 SOCstock of 0-30 cm soil depth (t ha-1)
Parameters : SOC (soils organic carbon measured, %, dry combustion)
Db (bulk density, in t m-3)

Calculation of indicator: SOCstock = Db * SOCcontent * 0.1 * soil depth in m

Baseline definition
Baselines are defined as the present status of soil organic matter

Threshold definition:
In Hungary 1 % OM is considered as threshold for agricultural soils, accept sandy soils, where the thresholds is 0,5 %.

Pilot method

Historical and new measurements were compared on selected sites.
(The results are reported in separate "specific" report).
Statistical analyses of OM01 and clay content as analysed.
Interpolation of OM data is based on soil types and digital soil mapping tools (in progress).
Soil Types were harmonized in the pilot area (joint filed observation)

Pilot results

The performance of sampling for OM and Db is routine, easy task. Measurement of OM % is based on modified Turin method in Hungary. Comparison of the used and suggested method resulted in different values. Dry combustion gives higher values. (see separate report).

The OM01 and OM02 results of the pilot area are given in table 1.
The relation ship between textures an OM01 is shown in Figure 6.

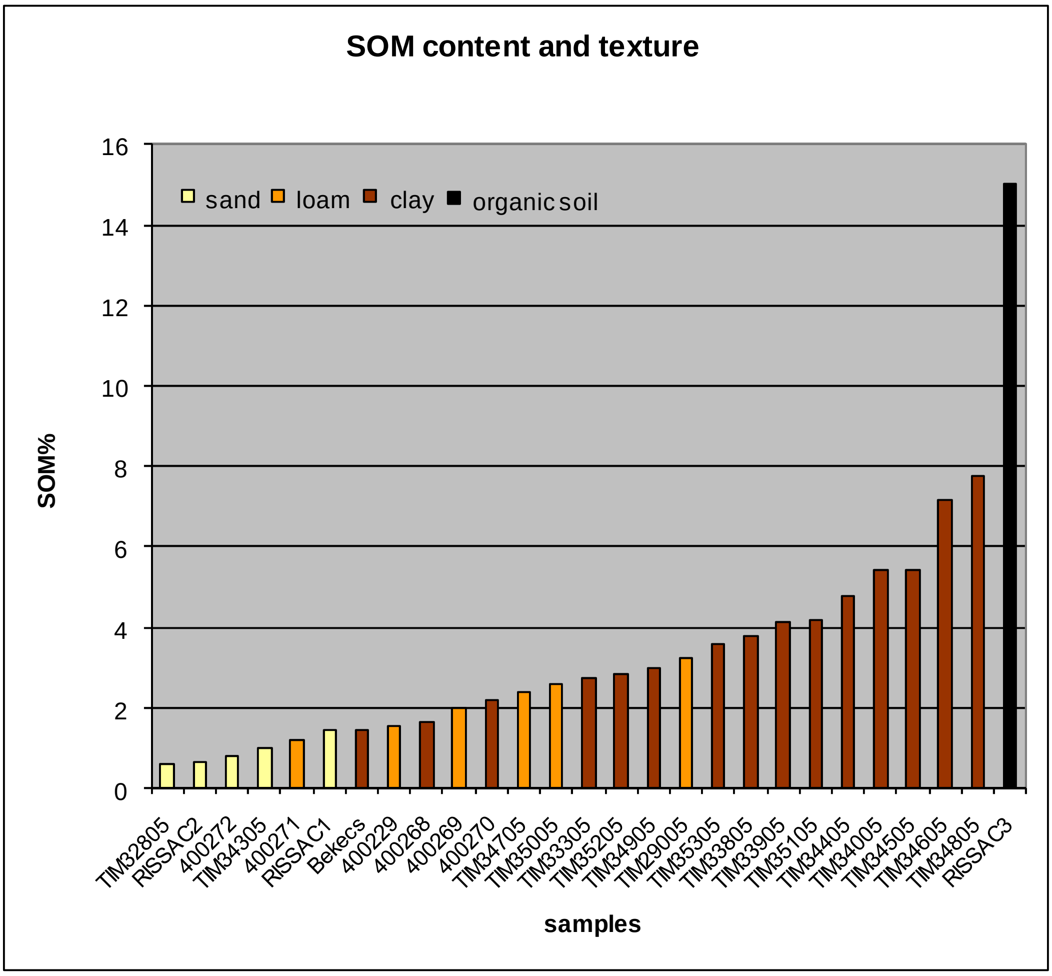


Figure 6. Relationship between textures an OM01

Figure 6. shows that higher clay content is associated with higher OM values.

Evaluation of pilot results

Pilot results included harmonization of soil types as well, based on the World Reference for Soil Resources. That result is supporting the digital soil mapping applications.

The methods suggested by the ENVASSO procedures and protocols are feasibility and easy to apply. Determination of the indicators is also simply.

The interpretation of indicator values in case of OM02 however might cause false conclusion.

In case of soils with deep and high OM content, the loss of OM rich soil may not be detected as change in stock if only the top 30 cm is monitored (Figure 2.)

Conclusions and recommendations

Recommendation: change the depth of monitored layer of OM02 depending on depth OM rich top soil.

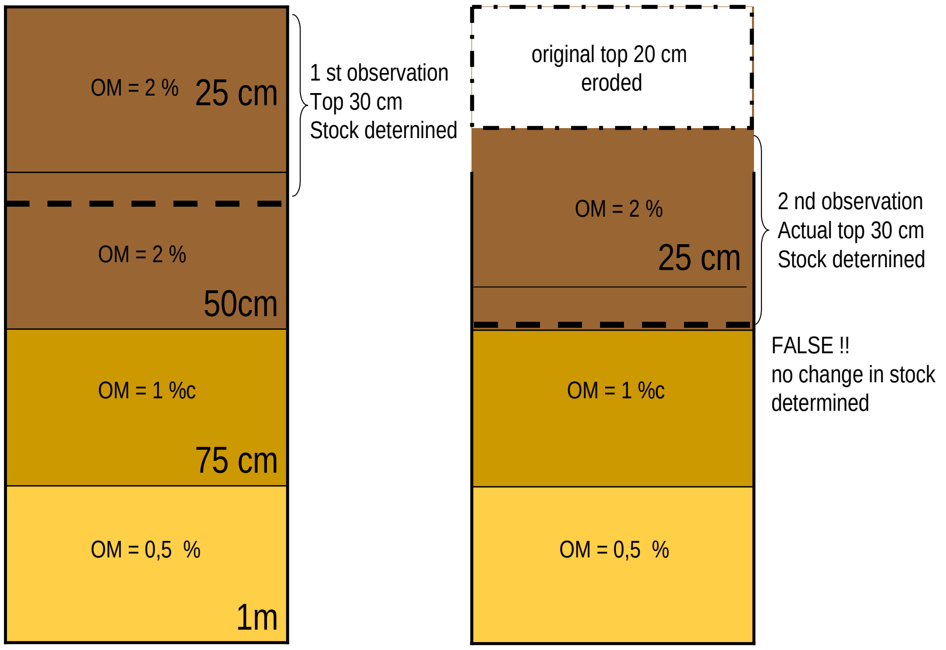


Figure 7. Recommendations for changes in sampling depths for monitoring OM02

Pilot area: Ruhr area, Germany

Lead Partner: LANUV NRW
Heinz Neite,
Jörg Leisner-Saaber,

IFUA Projekt GmbH,
Gerald Krüger

BGR
Rainer Baritz, Einar Eberhardt

Soil contamination by heavy metals in the Ruhr area

Description of the Pilot Area

Name of pilot area		**Ruhr area (Germany)**
Cooperation	**Lead partner**	**Heinz Neite, Jörg Leisner-Saaber, North Rhine-Westphalian State Agency for Nature, Environment and Consumer Protection (LANUV NRW)**
	Partner A	Gerald Krüger, IFUA Projekt GmbH
	Partner B	Federal Institute for Natural Resources and Geosciences (BGR) (ENVASSO WP3)
Pilot area	Country / Region	Germany / North Rhine-Westphalia
	Coordinates	bottom left: 2543550 / 5688950 top right: 2593750 / 5723800
	Area of pilot area (km^2)	1052 km²
	Climate	Atlantic
	Mean temperature (FAO 2006)	annual mean temp.: 9.6°C
	Average Annual Precipitation (FAO 2006)	annual average: 931 mm
	topography	plain
	Elevation (m)	appr. 30-200 m
	Vegetation (FAO 2006)	Densely populated urban area with a mosaic of mixed broad-leaved forests, non-irrigated agricultural land and grassland
	Major Land Use (FAO 2006)	Settlement, industry (28%); Farming (17%): Forestry (9%)
	Major soils (WRB 2006 RSGs)	Technosols, Cambisols, Luvisols, Anthrosols

Threat and related indicator(s) evaluated in pilot area

Threat	**soil contamination**
Indicator 1	CO01: heavy metal contents in soils: Cd, Hg, Pb
Indicator 2	
Indicator 3	

Rationale for selection of pilot area

The pilot area is located in the Ruhr area. The area represents a concentration of large cities with a history of coal, iron and steel mining. It is one of the most densely populated industrial centres in Europe thus exposed to high pollutant loads. A considerable amount of pollutants thus has to be attributed to emissions. Although emissions of heavy metals have decreased during the last decades, a constant threat to soils has to be assumed due to the persistence of heavy metals.

A good data basis regarding heavy metals in the top soils exists for the pilot area. The data have been collected from various data sources for more than 20 years. Examples are engineering projects, scientific investigations, monitoring projects or regional development plans.

Indicator Evaluation

Threshold exceedance of heavy metals represents an essential indicator for soil contamination. It can be seen as a long-term indicator, because heavy metal concentrations in soils usually do not show short-term changes. Compared to other parameters of soil pollution – e.g. various organic pollutants – many data exist regarding heavy metal concentrations. High concentrations are known for its impact on human health ("*direct path*"), plant growth and plant quality (referring to the aspects food or fodder, impact path "*soil-plant*"), grazing animals as well as surface and ground water (impact path "*soil-groundwater*"). The spatially explicit estimation of soil concentration is important for various reasons:

- planning purposes (land use, construction),
- precautionary soil protection (acc. to German Soil Protection Ordinance, BBodSchV[1])
- identification of priorities in the scope of hazard prevention
- management of re-located soil material .

Indicator

CO01 heavy metal contents in soil

In the pilot area extensive heavy metal concentrations in the top soils, caused by immissions and other diffusive sources (diffusive contamination), must be observed. For this indicator test, soils of outskirts and urban districts are investigated. The applied methodology is based on the Guideline for the creation of digital soil quality maps in urban areas (LANUV 2007). A regional hazard assessment for top soil pollutant concentrations is carried out on the basis of geo-statistically processed point measurements. The principle of this method includes input data harmonization in order to quantify spatial relationships. The method is based on variogram analyses followed by kriging as the spatial interpolation algorithm.

The indicator assessment requires that the rate of area is determined which shows estimates falling below or exceeding certain reference values. On the one hand, reference values refer to a baseline which characterizes a normal contamination quality ("precautionary values" according to BBodSchV) ; on the other hand , they can also refer to a threshold values which characterizes increased contamination "most sensitive trigger and action values" according to BBodSchV).

Pilot description

Spatial extent

The pilot area covers 1,052 km², and represents a main part of the so called Ruhrgebiet, the biggest metropolis region of Germany, thus having been intensively influenced by the coal, iron and steel industry. It is located in the centre of North Rhine-Westphalia (NRW) (Figure 1). The pilot area covers the cities of Bochum, Bottrop, Duisburg, Essen, Gelsenkirchen, Gladbeck, Herne, Mülheim and Oberhausen (Figure 2). The river Ruhr dominates the landscape in the South, whereas the river Rhine cuts through the western part. The pilot area mainly includes urban areas of anthropogenic use and outer districts dominated by agriculture and forestry.

[1] BBodSchV (= Federal Soil Protection and Contaminated Sites Ordinance)
http://igsvtu.lanuv.nrw.de/vtu/oberfl/de/dokus/5/dokus/50102.pdf

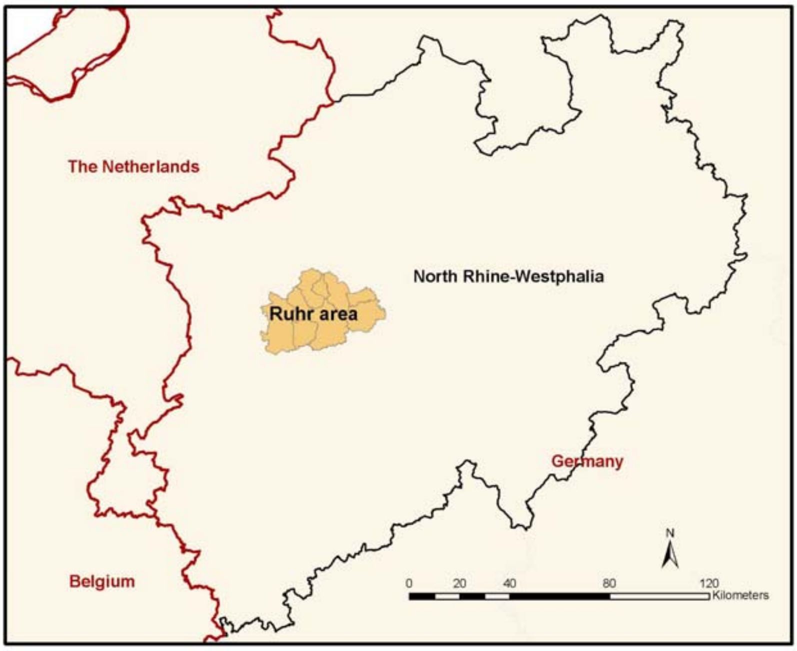


Figure 1. Pilot area (overview)

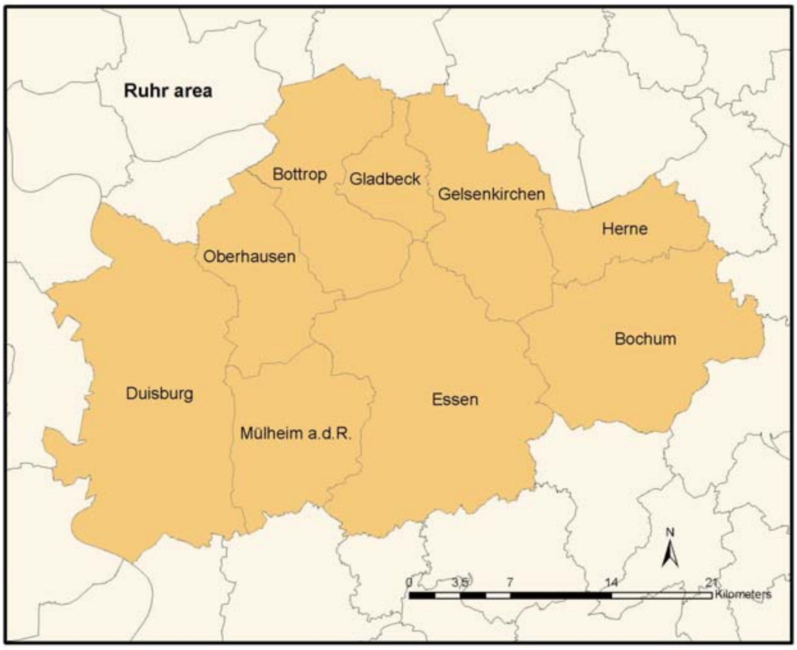


Figure 2. Pilot area (detail)

The population density of the pilot area is high; only in the outskirts agricultural and forest use becomes more important.

Data

For this project explicit soil sampling was not carried out. However, there is a high amount of already existing data. The soil data used for this indicator test in ENVASSO were derived from three different sources of different data quality (particularly with regard to the availability of descriptions of the sampling site and sampling strategies):

I. data of soil quality maps (=*Digitale Bodenbelastungskarten*[2]) for urban areas
II. data of the soil quality map for outer districts

2 See: http://www.lanuv.nrw.de/boden/boschu-lua/dig-bbk.htm

III. data of the FIS StoBo (FachInformationsSystem Stoffliche Bodenbelastung) (=Information system on soil contamination of North Rhine-Westphalia3)

In the scope of creating municipal soil quality maps the data mentioned in item 1. and 2. were previously and specifically recorded for some parts of the project area. These data can be indicated as being of good quality concerning site identification and representativeness of sampling. The sampling and analyses were carried out according to a manual: *Leitfaden zur Erstellung Digitaler Bodenbelastungskarten im Siedlungsbereich* (LANUV 2007) (= *Guideline for the creation of digital* soil quality maps in urban areas) and the *Leitfaden zur Erstellung digitaler Bodenbelastungskarten Außenbereich* (LUA 2000) (= *Guideline for the creation of digital* soil quality maps in outer districts*)*. The FIS StoBo NRW data, mentioned in item 3, can be characterized as more heterogeneous regarding its quality. Because FIS StoBo contains data from a large amount of projects and sources, some specific selection criteria had to be defined as minimum requirements for applying the data in this pilot project:

- samples of natural and anthropogenic soils
- sites with a specific land use:
- outer districts: arable land, grassland and forest
- urban districts: horticultural land, private garden, green area, parks and other recreation areas, brownfields, residential development zone etc.
- samples of top soils; sampling depth was often land use-specific,
- availability of information about concentrations of technogene substrates is not necessarily required
- information about flooding is also not absolutely necessary
- the position accuracy for the plot coordinates varies; at least, Gauss-Krueger coordinates in a 6-digit form are required, which corresponds to an accuracy of ca. 10 m.
- availability of analyses for total concentrations.

Besides soil data of the pilot area itself, sites in the direct vicinity of the municipals are also taken into account in order to improve the interpolations along the boundaries of the pilot area. Altogether, information from more than 5,000 sites was included in the evaluations. In addition to the plot data, other GIS-data about land use, flooding area and contaminated sites are needed (see chapter 4 C).

Pilot method

In the following flow chart (Figure 3), the steps of the methodology for creating the soil quality map Ruhr area are presented. It follows the method for creating digital soil quality maps in urban districts (LANUV 2007) with regard to immission effects. The basic assumption is that soil quality caused by deposition can be interpolated and spreads as the deposition itself. Compared to the impact of immission the method acts on the assumption that other influences, like geological background, land use, etc. are of insignificant importance for the region in respect to diffuse contamination of soils.

The approach naturally refers to top soils, because particularly in this soil layer deposition could have its main influence. The assumption that the influence of other pollution factors is minimized is essential for recording soil quality of that kind (e.g. by specific selection of sampling sites). The deposition-dependent soil quality can only be quantitatively assessed at sampling sites which were exposed to immissions for a long time - without any disturbance.

3 see: http://www.lanuv.nrw.de/boden/boschu-lua/fisstobo.html

STEP 1. Investigation and preparation of spatial data (land use, influence of flooding, contaminated sites)
↓
STEP 2. Development of a concept map
↓
STEP 3. Preparation and rectification of soil data
↓
STEP 4. Statistical analysis of valid soil data (descriptive statistics, outliers)
↓
STEP 5. Geostatistical analysis of valid soil data (variogram analysis)
↓
STEP 6. Interpolation (block-kriging)
↓
STEP 7. Interpretation of estimated concentrations supported by GIS

Figure 3. Steps of the methodology for creating the soil quality map Ruhr area

STEP 1 Preparation of spatial data

The interpretation of the soil quality map refers to diffuse pollution. Contamination caused by specific impacts therefore should not be taken into account because it starts to refer to local contamination. Areas influenced by these specific zoned pollutions hence should be excluded from further steps of the analyses. Considering the pilot area, these namely are areas influenced by flooding or contaminated sites. Further on the data have to be processed with regard to the accounted types of land use.

Land use is crucial for the method: a cartographical overview of land use types is presented in figure 4 (data source: RVR = Ruhr Regional Association[4]).

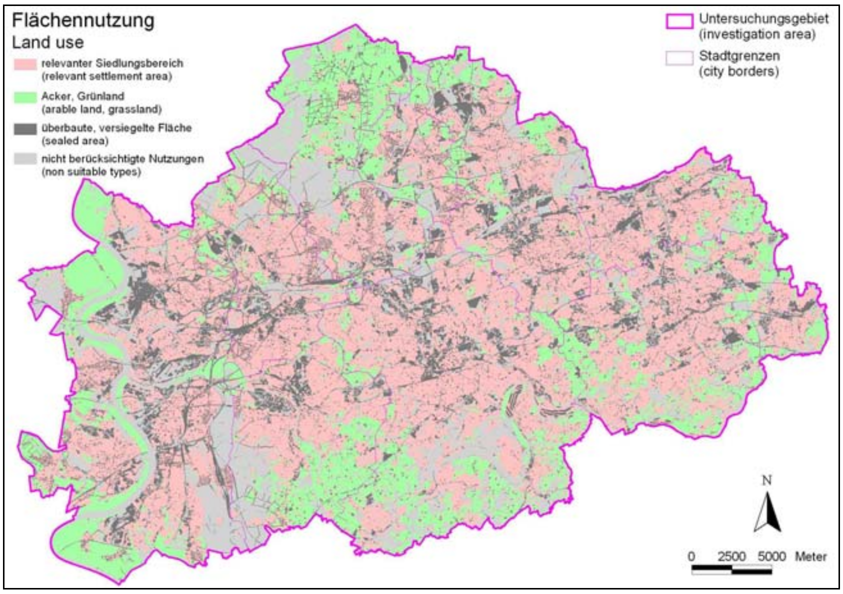


Figure 4. Types of land use of the ENVASSO pilot area “Ruhr area”
(data source: RVR = Ruhr Regional Association, Essen) Land use survey 2004-2005

According to the RVR-data, the pilot area shows 148 different types of land use. These types were re-classified into four main groups after prior testing the proper aggregation.

[4] see: http://www.rvr-online.de

Later interpretation of the soil quality map "Ruhr area" refers to the following land use groups:

- *relevant settlement area,* namely residential development zones
- open areas within residential areas,
- mixed housing areas and green areas, covering 40.3 % of the total pilot area, and
- arable land / grassland (19.1 %).

The groups *sealed area* (e.g. roads, buildings, industry), covering 17.7 %, as well as the *non suitable types* of land use *(*22.9 %) are not interpreted with regard to the soil quality map. The latter group includes land use types as e.g. forest (excluded because of its filtering function), accessory green areas, storage spaces, water areas. The pilot area is influenced by two streams, namely the river *Rhine* in the West, passing through the pilot area from the South to the North, and the river *Ruhr*, which mainly influences the southern landscape. The Ruhr flows from the East to the West, and merges into the *Rhine* in the city of Duisburg. Additionally, other smaller rivers characterize parts of the pilot area (e.g. *Emscher, Angerbach*). In the scope of the soil quality map "Ruhr area", the flooding areas are excluded, because features of local contamination. prevail. These areas are presented in Figure 5 (data source: Digital map of land with high flooding risk; LUA 2003). The map contains recently flooded and recorded areas as well as historical flooding land, including a 100 m buffer zone.

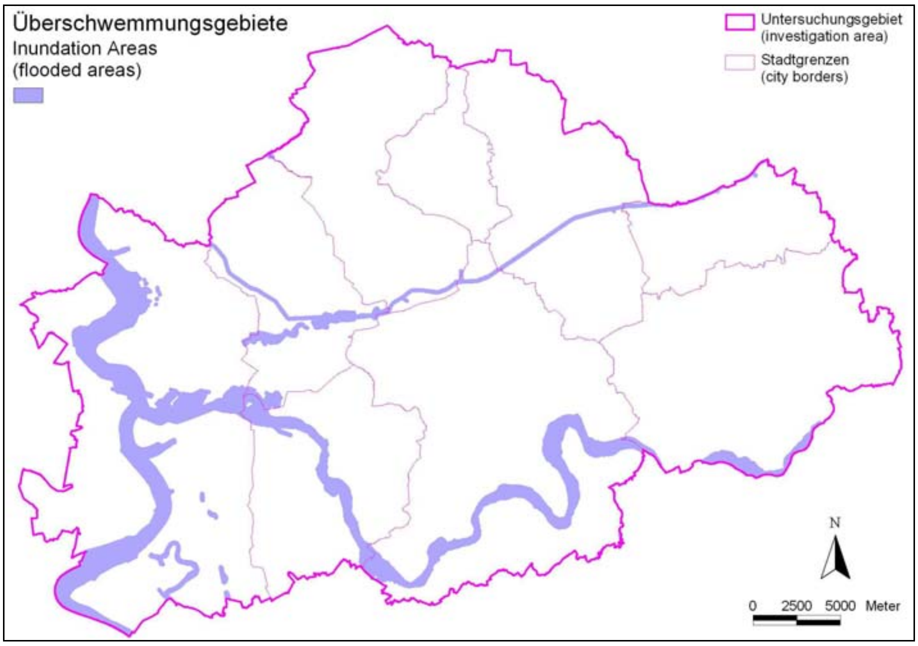


Figure 5. Areas at risk of flooding
(data source: LANUV NRW; Digital map of the area with high flooding risk)

Contaminated sites ("*Altlasten*") are clear cut areas showing contaminations derived by specific human activities as well. In the scope of creating the soil quality map for diffuse contamination, these sites thus also have to be excluded from the evaluations. Figure 6 shows the contaminated area taken from the local authorities inside the pilot area.

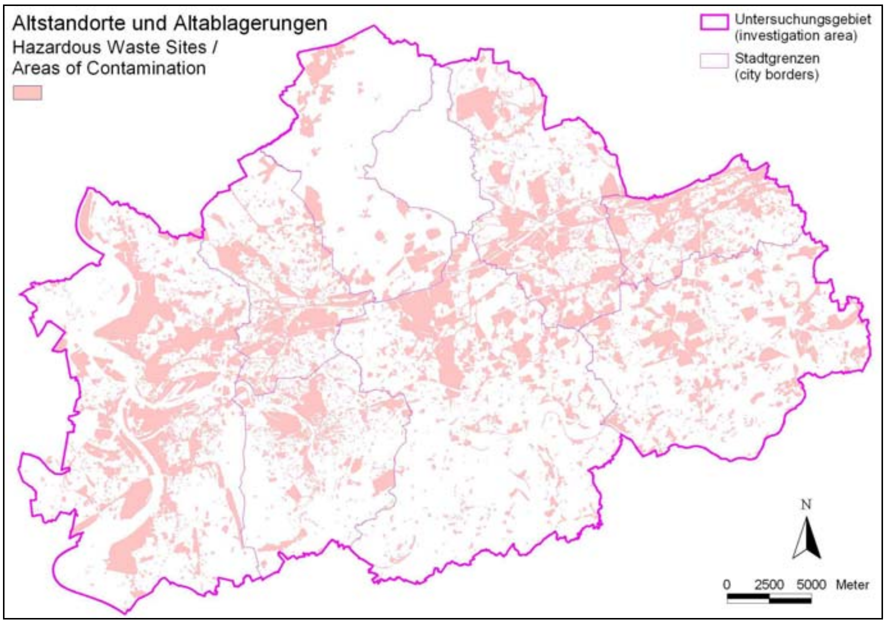
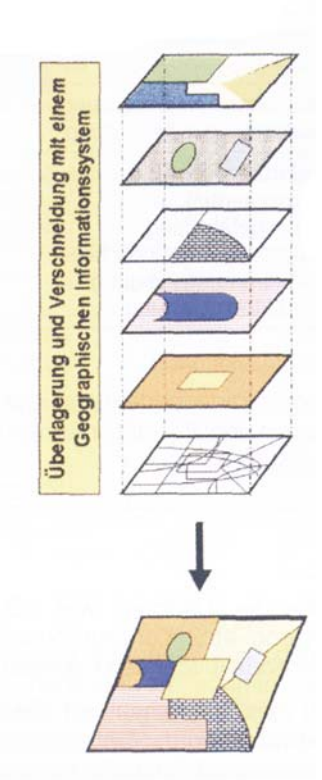


Figure 6. Contaminated sites
(data source: local authorities inside the pilot area)

STEP 2 Development of a concept map

The spatial information regarding land use, influence of flooding and contaminated sites are overlaid in the scope of a concept map. (compare Figure 7).



Basic maps
Pilot area
Land use (currently)
Flooding areas (currently, former)
Contaminated sites
If available: deposited materials, re-deposition of technic / natural substrates
Other (topography)
Concept map

Figure 7. Presentation of concept map
(according to SCHNEIDER et al. 2000, modified)

With respect to the pilot area the overlaid and merged units are considered to be more or less homogeneous with regard to the contamination regime. In the scope of method "soil quality maps – contamination", area falling inside of a specific unit can be interpreted together. In contrast to former municipal projects or evaluations conducted for the whole federal state of NRW, no scaling factors were applied here to homogenise the measured values. This approach depends on the presumption that data from plot level mainly impacted by depositions can be interpolated. Therefore, the pre-selection procedure is fundamental for the concept. An overview about the included spatial units is presented in Figure 8. When taking a larger scale view on this map, further sub- of land use can be identified.

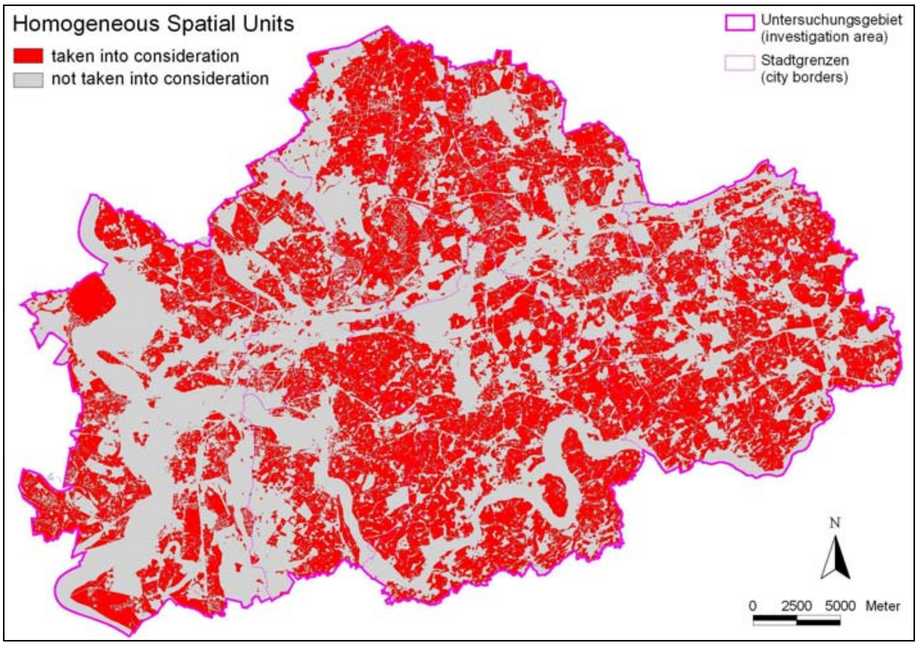


Figure 8. Homogeneous spatial units in the soil quality map "Ruhr area"

STEP 3 Pre-processing of soil data

A basic description of the existing soil data was given in chapter 4 B.

The relatively heterogeneous data bases were transferred into a single data base. As far as possible, missing information was completed by overlaying the spatial GIS data described in chapter 4 C. The lower the quality of the input data, the more intensive was the adjustment of the data set referring to the minimum quality requirements.

Based on the concept map, the adjustment of the data was carried out considering the following criteria:

- deleting sites in areas exposed to flooding
- deleting sites with inappropriate or undefined land use (forest5, land use currently not definable)
- deleting contaminated sites

Based on defined criteria for data quality the soil data were reviewed with respect to:

- exclusive consideration of sites with appropriate depths (0 to 10 max. 30 cm)[6]
- deleting sites with not precise coordinates

5 usually specific, hardly comparable situation regarding pollution as a result of combing-out effects and soil acidification

6 in some cases these areas were included, if it was check by investigations etc. that they are not polluted, although a certain potential was assumed

The location of the valid sites, including those in adjacent areas, can be seen in Figure 9.

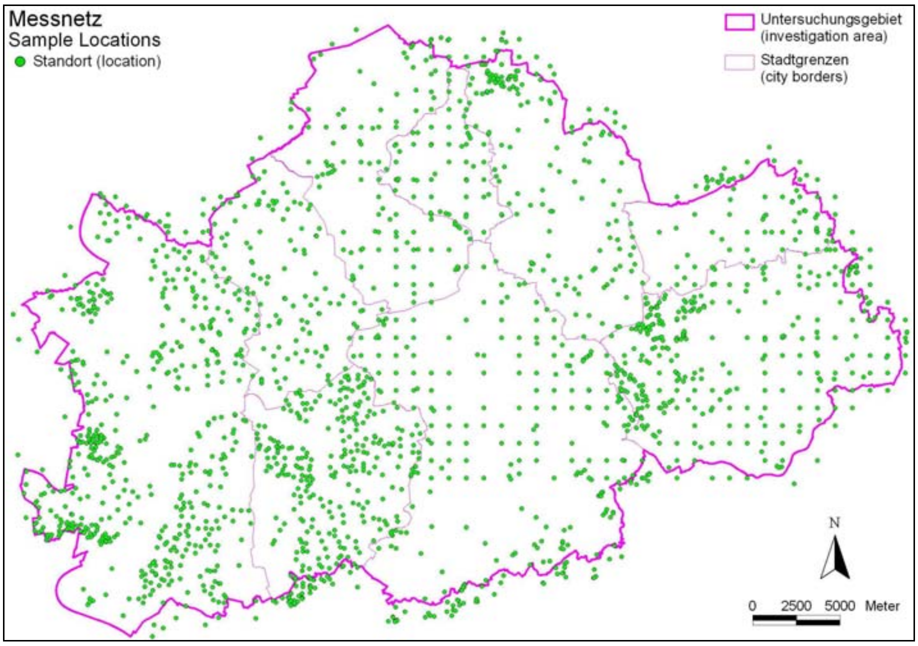


Figure 9. Selected sampling sites regarding soil quality map "Ruhr area"

The existing data are mainly characterized by reference depths of 0-10 cm or 0-30 cm. In the scope of this project 0-30 cm was chosen to be the reference depth.

For many land use types inside the urban districts, no major differences are found between the different top soil depth classes with regard to contamination However, for the outer districts, soil depth is important. In that case, the concentrations of grassland samples at a reference depth of 0-10 cm are mostly higher than those of arable land, where ploughing leads to thorough mixing of soil material and, thus to a more or less extreme dilution. To enable a comparison between values of grassland and arable land, the concentrations had to be referenced first using a so-called scaling factor. The applied parameter-specific scaling factors can be calculated from the quotient of the corresponding medians of the concentrations regarding arable land and grassland (compare methodology soil quality map outer district, LUA 2000).

STEP 4 Statistical analysis of soil data

The statistical populations are interpreted particularly with regard to their distribution and possible outliers. Referring to the question of their distribution it is of main interest, if the population mainly corresponds to a normal distribution or a log-normal distribution. The question of outliers is of importance, because single (incorrect) values can significantly influence the variograms as well as the subsequent interpolation.

For the identification of outliers the Median-5-Interquartil-Test [Median +/- 5 * (75. - 25. percentile)] is used (compare LANUV 2007), because it does not assume a specific distribution of data. For statistical evaluations the software UNISTAT is used. An overview of the data series, corrected with regard to outliers, is given in the following

Table 1. Parameters of valid soil data for soil quality map Ruhr area without statistical outliers [mg/kg]

Parameters	TOC	pH	Cd	Hg	Pb
Number	768	1029	1685	1447	2008
Mean	4.40	6.13	1.00	0.17	91.01
Median	3.30	6.13	0.89	0.13	72.00
Standard deviation	4.84	0.75	0.55	0.12	59.96
Minimum	0.85	4.00	0.01	0.01	4.00
Maximum	46.23	8.30	3.64	0.72	383.36
Lower quartile	2.30	5.60	0.65	0.09	50.17
Upper quartile	4.62	6.70	1.20	0.21	112.00
Interquartile range	2.32	1.10	0.55	0.12	61.83

STEP 5 Geostatistics: variogram analysis

For the geostatistical description of the spatial relationship of point data, experimental variograms are generated with the existing measured values. The mean trend of the variance of these values in the pilot area is calculated in relation to the distance and is adapted to a theoretical, mathematical variogram function. Figure 10 presents the schematic depiction of a variogram.

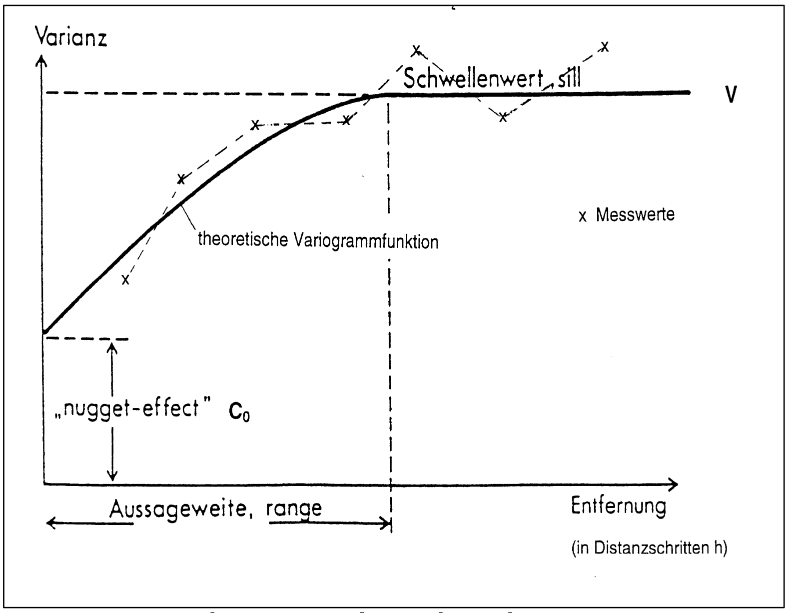


Figure 10. Schematic variogram
(from HEINRICH 1992, supplemented)

The results presented by variograms are described by the following parameters (according to RIES 1996, supplemented):

- Total variance (V), calculated by the arithmetic mean of all measured values.
- Nugget variance (C_0); consisting of sampling-, measuring- and analysis errors as well as non-solvable small-scale variance or local scale variability; also called nugget effect.
- Range (R): the distance at which the maximum of the variogram function is approximately reached (corresponds to Sill, see below); beyond this range there is no spatial relationship between the measured values, they are not correlated any more.
- Sill (S): the variance when reaching R; partial Sill: $Sp = S-C_0$
- Distance (or step) (h) for which a variogram value is calculated.

Figure 12. Distributions and variogram for mercury

Cd

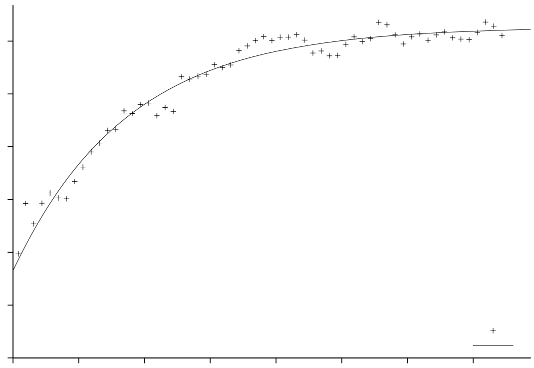
Klasse	Mittelpunkt	Häufigkeit
1	0,00	50
2	0,40	248
3	0,80	702
4	1,20	373
5	1,60	168
6	2,00	69
7	2,40	39
8	2,80	23
9	3,20	8
10	3,60	5
		1685

0.0000 702.0000

Cd-ln

Klasse	Mittelpunkt	Häufigkeit
1	-3,00	2
2	-2,40	2
3	-1,80	6
4	-1,20	74
5	-0,60	465
6	0,00	768
7	0,60	278
8	1,20	56
9	1,80	5
10	2,40	5
		1661

0.0000



Hg

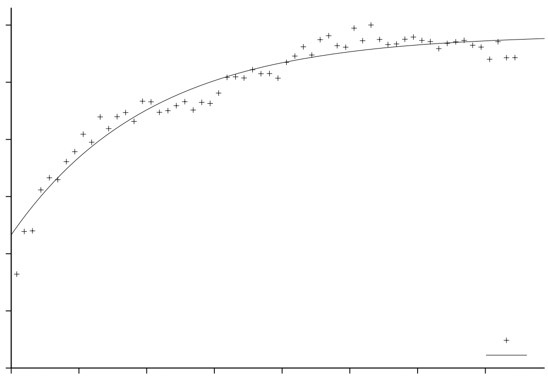
Klasse	Mittelpunkt	Häufigkeit
1	0,00	53
2	0,08	583
3	0,16	385
4	0,24	231
5	0,32	99
6	0,40	37
7	0,48	25
8	0,56	19
9	0,64	10
10	0,72	5
		1447

0.0000 58

Hg-ln

Klasse	Mittelpunkt	Häufigkeit
1	-5,00	0
2	-4,40	1
3	-3,80	51
4	-3,20	69
5	-2,60	415
6	-2,00	449
7	-1,40	346
8	-0,80	101
9	-0,20	31
10	0,40	11
		1474

0.0000 449



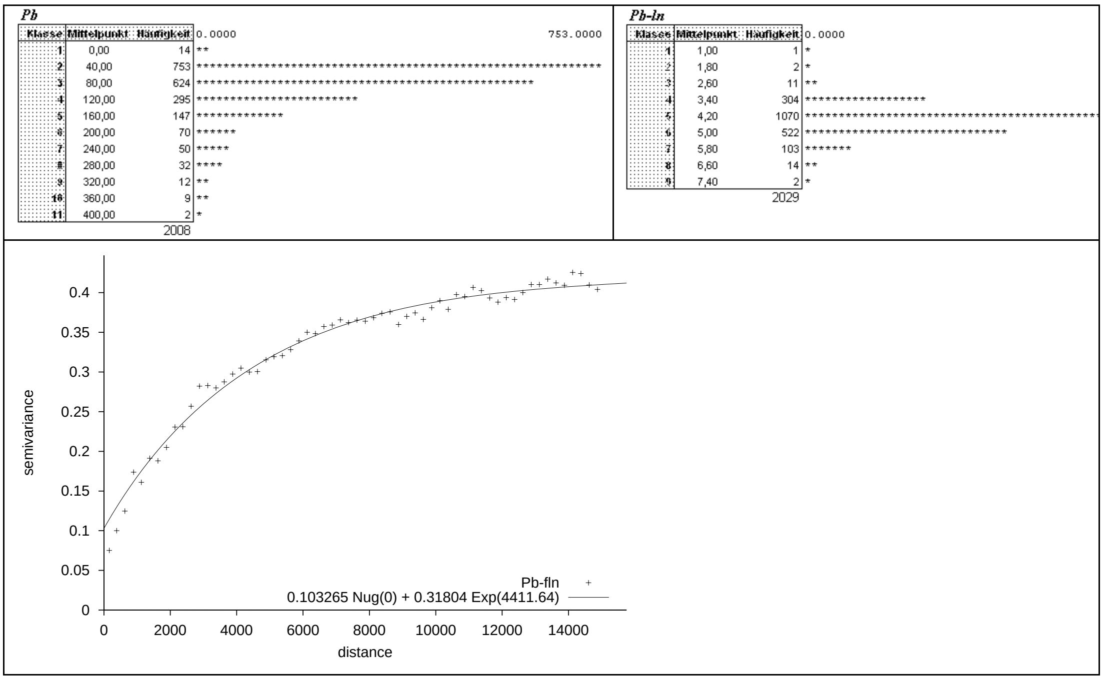


Figure 13. Distributions and variogram for lead

STEP 6 Interpolation

Kriging is used as the interpolation method which is best suited to cope with the framework conditions coming from the available data.

Kriging

Kriging is an interpolation method widely used in geostatistics. Taking into account the modelled theoretical variogram function, weights are optimized in a way that the variance of the estimated values is minimal and the estimated values are true to expectations, i.e. on average, the deviation between the real and estimated values is zero (HEINRICH 1992).

The following characteristics of kriging are important in the present context:

- On the basis of the variogram, the weights are assigned according to the spatial dependence, with adjacent points being assigned a higher weighting than more remote ones.
- If a further sampling point (MP2) is located between a given sampling point (MP1) and the point to be estimated (P), MP1 and P are shielded against each another; MP1 is assigned a lower weight for the estimation of P than it would be entitled due to its distance.
- An exact interpolation for each point of the random sample is carried out with a corresponding Krige variance of zero in case of a missing nugget effect. If the appertaining variograms are characterized by a high nugget variance, the estimated values also show deviations in the adjacent vicinity of the supporting values (STOYAN et al. 1997); the original and the interpolated value do not exactly correspond any more.
- If the nugget effect increases, nearby measured values lose importance, more remote ones thus gain more weight; with a pure nugget effect (i.e. there is no spatial relation between the measurements) all points have the same weight which corresponds to the arithmetic mean.
- High values are underestimated and low values are overestimated, i.e. the estimated surface is smoother than the real one (HEINRICH 1992).

It is possible to give an ubiquitous information about an estimation error with those areas being of greatest distance to a measuring point or those with the lowest sampling density showing the highest error level.

The more points are taken into account for an estimation, the smaller is the Krige variance; in ordinary kriging with a spherical variogram model and a regular sampling grid 25 measuring points within the range are sufficient for the estimation, because additional points can only reduce the Krige variance to a negligible extent (HEINRICH 1992); moreover a minimum number of points should be reached for an estimation.

To obtain estimations for grid cells due to the method, the so-called block-kriging is applied. Here the estimated block-mean is given for a 50 x 50 m grid cell. The order of magnitude of scale is about 1 : 100,000.

To obtain ubiquitous results, the minimum number of valid soil samples is uniformly set as 5, the range as 6,000 m. The interpolation is carried out, using the geostatistical software GSTAT.

Results of interpolation

The following figures present the estimated concentrations for cadmium, mercury and lead in the top soils of the total pilot area (reference depth 0-30 cm). For illustration reasons the kriging results are presented for the whole pilot area (and not just for the homogeneous spatial units for which the calculations are valid for; compare Figure 8).

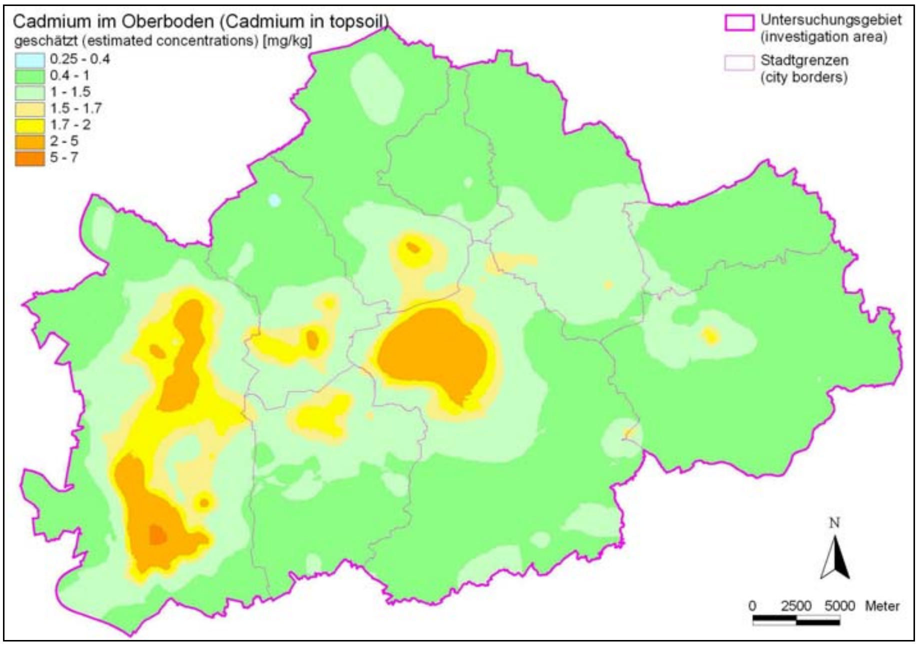


Figure 14. Soil quality map “Ruhr area”: estimated concentrations of cadmium [mg/kg]

The estimated concentrations for cadmium range from 0.3 to 6.9 mg/kg, with a mean value of 1.1 mg/kg.

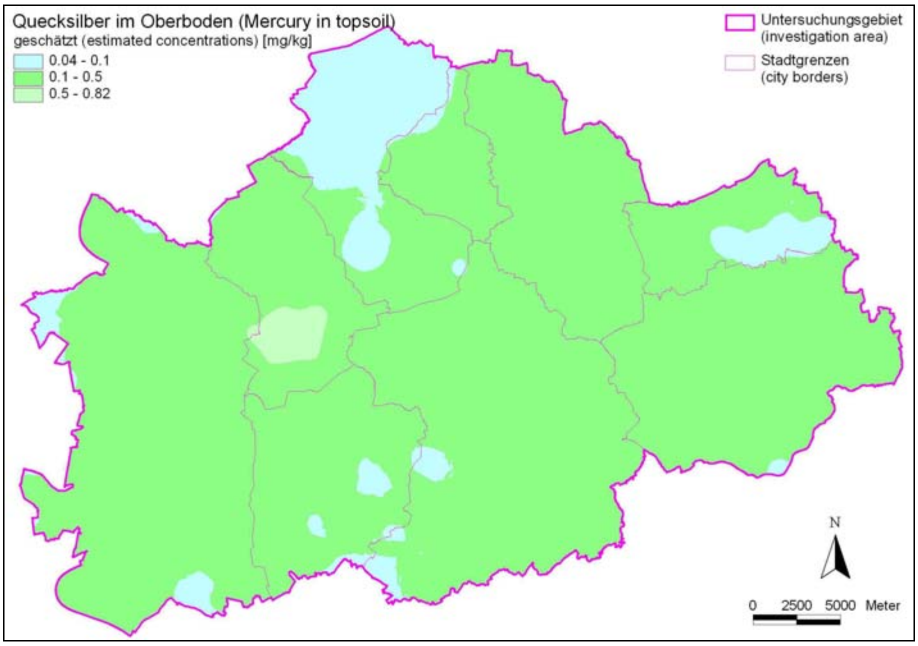


Figure 15. Soil quality map "Ruhr area": estimated concentrations of mercury [mg/kg]

The estimated concentrations of mercury range from 0.04 to 0.82 mg/kg, with a mean value for the entire area of 0.18 mg/kg.

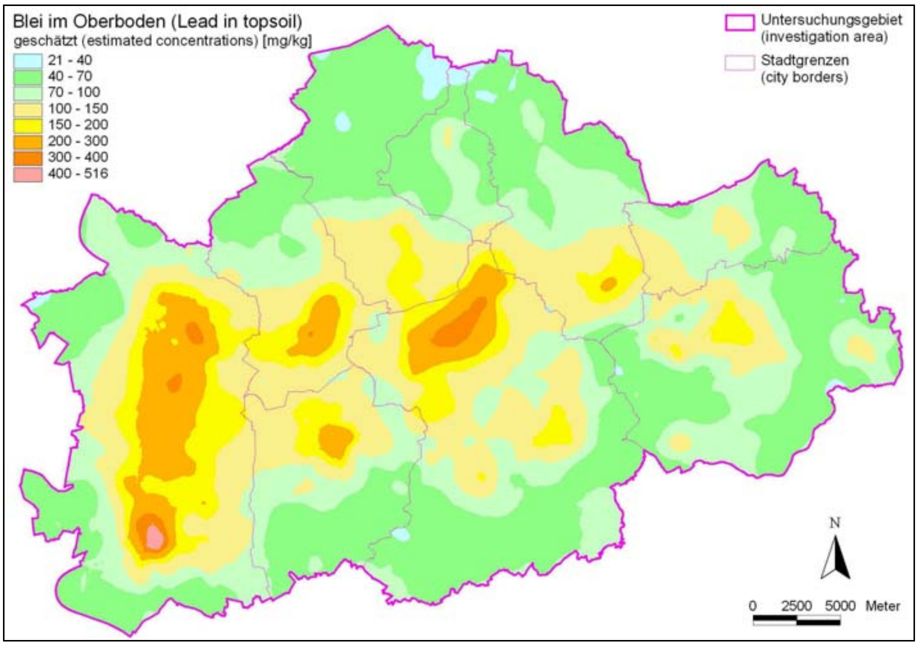


Figure 16. Soil quality map "Ruhr area": estimated concentrations of lead [mg/kg]

Showing a mean value of 102 mg/kg, the estimated concentrations of lead range between 21 and 516 mg/kg.

STEP 7 Interpretation: Calculation of indicators

In order to interpret the current soil condition for the threat diffuse contamination, heavy metal concentrations in top soils are compared against baselines and thresholds. The indicator refers to that part of the pilot area, for which calculated values are estimated, which for which the values fall below a specific baseline, or exceed a threshold. It could be quite evident to use existing regional background values for soil concentrations as a baseline. However, in the very densely populated urban-industrial pilot area, such background values change at a very small scale. As thresholds, values related to environmental threats should be applied. With regard to the interpretation of predicted values, it therefore seems feasible to use the different assessment values of the national BBodSchV (German Federal Soil Protection and Contaminated Site Ordinance) as baseline values, and threshold values according to Table 2). The following definitions are presented by the BBodSchV

Precautionary values: soil texture-specific assessment values; if these are exceeded, it usually must be assumed that a concern about a hazardous soil modification exists. In this study the medium precautionary value for the soil texture ("loam / silt") was taken into account, because most of the soils within the pilot area could be allocated to this group of soil texture.

Trigger and action values: hazard-related assessment values. If a trigger value is exceeded, an individual investigation has to be carried out to check, if a hazardous soil modification exists. If an action value is exceeded, it has to be assumed that a hazardous soil modification exists. The trigger and action values are related to different types of land use. For an overall comparison the corresponding most sensitive trigger or action value is taken into account.

Table 2. Assessment values for a comparison in the scope of soil quality map Ruhr area

	Description	Cd	Hg	Pb
Baseline	Precautionary value soil texture loam / silt	1.0	0.5	70
Threshold	Trigger or action value	2.0*	2.0**	200***

* integrated trigger value in house gardens and garden plots which are used as playing fields for children as well as for cultivating agricultural plants
** action value for grassland
*** trigger value for playing fields

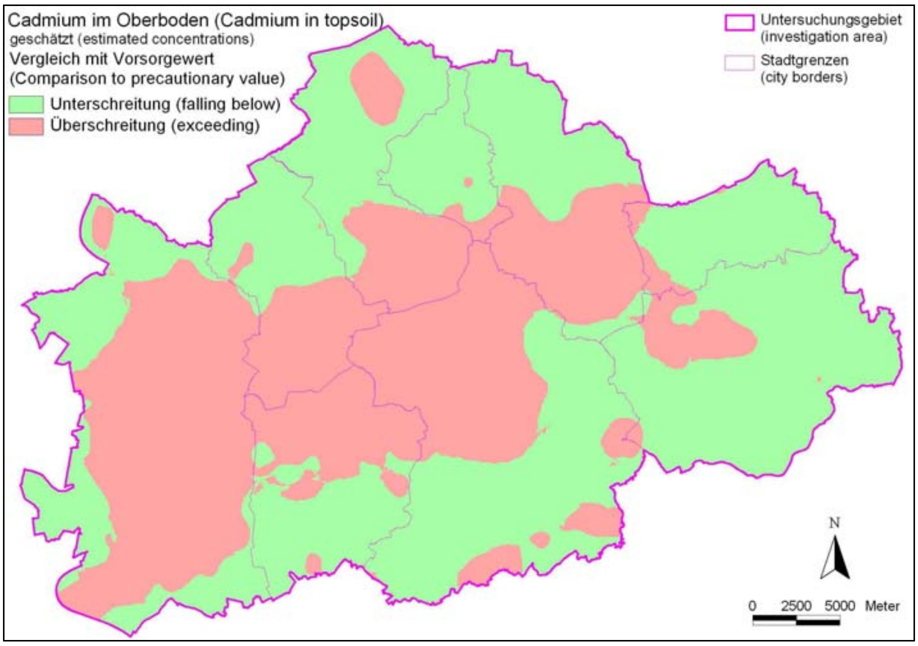


Figure 17. Comparison of the estimated regional cadmium concentrations from the soil quality map against the precautionary values

For the calculation of the indicators, the estimated concentrations of heavy metals (see Figures 14 – 16) are compared against the mentioned precautionary, trigger and action values. For illustrations purposes, the resulting maps also refer to the whole pilot area, although the results are only valid for the homogeneous spatial units (compare Figure 8).

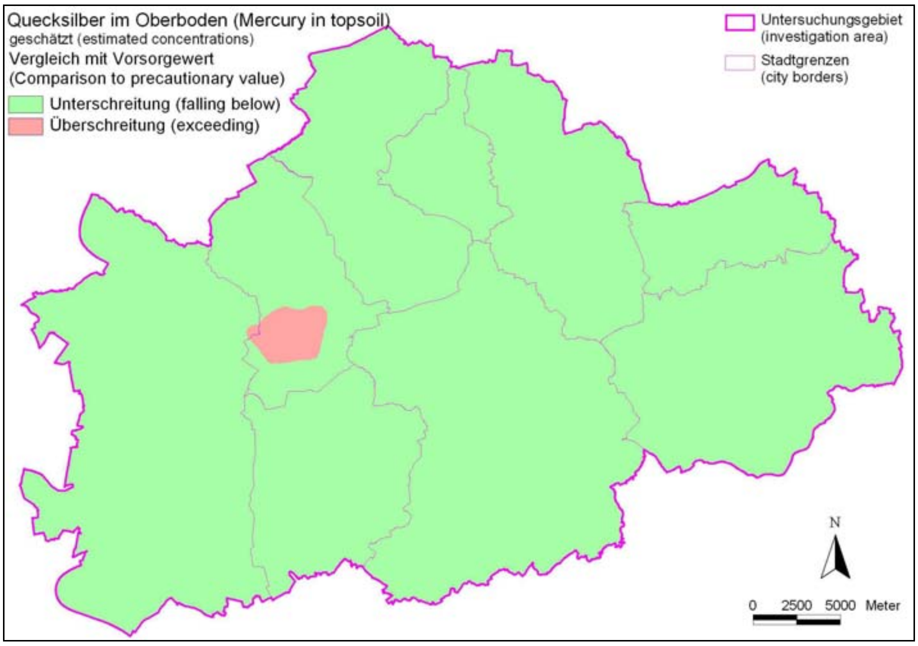


Figure 18. Comparison of the estimated regional mercury concentrations from the soil quality map against the precautionary values

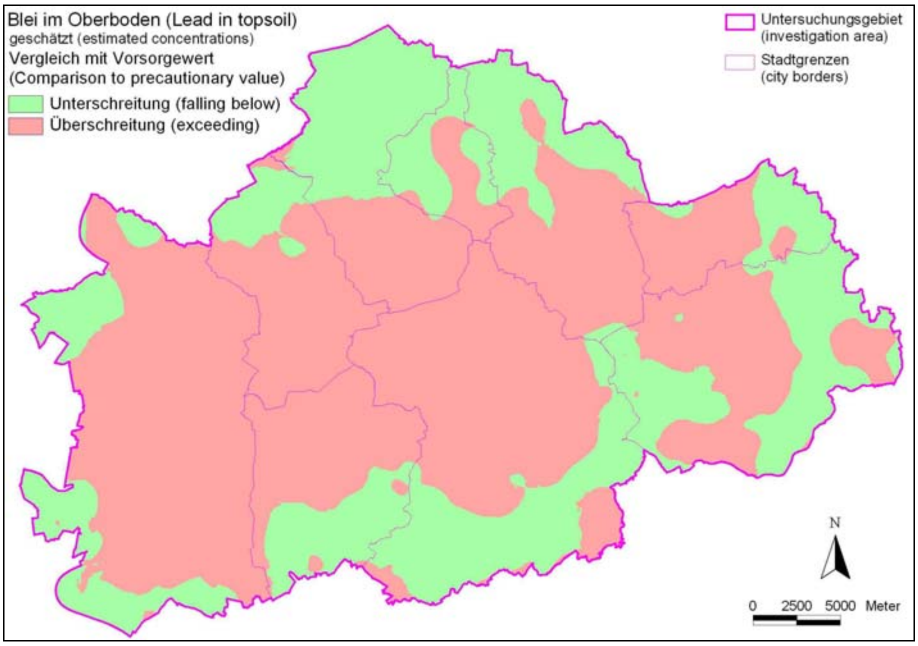


Figure 19. Comparison of the estimated regional lead concentrations from the soil quality map against the precautionary values

For mercury, the precautionary values are only slightly exceeded, whereas for cadmium and lead, the precautionary values are significantly exceeded.

The three following Figures show the comparisons between the estimated regional concentrations ("state", current soil condition) against the trigger and action values listed in Table 2.

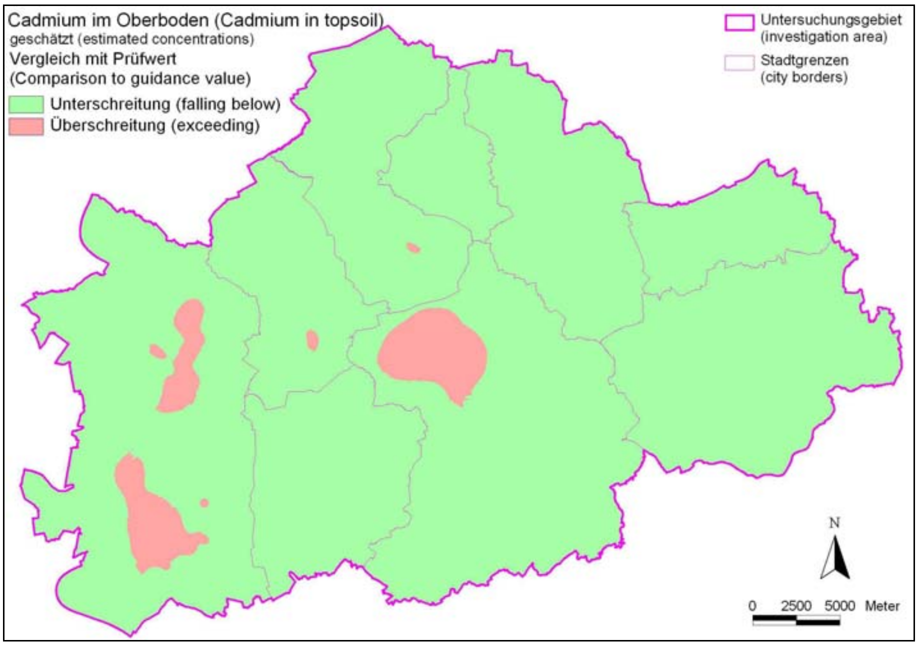


Figure 20. Comparison of estimated concentrations against the trigger value (cadmium)

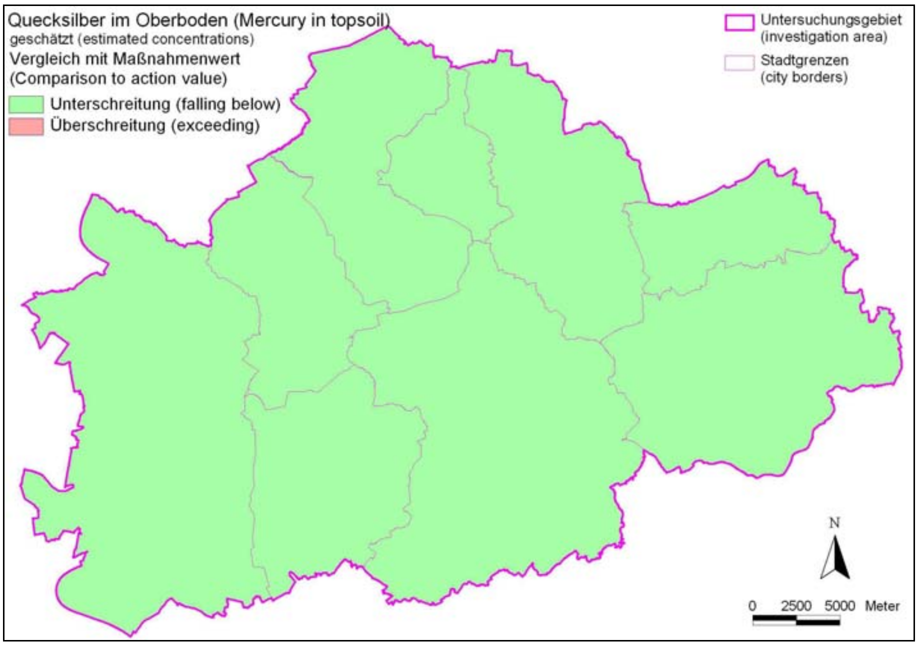


Figure 21. Comparison of estimated concentrations against the action value (mercury)

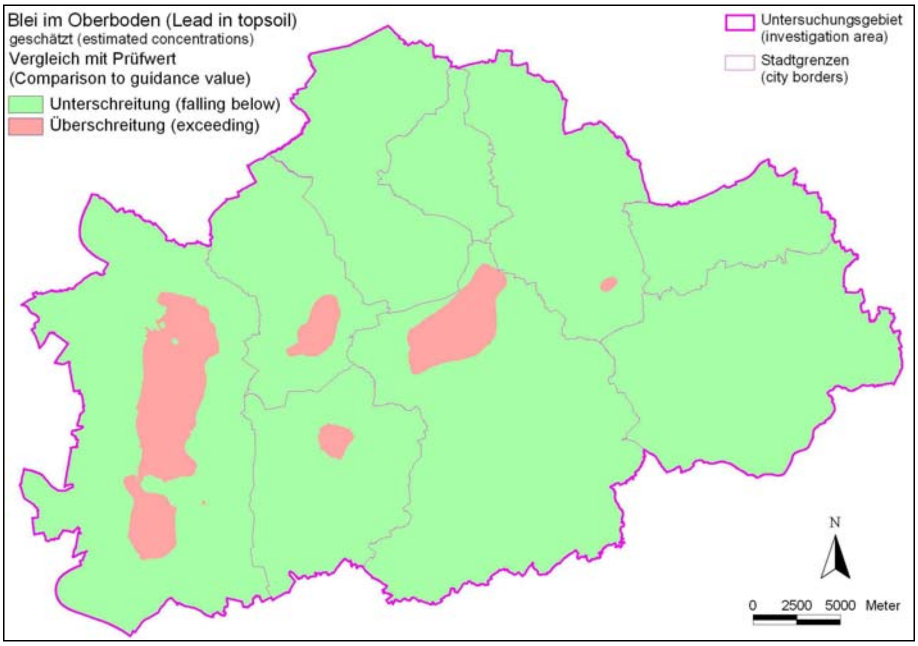


Figure 22. Comparison of estimated concentrations against the trigger value (lead)

For mercury, no exceedance of the action value was determined. However, on large areas, predicted concentrations of cadmium and lead exceed the trigger or action values (compare Table 3).

As shown in Step 1, a significant part of the pilot area has been excluded from further adaptation. Therefore, the indicators subsequently can be calculated on the basis of the corresponding, actually considered area, not comprising the exclusion areas (compare Figure 8). The results are presented in Table 3.

Table 3. Values of indicators referred to the considered area

Parameter	Unit	Cd [1)]	Cd [2)]	Hg [1)]	Hg [2)]	Pb [1)]	Pb [2)]
baseline	mg/kg	1,0	-	0,5	-	70	-
threshold	mg/kg	-	2,0	-	2,0	-	200
Total area	km²	1050.18	1050.18	1050.18	1050.18	1050.18	1050.18
Considered area	km²	500.97	500.97	500.97	500.97	500.97	500.97
Area with exceedance	km²	198.57	17.68	2.13	0.00	293.85	20.27
Area below the target value	km²	302.40	483.29	498.84	500.97	207.12	480.70
Area with exceedance	%	39.64	3.53	0.42	0.00	58.66	4.05
Area below the target value	%	60.36	96.47	99.57	100.00	41.34	95.95

[1)] baseline: comparison with precautionary value (see table 2)
[2)] threshold: comparison with trigger or action value (see table 2)

Evaluation of pilot results

The method applied in this study enables an extensive estimation of the heavy metal pollution in a defined reference depth of the top soils (here 0-30 cm) of the pilot area. Here the concentrations of the heavy metals cadmium, mercury and lead were investigated, and the diffuse, extensive soil contamination - which can mainly be attributed to deposition – is presented.

In this method, the original point-related information is upscaled using geostatistical interpolation. However, it is important to consider that specific types of land use (e.g. sealed and overbuilt areas) or areas of defined and often local impact situations (flooding areas, contaminated sites) have to be excluded from the evaluation. Important for this method is that the estimations go along with uncertainties (estimation impreciseness, estimation variance, measurement errors etc.), which - using Kriging methods - can be visualised and located. In fact, it is in principle possible to produce maps displaying defined degrees of uncertainty for predicted values.

Basically, this method can also be used for presenting extensive, temporal changes of soil concentrations. For the indicator, those changes are just to be expected over relatively long periods due to the high persistence of the investigated substances on the one hand and the significantly recently decreased emissions in the pilot area on the other hand. Some very specific frame conditions of the data base have to be considered for the evaluation of this method. In particular, the evaluated samples are derived from a period of more than 20 years. Therefore, the resulting maps of the “current” soil condition (“state” acc. to DPSIR concept) and thus cannot be assigned to a specific date. Therefore the present evaluation cannot be seen as a qualified basis for temporal change assessments. Should adequate data exist, the method is still be applicable.

Conclusions and recommendations

The applicability of the indicator CO01 was tested in the scope of a pilot area. With this method the indicator can also be applied to other areas in order to get information regarding soil quality and in order to intensify experiences with this methodology. However, this requires the availability of adequate data bases.

For further and detailed evaluations, the present method also allows comparisons of predicted soil concentrations with thresholds (here: trigger and action values from the national legislation) with respect to different types of land use. Because the scale of these values is controlled by the types of land use it becomes necessary to assess predicted values in relation to land use as well. This can be done with respect to further information acquired from existing maps. In the scope of this project, this step has not been carried out.
Furthermore, with regard to a period of approximately 20 years (corresponding to the requirements of ENVASSO regarding this indicator), time-related evaluations can be supplemented with new data to enable recording and estimating of changes regarding soil quality.

The extension of this indicator towards other groups of substances and individual substances is possible, but depends on regional conditions. In the scope of the pilot project, the additional calculation of PAH (polycyclic aromatic hydrocarbons) would be reasonable, because – as with heavy metals - they are also typical contaminants in the pilot area on a large scale via emissions. Moreover, the related data basis seems to be sufficient.

Depending on size of the area to which the indicator is applied, the scale and resolution have to be adjusted. For NRW-wide evaluations, for example, a spatial resolution of 500 x 500 m was used.

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Pilot area: Chemnitz, Germany and Czech Republic

Lead partner: LfUG
Heiner Heilmann,
Ronald Symmangk,
Anna Böhm

Josef Kozak, Vit Penizek (CUA)

Rainer Baritz, Jan Willer, Einar Eberhardt, Jens Utermann (BGR)

Description of the Pilot Area

Name of pilot area:		Pilot area 1:250,000 Sheet Chemnitz (Germany-CZ)
Names of participating partners	Lead partner	Heiner Heilmann, Ronald Symmangk, Anna Böhm (LfUG)
	Partner CZ	Josef Kozak, Vit Penizek (CUA)
	Partner WP3	Rainer Baritz, Jan Willer, Einar Eberhardt, Jens Utermann (BGR)
Location and description	Member State(s)	CZ and Germany (mainly parts of Saxony, smaller area of Thuringia and Bavaria)
	Coordinates	coordinates (map corners, WGS84) X Y NW 12° 0' 0"E 51° 0' 0"N NE 14° 0' 0"E 51° 0' 0"N SW 12° 0' 0"E 50° 0' 0"N SE 14° 0' 0"E 50° 0' 0"N
	Area of pilot area (km^2)	appr. 15,753 km²
	Climate	temperate suboceanic to temperate-subcontinental (acc. to soil regions vers. 2.0)
	Mean temperature (FAO 2006)	annual mean temp.: 5.2-8.2°C
	Average Annual Precipitation (FAO 2006)	annual average: 600-1500 mm
	Outline description of topography	level land, sloping land
	Elevation (m)	666 - 1011 m
	Vegetation (FAO 2006)	Herbaceous, Woodland, …
	Major Land Use (FAO 2006)	cropland (36%), forest (30%), grassland (8%), urban (9%), heterogeneous agricultural land (10%), Scrubs (5%)
	Major soils (WRB 2006 RSGs)	Cambisols, Luvisols, Albeluvisols, Podzols, Chernozems, Andosols

Threat and related indicator(s) evaluated in pilot area

Threat	Soil Contamination
Indicator 1	CO01 Heavy metal contents in soils

Rationale for selection of pilot area

The area of the map sheet Chemnitz of the European soil map 1 : 250,000 covers an area with former ore mining and smelting activities. Heavy metal contents of soils from natural as well as anthropogenic sources (here: diffuse contamination) may be increased. Due to this, also data availability was expected to be good.

Indicator Evaluation

Indicator

The indicator CO01 – Heavy metal contents in soils, belongs to the key issue “Diffuse Contamination by inorganic contaminants”. The objective is to identify the points or the area of exceedance of thresholds for soil contamination. According to the ENVASSO procedures and protocols, soil samples should be extracted by aqua regia (ISO 11466: 1995) and absolute content of elements [$mg \cdot kg^{-1}$] determined by flame or electrothermal atomic absorption spectrometric methods (ISO 11047: 19989) or by cold-vapour atomic spectrometry or cold-vapour atomic fluorescence spectrometry (ISO 16772: 2004).

Pilot description

Spatial extent

The sheet covers the area starting from Thuringia in the north-west, and a small area of Bavaria in the south-east, and reaches almost to the city of Dresden in the north-east and to Prague in the south-eastern part. The area of the sheet Chemnitz has a high proportion of mining and industrial area. That means that interpretations of the results need to consider, that the sources for pollutant emissions have to be known in order to separate from local contamination.

Data sources

Soil sample net Saxony and lab analyses

The data used for CO01-indicator were collected from 1993 to 1997 in a 4 by 4 km grid over the whole area of Saxony (Figure 1).

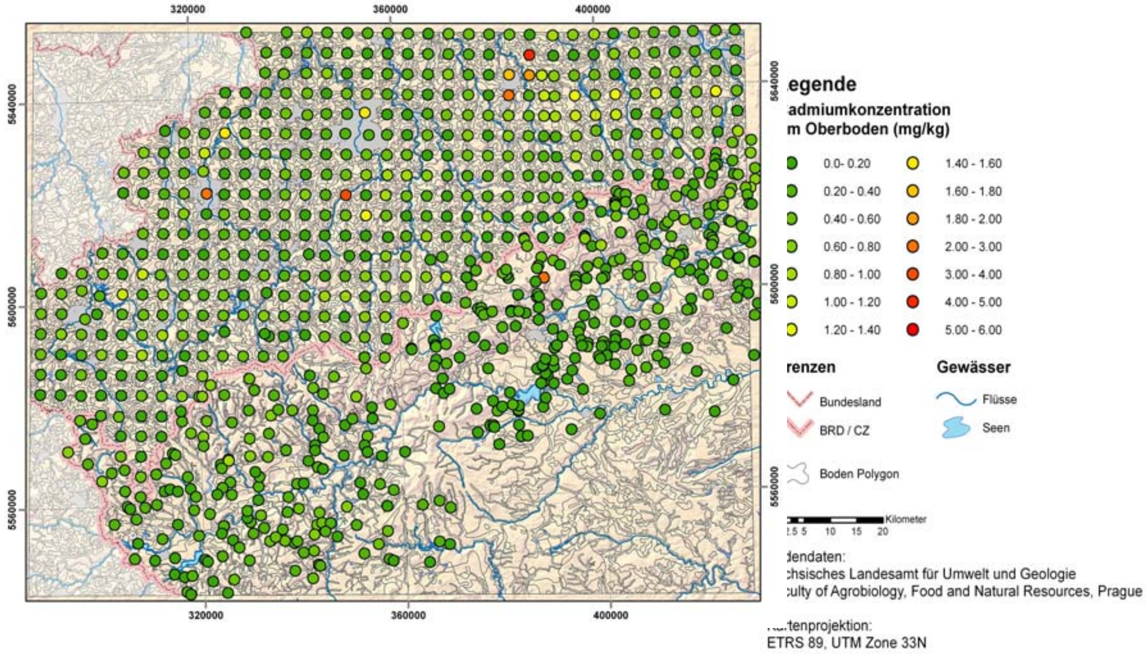

Figure 1. Soil monitoring plots with Cd concentrations in the area of the Sheet Chemnitz (systematic 4x4 km grid in Saxony; stratified soil monitoring network in CZ)

The soil samples were taken from topsoils and subsoils as well as from the organic layer (forest soils) (LfUG 2001). Figure 2 presents the sampling of the depth classes.

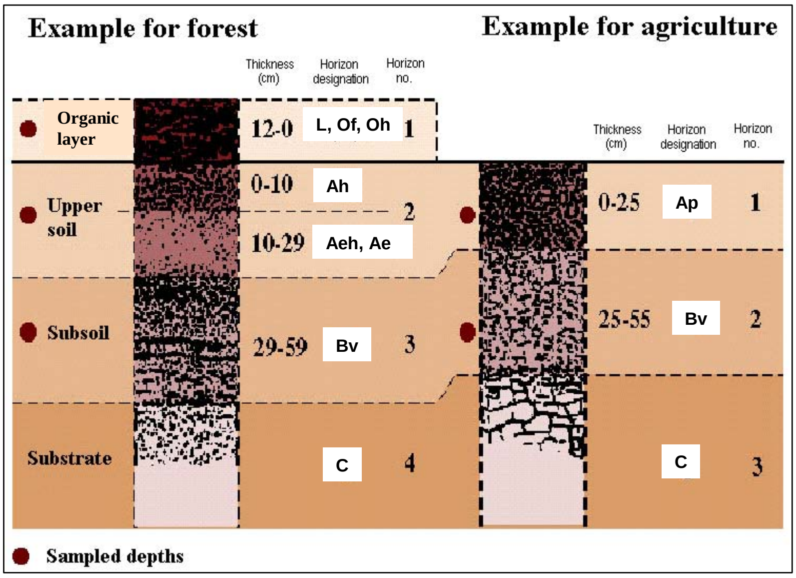

Figure 2. Formulas and factors used for the calculation of aqua regia values

The air-dried samples were analysed by total extraction, which is an acid extraction method with HF (hydrofluoric acid)/$HClO_4$ (perchloric acid)/HNO_3 (nitric acid). Afterwards the element content was determined by graphite pipe-atomic absorption spectrometric method (DIN V 38406) (LfUG 2001).

The element content determined with this method is usually higher than the contents of Aqua regia extraction. But UTERMANN et al. (1999) could show a significant relationship between contents determined with total and aqua regia extraction. In order to present the results in a compatible manner with the proposed aqua regia extraction, the total extractions were converted into 'synthetic' aqua regia values using the following formulas (Table 1):

Table 1. Formulas and factors used for the calculation of aqua regia values

Element	Formula	Factor
Cd, Cr, Cu, Ni, Pb, Zn	BGR7	Cd depending on parent material: 0.78 – 0.96
As	UBA	0.8
Tl	LfUG	0.75

Soil monitoring plots in the Czech Republic

The data originate from a monitoring, done by the Research Institute for Soil Conservation and Amelioration in Prague. Twenty sub-samples were used for one composite sample, the sites were located on agricultural land, both arable land and permanent grassland. The soil type was checked, and directly classified into WRB 1998. The soil profiles were described, and the following data were determined: humus content, pH, CEC, base saturation, texture, nutrient content. Soil samples were collected to a depth of 30 cm. Composite soil samples were collected from the area determined by a circle around the soil pit (radius ca. 50 m). The reason for that sampling was monitoring of the food chain parts, sponsored by the Czech Ministry of Agriculture. The localities were selected to represent major soil typological units in the area under study. The heavy metals were analysed according to aqua regia with 2M HNO3.

[7] BGR…Federal Institute for Geosciences and Natural Resources; UBA…Federal Environment Agency; LfUG…Saxon State Agency for Environment and Geology

Pilot method

While the corrections of the HF-derived Cd concentrations to aqua regia values were done by LfUG, BGR has calculated Cd contents for the upper 30 cm of the mineral soil using the weighted mean of the Cd contents of the soil horizons within this depth range, disregarding humus layers of forest soils. No changes were done with the CZ values because the reported reference depth was given as 30 cm. The sample from the Saxonian sites is characterised by the following statistical parameters (Table 2).

Table 2. Descriptive statistics of Cd data for all of Saxony and for Sheet Chemnitz

Statistical parameter	Statistical values of the sample	
	Saxony	Sheet Chemnitz
n	1.164	428
Minimum	0.002 mg·kg^{-1}	0.005mg·kg^{-1}
Maximum	7.44 mg·kg^{-1}	7.44 mg·kg^{-1}
Median	0.21 mg·kg^{-1}	0.32 mg·kg^{-1}

It becomes obvious, that a wide range exists between very low Cd contents of less than 0.1 mg·kg^{-1} and high contents over 7.0 mg·kg^{-1} in the upper 30 cm of soils. The median for all of Saxony amounts to 0.21 mg·kg^{-1} Cd, using the data for 0-30 cm. In contrast, the media for the topsoil values (A horizon) used by LfUG amounts to 0.45 mg·kg^{-1} Cd (according to Figure 2) (personal information from G. Rank, LfUG 2007). For the sheet Chemnitz, we have calculated values valid for a soil block of 30 cm depth (thus, smaller parts of the subsoil are included; subsoils are characterised by lower Cd contents than the topsoils; LfUG 1999).

For all plots in the pilot area (both Saxony and CZ), the exceedance of thresholds was calculated (by BGR) on the basis of national thresholds taken from the Federal Soil Protection Act (BBodSchV 1999). Therefore, so called precaution values (‘*Vorsorgewerte’*) (Table 3) were used.

Table 3. Vorsorgewerte ('precautionary values') from BBodSchV (1999) for soils depending on texture

Soil type	Cd [mg·kg^{-1}]
soils from clay	1.5
soils from silt	1.0
soils from sand	0.4

The exceedance was determined by comparing the Cd values of each plot with the *Vorsorgewert* from BBodSchV. The level of the *Vorsorgewert* represents 100%, thus factor 1. That means that exceedance by 50 % refers to *Vorsorgewert* x 1.5.

The results are illustrated in the map presented in Figure 3.

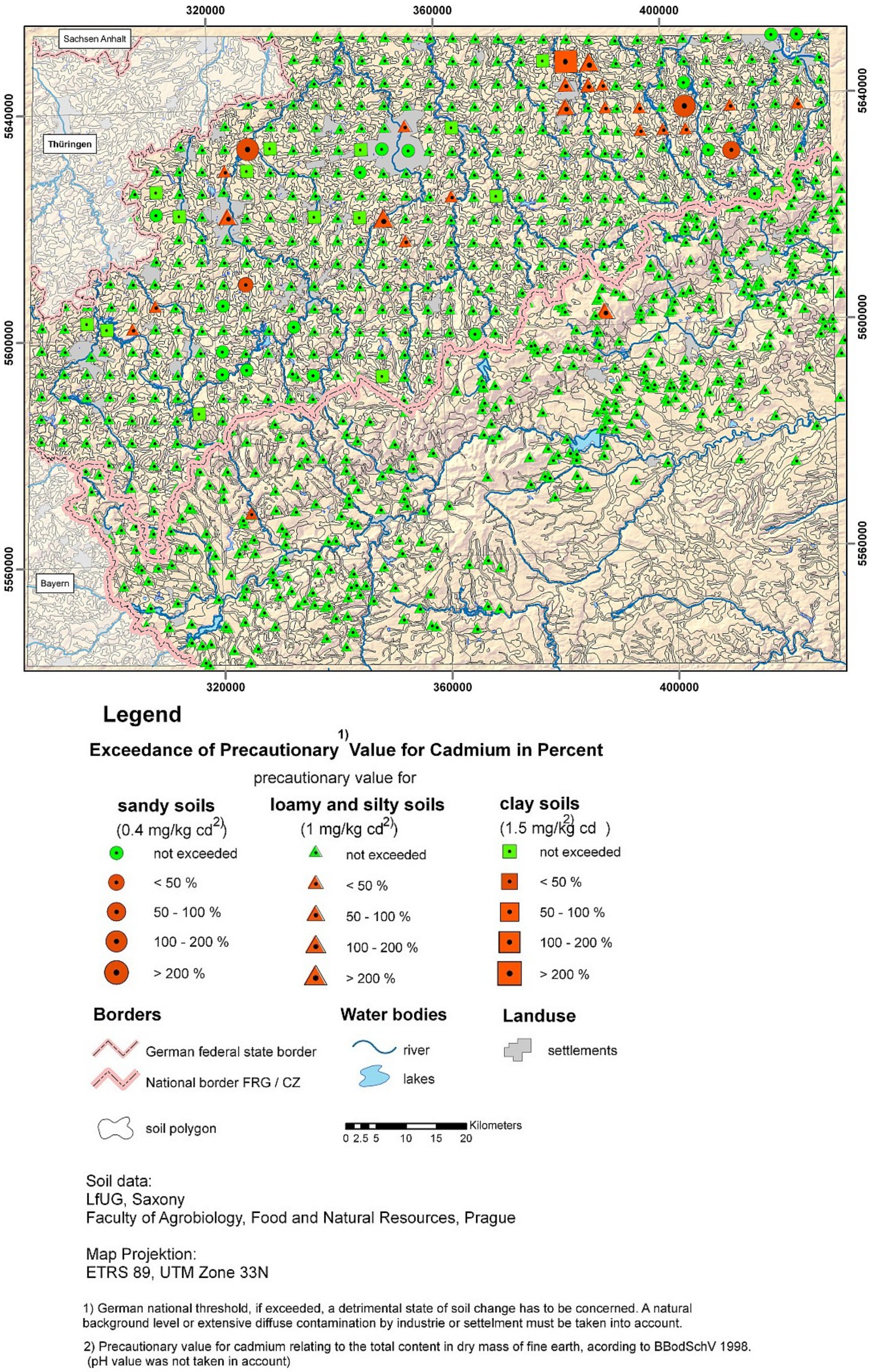

Figure 3. Exceedance of ‚Vorsorgewerte' for cadmium in the pilot area

Evaluation of pilot results

The result map shows the highest contents (highest exceedance) for cadmium south-east from the city of Freiberg, towards the city of Altenberg (south-eastern part of the Ore Mountains). Other areas with high values are next to the city of Zwickau, and in the nearby valleys of the Mulde river. There are different reasons for these high Cd contents:

Natural reasons

The geological underground in the area of Freiberg as well as in the eastern part of the Ore Mountains is generally characterised by high contents of heavy metals in the rocks. For example in and around Freiberg, over 1000 lodes with its aureoles exist in the underground (personal information from G. Rank, LfUG 2007). The soils in the above-mentioned regions have high geogenic Cd contents, accordingly.

Ca. 50% of the high Cd contents of the floodplain soils of the Mulde river close to Freiberg and Zwickau can be ascribed to the high Cd background contents in its catchment. The other 50% can be explained by human activities (Rank et al. 1998).

Anthropogenic reasons

About 50% of the high Cd contents in floodplain topsoils are caused by the former ore mining and smelting industry in the catchment of the Mulde river. This industry started in the 18th century near the cities of Freiberg, Glauchau and Zwickau. In order to avoid immissions near these cities, a first flue was built in Freiberg in 1905. As a consequence, the emitted Cd - totalling between 1.2 and 3.0 t $Cd \cdot a^{-1}$ between 1973 and 1983 in the Freiberg area (Fiedler and Klinger 1996) - were shifted downwind in south-east direction (Rank et al. 1998, Rank et al. 2002).

On the Czech part of the pilot area, two inventory sites show exceedance of the German thresholds. The eastern point is located north from the industrial area of Chomutov-Jirkov - an area with Cd- and Fe-enriched lodes. It is assumed that these concentrations are caused by a former nearby ironworks which manufactured the Cd-enriched iron ores. The second site is located west of Olovi, where also metallurgical industry was established because of poly-metallic lodes with lead and cadmium.

The Czech thresholds for Cd contents in soils are similar to the German *Vorsorgewerte*: maximal acceptable values for Cd: 0.4 $mg \cdot kg^{-1}$, except for sandy and loamy-sandy soils: 1.0 $mg \cdot kg^{-1}$, according to law no. 13/1992 (Ministry of Environment = Ministerstvo životního prostředí stanoví podle § 22 zákona České národní rady č. 334/1992 Sb., o ochraně zemědělského půdního fondu, ve znění zákona České národní rady č. 10/1993 Sb) and would have produced a similar map.

The indicator seems to give a useful overview of the threat by Cd contamination.

Conclusions and recommendations

The calculations according to the ENVASSO procedures and protocols identify the same polluted areas than those received from the previous Saxonian investigations (Figure 5). However, this method can only provide broad information about polluted areas, where there is need for further detailed investigations. In addition, the 'simple' calculation of a weighted mean value of heavy metal content for the upper 30 cm of soil has to be reflected critically because:

a) Heavy metal content in soils differs in dependence on soil-depth, pH-value and land use In Saxony, mineral topsoils under grassland and arable land have higher Cd contents than the organic layers and the mineral topsoils under forest use. The forest soils are characterized by lower pH-values where cadmium is highly mobile and easily leached into the subsoil (LfUG 1999a); <u>the indicator should possibly also be calculated for the subsoil</u>, at least for forest (for which the procedure had to be defined precisely to get comparable results). However, such a proposal has to be discussed, because subsoil values, since they tend to reflect geogenic (natural) heavy metal concentration, provide the evaluation basis for assessing the man-made components (anthropogenic effects). Thus, subsoil values may serve as the baseline (background) value to facilitate the interpretation of the level of contamination.

b) Heavy metal content in soils with high natural background values and exceedance of thresholds

In areas with high geogenic background values, heavy metal contents in soils are necessarily higher than in regions without, and are more likely to exceed threshold values (as in the pilot area, Figure 4).

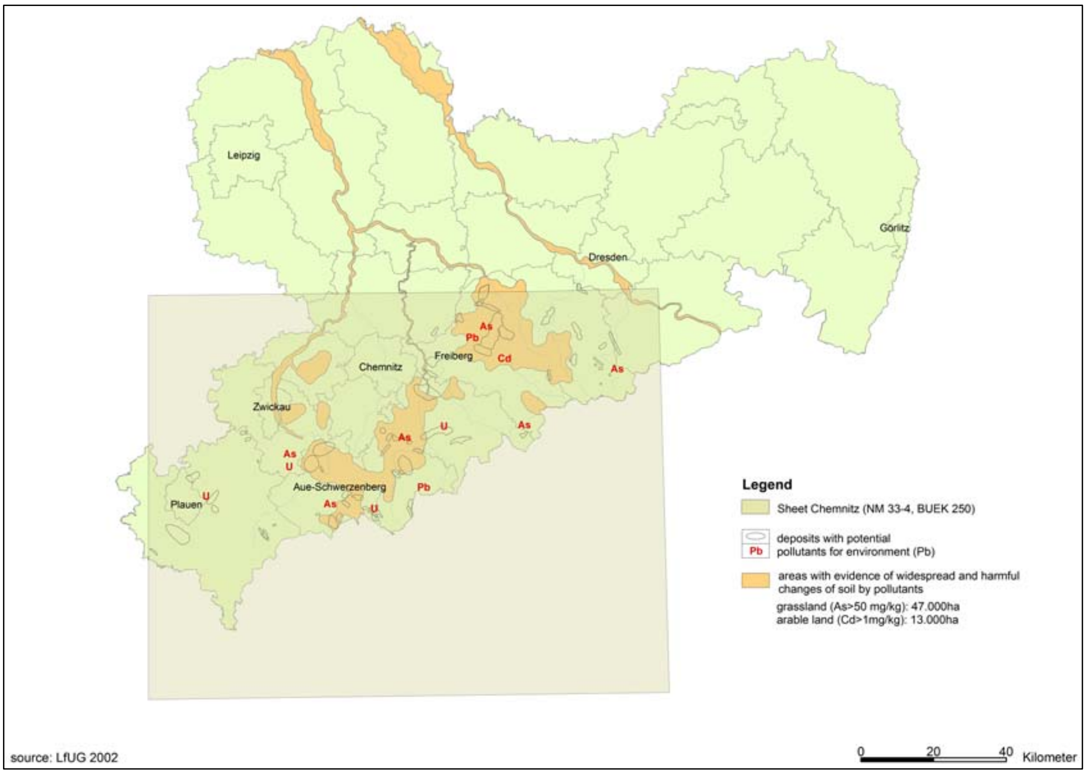

Figure 4. Areas with evidence of widespread geogenic pollution of heavy metals in the pilot area

Even the median (and not only maximum values of the) Cd content for Saxon soils is around 0.45 mg·kg^{-1}, meaning that 50% of Saxon soils would exceed the Cd-*Vorsorgewert* for sandy soils of 0.4 mg·kg^{-1} (personal information from G. Rank, LfUG 2007). In areas like this the *Vorsorgewerte* are not effective as indicators of "possibly detrimental soil alterations" (BBodSchV 1999), for which these threshold values actually were designed (LfUG 1999b).

In addition, the soil pH has not been considered in the interpretation of the threshold exceedance for Cd, although the following modifications of the *Vorsorgewerte* have to be taken into account if the pH-value is lower than 6 (as for most forest soils):

- for clayey soils, the Cd-*Vorsorgewert* for loamy and silty soils is effective (BBodSchV 1999)
- for loam/silt soils, the threshold for sandy soils is effective (BBodSchV 1999)

Another critical aspect to the interpretation is that of land use: *Vorsorgewerte* receive a specific interpretation for grassland and arable land in contrast to forested land. Forest is treated as a 'non-sensitive' (*nicht-empfindlich*) land use (BBodSchV 1999). This is crucial to the interpretations, because a high percentage of the pilot area is forested.

In conclusion, the ENVASSO procedures and protocols should contain a methodology to identify regional background values (like, e. g. , UTERMANN et al. 1999) and should specify how indicator value calculation (and possibly interpretation) should take background values as well as soil pH into account. It should be stated if the pH of the surface or uppermost mineral horizon has to be used for interpretation, or a mean pH of all considered horizons.

Calculation artefact

Weighted means of heavy metal concentrations of the upper 30 cm of the mineral soil as calculated from horizon values may blur high contents by overemphasizing low mean subsoil contents. This is especially problematic if the top part of the subsoil actually has relatively high values, which becomes reduced by the mixing across the whole horizon. *This effect would be less pronounced if (1) only the upper 15 cm were considered which are more likely to contain only A horizon material or (2) if only A horizon material would be considered with the disadvantage of a varying depth reference of the indicator values*.

For forested land, the ENVASSO procedures and protocols should state if and how humus horizons are to be considered when horizon-related values are used to determine heavy metal contents of the uppermost part of the soil (The German precautionary values were not developed for organic layers in forests).

Further comments and suggestions for contamination monitoring

Soil horizon-related sampling

With a horizon-related sampling scheme, determination of factors influencing heavy metal content in soils would be easier and could be better interpreted than by using depth classes. In general, the geogenic effects are reflected by values from mineral soil samples, while values for the O layers (forest floor horizons) in forests reflect anthropogenic influences (Figure 5). Furthermore the different physical and chemical processes in the soil horizons can be additionally considered for the interpretation of element concentrations.

Content of mobile elements/monitoring

The content of mobile elements in soils depends on various soil properties as well as on land use which itself is a factor influencing soil properties. For example, under forest soils are characterized by low pH-values. Just this parameter is important for mobility or fixation of elements (e.g. cadmium) and, as a consequence, for the bioavailability of these elements. It is possible to concentrate on the monitoring of the pH, and to use specific pedotransfer functions in order to assess changes of the mobile fraction (Utermann et al. 2005). It should be discussed whether the mobile fraction of Cd, Pb and Hg should also be determined. In addition, some support to discuss the results by considering land-use and pH may be provided by the ENVASSO Procedures and Protocols.

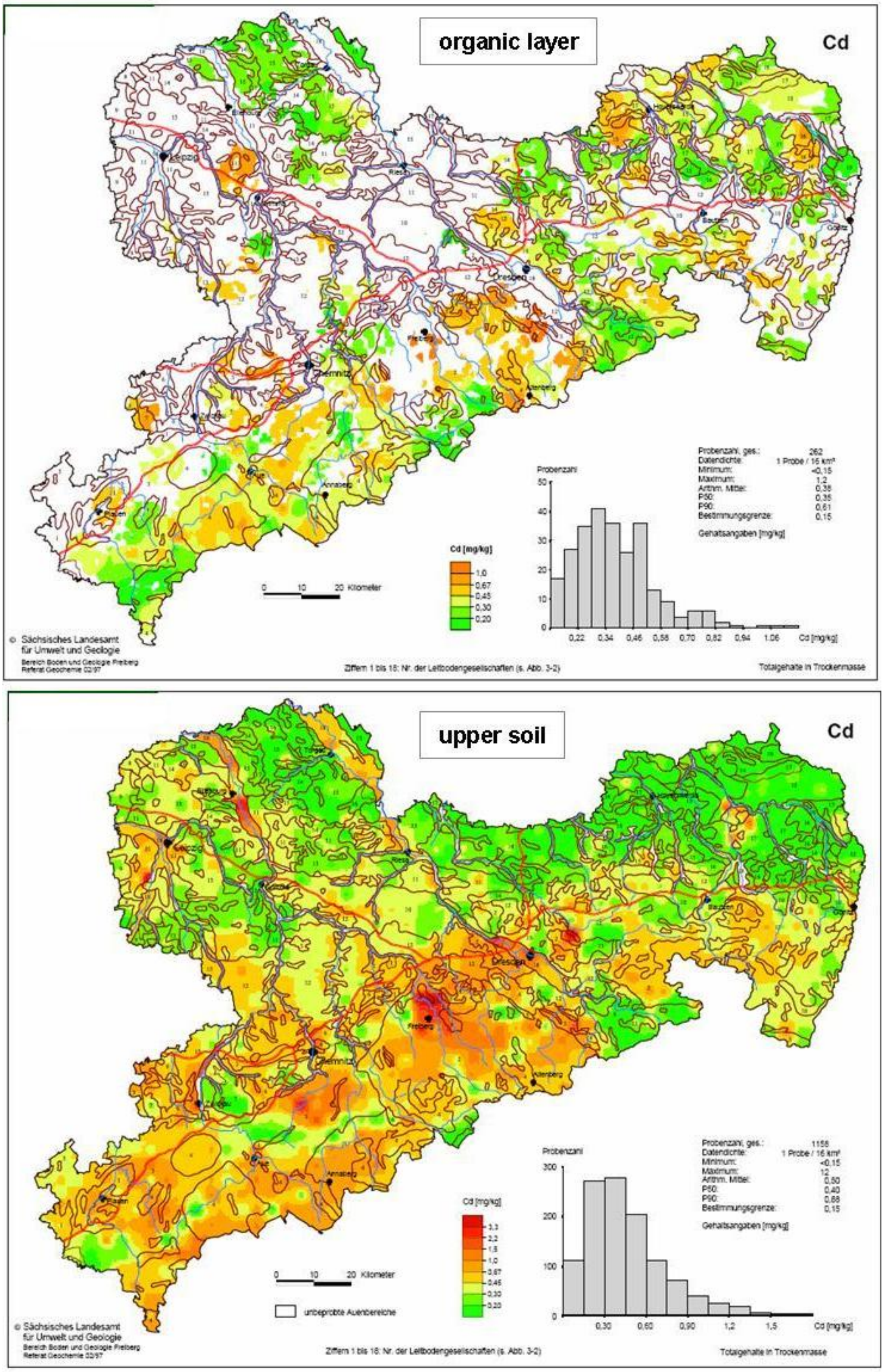

Figure 5. Cd content in the organic layer and the upper soil derived from the data of the 4x4 km grid

Cd content in the organic layer reflects anthropogenic influences; Cd content in the upper soil reflects geogenic influences (LfUG 1999a)

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Pilot area: City of Linz and Surrounding Area, Austria

Lead Partner: UBA-A
Gundula Prokop

Description of the Pilot Area

Name of pilot area		**City of Linz and Surrounding Area Official Title in German: "Bezirk Linz" and "Bezirk Linz-Land" → map1**
Names of participating partners	**Lead partner**	**Umweltbundesamt GmbH (Gundula Prokop / gundula.prokop@umweltbundesamt.at)**
	Partner A	
	Partner B	
	Partner C	
Location and description	Member State(s)	Austria
	Coordinates	"Centroid" of the area defined as Lambert co-ordinates X = 472309.359 Y = 481993.993043
	Area of pilot area (km^2)	556 km^2
	Climate	Cfb-Zone according to Köppen Geiger
	Mean temperature (FAO 2006*)	annual mean temp.: 8 – 10 °C
	Average Annual Precipitation (FAO 2006	annual average: 810 mm ± 53 mm 750 – 800 mm
	Outline description of topography	SM (sloping land / medium-gradient mountain)
	Elevation (m)	Medium: 309 m Min: 228 m Max: 605 m
	Vegetation (FAO 2006)	Mainly non irrigated cultivation (65% of the area)
	Major Land Use (FAO 2006)	Agricultural areas 65% Artificial surfaces 20% Forest and semi natural areas 13% Water bodies 2%
	Major soils (WRB 2006 RGs**)	See text & table below

Figure 1. Location of Pilot Area "Linz and Surrounding Area" for Indicator CO08.

Soil Type description for the region “Linz” and “Linz Land”

The description of the main soil types in the region Linz is based on the 1:1 Mio Soil Map (ESB, 1998; BMLFUW, 2006) according to the FAO-UNESCO Taxonomy, Version 2.0. A comparison between the different soil taxonomies - FAO, WRB, 1998 and the Austrian soil taxonomies, 1969 and 2000 is published in NESTROY, 2002. However, the different taxonomies do not allow a 1:1 translation. As shown in table 1 the main soil types in the region are Luvisols, Fluvisols and Cambisols.

Table 1. Main soil types in the region “Linz” and “Linz Land”

STU	FAO-Version 2.0	WRB 1998 (selection) Reference-Soil group(s)/ subunit	km^2	% area
Lg	Gleyic Luvisol	Luvisols/ leptic, gleyic, stagnic, chromic, dystric, haplic	182	33
Jc	Calcaric Fluvisol	Fluvisols/ histic, gleyic, mollic, arenic, stagnic, humic, calcaric, eutric, haplic	92	16
Be	Eutric Cambisol	Cambisols/ leptic, vertic, stagnic, gleyic, mollic, calcaric, skeletic, eutric, haplic	69	12
Bg	Gleyic Cambisol	Cambisols/ leptic, vertic, fluvic, stagnic, gleyic, mollic, sodic, gypsiric, chromic, dystric, haplic	59	11
Lo	Orthic Luvisol	Luvisols/ leptic, chromic, dystric, haplic,	39	7
Eo	Orthic Rendzina	Leptosols/ lithic, gleyic, rendzic, mollic, calcaric, eutric, haplic	37	7
Gd	Dystric Gleysol	Gleysols/ histic, sodic, dystric, haplic	32	6
Bd	Dystric Cambisol	Cambisols/ leptic, vertic, stagnic, gleyic, mollic, skeletic, dystric, haplic	29	5
Ec, Bv, U, Po	Eutric/Vertic Cambisol, Ranker, Orthic Podsol	See reference	19	3
Total			556	100

Source: based on the 1:1 Mio Soil Map (ESB, 1998, BMLFUW 2006, NESTROY, 2002).

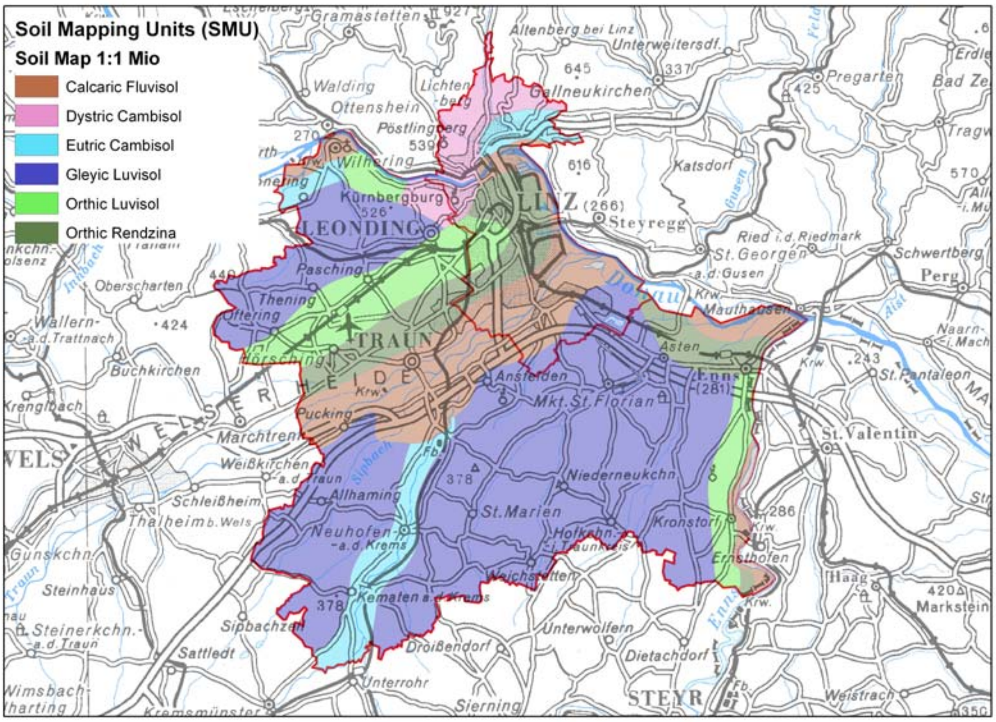


Figure 2. Soil types in the pilot area according to WRB 1998

Land Use according to CORINE Landcover 2000 Classification
About 20% of the pilot area artificial surfaces, 65% arable non-irrigated land, and 10% forest.

Table 2. Land use in the pilot area according to CORINE Land Cover 2000.

CORINE Code	LABEL1	LABEL2	LABEL3	km²	% area
111	Artificial surfaces	Urban fabric	Continuous urban fabric	4,4	1%
112	Artificial surfaces	Urban fabric	Discontinuous urban fabric	86,0	15%
121	Artificial surfaces	Industrial, commercial and transport units	Industrial or commercial units	11,6	2%
122	Artificial surfaces	Industrial, commercial and transport units	Road and rail networks and associated land	2,0	0%
124	Artificial surfaces	Industrial, commercial and transport units	Airports	2,9	1%
131	Artificial surfaces	Mine, dump and construction sites	Mineral extraction sites	0,8	0%
141	Artificial surfaces	Artificial, non-agricultural vegetated areas	Green urban areas	0,7	0%
142	Artificial surfaces	Artificial, non-agricultural vegetated areas	Sport and leisure facilities	1,4	0%
211	Agricultural areas	Arable land	Non-irrigated arable land	328,3	59%
231	Agricultural areas	Pastures	Pastures	1,7	0%
242	Agricultural areas	Heterogeneous agricultural areas	Complex cultivation patterns	14,4	3%
243	Agricultural areas	Heterogeneous agricultural areas	Land principally occupied by agriculture, with significant areas of natural vegetation	18,6	3%
311	Forest& semi natural areas	Forests	Broad-leaved forest	26,8	5%
312	Forest& semi natural areas	Forests	Coniferous forest	14,6	3%
313	Forest& semi natural areas	Forests	Mixed forest	31,3	6%
511	Water bodies	Inland waters	Water courses	9,4	2%
512	Water bodies	Inland waters	Water bodies	0,9	0%
Total				555,8	100%

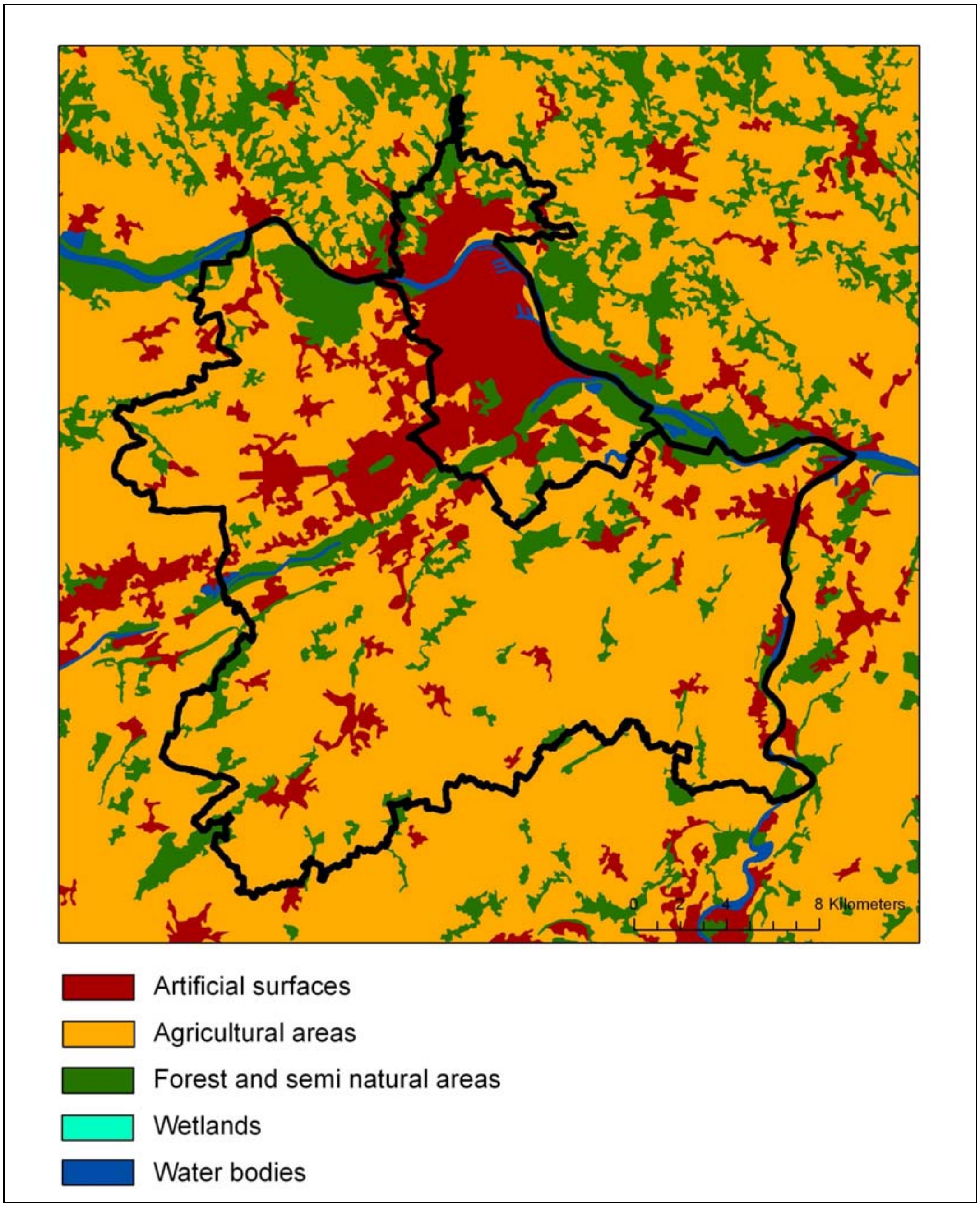


Figure 3. Land use in the pilot area according to CORINE Land Cover 2000.

* ftp://ftp.fao.org/agl/agll/docs/guidel_soil_descr.pdf
**ftp://ftp.fao.org/agl/agll/docs/wsrr103e.pdf

Table 4. Designated Groundwater bodies (according to WFD) connected to Pilot Area and risk status:

Reference No.	Name (long version)	Type of GW-body	Area in km^2	Quantitative status	Chemical status	Chemical status - parameter	Type of aquifer
GK100027	Unteres Ennstal (NÖ, OÖ) [DUJ]	single GW-body	118	no risk	no risk		pore groundwater
GK100036	Eferdinger Becken [DUJ]	single GW-body	120	no risk	no risk		pore groundwater
GK100038	Linzer Becken [DUJ]	single GW-body	97	no risk	no risk		pore groundwater
GK100045	Welser Heide [DUJ]	single GW-body	207	no risk	no risk		pore groundwater
GK100056	Schlierhügell and [DUJ]	group of GW-bodies	716	no risk	no risk		mainly fractured rock aquifer
GK100057	Traun - Enns - Platte [DUJ]	group of GW-bodies	785	no risk	risk	Desethylatrazin	mainly pore groundwater
GK100190	Böhmische Masse [DUJ]	group of GW-bodies	6365	no risk	no risk		mainly fractured rock aquifer

Threat and related indicator evaluated in pilot area

Threat	Soil Contamination
Indicator 1	CO08 Progress in the Management of Contaminated Sites
Indicator 2	
Indicator 3	

Rationale for selection of pilot area

The area is highly representative for local soil contamination.

The City of Linz is a city of medium size (200.000 cap / 96 km²) with a long history of heavy industry (steel and chemical industry) and high population density (1.900 cap/km²). The city has 2 industrial mega plants and a lot of supplying industry.

The surroundings are typical rural areas with scattered medium sized companies and medium population density (280 cap/ km²). The surroundings are typical commuting areas with an enormous increase in building activities in recent years. Agriculture and forestry are dominant land uses in the region.

The area is dependant on local groundwater abstraction. The area is connected to seven designated groundwater bodies (according to GWFD).

Documentation of actual and potential soil contamination is very well established in the pilot area. In addition, a great number of remediation measures were implemented in the last two decades.

Indicator Evaluation

Indicator

CO08 Progress in the Management of Contaminated Sites

Pilot description

Spatial extent

The pilot are covers 556km² and is situated within a tertiary basin of the pre-alpine region. In the North the pilot area borders on the Bohemian Massive.
Major rivers are the Danube and the river Traun, which discharges in the Danube.

Data

Sampling Design: not applicable

Testing: not applicable

Data description and standards
Indicator testing is based on data from the Database on Contaminated Sites maintained by the Austrian Federal Environment Agency. The database includes 49.792 sites with different levels of completeness.

Soil data: none

Map data
Each site of the database is
- either geo-referenced with a polygon according to the Gauss-Krueger system
- or disposes of cadastral numbers (as a minimum geo-reference).

Methodology used for calculations / estimations of parameters and indicators

Baseline definition
For the definition of baselines a reference year is recommended. I.e. the first year of monitoring.

Threshold definition
The threshold is based on expert judgement. For each management step the expected maximum number of sites is defined.

Pilot methodology

Terminology

The ENVASSO Fact sheet CO08 refers to 5 management steps for the management of contaminated sites. Each management was assigned to the corresponding national management step and its definition:

	Definition according to Fact sheet	..corresponds to national management step:
Tier 1	Site Identification / Preliminary Study	Ersterfassung abgeschlossen
Tier 2	Preliminary Investigation	Gefährdungsabschätzung abgeschlossen
Tier 3	Main Site Investigation	Prioritätenausweisung
Tier 4	Implementation of Remediation Measures	Sanierung in Durchführung Sanierung abgeschlossen
Tier 5	Measures completed	Sanierung abgeschlossen

Data compilation

For each management step the number of sites in the pilot area was derived:

	No. of Sites	comment
Tier 1	213	“Erstabschätzung abgeschlossen” A minimum data set is required for this standard assessment, which is primarily a desk study.
Tier 2	38	“Gefährdungsabschätzung durchgeführt”. Sites that were subject of an official risk assessment according to the national law (§13 ALSAG)
Tier 3	20	“Prioritätenausweisung”. Sites that were assigned with a priority for remediation
Tier 4	9 (+11)	“Sanierung in Durchführung oder abgeschlossen“ Remediation either completed or in progress 11 sites were remediated without being assigned with a priority
Tier 5	4 (+11)	“Sanierung oder Sicherung abgeschlossen“ Sites were remediation measures were completed; 11 of which were remediated without being assigned with a priority

Definition of thresholds

For each management step a threshold was defined based on expert judgement. The threshold represents the expected maximum number of sites for each management step.

- Tier 1: This threshold was defined based on regional surveys that have already been completed in the region.
- Tier 2 – 5: The thresholds for these tiers were derived based on expert judgement. For each tier 4% of the official national threshold (BMFLUW 2007) was calculated. The pilot area represents 4% of Austria’s population.

Tier	Threshold	Comment
1	1.654	“Erstabschätzung abgeschlossen” A minimum data set is required for this standard assessment, which is primarily a desk study.
2	400	“Gefährdungsabschätzung durchgeführt”. Sites that were subject of an official risk assessment according to the national law (§13 ALSAG)
3	212	“Prioritätenausweisung”. Sites that were assigned with a priority for remediation
4	102	“Sanierung in Durchführung oder abgeschlossen“ Remediation either completed or in progress.
5	102	“Sanierung oder Sicherung abgeschlossen“ Sites were remediation measures were completed.

Definition of baselines

For this indicator the definition of a reference year is most appropriate; i.e. the year when the management process started.

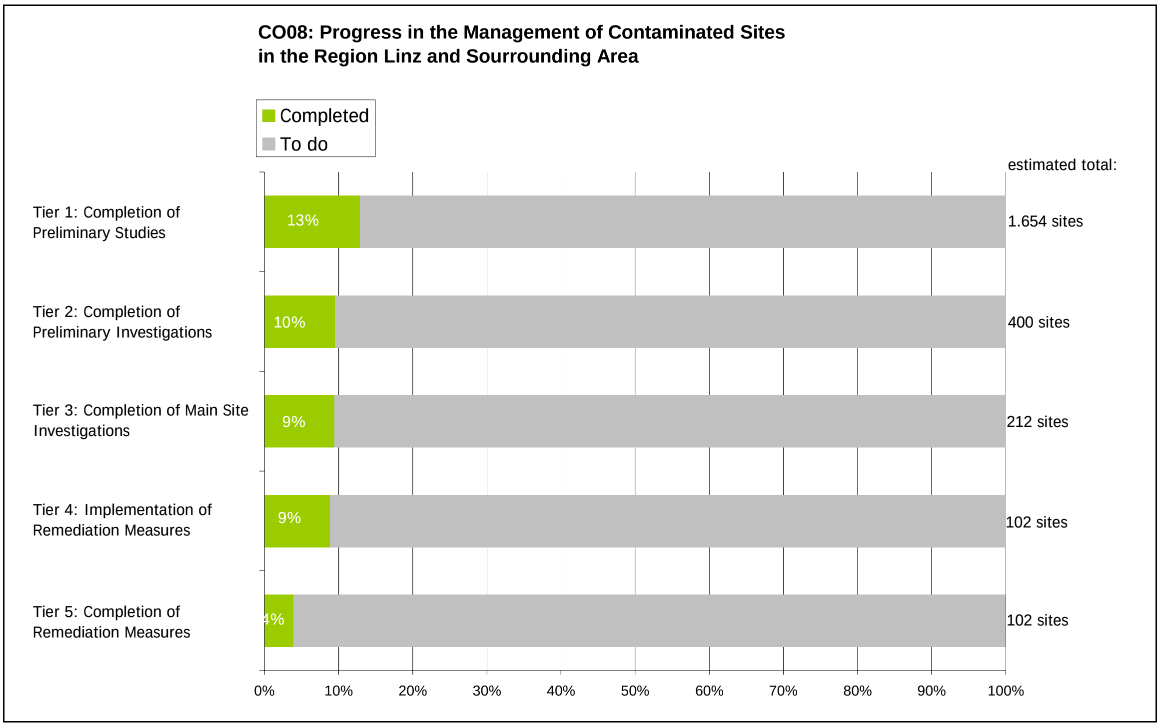
In the case of Austria, the year 1989 would be the most appropriate reference year.

Calculation of indicator

For each of the 5 tiers the percentage of completion is calculated.

Graphical presentation of indicator

Title: Progress in the Management of Contaminated Sites in the Pilot Area "Linz und Umgebung"



Evaluation of pilot results

Conclusions and recommendations

For monitoring at European level three management steps instead of five would be sufficient; i.e.

- Tier 1: Site identification
- Tier 2: Site assessment (the decision whether or not remediation is necessary)
- Tier 3: Site remediation (completed and in progress)

References

BMLFUW - Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft [Hrsg.] (2006): Hydrologischer Atlas Österreichs. 3. Lieferung, BMLFUW, Wien.

BMLFUW - Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft [Hrsg.] (2007): Altlastensanierung in Österreich: Effekte und Ausblick, Wien.

ESB – European Soil Bureau (1998): Soil Map of Europe 1:1 mio. JRC, European Commission.

NESTROY, O. (2002): Vergleichende Darstellung österreichischer und internationaler Bodensystematiken, basierend auf der bereinigten Fassung der Europa-Bodenkarte 1:1 Mio. vom Jahre 1998. In: Mitteilungen der Österreichischen Bodenkundlichen Gesellschaft, Heft 65, Wien 2002.

Pilot Area: England and Wales

Lead Partner: CU
Joao Pedro Carreira
Mark Kibblewhite
Monica Rivas-Casado

UL-F
Marko Zupan

Description of the Pilot Area

Name of pilot area		England and Wales, United Kingdom
Names of participating partners	**Lead partner**	**Joao Pedro Carreira Mark Kibblewhite Monica Rivas-Casado (CU)**
	Advisory Partner	Marko Zupan (UL – BF)
Location and description	Member State(s)	England, United Kingdom
	Coordinates	NW 5°W 55° N NE 2°E 55°N SW 5°W 50°N SE 2°E 50°N
	Area of pilot area (km^2)	150,000km^2
	Climate	Temperate Oceanic
	Mean temperature (FAO 2006*)	~ 10°C
	Average Annual Precipitation (FAO 2006	500-2500 mm
	Outline description of topography	High hills and rolling plains
	Elevation (m)	0 -1000 m
	Vegetation (FAO 2006)	Herbaceous, Woodland
	Major Land Use (FAO 2006)	Crops (30%) Grass (40%) Forest (10%) Urban (20%)
	Major soils (WRB 2006 RGs**)	Cambisols, Luvisols, Leptsols, Podzols, Fluvisols, Gleysols, Histosols, Stagnosols
A special investigation was made using data for a square sub-pilot area of 22,500 km^2 at NW 3°W 52° 0' N NE 2°E 52° 0' N SW 3°W 50° 40'N SE 2°E 50° 40'N		

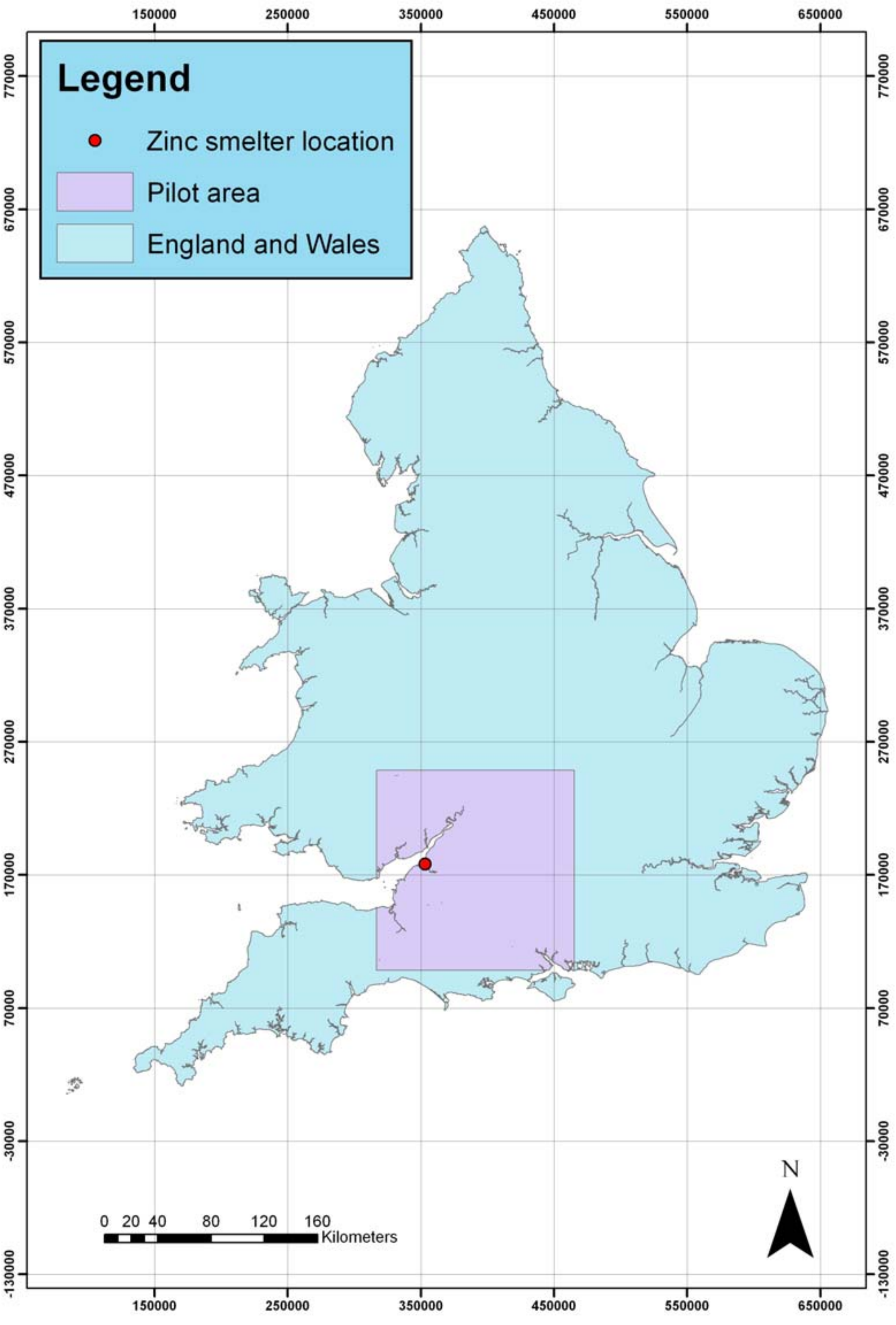


Figure 1. England and Wales pilot area

Threat and related indicator(s) evaluated in pilot area

Threat	Soil Contamination
Indicator	CO01 Heavy metal contents of soil

Rationale for selection of pilot area

England and Wales has a wide range of natural as well as past and current anthropogenic sources of contamination by heavy metals. A data set is readily available for cadmium and lead and some data is available for mercury.

The sub-pilot area includes a wide range of levels of natural background and contamination by cadmium. In particular it includes contamination from a large historic zinc smelter.

Indicator Evaluation

Indicator

The aim of this pilot was to investigate methods for estimating background values of heavy metals to be used when evaluating monitoring data for the indicator CO01 Heavy metal contents of soil.

Pilot description

Spatial extent

The main pilot area covers all of England and Wales (but not Scotland or Northern Ireland). The sub-pilot area covers parts of the counties of Somerset, Avon, Gloucestershire, Oxfordshire, Wiltshire, Hampshire and Dorset; it includes the major conurbation of Bristol and Bath. Within this sub-pilot area there are naturally elevated concentrations of cadmium. From about 1750 there has been intense industrial activity in this region, including smelting of metal ores and use of metals in manufacturing.

Data

The National Soil Inventory (NSI) provides data for 6127 plots located on a 5km grid. Two data sets were employed: NSI Topsoil1 and NSI Topsoil2.

The data for heavy metals was obtained by testing bulked sub-samples from each plot. The sampling depth was 15cm. cadmium and lead had been determined on aqua regia digests using Inductively Couple Plasma Optical Emission Spectrometry (ICP-OES). mercury was determined on nitric-sulphuric acid digests using cold-vapour atomic absorption spectrometry (AAS). The testing methods conform closely to those set out in the ENVASSO procedures and protocols

Topsoil1 samples were collected from 5686 plots between 1978 and 1983 and tested for cadmium and lead. Topsoil2 samples were collected from 2361 plots in the mid-1990's and tested for cadmium, lead and mercury.

Information on geology associated with plots was extracted from the NSI datasets. Information on soil types was extracted from Natmap Soilscape, which provides polygon vector data for 27 amalgamations of soil associations. Land cover information was extracted from CORINE.

Three methods for estimating background were investigated and modifications of these developed and tested.

1. ISO 19258:2005 was applied to the whole England and Wales data set, to determine means, standard deviations, medians, absolute medians and 10^{th} and 90^{th} percentiles
2. Data for the whole of England and Wales was categorised using ArcCatolog TM and ArcGISTM according to land cover, Soilscape and geology, to generate data subsets to which ISO 19258:2005 was applied.
3. Data for the sub-pilot area was Kriged and the generated surfaces explored to identify locations that could be described as background, by various techniques including visual trend analysis, lowest contour identification and location categorisation.

Pilot method

The whole of England and Wales data sets and transformations of these were examined for conformance to a normal distribution, using visual analysis of histogram, box and QQ plots and calculation of kurtosis and skewness parameters. For mercury conformance to a normal distribution remained weak due to the large number of test data reported as below the measurement detection limit (1614 out of 2361 samples). Prior to Kriging cadmium data for the sub-pilot area, two sample points were eliminated as potential outliers and the remaining data was transformed to SQRT([Cd]).

Method 1 (ISO 19258:2005)

Means, standard deviations, medians, median absolute deviations and 10^{th} and 90^{th} percentiles were identified in each of the transformed datasets to estimate background ranges of heavy metal concentrations in soils.

Table 1. Estimated background ranges of cadmium, lead and mercury in soil (mg kg^{-1}) in England and Wales

	Mean +/- 2 standard deviations	Median +/- 2 median absolute deviations	10^{th} to 90^{th} percentiles
cadmium	0.1 – 2.4	0.2 – 1.8	0.2 -1.4
lead	9 – 220	12 - 120	20 -130
mercury	0.0 – 0.6	0.0 – 0.3	0.1 – 0.5

Method 2 (Categorisation and ISO 19258:2005)

An analysis of variance (ANOVA) was made on the transformations of the whole of England and Wales data set using CORINE land cover, SoilScapes and NSI geology data to categorise plots locations. The mean cadmium and lead values for the categorised plots were compared. Mean cadmium concentrations for the agriculture and semi-natural / forest land cover categories were significantly different. Examination of probability plots for residuals confirmed that Ln(SQRT[Cd]+1) was the optimal transformation when examining the whole data set.

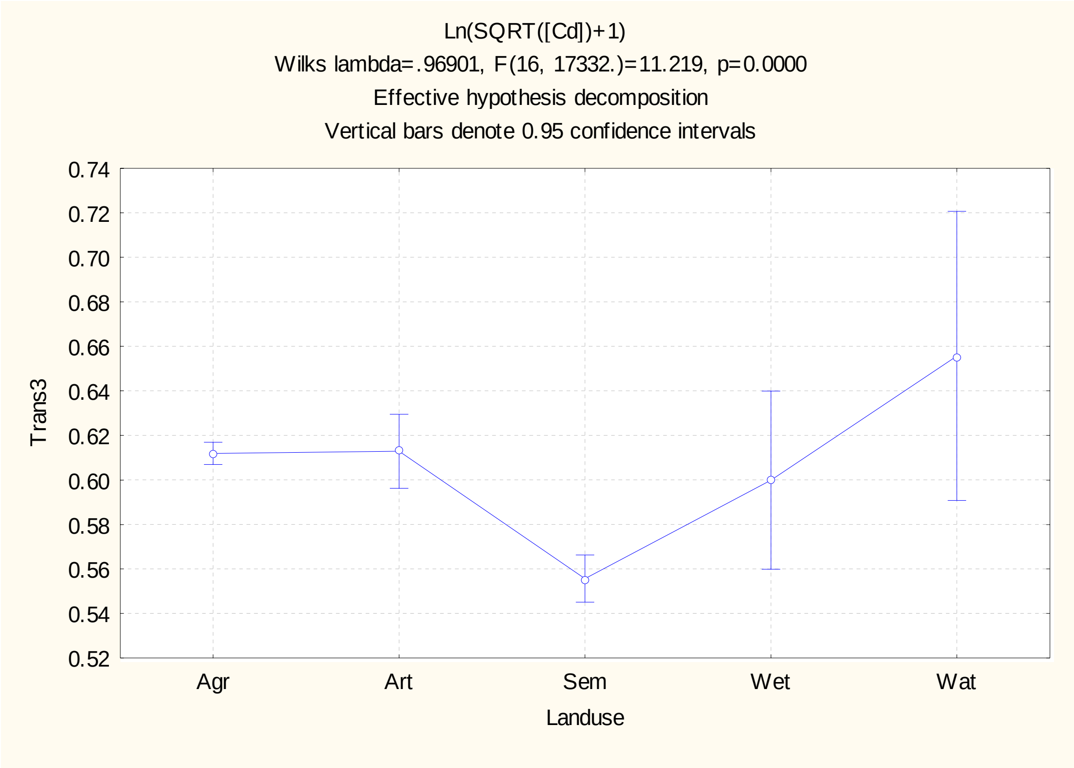


Figure 2. Comparison of mean transformed cadmium concentrations Ln (SQRT([Cd]+1) for different land cover categories

Means, medians and 10th and 90th percentiles for selected categories were identified to estimate background ranges of cadmium and lead concentration for sites categorised by land cover and sites categorised by selected land cover, geology and soil type combinations.

Table 2. Estimated background ranges of cadmium in soil (mg kg^{-1}) in England and Wales categorised by land cover, geology and soil type

Land Cover	Geology	Soil type	Mean +/- 2 standard deviations	Median +/- 2 median absolute deviations	10th to 90th percentiles
Artificial (Urban)	All	All	0.1 -2.3	0.2 – 2.0	0.2 -1.4
Agriculture	All	All	0.1 -2.3	0.3 – 1.9	0.3 -1.4
Semi-natural / forest	All	All	0.0 -2.4	0.1 -1.8	0.1 -1.3
Agriculture	Mudstone	Stagnic Luvisol	0.3 -1.9	0.4 -1.5	0.4 -1.4
	Chalky till	Luvic Stagnosol	0.2 – 1.3	0.2 – 1.1	0.3 -1.0
	Chalky till	Vertic Stagnosol	0.3 -1.4	0.4 -1.3	0.4 -1.2
	Sandstone/ mudstone/ shale	Histic Stagnosol	0.3 -2.3	0.2 -1.8	0.2 -1.4
Semi-natural / forest	Sandstone/ mudstone/ shale	Histic Stagnosol	0.0-1.7	0.1 -1.3	0.1 -1.0

Table 3. Estimated background ranges of lead in soil (mg kg^{-1}) categorised by land cover, geology and soil type

Land Cover	Geology	Soil type	Mean +/- 2 standard deviations	Median +/- 2 median absolute deviations	10th to 90th percentiles
Artificial (Urban)	All	All	11 - 370	17 – 210	28 -180
Agriculture	All	All	10 - 150	14 – 92	19 -84
Semi-natural / forest	All	All	11 – 450	16 -290	26 -230
Agriculture	Mudstone	Stagnic Luvisol	14 -110	17 -74	23 -89
	Chalky till	Luvic Stagnosol	9 - 65	11 -48	13 -42
	Chalky till	Vertic Stagnosol	12 -58	14 -48	16 -43
	Sandstone/ mudstone/ shale	Histic Stagnosol	14 -320	18 -220	28 -240
Semi-natural / forest	Sandstone/ mudstone/ shale	Histic Stagnosol	19 -500	29 -350	36 - 260

Method 3 (Spatial analysis relative to known anthropogenic source)

A semi-variogram was prepared from cadmium data for plots in the sub-pilot area which indicated spatial correlation.

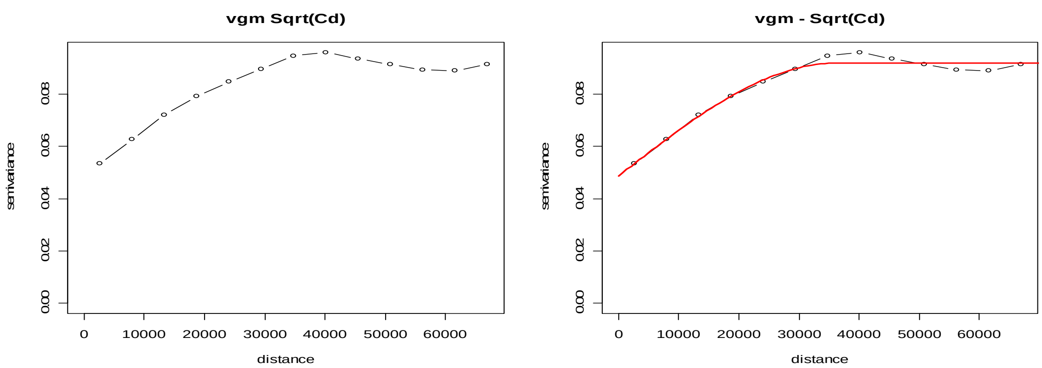


Figure 3. Semi-variogram of transformed cadmium concentrations (SQRT[Cd]) within sub-pilot area

The data was then Kriged to produce points on a 2km grid and these points were used to create a surface in ArcGIS^{TM} by simple spline interpolation. As expected, examination of prediction errors revealed higher errors in the vicinity of missing plot data, but overall prediction errors were a small compared with estimated values. Three transects were taken from the location of an historic zinc smelter with the objective of identifying values where the impact of past cadmium emissions was no longer evident and “return to background” values could be identified. The three estimates of background obtained were 0.9, 0.7 and 0.3 mg kg $^{-1}$. Contours with an interval of 0.1 mg kg $^{-1}$ of predicted cadmium concentration were drawn and background estimated as equivalent to the contour below the lowest contour completely encircling the smelter location. The estimate of background obtained was 0.7 mg kg $^{-1}$.

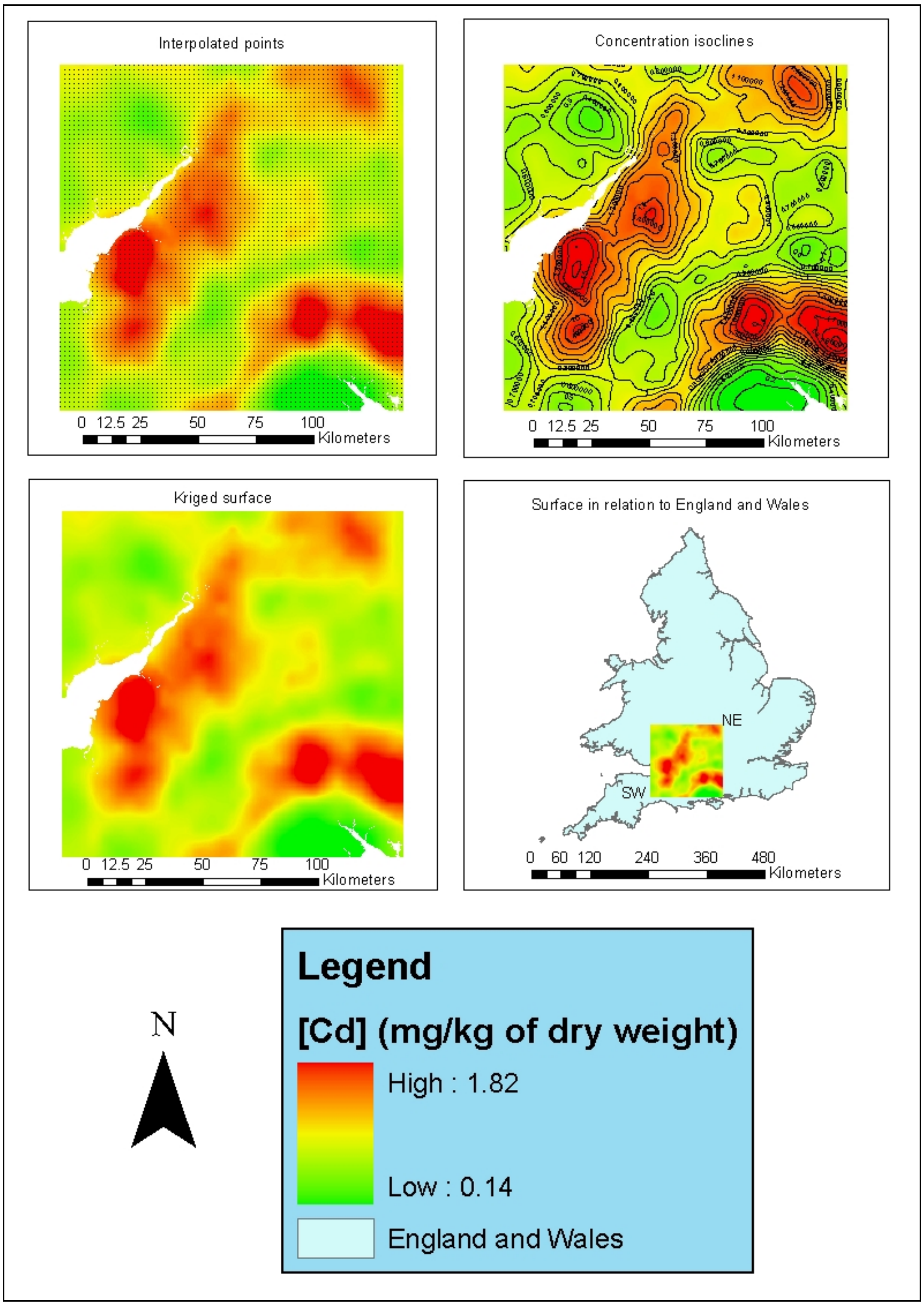


Figure 4. predicted cadmium concentration surface within sub-pilot area

Method 4 (Spatial analysis of plot characteristics)

A set of layers were generated using ArcMap^{TM} corresponding to distance from potential sources (artificial (urban), similar geology, semi-natural and forest areas, similar soilscape, and smelter location). The predicted concentration gradient (see Method 3) was included as a further layer on the basis that a high gradient may be indicative of local contamination. These layers were combined in a raster calculation (giving equal weighting to all layers) to produce a surface which was re-classified according to values from 1 to 5 where 1 is least suitable as a location for background estimation and 5 is most suitable. Zones with pixels with a value of 5 were identified and the predicted cadmium concentrations sampled within these to provide background estimates. Five zones were identified and sampled and the estimate of background obtained was 0.66 +/- 0.78 mg kg^{-1} or 0 to 1.4 mg kg^{-1}

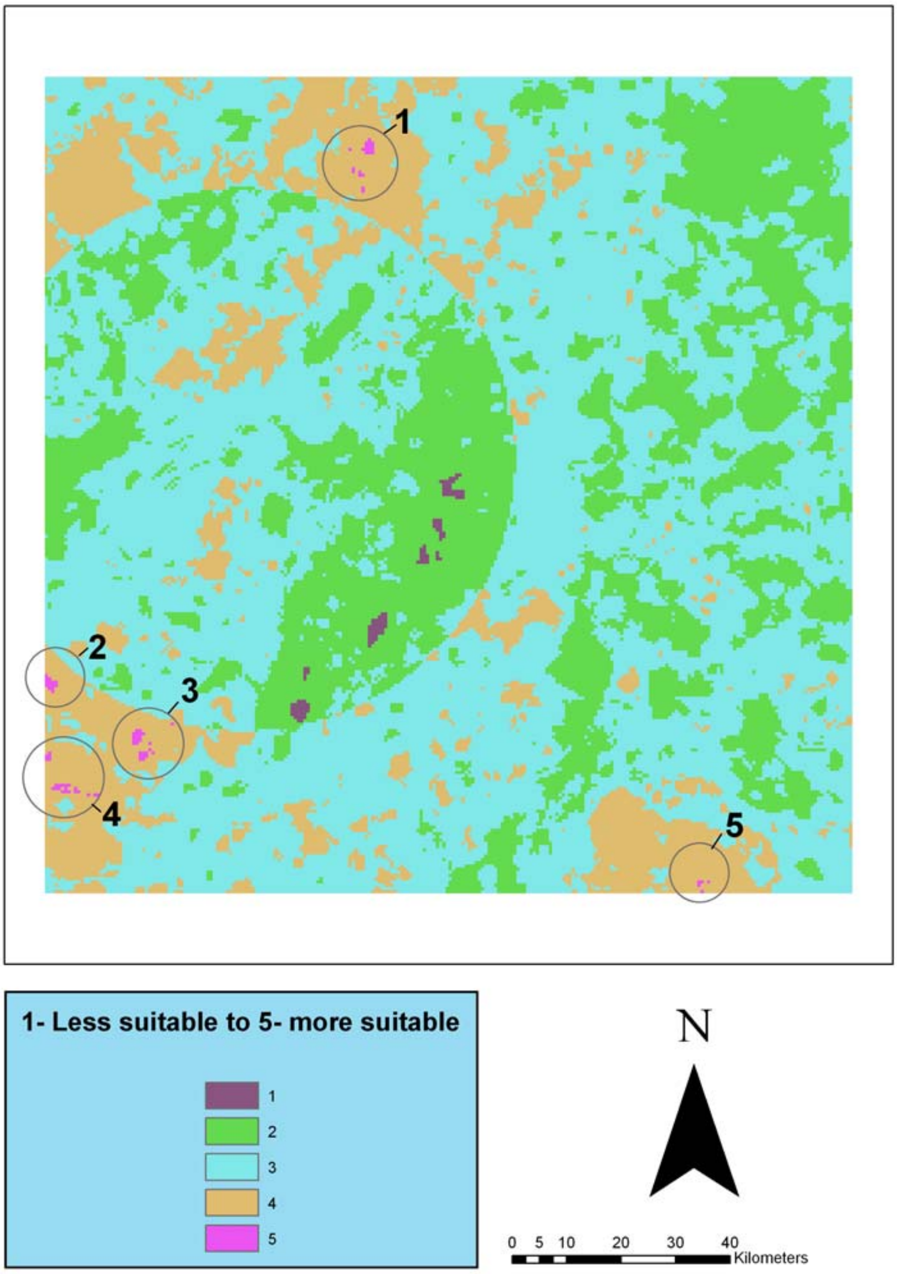


Figure 5. Re-classified raster surface identifying zones for estimating background ranges of cadmium concentration in sub-pilot area

Evaluation of pilot results

In the absence of any anthropogenic sources, natural variations in geochemistry lead to a wide range of metal contents in soils. For some soils these natural metal contents are much less than anthropogenic inputs but for others the opposite is true. Over larger areas than a few hectares, in industrialised landscapes, such as were examined in this study, some soils will have higher metal contents naturally while for others this is due to anthropogenic contamination. Thus the natural background levels and those enhanced by contamination overlap and the method described in ISO 19258:2005 cannot resolve them. However, the estimates of background ranges that are obtained provide useful information and can be used to identify soils that have particularly high levels of metals relative to those that prevail in the surrounding landscape.

Comparison of the estimated background ranges of metals obtained as the mean +/- two standard deviations, the median +/- two median absolute deviations and the range between the 10th and 90th percentiles indicates that narrower ranges were generally provided by the last of these methods and the widest ranges by the first. The influence of outliers on mean values is well known and the consequence in this context is that the indicated background range may be biased to higher or lower values. Therefore range estimation as the median +/- two median absolute deviations is preferred.

Categorisation of plots according to land cover reduces the heterogeneity of the landscapes being examined. Current land cover is not a reliable indicator of past land management: for example, many semi-natural areas in the pilot area have a past history of industrial uses including metal mining and processing. Nonetheless by categorising plot locations quite different estimates of background ranges were found for some land covers, for example agriculture and semi-natural categories (14-92 mg kg^{-1} and 16-290 mg kg^{-1} for lead contents, respectively). The influence of soil parent material is also clearly demonstrated by the different estimates of background ranges of lead in soil formed from chalky till as compared to sandstones, mudstones and shales (11-48 mg kg^{-1} and 18-220 mg kg^{-1}).

In the vicinity of an historic or current point source of soil contamination it is of interest to know the spatial extent of contamination and to estimate the level above which background contaminant levels have been enhanced. The former may be useful to define an area where remedial measures may be required. The latter provides a benchmark for assessing impacts from the contaminant that are not associated with the source. In this study the spatial extent of contamination by cadmium from an historic smelter was modelled by estimating concentration isoclines. Background was estimated by reference to the concentration at the edge of the apparent extent of influence. This method was not found to be satisfactory because the pattern of isoclines indicated that other sources were present within the area of influence, complicating the discernment of the boundary of this area. This suggested that a better approach would be to identify a number of different types of potential cadmium sources in the landscape and conduct a spatial analysis to identify locations where all of their different influences were expected to be weaker. These locations were successfully identified but the range of cadmium levels obtained was quite wide (0 to 1.4 mg kg^{-1}) and very similar to the estimate for all of England and Wales (0.2 to 1.8 mg kg^{-1}). Nonetheless this approach may be a valuable addition, because it offers a means for selecting sites for sampling background contaminant concentrations in soils which could be more efficient and no less powerful than sampling plots within for example a regular grid.

Conclusions and recommendations

1. Estimation of background ranges for heavy metals in soils can be achieved according to ISO 19258:2005 and the estimate based on the median +/- two absolute medians is preferred because it is less influenced by outliers.
2. Categorisation of data according to land cover and geology to estimate background ranges for heavy metals in soils within these categories is advantageous because different ranges result that can be more meaningfully compared with observed values for specific locations.

References

International Organisation for Standardisation (2005) ISO 19258:2005 – Soil Quality – Guidance on the Determination of Background Values

Pilot area: Warsaw, Poland

Lead Partner: WUT
Stanislaw Bialousz
Sebastian Rozycki
Przemyslaw Kupidura

Description of the Pilot Area

Name of pilot area		Warsaw (Poland)
Names of participating partners	**Lead partner**	**Stanislaw Bialousz Warsaw University of Technology (WUT), Faculty of Geodesy and Cartography**
Location and description	City	Warsaw
	Coordinates	52° 13'56.28'' N 21° 00'30.36'' E
	Area of pilot area	518 km^2
	Climate	Sub-atlantic climate
	Mean temprature (FAO 2006)	7,8ºC
	Average Annual Precipitation (FAO 2006)	493 mm
	Outline description of topography	Level land
	Elevation	78 – 115 m
	Vegetation (FAO 2006)	Herbaceous, Woodland, ...
	Major Land Use (FAO 2006)	Settlement, Industry (47.7%) Farming, Orchards (30.5%) Forestry (16.4%) ...
	Major Soils (WRB 2006 RGs)	Anthrosols (Hortic, Fluvic, Eutric, Technic) Fluvisols (Mollic, Eutric, Clayic) Luvisols (Haplic, Albic) Arenosols (Haplic, Brunic, Technic Podzols (Placic, Haplic)

Threat and related indicator evaluated in pilot area

Threat	Soil sealing
Indicator 1	SE01 sealed area

Rationale for selection of pilot area

Warsaw – capital city of Poland with 1,7 million citizens is the biggest polish city. There is large diversity of built up area types in Warsaw so the results of estimation of sealed area can be useful for other cities in Poland. Additionally, proposed methodology can be used for other countries for all types of land use.

There are many data sources existing for Warsaw (large scale city maps, topographic maps, satallite images etc.) so it can be considered as an excellent pilot area for development of methodology of sealed area (SE01) estimation.

Indicator Evaluation

Indicator

SE01 – sealed area

Pilot description

Spatial extent

Warsaw is the city located in the central-east part of Poland (Figure 1)

Figure 1. Location of Warsaw

Warsaw consists of many different types of built up areas, from very high density (historical city center) to very low density (residential housing, green areas). Accordingly, it can be considered as representative pilot for other cities.

Data

- large scale city maps – 1:1000
- topographic maps – 1:10000
- satellite images of very high resolution– QuickBird (pixel 0,61m x 0,61m), SPOT (2,5m x 2,5m)

Pilot methodology

The apparently best method for estimation of sealed areas is using cadastral data for estimation of built up areas. Unfortunately, lack of accurate information on sealed area within each built up area (or at least each kind of built up area) makes this source of data far imperfect for this purpose (Figure 2).

In the figure 2, lack of any information on actual sealed area can be seen. In polish cadaster there is no distinction between different types (depending on percentage of sealed area) of built up areas – they are marked with the same symbol.

The proposed method consists in measuring of sealed areas using large scale city maps and using estimated values in modeling using satellite images. Instead of large scale city maps, topographic maps can be used. The question: what is the accuracy of topographic maps (1:10000) depending on estimation of sealed areas, can be answered comparing results of measurement made on topographic maps and on city maps (treated as a ground truth).

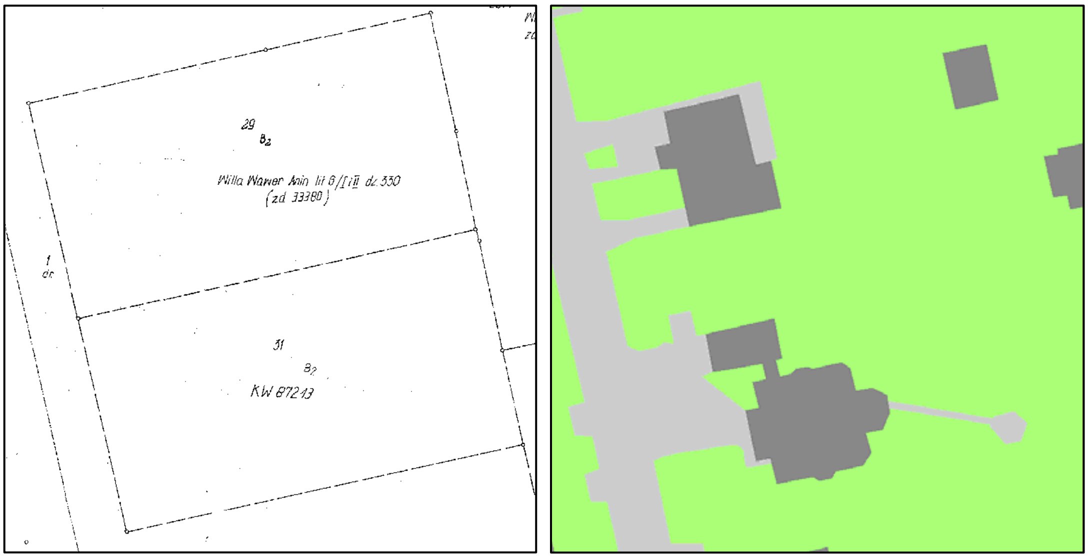


Figure 2. On the left – cadastral map, on the right – "ground truth" – result of measuring of city map.

Green –non-sealed area, grey – sealed area (dark grey – buildings, light grey - roads, paved foot-paths)

There are following classes of built up areas distinguished for pilot area:

a) very high density: old cities, traditional bordering buildings (tenement-houses with annexes, with „wells")
b) very high density: industrial areas
c) high density: bordering buildings along streets and with green areas inside
d) high density: public domain
e) medium density: blocks scattered in green areas
f) low density: residential housing
g) very low density: green areas

The methodology consists of following steps:

1a. Measurement of sealed area percentage on large scale city maps, for particular samples relevant to distinguished built up area classes
1b. Measurement of sealed area percentage on topographic maps, for particular samples relevant to distinguished built up area classes
2. Comparison of results of steps 1a and 1b – estimation of accuracy of topographic maps
3. Delimitation of particular zones of built up area in satellite image of very high resolution.
4. Estimation of total sealed area using sample values estimated in step 1.

Evaluation of pilot results

Table 1. Result of application of method

Class of built up area	Sealed area after city map [%]	Sealed area after topographic map [%]	Absolute difference between results [col 3 - col 2] [%]
1	2	3	4
Very high density (fig.3)	96	97	1
Very high density (industrial zones)	91	n.d.*	n.d.*
High density (bordering buildings) (fig.4)	74	79	5
High density (public domain) (fig.5)	75	78	3
Medium density (blocks) (fig.6)	52	47	5
Low density (fig.7)	26	23	3
Very low density	20	n.d.*	n.d.*

Figures 3 – 7 are showing comparison of accuracy of two different data sources: large scale maps and topographic maps. Despite some differences seen in these figures, obtained results showed in Table 1 prove, that topographic maps can be also considered as an efficient source of data for the purpose being discussed.

Figure 3. Zone of very high density, a) after city map, b) after topographic map

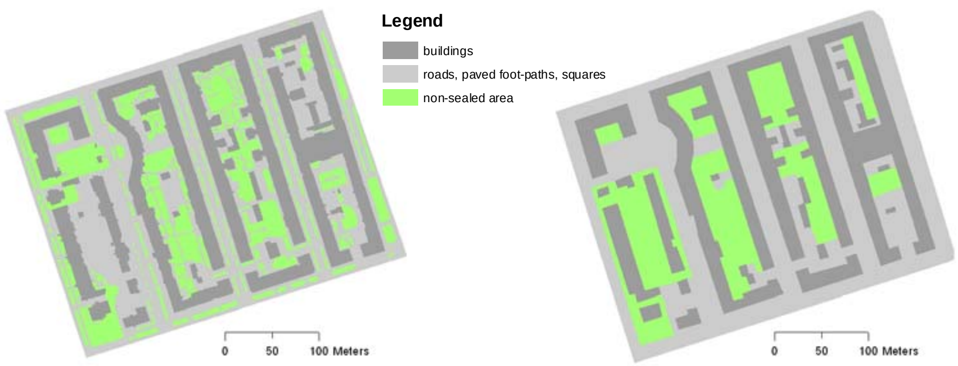


Figure 4. Class of high density (bordering buildings), a) after city map, b) after topographic map

Figure 5. Class of high density, a) after city map, b) after topographic map

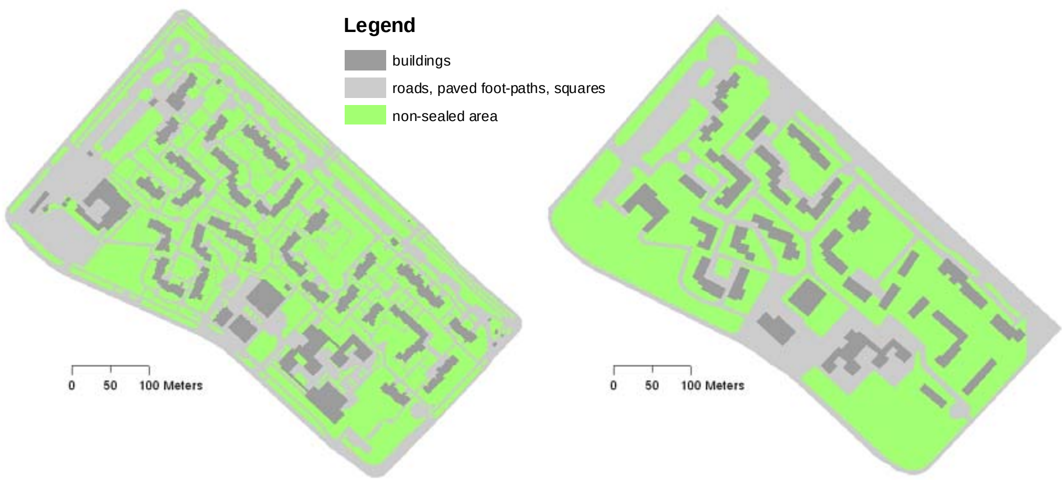


Figure 6. Class of medium density, a) after city map, b) after topographic map

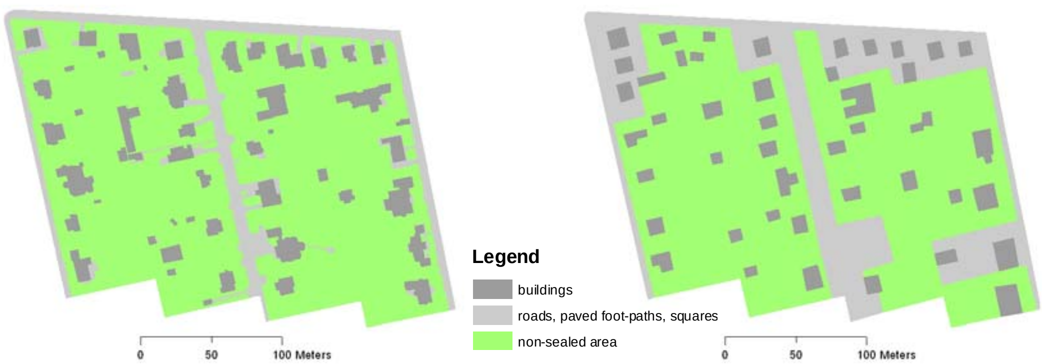


Figure 7. Class of low density, a) after city map, b) after topographic map

Figure 8 shows different classes of built up areas determined using QuickBird image, super imposed on the image.

Figure 8. Result of zone borders delimitation in satellite image (QuickBird)

Determination of particular built up area classes in the process of photo-interpretation of satellite image of very high resolution is sufficiently easy. As the last step of proposed method, one can use values of percentage of sealed area in different classes of built areas, for estimation of total percentage of sealed area for indicate area.

In this report there is no such summary for the city of Warsaw, because the delimitation of particular built up areas is not finished. Such a summary will be certainly placed in the final report.

Conclusions and recommendations

The percentage of sealed area within different classes of built up areas is very diversified. Due to this diversification, application of cadastral data for estimation of sealed area can be limited. The results obtained using this data source can be inaccurate. The most accurate method is the measurment on large scale maps. It is also time-consuming, so the modelling using samples determined on large scale maps and then delimitation of different classes in satellite image can be applied.

The conducted comparison shows that topographic maps can be used instead of large scale city maps. The difference between sealed area estimated on two types of maps is practically negligible.

Pilot area: North Rhine-Westphalia, Germany

Lead Partner: LANUV NRW
Heinz Neite,

Description of the Pilot Area

Name of pilot area		North Rhine-Westphalia (Germany)
Names of participating partners	**Lead partner**	**Heinz Neite, North Rhine-Westphalian State Agency for Nature, Environment and Consumer Protection (LANUV NRW)**
	Partner A	
	Partner B	
	Partner C	
Location and description	Member State(s)	North Rhine-Westphalia
	Coordinates	extreme border points: N: 8° 39'/ 52° 32' E: 9° 28'/ 51° 51' S: 6° 25'/ 50° 19' W: 5° 52'/ 51° 03'
	Area of pilot area (km^2)	approx. 34,000 km²
	Climate	Transition zone from atlantic to sub-atlantic climate
	Mean temperature (FAO 2006)	annual mean temp.: 5-9°C
	Average Annual Precipitation (FAO 2006)	annual average: 600-1500 mm
	Outline description of topography	level land, sloping land
	Elevation (m)	30-900 m
	Vegetation (FAO 2006)	Herbaceous, Woodland, …
	Major Land Use (FAO 2006)	Farming (50%); Forestry (25%); Settlement, Industry (21%), …
	Major soils (WRB 2006 RGs)	Cambisols, Luvisols, Planosols,

Threat and related indicator(s) evaluated in pilot area

Threat	Soil sealing
Indicator 1	SE01 sealed area
Indicator 2	-
Indicator 3	-

Rationale for selection of pilot area

North Rhine-Westphalia is the most populous and most densely populated German federal state where 18,1 million people are living on an area of 34084 km². With about 530 persons/km² its population density is higher than that of any other German territorial state and more than twice as high as the German mean (230 persons/km²).

With 22 % (in 2006) the percentage of settlement and transport area is also well above the mean for all other federal states with about 13 %. During the last 20 years the area used for settlement and transport increased steadily, between 1989 and 2005 by about 10 to 20 ha per day.

Normally this increase in settlement and transport area is to the detriment of agriculturally used areas. Agricultural land used for production of food and feeding stuff as well as renewable primary products decreased about 5 % in NRW during the last 15 years.

Indicator Evaluation

Indicator

SE01 sealed area

The term "Areas used for settlement and transport" should not be used synonymously with "Sealed area" of a region. Sealed areas are those overbuilt or covered by impermeable materials (e.g. area by concrete) that have permanently lost their natural functions as soils. In 2005 the percentage of sealed areas in NRW was about 46 % of the area used for settlement and transport but about 10 % of the total area.

Since 2005 information on the percentage of sealed areas are collected by all federal states in a standardised manner. They can be used for presentation of time-series and trends, with 2000 as a reference year.

Pilot description

Spatial extent

North Rhine-Westphalia (Nordrhein-Westfalen) is one of 16 federal states of Germany located in the middle of Europe also bordering the Netherlands and Belgium (fig. 1).

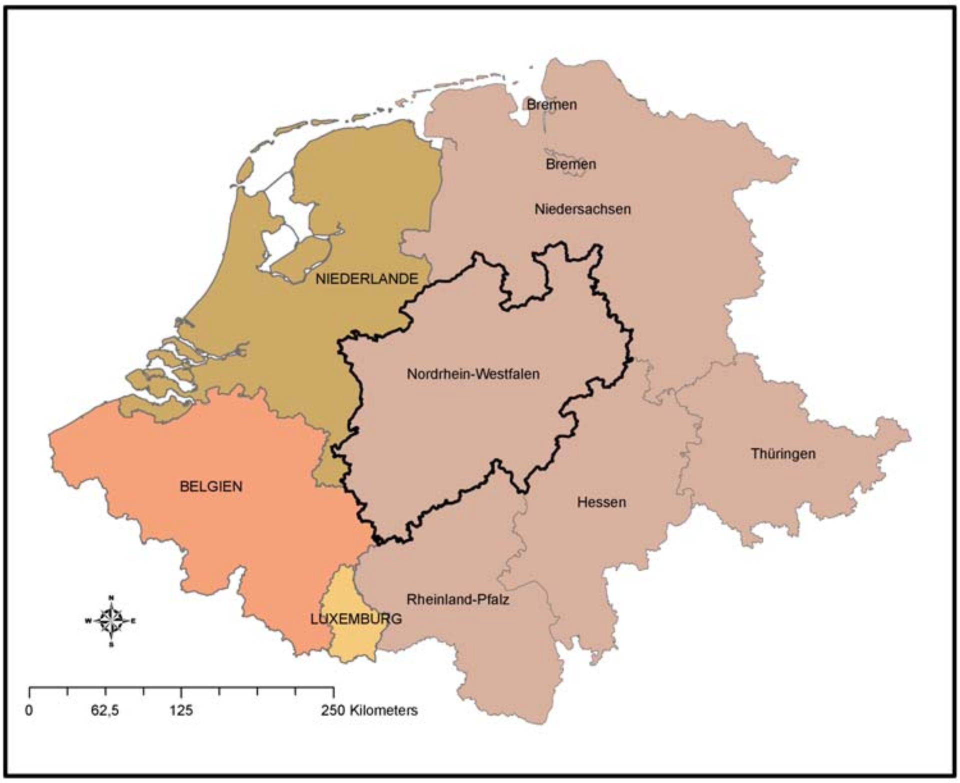


Figure 1. Location of North Rhine-Westphalia

Physio-geographically, NRW can be considered highly representative for most central European landscapes: Pleistocene lowlands in the north, vast Holocene alluvial down-stream sediments, and mountain ranges, composed of mainly shifts from the Variscan

Orogen. Mesozoic geology (e.g. Bunter Sandstone or limestone) which is otherwise very typical for central European mountain ranges, is not well-represented in NRW.

At the continental scale, NRW represents a very specific mosaic of land uses: one of the most densely populated industrial and urban regions in Europe on the one hand and rural regions on the other hand, which are agriculture-dominated in the North, and forestry-dominated in the South.

Data sources

The determination of the "sealed area" is based on a survey of actual land uses, conducted by all states in accordance with the agrarian statistics law. In this context areas used for settlement and transport area determined by the land-registry of districts and independent cities each year and reported to the state agencies for data processing and statistics.

The following land uses are included by areas used for settlement and transport:

- Areas covered by buildings and open space
- Plant areas exclusive of digging and mining areas
- Recreation areas
- Transport areas
- Cemeteries

In comparison to other base data (e.g. analysis of satellite images or aerial photographs) the data of area surveys differentiated by actual land uses are:

- available in all federal states in the same quality and data density since 2000
- and therefore are qualified for time-series.

Pilot methodology

Sealing in particular depends on the development of areas used for settlement and transport. In that process soils are overbuilt, paved, heavily compacted or totally or partially sealed in different ways. Settlement and transport areas include however considerable amounts of not-sealed sites without being covered by buildings as well. Therefore, sealed areas are defined as those sub areas used for settlement and transport that are totally overbuilt or covered (e.g. asphalt or concrete roads).

As, up to now, area-wide data on soil sealing exist neither in NRW nor for the whole of Germany, sealing usually is estimated on the basis of the survey differentiated by actual land use. Further calculations are made by allocating specific ratios of sealing for every type of land use. The ranges for percentage of sealed area mentioned in table 1 were confirms in different studies.

Table 1. proportion of sealed area for different types of land use (LU) assigned to areas used for settlement and transport, reference year 2000

Land use (LU)	LU-code	percentage of sealed area (min. – max.) (%)	percentage of sealed area depending on settlement density?
Transport areas	LU 500	50-70	yes
Areas covered by buildings and open space	LU 100/ 200	45-55	yes
Recreation areas	LU 400	10-15	yes
Plant areas exclude of digging and mining areas	LU 300	20	no
Cemeteries	LU 940	15	no

The mentioned percentage of sealed area are not identical everywhere. In parts they depend on the density of settlement (see table 1). Areas for buildings, traffic infrastructure and recreation are in short supply in densely settled regions, so sites are used more intensively, and thus the percentage of sealed area is higher. On the other hand, the percentage of sealing on plant areas and cemeteries is assumed not to depend on the density of settlement.

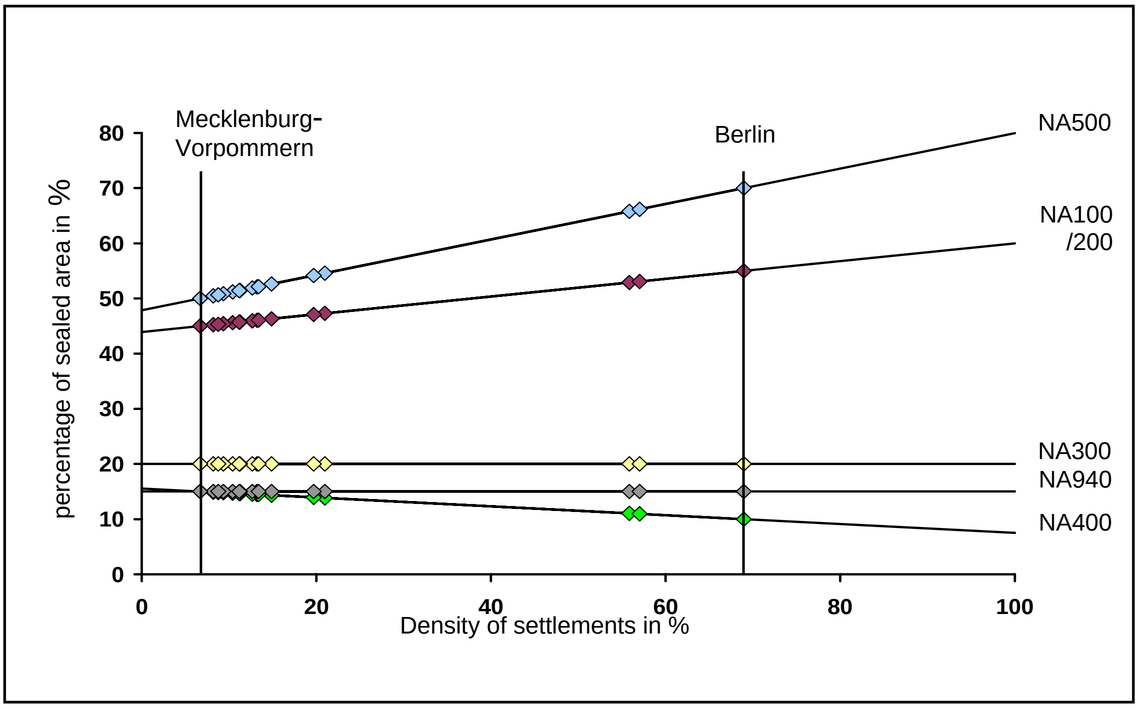
As a measure of density the density of settlement (i.e. the proportion of the area used for settlement and transport of the total surface area of the federal state) is taken into account for further calculations. The density of settlement in NRW was about 21 % in 2000.

As a next step minimum and maximum values of the ratios of sealing (see tab. 1) are related to the values of settlement density in 2000. The minimum values are allotted to that federal state with the lowest settlement density (Mecklenburg-Vorpommern: 6.7 %), maximum values to that with the highest density respectively (Berlin: 69%). All other states are ranked on a straight line between these two extremes.

From fig. 2 the percentage of sealed area for every type of land use (LU) for instance can be read for NRW with the density of settlement of 21 %. These are:

- Transport areas (LU 500) 56 % of sealed area
- Areas covered by buildings and open space (LU 100/200) 48 % of sealed area
- Recreation areas (LU 400) 13 % of sealed area
- Plant areas (LU 300) 20% of sealed area
- Cemeteries (LU 940) 15 % of sealed area

The sealed area of a federal state results from the sum of the sealed areas of these five types of land use within the area used for settlement and transport.



NA = type of land use-codes see table 1,
Source:figure from UGRdL (http://www.ugrdl.de/introduction.htm)

Figure 2. proportion of sealed area differentiated by types of land use and federal states in relation to density of settlement for the reference-year 2000.

Evaluation of pilot results

Pilot results

Results for areas used for settlement and transport and thus estimated sealed areas are available since 2000. They can be specified as absolute values (as ha), as an index (year of reference 2000 = 100) or as the daily increase (ha/day).

Between 2000 and 2006 (table 2) the area used for settlement and transport in NRW has increased from 714,700 ha to 747,100 ha (that are 21.9 % of the states territory of about 3,400,000 ha overall). That corresponds to an increase over a period of 6 years:

- of 32400 ha or 324 km² in total
- of 4:5 % referring to the reference year 2000
- of about 14:8 ha per day.

Table 2. Increase of land use for settlement and transport in NRW between 2000 and 2006

	2000	2001	2002	2003	2004	2005	2006	2000-2006
ha	714700	720700	726500	729800	737000	741800	747100	**32400**
% (2000=100)	100	100.8	101.6	102.1	103.1	103.8	104.5	**4.5**
ha/ day	-	16.4	15.9	9.0	19.7	13.2	17.3	**14.8**

Since the year 2000 up to 2006 (see table 2) the sealed area in NRW has increased from 3320 to 3457 km² (that are 46.3 % of the area used for settlement and transport). That's an increase over a period of 6 years:

- of 13700 ha or 137 km² in total
- of 4.1 % referring to the reference year 2000
- of about 6.3 ha per day.

Table 3. Increase of sealed area in NRW between 2000 and 2006

	2000	2001	2002	2003	2004	2005	2006	2000-2006
ha	332000	334500	337200	338500	341500	343400	345700	**13700**
% (2000=100)	100	100.8	101.6	102.0	102.9	103.5	104.1	**4.1**
ha/ day	-	6.8	7.4	3.6	8.2	5.2	6.3	**6.3**

Conclusions and recommendations

With regard to the threat „soil sealing“ the indicator „sealed area“ is applied to the pilot under the terms of an actual method harmonised at the federal level. The findings from the pilot NRW indicate that the indicator "sealed area" is suitable to demonstrate and monitor impacts on the environment caused by consumption of land:

- base data are collected with a standardised method in all federal states since 2000,
- with these data time series can be generated providing prediction of trends,
- the presented method for calculating the indicator is easy and comprehensible.

With the indicator "sealed area" the development of soil sealing within areas used for settlement and transport can annually be estimated for NRW – as well as for the other federal states. Therefore yet another aspect concerning effects to the environment caused by land consumption will be acquirable.

However the indicator "sealed area" covers only a part of environmental detraction caused by land consumption. Thus the indicator "sealed area" cannot replace the indicator "land consumption by settlements and transport" (ENVASSO-Indicator SE03), but delivers important and valuable additional information.

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Pilot area: Chemnitz, Germany and Czech Republic

Lead Partner: LfUG
Heiner Heilmann, Ronald Symmangk, Anna Böhm

Josef Kozak, Vit Penizek (CUA)

Rainer Baritz, Jan Willer, Einar Eberhardt, Jens Utermann (BGR)

Description of the Pilot Area

Name of pilot area:		**Pilot area 1:250,000 Sheet Chemnitz (Germany-CZ)**
Names of participating partners	**Lead partner**	**Heiner Heilmann, Ronald Symmangk, Anna Böhm (LfUG)**
	Partner CZ	Josef Kozak, Vit Penizek (CUA)
	Partner WP3	Rainer Baritz, Jan Willer, Einar Eberhardt, Jens Utermann (BGR)
Location and description	Member State(s)	CZ and Germany (mainly parts of Saxony, smaller area of Thuringia and Bavaria)
	Coordinates	coordinates (map corners, WGS84) X Y NW 12° 0' 0"E 51° 0' 0"N NE 14° 0' 0"E 51° 0' 0"N SW 12° 0' 0"E 50° 0' 0"N SE 14° 0' 0"E 50° 0' 0"N
	Area of pilot area (km^2)	appr. 15,753 km²
	Climate	temperate suboceanic to temperate-subcontinental (acc. to soil regions vers. 2.0)
	Mean temperature (FAO 2006)	annual mean temp.: 5.2-8.2°C
	Average Annual Precipitation (FAO 2006)	annual average: 600-1500 mm
	Outline description of topography	level land, sloping land
	Elevation (m)	666 - 1011 m
	Vegetation (FAO 2006)	Herbaceous, Woodland, …
	Major Land Use (FAO 2006)	cropland (36%), forest (30%), grassland (8%), urban (9%), heterogeneous agricultural land (10%), Scrubs (5%)
	Major soils (WRB 2006 RSGs)	Cambisols, Luvisols, Albeluvisols, Podzols, Chernozems, Andosols

Threat and related indicator(s) evaluated in pilot area

Threat	**Soil Sealing**
Indicator 1	SE01 Sealed Area

Rationale for selection of pilot area

For the area of the map sheet Chemnitz of the European soil map 1 : 250,000, the problems related to cross-border calculation of indicators for soil sealing can be demonstrated. Data availability and methods of data generation and processing greatly vary between the Czech Republic and Germany.

Indicator Evaluation

Pilot description

Spatial extent

The map sheet covers the area starting from Thuringia in the north-west, and a small area of Bavaria in the south-east, and reaches almost to the city of Dresden in the north-east and to Prague in the south-eastern part.

Data sources

The data from Saxony were obtained from different sources like statistical data, cadastral data and remote sensing data. Statistical data were focused and were the base for the cadastral method according to procedures and protocols.

The analyses of extent of sealed soil in the Czech part of the pilot area Chemnitz was based on CORINE data. Availability of other data is limited. The cadastral maps, which are used for delineation, are not fully digitized yet. Vectorized form of the cadastral map covers minor area. Remote sensing data are another possible source of data that can be used for sealing delineation, but it requires a advanced processing. CORINE are an easily accessible source of data that can be process by simply GIS tools. Precision of the data is limited, but still, it can provide at least an overview of the status of sealing.

Pilot method

Saxony - Statistical data (Cadastral Method)

Statistical, cadastral data of the 230 municipalities in the Saxon part of the pilot area in 2006 (http://www.statistik.sachsen.de) were used to calculate sealing parameters according to procedures and protocols of WP4. The used approach for the Saxon part of the pilot area is similar to the approach of North Rhine Westphalia.

Because of the demands of procedure and protocols the following definitions were made which enabled the calculation of the different components of SE01-indicator.

Definitions:

- consumed land:
  This is the area of settlement and transport. To this area belong building gaps, brownfields and other open areas (e.g. for recreational purposes) too.
- sealed area:
  It is calculated by multiplication of consumed land with the average sealing coefficient of 0.5. This value is commonly used and is considered as a good measure for the grade of sealing in municipalities.
- potential permanent settlement area:
  This is the area of settlement and transport too, because there are many internal reserves for establishing new settlement and transport infrastructure. These reserves are enough to satisfy the needs of new areas for permanent settlement.
- area not suitable for permanent settlement:
  These are all areas which belong to nature protection areas, FFH[8]-reserves (according to NATURA 2000), SPA[9]-reserves (according to NATURA 2000), woodlands, grasslands and surface waters.

The values which were calculated are presented in Table 1.

[8] FFH – Flora-Fauna-Habitats Directive
[9] SPA – Special Protected Area

Table 1. Summarised values of soil sealing in the Saxonian part of the pilot area

	2000	2001	2002	2003	2004	2005	2006
A_{MUN} [ha]*	743790	743801	743798	743815	743828	743847	743887
A_{ST} [ha]	93030	94146	95006	95627	96444	96593	97445
A_S [ha]	46515	46934	47503	47814	48222	48297	48723
Rel. A_S_A_{MUN} [%]	6,3	6,3	6,4	6,4	6,5	6,5	6,5
Rel. A_S_A_{ST} [%]	50	50	50	50	50	50	50
G_{ABS} [ha]	0	419	570	311	409	75	426
G_{REL} [%]	0,0	0,9	1,2	0,7	0,9	0,2	0,9
GR [ha*d^{-1}]	0,0	1,1	1,6	0,9	1,1	0,2	1,1
GR [ha*yr^{-1}]	average growth of sealed area in 2000-2006: **315 ha*yr^{-1}**						

(derived from municipality data)

A_{MUN}…area of the municipalities; **A_{ST}**…area of settlement and transport; **A_S**…sealed area, **Rel. A_S_A_{MUN}**…percentage of sealed area in the municipalities, **G_{ABS}**…absolute increase of sealed area from year to year; **G_{REL}**…relative increase of sealed area from year to year; **GR**…growth rate in [ha*d^{-1}] and [ha*yr] *…small differences in A_{MUN} from year to year are caused by benefits and losses of areas which belong to municipalities at the border of map

At first the sealed area (A_S) was calculated (Step 1 of procedures and protocols) as described in the respective definition above. By this the total sealed area in [ha] was received (Figure 1).

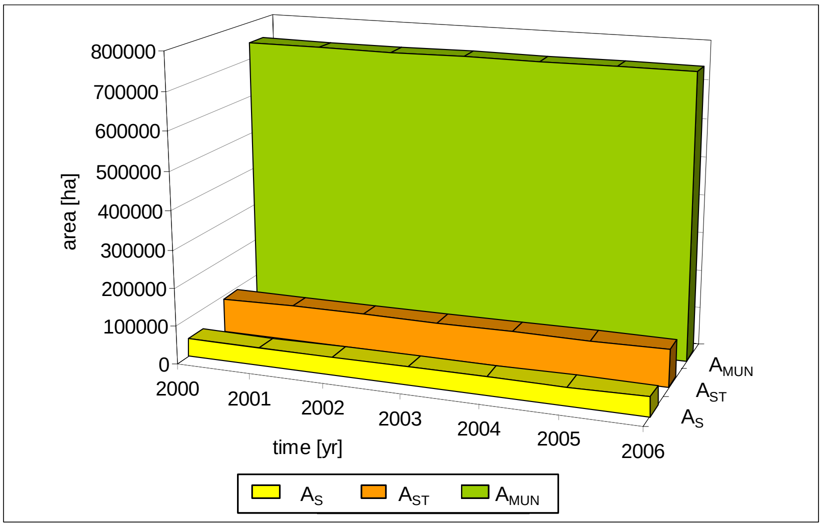

Figure 1. Development of the area of municipalities (A_{MUN}), area for settlement and transport (A_{ST}) and sealed area (A_S) in the pilot area

In the next step the percentage of sealed area in the municipalities (Rel. A_S_A_{MUN}) and the sealing degree of consumed land (Rel. A_S_A_{ST}) were calculated (Step 2 of procedures and protocols). Because of using a sealing coefficient of 0.5, the percentage of sealed area in the area of settlement and transport is always 50%.

To follow further Step 2 the 'area not suitable for permanent settlement' was determined by using GIS. First the areas of respective categories as defined above were identified and joined to one geometry in the GIS. After that this new geometry was intersected with the geometry of the municipalities in 2006 which resulted in the 'area not suitable for permanent settlement' per municipality. The 'area not suitable for permanent settlement' in the pilot area as a whole contains 311760ha.

The area that is potentially suitable for permanent human habitation was not calculated by subtracting the ‘area not suitable for permanent settlement’ from the total area of the municipalities (Step 2, iv) c)), because that makes no sense as the following example (Table 2) of one municipality in the pilot area shows:

Table 2. Calculated potential permanent settlement area

Municipality:	**Mildenau**
Area of the municipality[ha]:	3167
Area not suitable for permanent settlement [ha]:	1403
Area of settlement and transport [ha]:	241
Area potentially suitable for permanent settlement (Step 2, iv) c)) [ha]:	**1523**

This calculated potential permanent settlement area would have a size of ca. 1500 ha, but it includes all arable land. In the case of arable land only a small proportion according to zoning plan of Saxony can be used for settlement and transport in the future, but generally the exact proportion can hardly be foreseen. That is why the already consumed land was defined as potential permanent settlement area.

Additionally, the potential permanent settlement area for the pilot area as a whole can be enhanced by an area that is derived from the ‘Strategy of sustainability in Saxony’ (SMUL 2007). On the basis of this strategy a land consumption of 2.5 $ha \cdot d^{-1}$ is planned in Saxony from 2008 up to 2010, which equals a yearly increase of the potential permanent settlement area of around 370 $ha \cdot yr^{-1}$ in the pilot area in general as from 2008. The exact distribution to the particular municipalities is not yet known and depends on the importance of local or regional functions of the respective municipalities.

Finally the absolute and relative increase (G_{ABS}, G_{REL}) as well as the growth rate (GR) was calculated using Step 3 of procedures and protocols. The absolute and relative increase was calculated from year to year and sealed area in 2000 complies 100% (Figure 2).

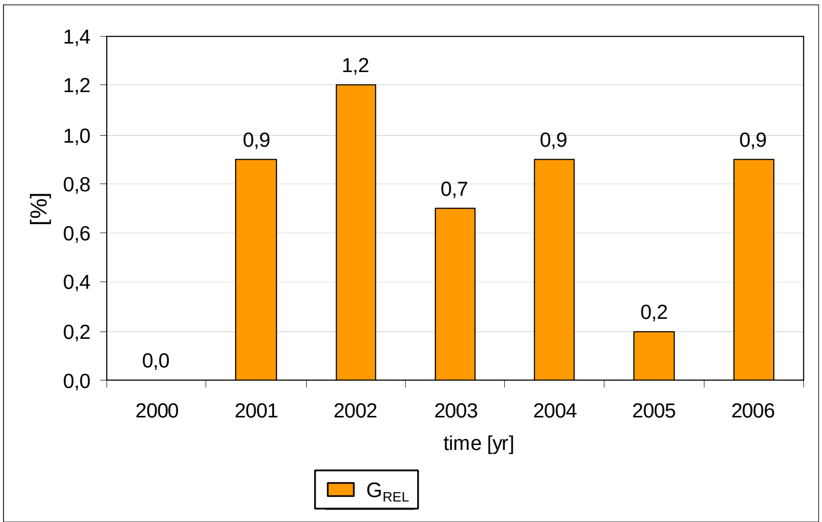

Figure 2. Relative growth (G_{REL}) in [%] of sealed area from year to year (sealed area in 2000 = 100%)

In the years from 2000 to 2006 the sealed area increased between 0.2% and 1.2%. per year This sums up to a total relative increase of 4.7%. A strong increase happened from 2005 to 2006. That could be an effect of abolishing the public subsidies for building of private homes in 2006 (so called 'Eigenheimzulage'). Furthermore an above-average economic growth of 4.1% (is the real increase in the gross domestic product) was recorded for Saxony in 2006 (http://www.statistik.sachsen.de).

Saxony - Cadastral data

A further possibility to determine soil sealing in Saxony is using cadastral data from the Saxon State Agency for Surveying. These data have a high spatial resolution up to a scale of 1 : 500. Because each particular parcel of land is identifiable with its respective use, soil sealing can be determined exactly. An example of the data is displayed in Figure 3, which shows the municipality of 'Freiberg' (part of the pilot area). The summarized land use categories were classified from 77 several kinds of land use objects. For each parcel, different sealing coefficients - depending on land-use - can be used for calculating soil sealing.

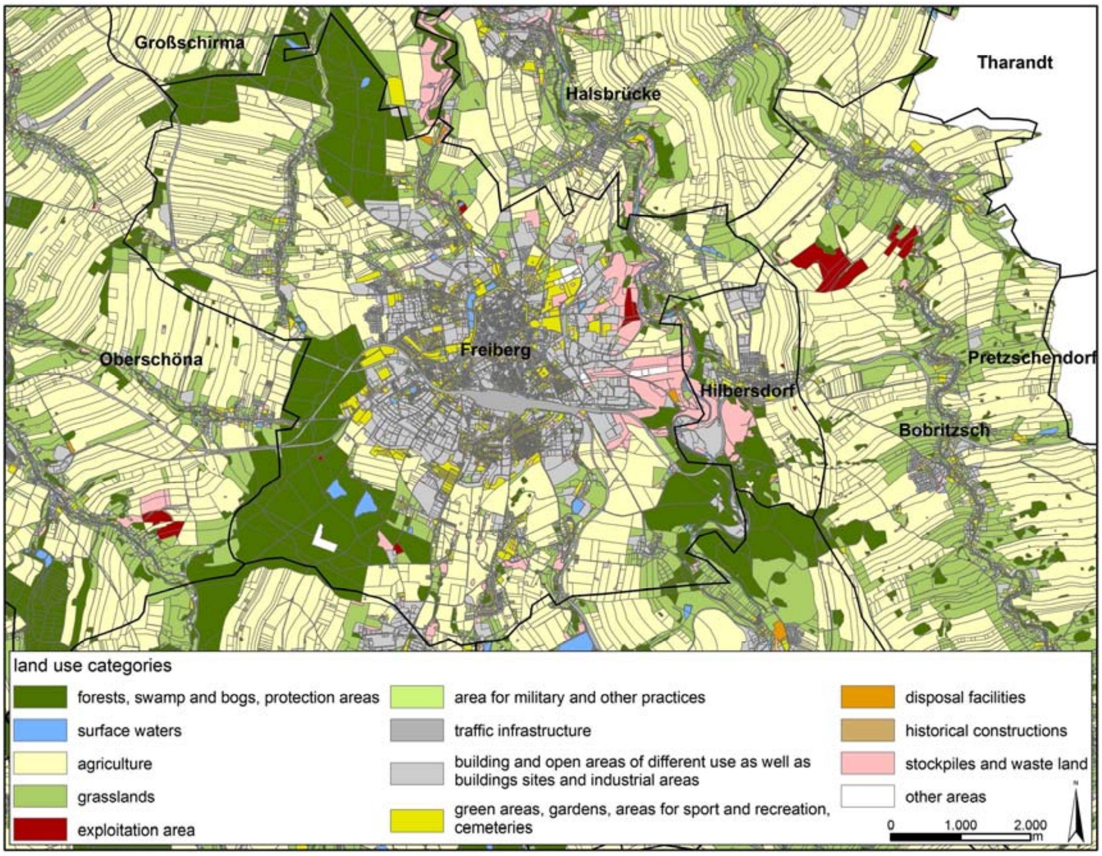

Figure 3. Summarised land use categories on the basis of cadastral data of high resolution

Data source: Saxon State Agency for Land Survey

These data, however, could not be used for the calculations in ENVASSO, because the data for the different municipalities were obtained in various years. This is why a data harmonization would be necessary before it will be possible to determine soil sealing in large areas. Furthermore, for some municipalities in the pilot area data are not yet available.

Saxony - Remote sensing data

A third possibility for determination soil sealing is remote sensing data. For the year 2003 such data are available from IRS-1c-satellite (Indian Remote Sensing Satellite).
For the analysis of images a "multiple level of detail"-approach was used, because images of different spatial resolutions (panchromatic-images 5x5m, spectral images 23x23m) were combined (LfUG 2003).

One step in the analysis of the remote sensing data (spectral images of IRS 1c) was a land use classification using ERDAS Imagine- and eCognition-software. After that the respective land use classes of settlement and transport were classified using NDVI in order to determine soil sealing. Results of this classification were 11 classes of sealing degree (classes: [1]: 0%, [2]: 1-10%, [3]: 11-20%, [4]: 21-30%, [5]: 31-40%, [6]: 41-50%, [7]: 51-60%, [8]: 61-70% ,[9]: 71-80%, [10]: 81-90%, [11]: 91-100%). In table 3 some examples for the soil cover in dependence of sealing degree are given (LfUG 2003).

Table 3. Examples of sealing degree and respective soil covers (LfUG 2003)

sealing degree (%)	soil cover
0	natural soils
20	unmounted pathways
30	sports field
40	water permeable covers (gravel surfaces), perforated flagstones on natural soils
60	small cobbles with large and open joints
70	medium and large cobbles with open joints over a sand and gravel bed
80	bound cobbles and flagstones
90	asphalt layers, cobbles and flagstones with closed joints, demolition areas (with concreted parts)
100	buildings

The results of sealing classification from remote sensing data fit well with the statistical data as the comparison of both data sources shows (Table. 4).

Table 4. Comparison of soil sealing derived from statistical data and remote sensing data in 2003

	statistical data	remote sensing data
area of settlement and transport	95.627 ha	**124.766 ha** = sum of all sealing classes with 1-100% soil sealing
sealed area	47.814 ha	**55.610 ha** = sum of all sealing classes with 41-100% soil sealing

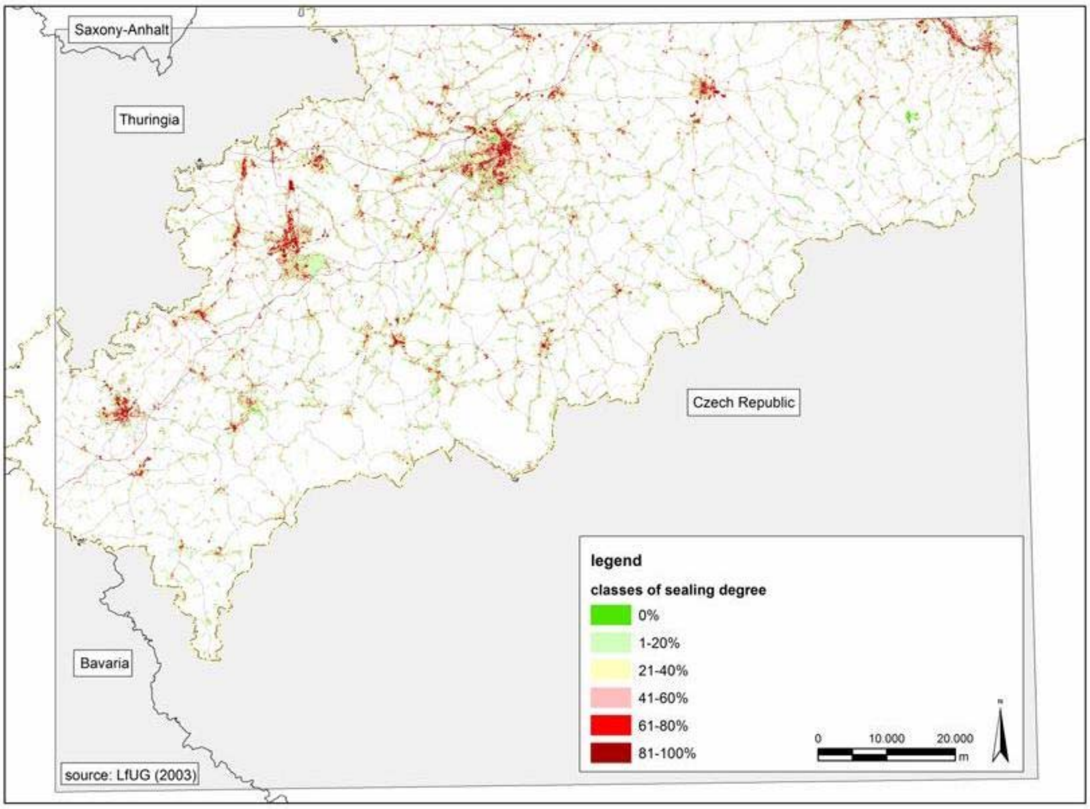

Figure 4. Map of soil sealing in the Saxon part of the pilot area

The area of settlement and transport from remote sensing data correspond to the sum of all sealing classes with a sealing degree equal or higher than 1%. Sealed area was calculated according to the assumption that the area of settlement and transport in Saxony has a sealing degree of 50%. That's why classes with a sealing degree of 41% or higher were summarized.

Besides these calculations an important result derived from the remote sensing data was a map of the different sealing classes (LfUG 2003) (Figure 4). The map (Figure 4) displays the spatial distribution of soil sealing over the Saxonian part of the pilot area. But high resolution of the remote sensing data (especially the panchromatic images) allows zooming into the map to show more details (Figure 5).

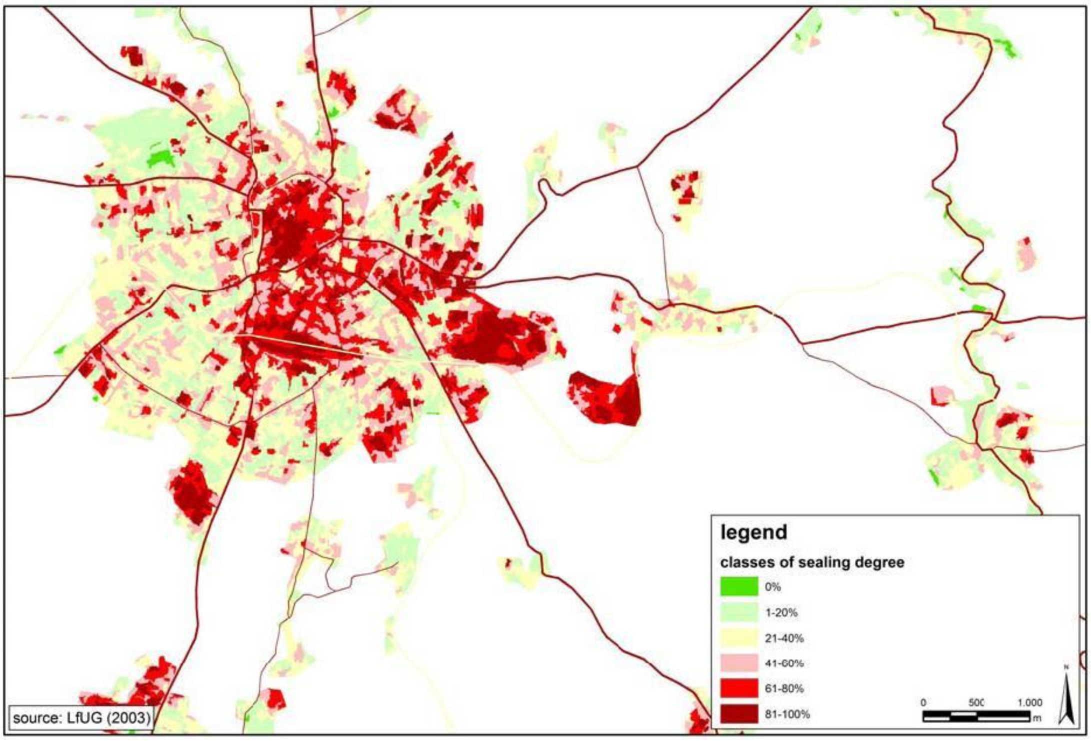

Figure 5. Detailed map of soil sealing in 'Freiberg' (Saxony) and its surrounding areas

The chosen IRS-1c-data comply with the remote sensing method according to procedures and protocols. In this case the remote sensing data has to be intersected with relevant assessment units (for example municipalities) to calculate sealed area per assessment unit and the further required parameters from procedures and protocols. However, Saxonian remote sensing data exist only for 1 year; therefore the growth parameters could not be calculated.

Czech Republic - Remote sensing data

An analysis of sealed areas is based on CORINE data from years 1991 and 2001. It described extent in both years and comparison of development (trend) of soil sealing – respectively of area with high proportion of sealed areas. As areas with sealed soils were set following CORINE classes: 111, 112, 121, 122, 124, 132, 133.

The other classes represent land use where very limited extent of sealed soils is expected. Disputable class is class 131, which represents mining areas. This class was not included in the analysis. The analysis was performed with 100 m grid data with the Spatial Analyst extension of ArcGIS.

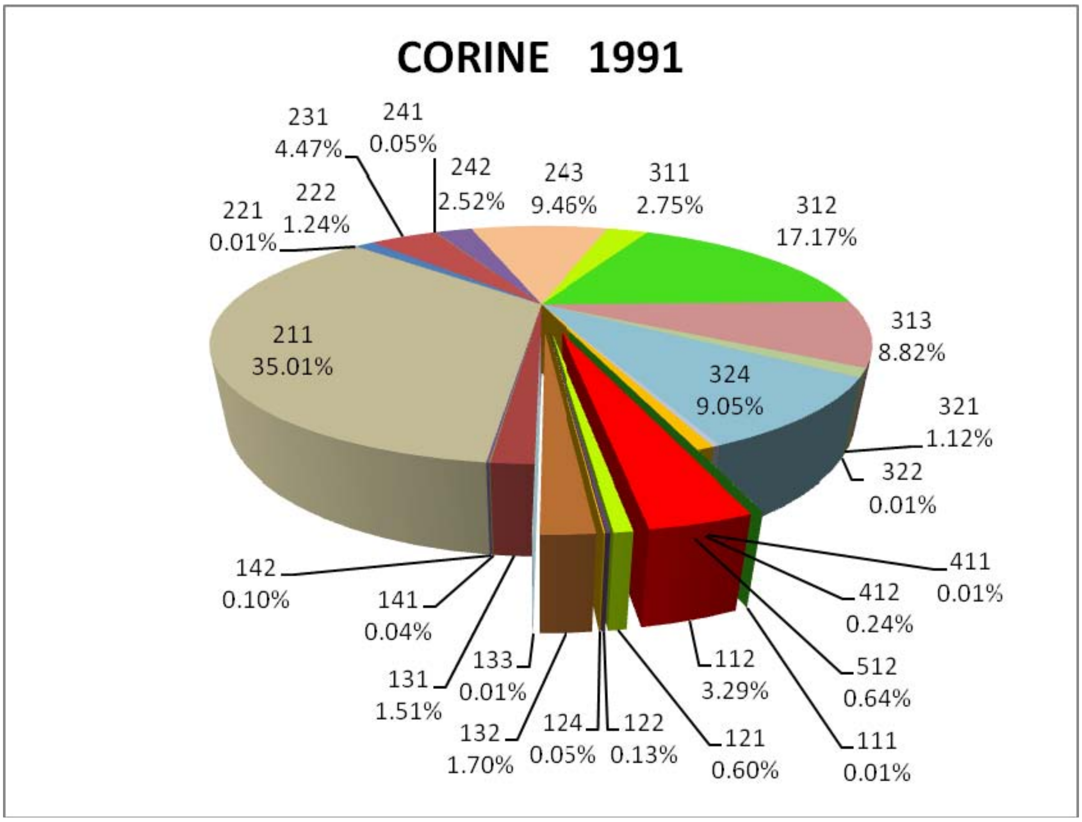

Figure 6. Proportion of land use classis in year 1991.

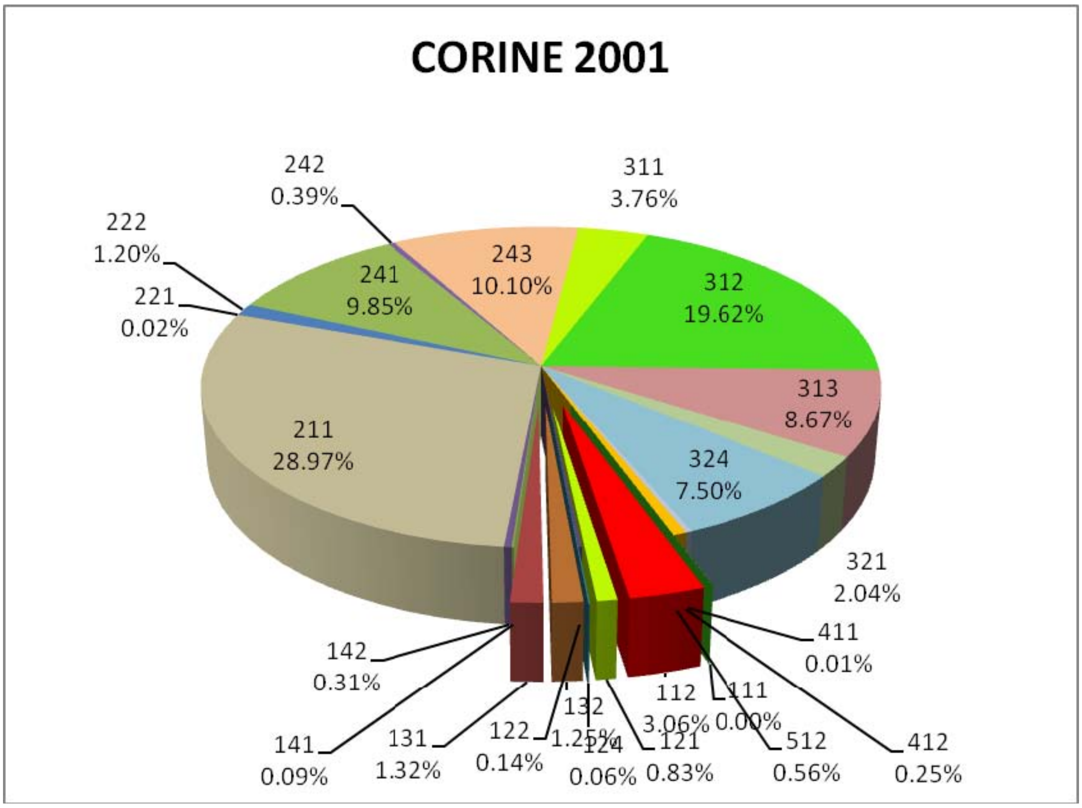

Figure 7. Proportion of land use classis in year 2001.

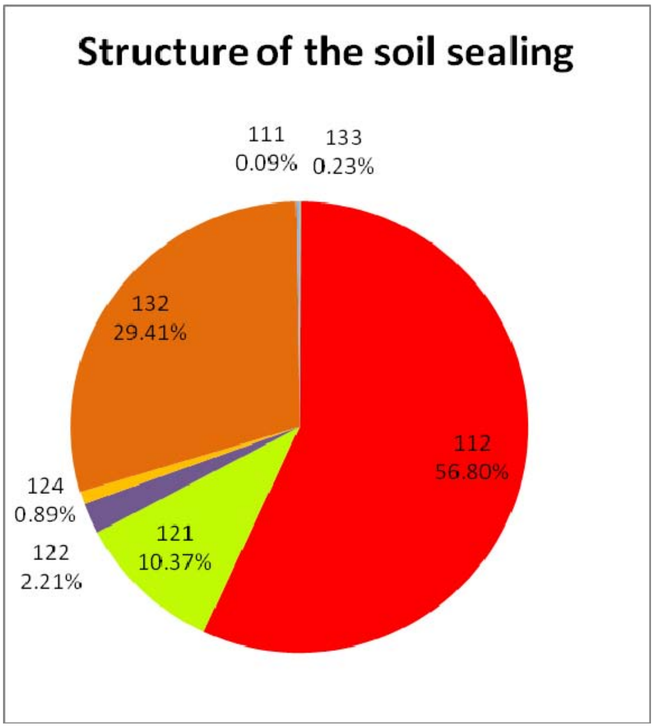

Figure 8. Structure of sealed areas according CORINE land use classes in 1991.

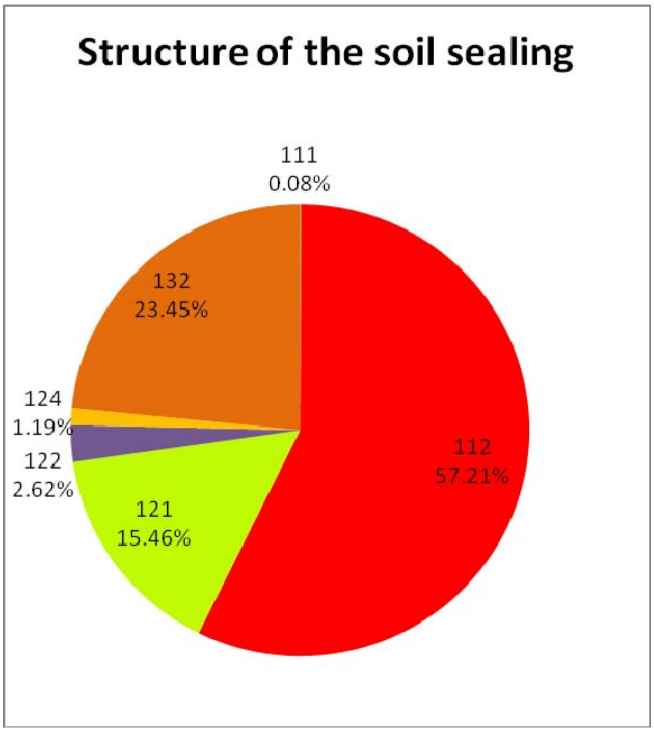

Figure 9. Structure of sealed areas according CORINE land use classes in 2001.

The majority of the area belongs to class 112 (in both years about 57%). Almost no increase of this class was detected. The last decade the increase was expected because of extended building of houses. The CORINE is probably not able to identify these changes because of its resolution. Important part of the sealed area is represented by dumps (class number 132). Here is evident big decrease of the extent between year 1991 and 2001, which can be done by reclamation of these areas (de-sealing?). The decrease was about 6%. Evident increase is presented by class 121 representing industrial and shopping areas. These areas increased for more than 5%. The economical grow of the Czech Republic in this decade, represented by construction of new companies, cargo-stores, shopping centers is reason of this increase. To this problem can be connected a slight increase of the class 122 (traffic corridors) as well.

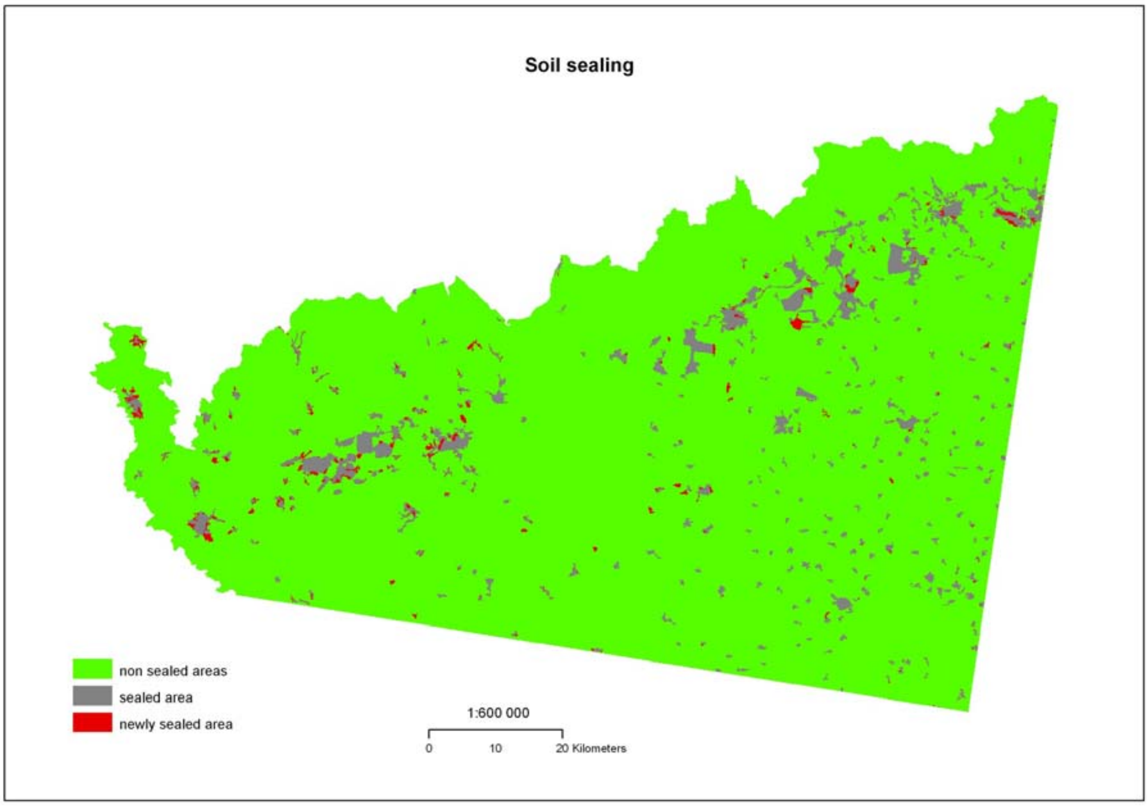

Figure 10. Extent of soil sealing in the CZ part of the pilot area according to CORINE land uses. Red color symbols the sealing of last decade.

References

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SMUL (2007): Sachsen hat Zukunft – Nachhaltigkeitsstrategie für den Freistaat Sachsen. – Stand Mai 2007, 43 S., Dresden.

Internet:

http://www.statistik.sachsen.de/Index/21gemstat/unterseite21.htm

http://www.statistik.sachsen.de/12/pressearchiv/archiv2007/pm04507.htm

Pilot area: Bodrogköz, Hungary

Lead Partner: UNIMIS
Endre Dobos

Description of the Pilot Area

Name of pilot area		Bodrogköz
Names of participating partners	**Lead partner**	**Unimis**
	Partner A	
	Partner B	
	Partner C	
Location and description	Member State(s)	Hungary
	Coordinates	EOV (Hungarian Projection) LLX:830225 LLY:319596 URX:851415 URY:337100
	Area of pilot area (km^2)	350
	Climate	Temperate
	Mean temperature (FAO 2006*)	10 C
	Average Annual Precipitation (FAO 2006)	550 mm
	Outline description of topography	Alluvial plain
	Elevation (m)	100-110m
	Vegetation (FAO 2006)	Mainly agriculture, with some forest spots and wet pastures
	Major Land Use (FAO 2006)	Farmland
	Major soils (WRB 2006 RGs**)	Vertisols, Arenosols, Gleysols, Fluvisols

Threat and related indicator(s) evaluated in pilot area

Threat	Soil Sealing
Indicator 1	SE01 Sealed area
Indicator 2	SE04 Land take
Indicator 3	

Rationale for selection of pilot area

The area representing a physiographically homogene landscape, typical for the Pannonian plain. It has 22 official monitoring points, and have a relatively rich soil database behind. It has also an interpreted and georeferenced historical landuse map available, helping to monitor the landuse changes in the last two centuries.

Indicator Evaluation

Indicators

SE01 Sealed area
SE04 Land take

Pilot description

Spatial extent

The area covers western part of the lower Bodrogköz

EOV (Hungarian Projection)
LLX:830225
LLY:319596
URX:851415
URY:337100

Data

- Data sources
  –
  - Historical maps
    - 1763-87 (Low quality, 1: 28.800)
    - 1819-69 (Medium quality, 1: 28.800)
    - 1872-84 (High quality, 1: 25.000)

  –
  - Digital orthophoto (High quality)
    - 2005

Pilot methodology

The method here is based on existing topographical maps and remote sensing data. Several mapping campaigns have been completed for military purposes in the last two and a half centuries, which give us a relatively accurate delineations of the settlement areas. This procedure aims to delineate these areas and compare its temporal changes.

- Data preprocessing:
  - georectification and georeferencing based on the Hungarian projection system

- Data format
  - Rasters are in img format
  - Vecotrized settlement data is in ESRI shapefile format

Analysing steps

Step 1:
Visual interpretation of historical maps and orthophotography
(Manual, screen-based digitalization of the settlement borders)

Step 2:
Calculation of the total coverage of the settlement areas (SE01)

Step 3:
Calculate the increase compared with the first datasource (1783 situation)
Calculate the percentage of built-on area (SE04)

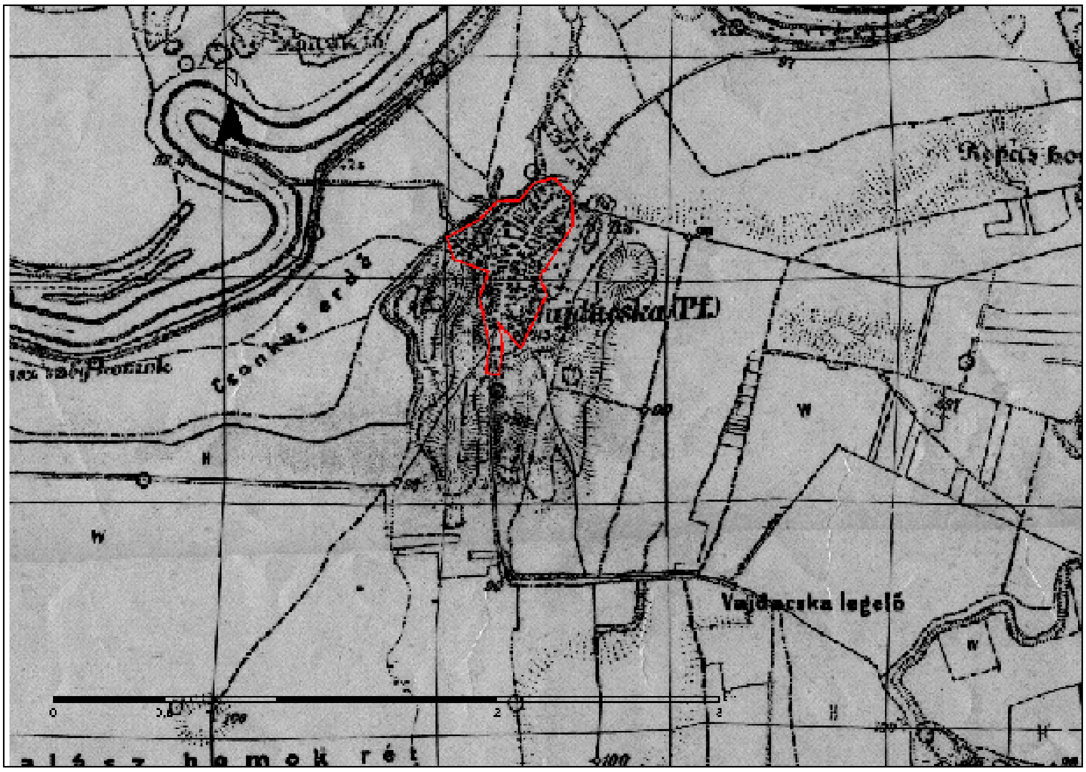


Figure 1. Delineation of the settlement area on the third military survey map

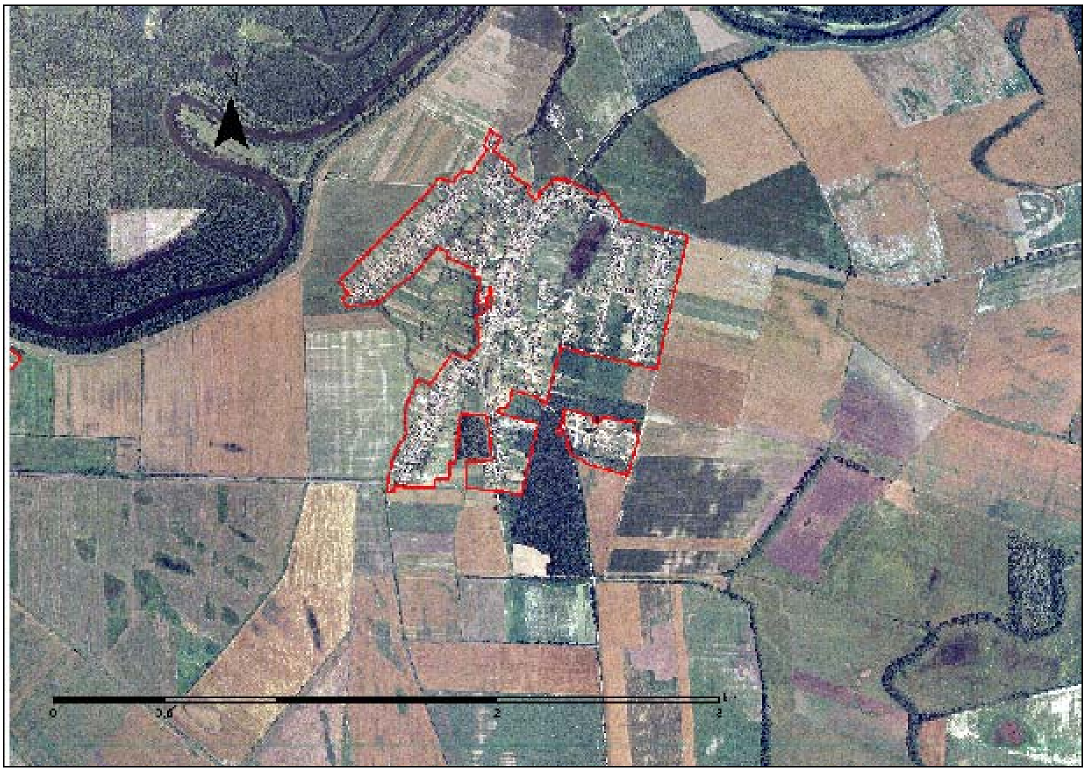


Figure 2. Delineation of the settlement area on the othophoto map

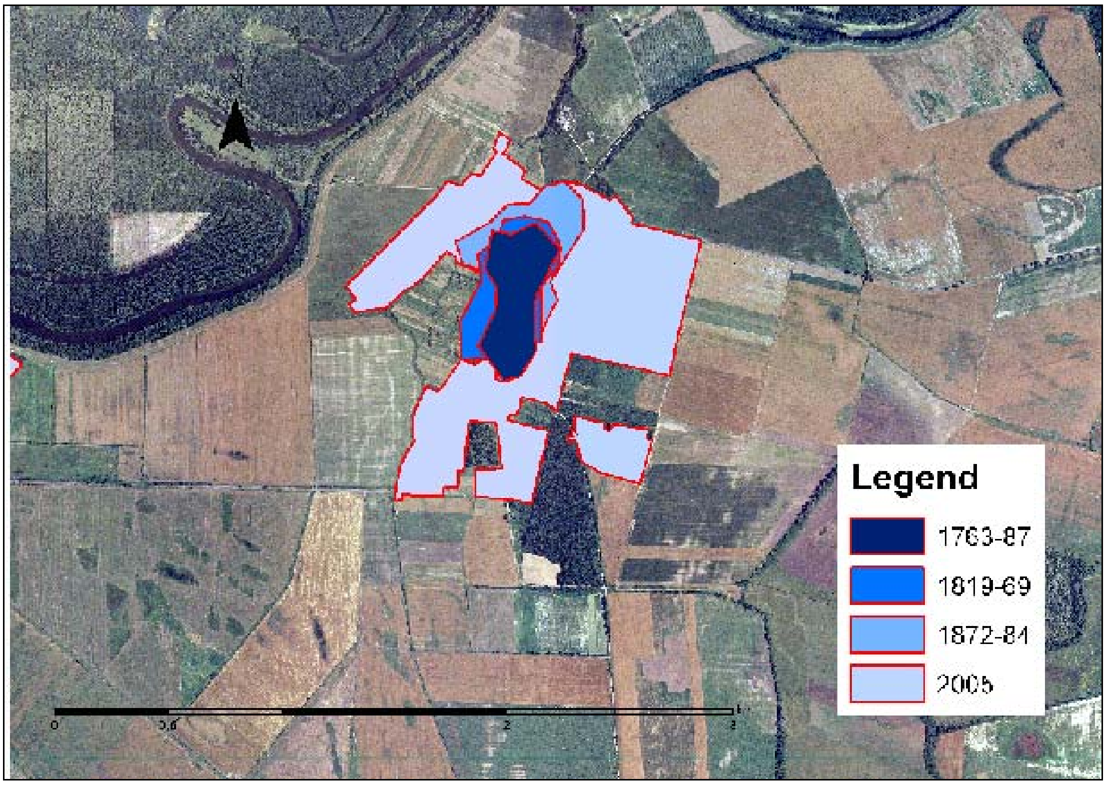


Figure 3. The temporal changes of the settlement area

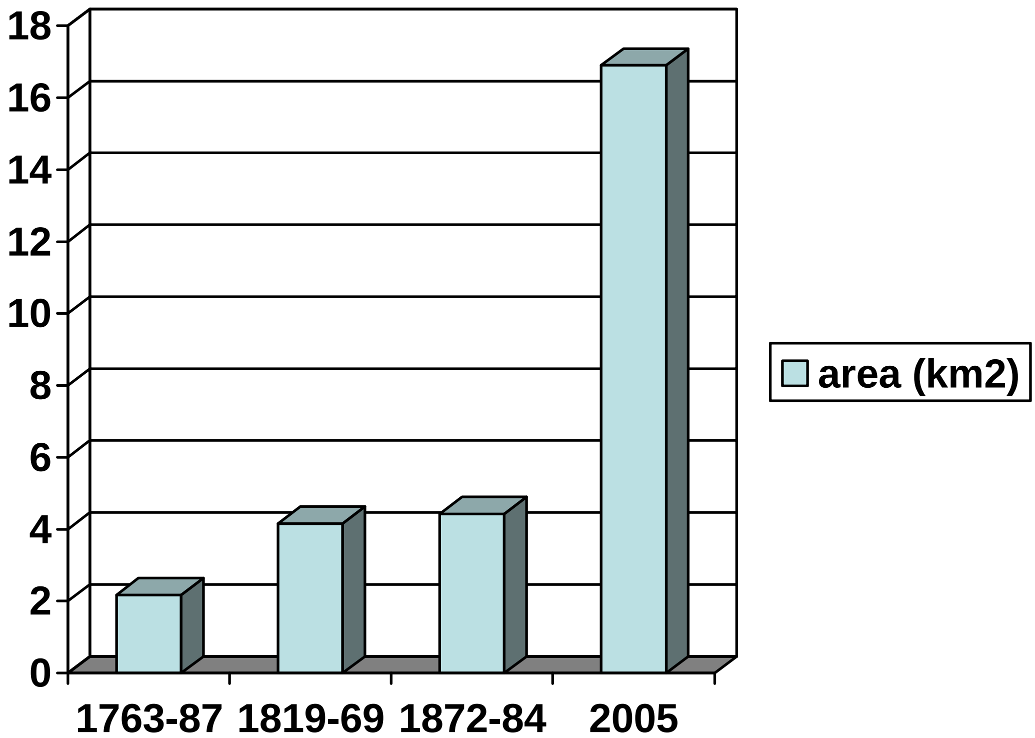


Figure 5. The spatial coverage of the settlement area

Table 1. Calculated values for the indicators

Time period	Actual spatial coverage of the settlements (ha) SE01	Percent coverage of the settlements for 350 km2	Increase from 1763 in percent SE04
1763-87	218	0,6	100
1819-1869	416	1,2	190
1872-1884	443	1,3	203
2005	1690	4,8	775

Evaluation of pilot results

Feasibility and experience of applying ENVASSO procedures and protocols

The proposed procedure is relatively easy to complete if historical data is available. However, monitoring recent changes does not require historical data. Orthophotos are commonly available for a quite rich time series for the majority of Europe. Selecting representative pilot areas and performing this procedure in a certain time sequence would give feasible results and could catch the major trends. Using orthophotos would help to standardize the procedure over Europe and limit the problems arising from the different quality and information content of the national cadastral system.

Output performance

e.g. Minimum Detectable Change achievable and comparison with WP1 requirements; definition of baselines and application of thresholds

The procedure is based on the manual delineation of the settlement areas. Manual delineation may introduce some error into the system, due to the different style of the digitizing person, which may have a great impact on the minimum detectable changes. A potential improvement of the procedure is to do ontime comparison of the orthophotos from different times and identify the visible differences between the images. Digital (automatized) methodology is also available to classify build up areas, but the uncertainty of this classified images is much higher then targeted minimum detectable change.

Identified strengths and weaknesses of

a. the estimation of indicator values
b. the interpretation of indicator values

The indicators SE01 and SE04, as suggested in the Procedures and protocols are redundant. The extent of the sealed areas or the settlement area represent the basic information, all others are simply generated/calculated from them.

Conclusions and recommendations

- Calculation of the settlement area has a high correlation with the build-up area
- Using settlement areas to estimate sealing is much easier and requires less resources, while characterize the sealing trends very well.
- ***Recommendation:*** use settlement area measures instead of real sealed area

Pilot area: Tsalapitsa Village, Plovdiv district, Bulgaria

Lead Partner: ISSNP
Prof. Nikola Kolev
Nikola Kolev, Toma Shishkov,
Milena Kercheva,
Svetla Rousseva,
Ekaterina Filcheva,
Martin Nenov

ICPA
Catalin Simota

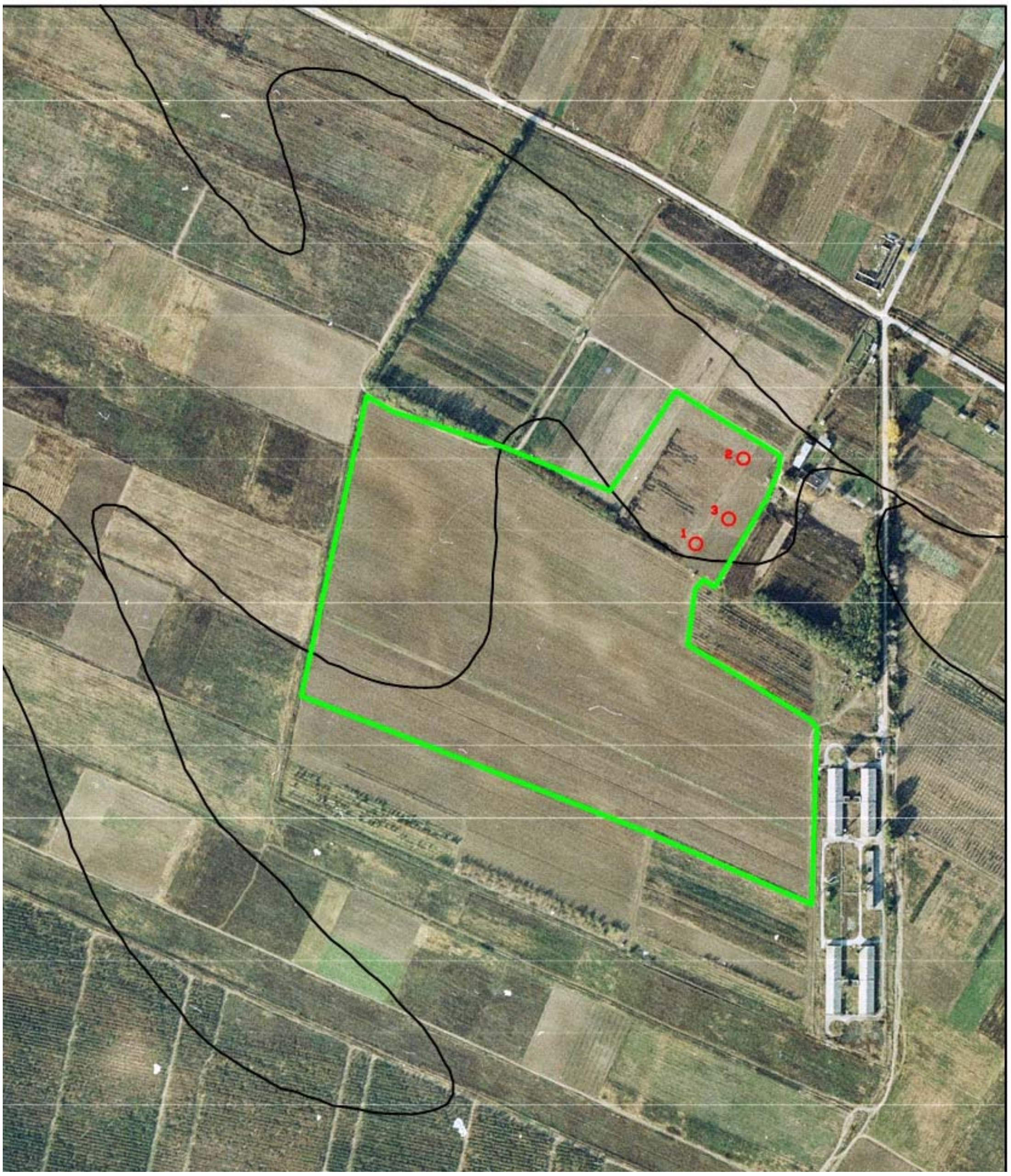
Description of the Pilot Area

Name of pilot area		Village Tsalapitsa, Plovdiv district
Names of participating partners	**Lead partner**	**Institute of Soil Science "Nikola Poushkarov", Sofia, Bulgaria**
	Partner A	Nikola Kolev, Toma Shishkov, Milena Kercheva, Svetla Rousseva, Ekaterina Filcheva, Martin Nenov
Location and description	Member State(s)	Bulgaria (Thracian plain)
	Coordinates	Profile1 N 42°10.794' E 024°32.452' Profile 2 N 42°10.904' E 024°32.380' Profile 3 N 42°10.843' E 024°32.489' Local weather station N 42°10.844' E 024°32.570'
	Area of pilot area (km^2)	0,016 km^2
	Climate	Temperate continental of transition with Mediterranean influence. Mesic-xeric soil climate
	Mean temperature (FAO 2006*)	Mean annual 12,3 °C (see also Table 1)
	Average Annual Precipitation (FAO 2006	516 mm (see also Table 1)
	Outline description of topography	Alluvial flat plain
	Elevation (m)	191 m to the South and 193 m to the North
	Vegetation (FAO 2006)	Climate conditions are favorable for growing of cereals, soybeans, fodder plants, vegetables, rise, fruits and melons, pulses. CeBa, CeMa, CeWh, OiSo, FoAl, RoSu, PuPe, PuBe
	Major Land Use (FAO 2006)	AA (AA1, AA2, AA6) Human influence PL, IU, SC, MO, FE
	Major soils (WRB 2006 RGs**)	Fluvisols and Luvisols

The total enclosed territory to the village Tsalapitsa is 6 630 ha (determined by plan meter) according to the soil map in scale 1:10,000 (Figure 2).

The territory is situated in the western part of Thrace plain, Plovdiv district. The river Maritsa forms an extended alluvial valley, which is formed on the old topography of paleo-plain during the Pliocene. There is no evidence of old high or middle river terraces of Pleistocene origin. The relief is flat and smooth. Parent materials are deposits of different origin. The contemporary relief is affected by process of erosion. The Holocene deposits are throughout of the interior plain. The biggest part of the valley is occupied with accumulated clayey sands. The level of ground water table is about 4-6 meters, determined by the river Maritsa. The temporary flooded terraces of valley are 1-2 meters over the level of river Maritsa.

Figure 2. Scheme of location of Bulgarian Pilot area (referenced to the topographic map 1:10,000), village Tsalapitsa, district Plovdiv.



Legend

Pilot area

Reference profile

Horizontal

Figure 3. Aerial photo with the location of Bulgarian Pilot area.

The following soil varieties occupy the territory enclosed to the village Tsalapitsa (soil survey 1972):

Haplic and Pellic Vertisols 8,31%, Vertic Chromic Luvisols 15,7%, Fluvic Chromic Luvisols 16,26%, Chromic Luvisols 4,03%, Haplic Fluvisols 47,81%, Calcic Fluvisols 7,4%, Sodium Fluvisols 0,31%, swamps 0,23%.

The Pilot Area is located at the south-western part of territory, where soil varieties occur like Haplic Fluvisols, Fluvic Chromic Luvisols, and Calcic Fluvisols (Figure 3).

The duration of the period with constant air temperature above 10^{o}C is 209 days and ∑ t^{o} be 3795^{o}C for the period and some other basic climate characteristics are presented in Table 1.

Table 1. Mean (1961-1990) monthly and annual air temperature (T,^{o}C), precipitation (R, mm), potential evapotranspiration (PET, mm). Mean soil temperature (Ts) at different depths.

	I	II	II	IV	V	VI	VII	VIII	IX	X	XI	XII	annual
Ta, ^{o}C	0.4	3.0	6.9	12.3	17.2	21.0	23.1	22.3	18.7	12.8	7.3	2.6	12.3
R, mm	40	34	39	42	65	54	49	38	32	31	44	45	516
PET^{a}, mm	16	23	48	77	107	131	146	127	85	46	22	16	588
PET^{b}, mm	2	7	23	53	94	124	143	127	88	48	19	5	733
R/PET^{a}	2.5	1.5	0.8	0.5	0.6	0.4	0.3	0.3	0.4	0.7	2.0	2.8	0.9
Depth	Mean monthly and annual soil temperature (Ts , ^{o}C), station Plovdiv I.												
2 cm	1.5	3.1	7.6	14.1	19.9	23.5	25.8	26.1	20.8	14.0	8.5	3.6	14.0
5 cm	1.8	3.1	7.5	14.1	19.7	23.3	25.5	25.3	20.8	14.4	8.8	3.8	14.0
10 cm	1.9	3.1	7.3	13.5	18.9	22.6	24.8	24.5	20.5	14.4	8.8	3.8	13.6
20 cm	2.7	3.3	7.2	13.0	18.5	21.8	23.8	23.9	20.3	14.4	9.3	4.6	13.6

PET^{a} - FAO 56 (Allen et al., 1998) Penman-Monteith method for estimation of reference evapotranspiration
PET^{b} - Thornthwaite method for estimation of potential evapotranspiration (Thornthwaite, Holzman, 1939)

Threat and related indicator(s) evaluated in pilot area

Threat	Soil Compaction
Indicator 1	**CP01 Density** (bulk density, packing density, total porosity).
Indicator 2	**CP02 Air Capacity** (volume of air-filled pore at a certain suction of 3, 5, and 10 kPa).
Indicator 3	**CP06 Estimated Vulnerability to Compaction** is based on texture, density, climate, land use.

At the Bulgarian Pilot Area the additional indicators recommended in WP1 in the frame of ENVASSO Project were also measured and analyzed:

- CP03 Permeability – saturated hydraulic conductivity by laboratory method.
- CP04 Visual assessment of structure and testing in the field.
- CP05 Mechanical resistance (penetration resistance) measured in the field.

Rationale for selection of pilot area

Test Pilot Area for soil compaction is based on the background of long term data obtained at the experimental station of Nikola Poushkarov Institute of Soil Science in the village of Tsalapitsa. Pressure pans are a problem on sandy soils that have insufficient clay content to cause naturally break up the compacted soil.

The area is most representative for the vast territory of river Maritza alluvial plain. From the ancient time the human activity over soils is cultivation, irrigation and pasture. Truncated soils are often related with paddy fields.

The clayey loam sandy texture contributes to the compaction of the subsurface and deeper horizons. The crop rotation and plough at different depths are used in practice.

The Pilot Area of Tsalapitsa village, where soil compaction is studied is situated between the points No 169 and 185 of the National “Land and Soil” Monitoring System (NLSMS) based on the National monitoring grid 16 x 16 km, carried out since 2004 by the Executive Environmental Agency (Figure 4).

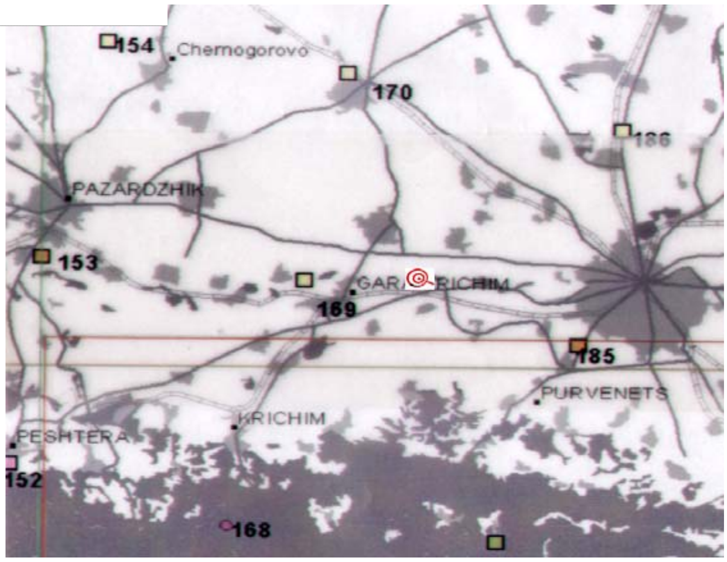


Figure 4. The scheme of National Soil Monitoring grid distribution in the district Plovdiv.

Indicator Evaluation

The evaluation of the top 3 indicators and of the additional 3 indicators for soil compaction is based on:

- existing soil maps at the scale 1:10000 and the soil survey reports;
- existing data for bulk density indicating soil compaction process;
- new geo-referenced data for particle size distribution function, bulk density, particle density, soil water retention curve, saturated hydraulic conductivity, penetration resistance;
- long term meteorological data (air temperature, precipitation, potential evapotranspiration) for the period 1961-1990 representative for contemporary climate.

Spatial extent and sampling design for each indicator.

The site is geo-referenced and it is representative as most widespread soil variety, land use, type of vegetation, and topography for the area of 18 ha. The sampling area of 12000 m^2 (300 x 40 m) is performed by three profiles, with coordinates, two of them are situated on the temporary beaten track and one profile on the arable land, plough to the depth 0-24cm. Soil penetration has been studied at different management practices at the moment of soil survey during May-June, 2007. The locations of sampling sectors with different management practices are identified according to the scheme (Figure 5).

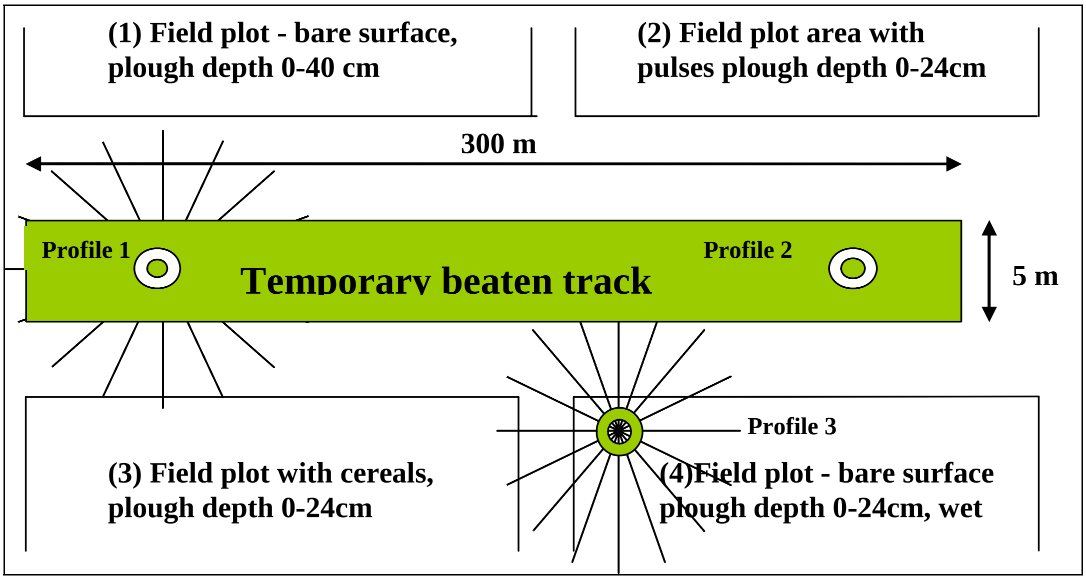


Figure 5. Scheme of sampling sectors with different management practices.

The strict scheme of core samples collection throughout the profile depth for each soil horizon is applied after Jan van den Akker (ALTERRA) (Table 2).

Table 2. Scheme of data requirement selection and collection according to Jan van den Akker (ALTERRA).

Layer no.:					Texture	SOC	Dry bulk density	Particle density	Air-filled pore volume	Sat. Hydr. Conductivity	Penetrometer resistance	Visual classification	Depth	Precompaction stress	Ploughing depth
					%	%w/w	t/m3	t/m3	%v/v	cm/d	Mpa	-	cm	kPa	cm
1	Topsoil		? cm		X	X	X	x			X	x	X	(x)	X
2	Ploughpan mixed with topsoil		5 cm		x	X	X	x	X	X	X	x	X	x	
3	Ploughpan		5 cm		X	X	X	x	X	X	X	x	X	x	
			5 cm								X	x			
4	15 - 20 cm below top ploughpan (layer 3)		5 cm		(x)	(x)	X	x	X	(x)	X	x	X	(x)	
			5 cm								X	x			
5	25 - 30 cm below top ploughpan (layer 3)		5 cm		x	x	X	x	X	x	X	x	X	x	
			5 cm								X	x			
6	35 - 40 cm below top ploughpan (layer 3)		5 cm		(x)	(x)	X	x	X	(x)	X	x	X	(x)	
			5 cm								X	x			
7	45 - 50 cm below top ploughpan (layer 3)		5 cm		(x)	(x)	(x)	(x)	(x)	(x)	X	x	(x)	(x)	
			5 cm								X	x			
			5 cm								80 cm	80 cm			
			5 cm								x	(x)			
			5 cm								x	(x)			
			5 cm								x	(x)			
											100 cm	100 cm			
8	Compacted Horizon				x	X	X	x	X	X	X	x	X	x	
	Soil profile description	Soil survey with auger					X			X	= REQUIRED				
		Soil survey with soil pit					(x)			x	= medium priority				
										(x)	= low priority				
	Drainage condition	Class					X				decadal -				
		Groundwater level (winter/summer)					x								
		Groundwater level (highest/lowest)					x								
	Landuse	Arable/Pasture/Forest/Nature					X								
		Crop					x								
	Soil management and tillage	Ploughing/loosening/no-till (depth)					X								
		Deep-loosening (depth)					X								
	Machinery / Ground pressure	Machinery used (type / brand)					x								
	(of heavy machinery)	Tires used (type/brand)					x								
		Weight					X								
		Load per wheel					X								
		Width tire					X								
		Inflation pressure					X								
	Climate	Name and coordinates weather station					X								
		Mean percipitation (summer/winter)					X								
		Mean evapotranspiration (summer/winter)					X								
		Mean precipitation (month or decade)					x								
		Mean evapotranspiration (month or decad					x								
		Air temperature (summer/winter)					x								
		Air temperature (month or decade)					(x)								
	Air-filled porevolume (% v/v)	at a suction of 3 kPa					x								
	(depths: see above)	at a suction of 5 kPa					X								
		at a suction of 6 kPa					(x)								
		at a suction of 10 kPa					x								

Indicator: Density (CP01)

Bulk density, packing density, total porosity

Pilot description

Spatial extent

The representative and homogeneous area of topography, soil variety and land use is 12000 m^2 performed by three profiles to depth 180cm.

Data

Sampling design

Scheme of data requirement selection and collection is according to table 2.
In order to test the whole complex of soil compaction indicators on the Pilot Area the new study is carried out in the frame of ENVASSO Project.

Required data according to the WP4 “Procedures&Protocols” are:

a. Texture (%), classes;
b. Soil Organic Carbon (w w^{-3});
c. Bulk density (t m^{-3}).
d. Particle density (t m^{-3}).
e. Total porosity (%v v^{-1})

Data description and standards

Bulk density is determined according to the ISO 11272:1998 named: “Soil quality – Determination of dry bulk density”.

Testing

Bulk density is determined with 100 cm^3 rings without deflection and compaction applied into vertical or horizontal soil surface far enough to fill the representative sampler taken with a metal sampling tool. With respect to scheme (table 2), soil samples from seven depths are taken with at least five replicates from each soil layer.
The preliminary pedologic study confirms the identity of land units performed by the Profile 1, 2 and 3. As site specific Profile 1 was chosen, situated on temporary beaten track and Profile 3 on cultivated land (Figure 5).

***Methodology* used for calculation/estimation of parameters and indicators**

Bulk density is a direct measure of soil compaction determined from undisturbed cores of soil sampled in the field. Packing density is calculated from bulk density and clay content and is closely related to porosity.

Baseline definition

Baseline values for soil compaction depend on start period when heavy machines force compaction deeper into the subsoil. Baseline values for the structural status of soil depend on specific characteristics as texture, organic matter content, land use. In most cases the agricultural soils are long-term cultivated and there is lack of information for the authentic local baseline for particular soil type and land use. Thus the arable field plot used in the experimental station of Tsalapitsa (e.g. Var3 in Figure 6) could be used only for a relative estimation of the impact of specific traffic or other agricultural practice on soil compaction at given climatic conditions of particular year.

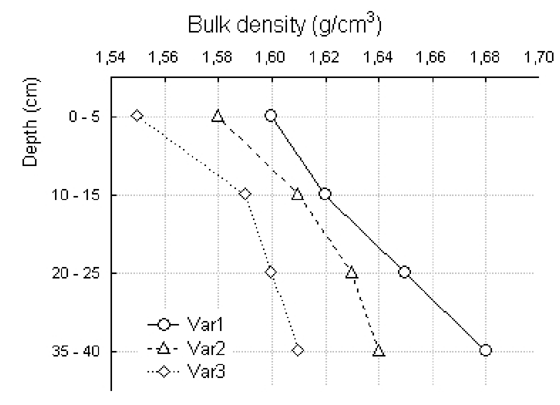


Figure 6a. Influence of heavy machinery on soil compaction. Haplic Fluvisol (Eutric), village Tsalapitsa, 2005. Var1 - intensive traffic of tractor; Var2- medium traffic of tractor; Var3 – arable land

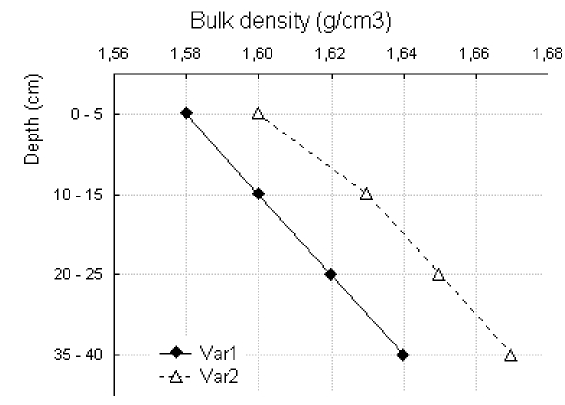


Figure 6b. Influence of irrigation on soil compaction, Haplic Fluvisol (Eutric), village Tsalapitsa, 2004.
Var1 – furrow irrigation
Var2- non-irrigated variant

Threshold definition

According to the WP1 report of soil compaction indicators selection and specification, soils with high packing density can be regarded as compact. The packing density threshold of 1,75 g cm^{-3} can easy be converted into a dry bulk density value using the Equation PD = D_b + 0,009 C, where:

D_b is the bulk density (g cm^{-3} or t m^{-3});
PD is the packing density (g cm^{-3} or t m^{-3})
C is the clay (particles size <0.002 mm) content (%, w w^{-1}).

Three classes of packing density are recognized:
low <1,40g.cm^{-3},
medium 1,40 to 1,75g cm^{-3} and
high >1,75 g cm^{-3}.

This indicator for soil compaction is compared with another one based on the fact that soil compaction reduces mainly drainage-aeration pores (air-filled pore volume at suction 30 kPa corresponds approximately to field capacity). This approach is used for calculation of optimal, critical and limiting values of bulk density at 20% (15% for fine textured soils – physical clay (<0.01 mm content >45%), 10% and 5% drainage-aeration pores (AP), respectively, using experimental data for particle density (d_p) and field capacity (FC) (Kuznetsova, 1990):

$$BDopt,crit,lim = \frac{(100 - AP_{opt,\,crit,\,lim})d_p}{100 + FC_w.d_p}$$

Using experimental data for 22 representative soil profiles from virgin lands in Bulgaria the reference values of bulk density were calculated for each textural class of A and B horizons (Kercheva, Dilkova, 2005). Textural classes were determined according to the scheme of Katschinski (1959), which is based on content of the physical clay (particles with sizes less than 0.01 mm). It was found that most medium textured soil layers from A horizons had optimal bulk densities - 1.0 – 1.2 g/cm^3, while in fine textured soil layers, bulk densities classified as critical and limiting varied from 1.2 to 1.35 g/cm^3 in average. In fine textured illuvial horizons the aeration conditions were unfavorable (1.25-1.60 g/cm^3) because of limiting content of drainage aeration pores. Medium textured illuvial soil layers had better aeration status and there are cases with optimal (1.0-1.2 g/cm^3) as well as critical and limiting values of bulk density (1.55-1.75 g/cm^3).

For each textural class of A and B horizons regression equations between the calculated reference bulk density values and humus and clay content (<0.001mm) were found (Table 3, Figures 7, 8), which could be useful when field capacity and soil particle density data missed (Kercheva, Dilkova, 2005).

Table 3. Regression equations of optimal, critical and limiting bulk density with humus (hum) and clay

(<0.001mm) content (cl_1) for different textural classes of A and B horizons (Kercheva, Dilkova, 2005).

Humic horizons: A, A_1A_2,

Textural class* Physical clay< 0.01 mm, %	BD_{opt} g/cm^3	BD_{crit} g/cm^3	BD_{lim} g/cm^3	R^2	SEE
10-30	1.75-0.22.hum	1.97-0.27.hum	2.07-0.27.hum	86	0.10
30-45	1.49-0.10.hum	1.67-0.12.hum	1.77-0.12.hum	76	0.06
45-75	1.58-0.06.hum-0.005 cl_1	1.68-0.07.hum-0.005 cl_1	1.77-0.08.hum-0.005 cl_1	73	0.07

Illuvial horizons: B

Textural class Physical clay< 0.01 mm, %	BD_{opt} g/cm^3	BD_{crit} g/cm^3	BD_{lim} g/cm^3	R^2	SEE
30-45	1.42-0.12.hum	1.60-0.14.hum	1.68-0.15.hum	72	0.03
45-60	1.70-0.009. cl_1	1.80-0.010. cl_1	1.90-0.010. cl_1	39	0.06
60-75	2.05-0.016. cl_1	2.17-0.017. cl_1	2.29-0.018. cl_1	39	0.09

** Textural classes were determined according to the scheme of Katschinski (1959), which is based on content of the physical clay (particles with sizes less than 0.01 mm)*

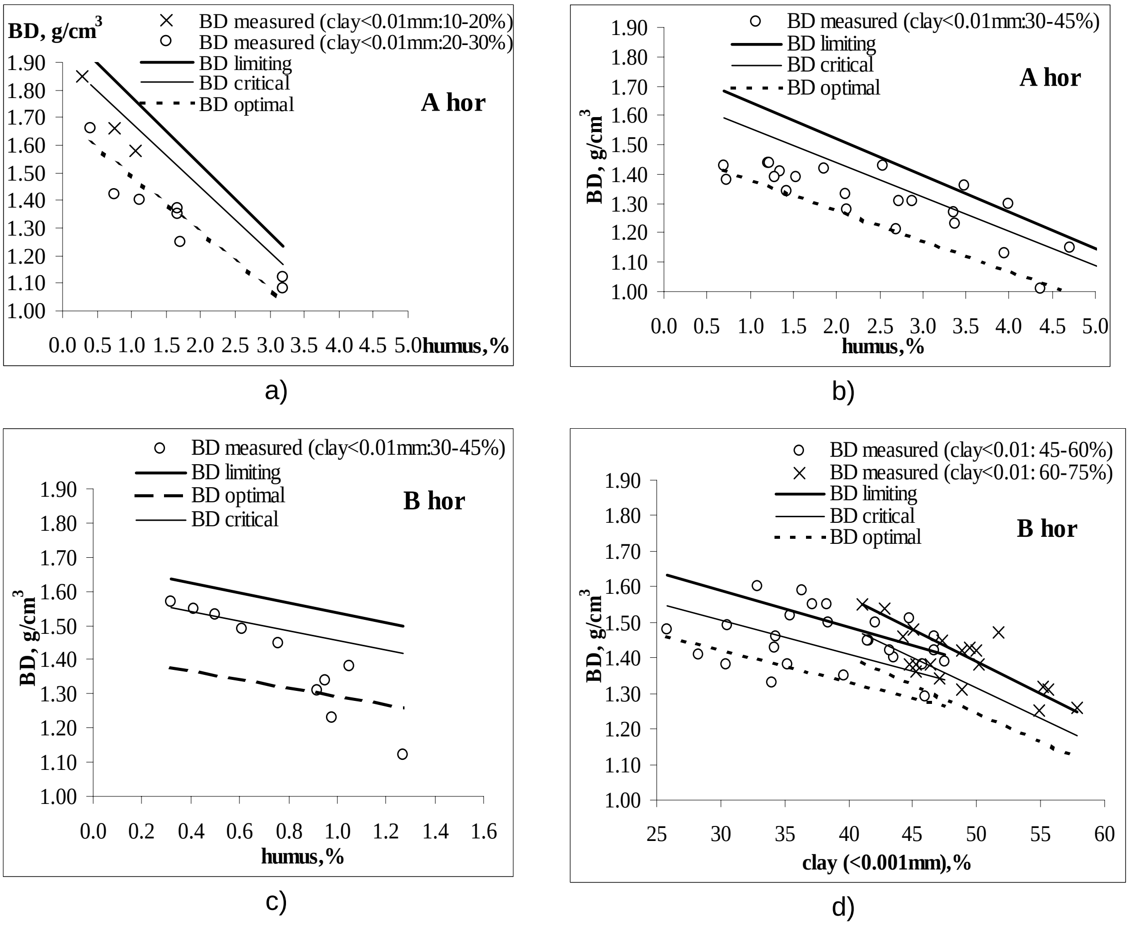


Figure 7. Measured values (BD measured) of 22 representative soil profiles and relationships of the optimal, critical and limiting values of soil bulk density (BD) of A and B horizons in different textural classes (Kercheva, Dilkova, 2005)

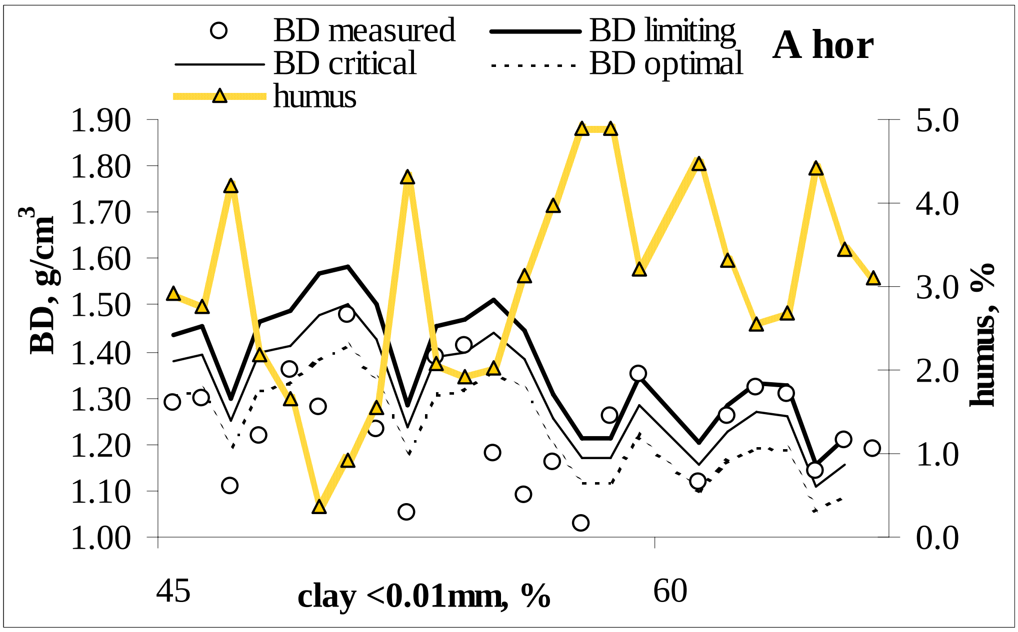


Figure 8. Measured values (BD measured) and calculated optimal, critical and limiting values of soil bulk density (BD) of A horizons with clay (< 10 μm) content = 45-60 and 60-75%. (Kercheva, Dilkova, 2005).

Pilot methodology

A preliminary field work was done for selection the most representative site in regard to relief homogeneity, most widely spread soil variety and common land use.

Soil morphological description, particle size distribution, organic matter content and composition, CEC, and land use are used to characterize the studied area. Part of data set will be integrated into SoDa base.

Soil map at scale 1:10 000 is used as well as digital soil map, topographic map at scale 1:10,000 and aerial photos.

Compilation of soil data and maps for the pilot area

The distance between Profile1 and Profile3 is actually 25 meters. Both profiles are identical in morphology, soil type and differ in applied management practices and pronounce of degree soil compaction. Soil characteristics and specific data do not have detectable change deeper than the surface horizon 0-30cm up to the depth of 180cm. For this reason Profile1 is with complete analytical data of texture (Table 4a, 4b), organic matter content and composition (Table 5), CEC, base saturation and exchangeable cations (Table 6). Analytical data of Profile3 (arable land, plough) deeper than 0-30cm are of similar composition and constituent.

Table 4a. Soil texture of the Haplic Fluvisol (Eutric), PA Bulgaria, village Tsalapitsa (according to the method of Katschinski (1959) revised).

Horizon	Depth, cm	Particle size distribution (mm), %							
		>1	1-0.25	0.25-0.05	0.05-0.01	0.01-0.005	0.005-0.001	<0.001	≤ 0.01
Profile 1, temporary beaten track									
Ap_1	0-12	0,0	41,8	33,0	7,5	3,7	8,7	5,3	17,7
Ap_2	12-17	0,0	40,6	30,4	7,1	8,8	6,0	7,1	21,9
A	17-24	0,0	33,6	35,4	12,0	5,7	5,7	7,6	19,0
AC_1	24-40 (29-34)	0,0	33,4	31,0	9,1	5,6	5,5	14,5	25,6
AC_2	40-58	0,0	31,8	31,1	6,0	5,6	7,6	17,9	31,1
AC_2' sample	40-58 (49-54)	0,0	29,0	37,6	4,6	5,5	5,2	18,1	28,8
AC_3	58-77	0,0	40,2	27,5	5,2	5,4	4,5	17,2	27,1
AC_3' sample	58-77 (59-64)	0,0	31,6	35,1	6,6	7,5	3,5	15,7	26,7
C_1	77-102	0,0	41,8	39,5	4,3	0,8	6,7	6,9	14,4
C_2	102-140	0,0	39,9	39,9	5,9	3,4	5,8	5,2	14,4
Arable land, plough									
Ap	0-30	0,0	44,1	29,4	7,4	6,7	5,9	6,5	19,1
The deeper data of soil texture are identical to the Profile 1.									

Table 4b. Soil texture of the Haplic Fluvisol (Eutric), PA Bulgaria, village Tsalapitsa (transformed from the textural scheme of Katschinski to FAO & EU)

Horizon	Depth, cm	clay <0,002 mm	silt 0,002-0,05 mm	sand 0,05-2,0 mm	FAO texture class	EU texture class
Profile 1, temporary beaten track						
Ap_1	0-12	9,0	16,2	74,8	loamy sand	coarse
Ap_2	12-17	9,7	19,3	71,0	loamy sand	coarse
A	17-24	10,1	20,9	69,0	sandy loam	coarse
AC_1	24-40	16,9	18,7	64,4	sandy loam	coarse
	(29-34)					
AC_2	40-58	21,2	15,9	62,9	sandy clay loam	medium
AC_2'	40-58	20,3	13,1	66,6	sandy clay loam	medium
sample	(49-54)					
AC_3	58-77	19,1	13,2	67,7	sandy loam	medium
AC_3'	58-77	17,2	16,1	66,7	sandy loam	medium
sample	(59-64)					
C_1	77-102	9,8	8,9	81,3	loamy sand	coarse
C_2	102-140	7,7	12,6	79,7	loamy sand	coarse
Arable land, plough						
Ap	0-30	9,0	17,5	73,5	loamy sand	coarse
The deeper data of soil texture are identical to the Profile 1.						

Table 5. Content and composition of soil organic matter of Haplic Fluvisol (Eutric), PA Bulgaria, village Tsalapitsa.

Profile			Organic carbon (%)				Organic carbon (%)		**Unext-racted**	**Extracted with**
Horizon	Depth in cm	Total C	$C_{ext.}$ - Extracted with 0.1 M $Na_4P_2O_7$+0.1M NaOH			C_h/ C_f	Humic acids fractions		organic carbon	0.1N H_2SO_4
		%	$C_{ext.}$	C_h - Humic acids	C_f - Fulvic acids		"free" and R_2O_3 complexed	Ca comple-xed	(%)	(%)
Profile 1, temporary beaten track										
A_{p1}	0-12	0.57	0.20[a] 35.09[b]	0.15 26.32	0.05 8.77	3.0	100.00	0.00	0.37 64.91	0.02 3.50
A_{p2}	12-17	0.38	0.17 44.74	0.17 44.74	0.00	-	0.00	100	0.21 55.26	0.03 7.89
A	17-24	0.40	0.17 42.50	0.13 32.50	0.04 10.00	3.25	0.00	100	0.23 57.50	0.03 7.50
AC_1	24-40 (29-34)	0.37	0.15 40.54	0.09 24.32	0.06 16.22	1.50	0.00	100	0.22 59.46	0.02 5.41
AC_2	40-58	0.30	0.11 36.67	0.07 23.33	0.04 13.33	1.75	-	-	0.19 63.33	0.04 13.33
AC_2' sample	40-58 (49-54)	0.31	0.12 38.71	0.09 20.03	0.03 9.68	3.0	0.00	100	0.19 61.29	0.03 9.68
AC_3	58-77	0.28	0.10 35.71	0.10 35.71	0.00	-	0.00	100	0.18 64.29	0.02 7.14
AC_3' sample	58-77 (59-64)	0.25	0.09 36.00	-	0.09 36.00	-	0.00	0.00	0.16 64.00	0.04 16.00
C_1	77-102	0.16	0.06 37.50	-	0.06 37.50	-	0.00	0.00	0.10 62.50	0.05 31.25
C_2	102-140	0.13	0.04 30.77	-	0.04 30.77	-	0.00	0.00	0.09 69.23	0.01 7.69
Arable land, plough										
A_p	0-30	0.44	0.20 45.45	0.15 34.09	0.05 11.36	3.00	100.00	0.00	0.24 34.09	0.03 2.91
The deeper data of content and composition of organic matter is likely to the Profile1.										

[a] *% of soil sample*
[b] *% of total C*

Table 6. Cation exchange capacity, base saturation and composition of the main exchangeable adsorbed cations of Haplic Fluvisol (Eutric), PA Bulgaria, village Tsalapitsa,

where strongly acidic (T_{CA}), weakly acidic (T_A) positions of soil adsorbent; total acidity ($H_{8,2}$); exchangeable acidity (Al).

Horizon depth, cm	pH H_2O	$CEC_{8,2}$	T_{CA}	T_A	Exch $H_{8,2}$	Exch Al	Exch.Ca	Exch Mg	T_{CA}	T_A	Exch. $H_{8,2}$	Exch. Al	Exch. Ca	Exch. Mg	Base saturation V, %
		mequ/100g soil							% of $CEC_{8,2}$						
Profile 1, temporary beaten track															
Ap_1 0-12	6,4	18,0	16,0	2,0	2,2	0,0	12,8	3,1	88,89	11,11	12,22	0,0	71,11	17,22	87,78
Ap_2 12-17	6,2	18,1	15,8	2,3	2,6	0,0	12,5	3,1	87,29	12,71	14,36	0,0	69,06	17,13	85,64
A 17-24	6,3	17,7	15,1	2,6	2,6	0,0	11,9	3,0	85,31	14,69	14,69	0,0	67,23	16,95	85,31
AC_1 24-40 Sample (29-34)	6,1	18,0	15,3	2,7	2,9	0,0	12,0	3,2	85,00	15,00	16,11	0,0	66,67	17,78	83,89
AC_2 40-58	6,1	18,2	15,5	2,7	3,1	0,0	12,0	3,2	85,16	14,84	17,03	0,0	65,93	17,58	82,97
AC_2' 40-58 sample (49-54)	6,1	18,5	15,7	2,8	3,1	0,0	12,6	3,1	84,86	15,14	16,76	0,0	68,11	16,76	83,24
AC_3 58-77	6,0	18,7	15,5	3,2	3,5	0,0	12,2	3,2	82,89	17,11	18,72	0,0	65,24	17,11	81,28
AC_3' 58-77 sample (59-64)	6,1	18,5	15,4	3,1	3,1	0,0	12,0	3,2	83,24	16,76	16,76	0,0	64,86	17,30	83,24
C_1 77-102	6,3	18,3	15,8	2,5	2,6	0,0	12,5	3,0	86,34	13,67	14,21	0,0	68,31	16,39	85,79
C_2 102-140	6,4	18,6	16,0	2,6	2,3	0,0	13,0	3,2	86,02	13,98	12,37	0,0	69,89	17,20	87,63
Arable land, plough															
Ap 0-30	5,5	23,0	18,8	4,2	4,7	0,6	15,6	2,4	81,74	18,26	20,43	2,6	67,83	10,43	79,57
The deeper data of CEC and composition of exchangeable cations is likely to the Profile 1.															

Method development and application (i.e changes to WP4 Procedures&Protocols)

The following parameters and indicators are measured and calculated:

- Step 1: Undisturbed soil samples were taken with 100 cm^3 rings at medium soil water content (near the field capacity) according to ISO 11272.
- Step 2: Disturbed soil samples were taken for particle size distribution analysis and particle density analysis of the same soil depths.
- Step 3: Determine of bulk density value according to ISO 11272.
- Step 4: Perform of performing particle size distribution analysis on disturbed soil samples.
- Step 5: Perform of particle density analysis with 100 cm^3 pycnometers (Table 7). (samples for soil particle density determinations included both soil mineral and soil organic parts).
- Step 6: Calculation of total porosity.
- Step 7: Calculation of packing density.
- Step 9: Calculation of reference bulk density values as alternative method for determination of threshold values for bulk density.

Table 7. Particle density of Haplic Fluvisol (Eutric), ENVASSO WP 5: PA Bulgaria, village Tsalapitsa, 2007.

Horizon	Depth, cm	Particle density, g/cm^3
Profile 1, temporary beaten track		
A_{p1}	0-12 cm	**2,72**
A_{p2}	12-17 cm	**2,70**
A	17-24 cm	**2,73**
AC_1	29-34 cm (24-40 cm)	**2,78**
AC_2	40-58 cm	**2,77**
AC_2' sample	49-54 cm (40-58 cm)	**2,77**
AC_3	59-64 cm (58-77 cm)	**2,79**
AC_3' sample	59-54 cm	**2,70**
C_1	77-102 cm	**2,68**
C_2	102-140 cm	**2,69**
Arable land, plough		
A_p	0-30 cm	**2,74**

The obtained data for soil bulk density and the estimation of packing density and limiting bulk density along the two soil profiles indicate moderate to high soil compaction (Figure 9). As it is expected under temporary beaten track it starts from the top horizon, while in the arable plot it is expressed by the formation of plough pan at 22-40 cm depth, found also in previous studies on this field (Figures 6a, 6b).

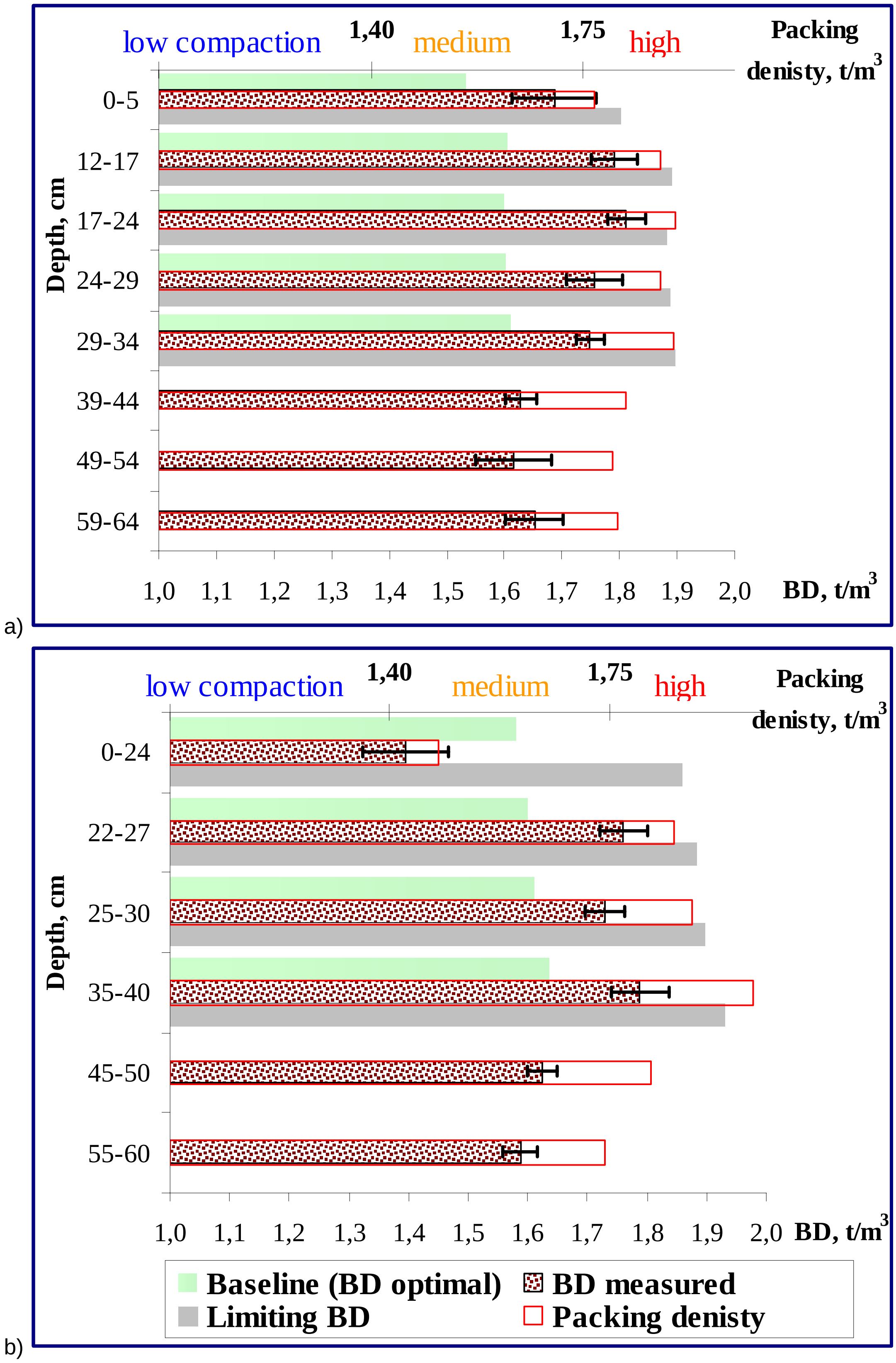


Figure 9. Density indicator of studied soil profiles: (a)- temporary beaten track, (b) – arable field), Haplic Fluvisol (Eutric), ENVASSO WP 5: PA Bulgaria, village Tsalapitsa, 2007.

Table 8. Assessment soil compaction status of Haplic Fluvisol (Eutric), ENVASSO WP 5: PA Bulgaria, village Tsalapitsa, 2007.

Depth,	Db,	clay	Packing density	Humus	Threshold values of Db, t m^{-3}		
cm	t.m^{-3}	<0.002 mm	t.m^{-3}		optimal	critical	limiting
					(Kercheva, Dilkova 2005)		
Profile 1 on the temporary beaten track							
0-5	1.69	9.0	1.77	0.99	1.53	1.70	1.80
12-17	1.79	9.7	1.88	0.66	1.61	1.79	1.89
17-24	1.81	10.1	1.90	0.69	1.60	1.78	1.88
24-29	1.76	13.5	1.88	0.67	1.60	1.79	1.89
29-34	1.75	16.9	1.90	0.64	1.61	1.80	1.90
39-44	1.63	21.2	1.82	0.52			
49-54	1.62	20.3	1.80	0.54			
59-64	1.65	17.2	1.80	0.48			
Profile 3 - arable land, plough							
0-24	1.40	9.0	1.48	0.76	1.58	1.76	1.86
22-27	1.76	10.1	1.85				
25-30	1.73	16.9	1.88				
35-40	1.79	21.2	1.98				
45-50	1.62	20.3	1.80				
55-60	1.59	17.2	1.74				

Evaluation of pilot results

There is a good agreement between the ENVASSO method and a local model (Kercheva, Dilkova, 2005) for estimation of soil density of subsoil layers of both studied soil profiles (Table 3, Figure 9). Packing density of the top plough layer is above the threshold value for medium compaction, while the other evaluation method suggests optimal density. The dependence of reference values of bulk density on humus content in A horizons (Kercheva, Dilkova, 2005) suggests that packing density and its threshold values could be used preliminary as indicator for subsoil compaction.

Indicator: (CP02) Air Capacity

(volume of air-filled pore at a certain suction of 3, 5, and 10 kPa).

Pilot description

Spatial extent

Representative and homogeneous area of topography, soil variety and land use is 12000 m^2 performed by three profiles to depth of 180cm.

Data

New data for soil water retention at suctions - 3, 5 and 10 kPa are obtained in the frame of ENVASSO Project at the tested sides.

Sampling design

Scheme of data requirement selection and collection is according to table 2 and 9.
Data description

Table 9. Scheme of significance of data arranged according to Jan van den Akker (ALTERRA) is:

Air-filled pore volume (% v/v)	at a suction of 3 kPa			**x**
(depths: see table 2)	at a suction of 5 kPa			**X**
	at a suction of 6 kPa			(x)
	at a suction of 10 kPa			**x**

X = *REQUIRED*
x = *medium priority*
(x) = *low priority*

Testing

Air-filled pore volume is determined using core samples of 100 cm^3 volume without deflection and compaction applied into vertical or horizontal soil surface far enough to fill the representative sampler taken with a metal sampling tool. With respect to scheme (Table 2), five replicates of core samples from each soil layer were taken.

The pedologic study confirms the identity of Profile 1, 2 and 3. For study evaluation Profile 1 was chosen, situated on temporary beaten track and Profile 3 on cultivated land (Figure 5).

Methodology used for calculation/estimation of parameters and indicators

Air-filled pore volume is determined by a suction plate method similar to those proposed in ISO 11274: 1998 in two stages:

- Stage 1. Wetting of soil samples at 0.02 kPa on a sand bath.
- Stage 2. Drainage of the wetted samples at 1, 3, 5, 10 kPa using a suction type apparatus (Shot filters).

The air capacity is the difference between total porosity and the water content at a given suction.

Baseline definition

There were no baseline data.

Threshold definition

Threshold value of 10% for an air capacity (air-filled pores) at a soil water suction of 5 kPa.

Pilot methodology

Compilation of soil data and maps for the pilot area

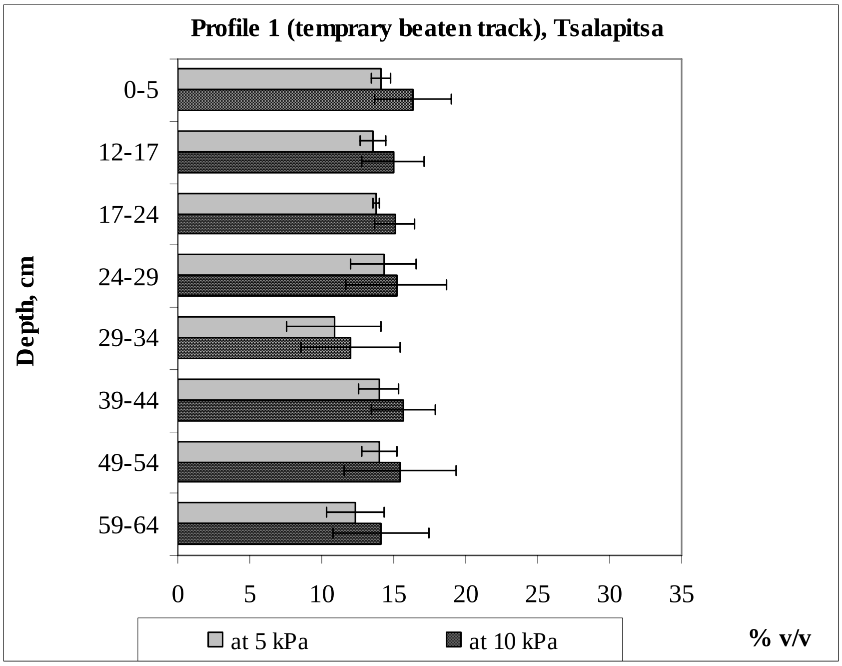
Geo-referenced Profile 1 and Profile 3 situated at 25 meters far each other are studied. Both profiles are identical in morphology, type of soil and differ in applied management practices and pronounce degree of soil compaction. The soil water retention is determined on the undisturbed soil core samples of 100 cm^3 taken for soil bulk density determination.

Method development and application (i.e. changes to WP4 Procedures&Protocols)

Data for water content and air filled pores at 3, 5, and 10 kPa are presented in Table 10. As it is shown (Figure 10) the reduction of air-filled pores volume at both studied profiles corresponds to the profile curves of bulk density – starting from the top under the temporary beaten track, and with a sharp change in the plough pan under the plough layer of arable plot.

Table 10. Field soil water content at sampling (W), dry bulk density (D_b), total porosity (T), water content and air capacity at 3, 5 and 10 kPa. (n=5 replicates),
Haplic Fluvisol (Eutric), ENVASSO WP 5: PA Bulgaria, village Tsalapitsa, 2007.

Depth,	W,	D_b,	T	Water content % $v.v^{-1}$ at			Air-capacity % $v.v^{-1}$ at		
cm	% $v.v^{-1}$	$t.m^{-3}$	% $v.v^{-1}$	3 kPa	5 kPa	10 kPa	3 kPa	5 kPa	10 kPa
Profile 1 on the temporary beaten track									
0-5	16.1	1.69	38.0	27.1	23.9	21.7	10.9	14.1	16.3
12-17	19.0	1.79	33.7	22.2	20.2	18.7	11.5	13.5	15.0
17-24	18.3	1.81	33.7	21.5	19.9	18.6	12.2	13.8	15.1
24-29	21.8	1.76	36.8	24.0	22.6	21.6	12.8	14.3	15.2
29-34	25.5	1.75	37.1	27.4	26.3	25.1	9.7	10.8	12.0
39-44	26.4	1.63	41.2	28.7	27.3	25.6	12.5	13.9	15.7
49-54	27.3	1.62	41.7	29.1	27.6	26.2	12.6	14.0	15.4
59-64	27.9	1.65	40.8	30.0	28.4	26.7	10.8	12.3	14.1
Profile 3 - arable land, plough									
0-24	14.5	1.40	49.0	21.3	19.4	17.4	27.7	29.6	31.6
22-27	26.2	1.76	36.0	27.2	25.8	24.0	8.8	10.2	12.0
25-30	26.1	1.73	37.8	27.1	25.7	24.1	10.7	12.1	13.6
35-40	22.3	1.79	35.5	24.1	22.5	21.0	11.4	13.0	14.5
45-50	25.1	1.62	41.4	26.7	25.2	23.3	14.7	16.1	18.0
55-60	27.2	1.59	42.9	29.3	27.8	26.4	13.6	15.1	16.6



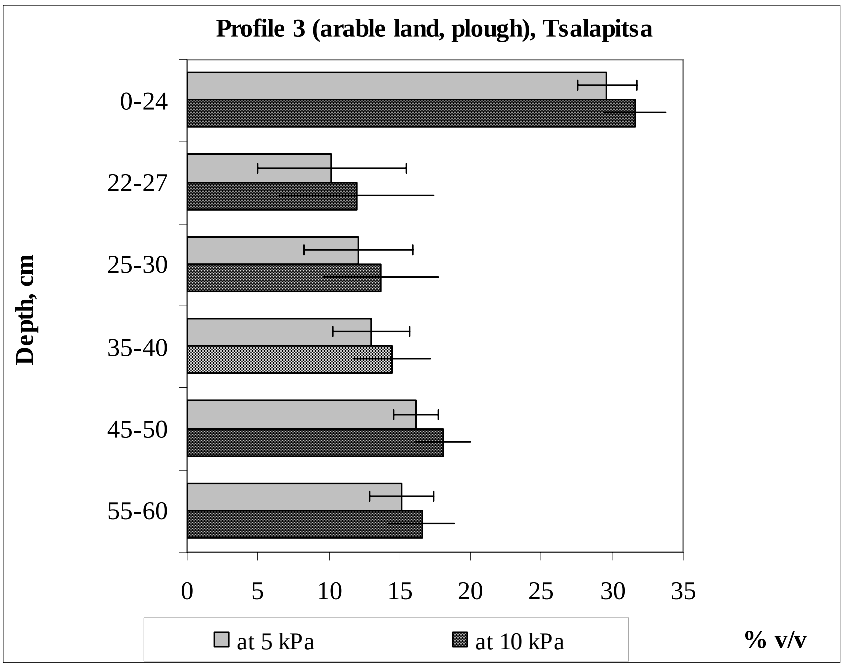


Figure 10. Air filled pores volume at 5 and 10 kPa, Haplic Fluvisol (Eutric)
ENVASSO WP 5: *PA Bulgaria, village Tsalapitsa, 2007.*

Evaluation of pilot results

The air filled pores volume at water suction of 5 kPa is under the threshold of 10% only in some replicates, while the packing density values show high degree of compaction in almost all layers except the top layer of the arable plot (Table 8, Figure 9). It could be concluded that the structure of this soil is much better than expected on basis of the packing densities. It seems that there are still a lot of large pores in the further very dense soil.

Indicator (CP06): Vulnerability to Compaction

Pilot description

Spatial extent

This indicator combines several controlling factors into a single vulnerability assessment model over the studied territory.

Data

Data description
Significance of data arranged according to Jan van den Akker (ALTERRA) is:

Drainage condition	**Class**	**X**
	Groundwater level (winter/summer)	x
	Groundwater level (highest/lowest)	x
Landuse	Arable/Pasture/Forrest/Nature	X
	Crop	x
Soil management and tillage	Ploughing/loosening/no-till (depth)	X
	Deep-loosening (depth)	X
Machinery / Ground pressure	Machinery used (type / brand)	x
	Weight	X
	Load per wheel	X
	Width tire	X
	Inflation pressure	X
Climate	Name and coordinates weather station	X
	Mean percipitation (summer/winter)	X
	Mean evapotranspiration (summer/winter)	X
	Mean percipitation (month or decade)	x
	Mean evapotranspiration (month or decade)	x
	Air temperature (summer/winter)	x
	Air temperature (month or decade)	(x)

X	*= REQUIRED*
x	*= medium priority*
(x)	*= low priority*

Methodology used for calculation
Calculation of potential evapotranspiration is according to the Thornthwaite method according to the discussion during ENVASSO workshop held in Sofia (11-16 June 2007).

Pilot methodology

Compilation of data for the pilot area
The meteorological data for the period of contemporary climate (1961-1990) are used for determination of susceptibility class for:

- average for the period 1961-1990;
- for six years period (e.g., 1985-1990);
- average year;
- wet year;
- dry year.

The representative years are determined on the basis of probability of exceedance of annual precipitation (90% of dry year, 50% for average year and 10% of wet year) determined for 70-years period (1931-1970).

Method development and application (i.e. changes to WP4 Procedures&Protocols)
The two-stage methodology described in Chapter "Vulnerability to compaction" of the ENVASSO Procedures and Protocols was applied for the Pilot Area.

The assessment of inherent susceptibility (Stage A) is based on the measured data for soil texture, bulk density and estimated packing density of subsoil. It is estimated that Haplic Fluvisol (Eutric) has medium susceptibility to soil compaction (Stage A of Table 11).

Table 11. Vulnerability to soil compaction of the Bulgarian Pilot Area.

Stage A Assess inherent susceptibility

Soil	Topsoil state	clay% Subsoil	Texture class	code	D_b, $t.m^{-3}$ subsoil	PD, $t.m^{-3}$	PD class	Susceptibility class
		21	medium	2				
Fluvisol	firm				1.63	1.82	High	M
	loose				1.62	1.81	High	M

Stage B Determination of vulnerability class

Soil	Topsoil state	Period	R (mm)	PET^b (mm)	PSMD (mm)	Climate zone	Vulnerability to compaction
Fluvisol	firm (loose)	1985-1990	399	735	336	Dry	N (N)
		1961-1990	516	733	217	Sub-humid	N(N)
		Average year 1982	517	743	226	Sub-humid	N(N)
		Wet year 1979	712	757	45	Perhumid	V(E)
		Dry year 1989	360	744	384	Dry	N(N)

Evaluation of pilot results

The method of calculation of potential evapotranspiration is not pointed out in the ENVASSO Procedures and protocols. This could lead to confusion when climate zones are determined according to the values of potential soil moisture deficit (PSMD). If this indicator will be estimated for monitoring purposes on 6 years period it should be calculated for each year separately, otherwise the effect of wet years (as well as wet seasons in the year) on soil compaction will be neglected.

Indicator (CP03): Permeability – Saturated Hydraulic Conductivity.

Pilot description

Spatial extent

Representative and homogeneous area of topography, soil variety and land use is 12000 m^2 performed by three profiles to depth of 180cm.

Data

New data of soil samples for saturated hydraulic conductivity are obtained in the frame of ENVASSO project at the tested sites. Scheme of data requirement selection and collection is according to table 2.

Data description

Scheme of significance of data arranged according to Jan van den Akker (ALTERRA) is:

Saturated hydraulic conductivity (cm/day)	Ploughpan mixed with topsoil			**X**
(depths: see table 2)	Ploughpan			**X**
	10 cm below top ploughpan			(x)
	20 cm below top ploughpan			**x**
	30 cm below top ploughpan			(x)

X	*= REQUIRED*	
x	*= medium priority*	
(x)	*= low priority*	

Testing

Saturated hydraulic conductivity is determined using core samples of 200 cm^3 volume without deflection and compaction applied into vertical or horizontal soil surface far enough to fill the representative sampler taken with a metal sampling tool. With respect to scheme (Table 2), three depths of core samples from each soil layer were taken.

The pedologic study confirms the identity of Profile 1, 2 and 3. For study evaluation Profile 1 was chosen, situated on temporary beaten track and Profile 3 on cultivated land (Figure 5).

Methodology used for calculation/estimation of parameters and indicators

The hydraulic conductivity of saturated soil was determined by the constant-head laboratory method on undisturbed soil core samples of 200cm^3..

Baseline definition

There were no baseline data.

Pilot methodology

Compilation of soil data and maps for the pilot area

Geo-referenced Profile 1 and Profile 3 situated at 25 meters far each other are studied. Both profiles are identical in morphology, type of soil and differ in applied management practices and pronounce degree of soil compaction. Saturated hydraulic conductivity is determined on the undisturbed soil core samples of 200 cm^3.

Method development and application (i.e. changes to WP4 Procedures&Protocols)

Data for saturated hydraulic conductivity are presented in Table 12.

Table 12. Saturated hydraulic conductivity (K_f, cm/day) of soil samples *determined for ENVASSO project, WP5: Bulgarian pilot area on subsoil compaction,village Tsalapitsa, 2007.*

Depth, cm	K_f, m/day		
	Measured	Mean	Standard deviation
Profile 1 on the temporary beaten track			
12-17	0,120	0,099	0,028
	0,067		
	0,109		
17-24	0,089	0,101	0,052
	0,056		
	0,158		
Profile 3 arable land, plough			
22-27/23-28	1,577	0,938	0,598
	0,391		
	0,847		
25-30	0,248	0,508	0,367
	0,009*		
	0,768		
45-50	0,257	0,221	0,107
	0,305		
	0,100		

**Ignored when assessing the mean*

Evaluation of pilot results

The saturated hydraulic conductivity of the most compacted soil layers under the temporary beaten track is nearly the threshold value (10 cm/day). In the arable field K_f values are higher which could be explained with land use and different structure.

Indicator (CP04): Visual Assessment of Structure and Testing in the Field.

Pilot description

Spatial extent

The indicator is based on soil profile morphological diagnostic and assessment classes. Data extrapolation is available to characterize enclosed territory within the homogeneous soil unit and land management practices.

Data

Field morphological site specific diagnostic and analysis performs soil structure expressed as size, strength of aggregates, and usually porosity throughout the profile.

Sampling design

Scheme of data requirement selection and collection is according to table 2.

Data *description*

Required data according to the WP4 "Procedures&Protocols" are:

a. Soil structure morphological diagnostic;
b. Texture%, classes (field test);
c. Root penetration depth (field test);
d. Ground water table (available data from local soil survey).

Testing

This is a direct and complete determination of compaction and structural degradation. Field site testing presented by Profile 1 and 3 is according to the WP4 “Procedures&Protocols” description.

Methodology *used* for analysis

Assessment of packing density is obtained from the soil structure and particle size class for subsoil horizons particularly with sandy loam texture described in WP4 “Procedures&Protocols”.

Pilot methodology

Compilation of soil data and maps for the pilot area

Method for visual assessment of structure is tested at the Profile 1 and 3 (Figure 5). Both profiles are identical in morphology, soil type and differ in applied management practices and pronounce of degree soil compaction.

Soil survey data (1972), soil map and topographic one at scale 1:10,000 are also used.
The results of particle density visual assessment for Haplic Fluvisol (Eutric) are performed in Table 13.

Method development and application (i.e changes to WP4 Procedures&Protocols)

Field soil structure analysis is a visual procedure for morphological soil diagnostic with compliance to the WP4 “Procedures&Protocols” description.

Step 1: Field soil structure analysis in each determined soil layer.

a. Test of soil or ped strength (classes)
b. Test degree of ped development (classes)
c. Test size and shape of peds (classes)

Step 2: Determine of packing density class

a. Assign a packing density class by inserting the soil structure data (step 1) in the proposed conversion table in WP4 “Procedures&Protocols (step 2).

Evaluation of pilot results

Method could be easily used for structure degradation analysis in a whole soil profile. Assessment is subjective and demands highly skilled field expertise. Interpretation of subsoil compaction performs affects on pore continuity, soil structure and rooting, however depends on climate and drainage conditions.

The packing densities determined with this method is for all layers equal or lower than the packing density calculated with equation $Pd = Bd + 0.009\ C$ (see indicator CP01). .

It could be concluded that the structure of this soil is much better than expected on basis of the calculated packing densities. This is in agreement with the findings based on the air-capacity (CP02) and with moderately low to moderately high saturated hydraulic conductivities in CP03.

Table 13. Packing density: visual assessment of Haplic Fluvisol (Eutric), ENVASSO WP5: PA Bulgaria, village Tsalapitsa, 2007.

Horizon	Depth, cm	Ped strength	Degree of ped development	Size and shape of peds	Assessment of packing density
Profile 1, temporary beaten track					
A_{p1}	0-12	Very weak	Apedal-single grain	Granular Fine 1-2mm	Low packing density <1,40g/cm^3
A_{p2}	12-17	Moderately weak	Weakly developed	Granular Fine 1-2mm (70%) Medium 2-5mm (30%)	Low packing density <1,40g/cm^3
A	17-24	Moderately weak	Massive	Coarse subangular blocky 20-50mm	Medium packing density 1,40-1,75g/cm^3
AC_1	24-40 (29-34)	Moderately firm	Moderately developed	Medium subangular blocky 5-10mm	Medium packing density 1,40-1,75g/cm^3
AC_2	40-58	Moderately firm	Moderately developed	Medium subangular blocky 5-10mm	Medium packing density 1,40-1,75g/cm^3
AC_2' sample	40-58 (49-54)	Moderately firm	Moderately developed	Medium subangular blocky 5-10mm	Medium packing density 1,40-1,75g/cm^3
AC_3	58-77	Moderately weak	Moderately developed	Coarse subangular blocky 20-50mm	Medium packing density 1,40-1,75g/cm^3
AC_3' sample	58-77 (59-64)	Moderately weak	Moderately developed	Coarse subangular blocky 20-50mm	Medium packing density 1,40-1,75g/cm^3
C_1	77-102	Moderately weak	Weakly developed	Fine subangular blocky 5-10mm (50%) Very fine subangular blocky (<5mm) (50%)	Low packing density <1,40g/cm^3
C_2	102-140	Very weak	Massive	Granular Fine 1-2mm (50%) Medium 2-5mm (50%)	Low packing density <1,40g/cm^3
Profile 3, Arable land, plough					
A_p	0-24	Moderately weak	Weakly developed	Medium granular 2-5mm (75%) Coarse subangular bloky 20-50mm (25%)	Low packing density <1,40g/cm^3
A	24-30	Moderately weak	Massive	Coarse subangular blocky 20-50mm	Medium packing density 1,40-1,75g/cm^3
AC_1	35-40	Moderately weak	Moderately developed	Medium subangular blocky 5-10mm	Low packing density <1,40g/cm^3
AC_2	45-50	Moderately weak	Moderately developed	Medium subangular blocky 5-10mm	Low packing density <1,40g/cm^3
AC_3	55-60	Moderately weak	Moderately developed	Coarse subangular blocky 20-50mm	Medium packing density 1,40-1,75g/cm^3

Indicator: (CP05) - Penetration resistance measured in the field.

Pilot description

Spatial extent

The indicator is applied at four testing plots of 200 m^2 area each according to the scheme figure 5.

Data

Data for penetration resistance are for four tested plot areas to the depth of 40 cm obtained within the frame of the ENVASSO project.

Sampling design

Scheme of data requirement selection and collection is according to the table 2 and figure 5.

Testing

Testing was carried out on May 2007 at the nearest to the studied profiles 1, 2, 3 field plots during the same time of the day. The field plots differ in soil moisture content (no irrigation influence), tillage practices and crop rotation figure 5.

The penetration measurements were accomplished by driving the cone penetrometer into the soil with falling weight. The cone area dimensions: base area diameter d=9 mm, S=63.6 mm^2, top angle 60^o.

Methodology used for calculation/estimation of parameters and indicators

Standard procedure for field penetration resistance testing by 10 replicates is used.
Basic statistics is applied for data calculation.

Baseline definition

Baseline values for soil penetration resistance depend on soil moisture content at the moment of start period when heavy machines force compaction deeper into the subsoil. Baseline values for the structural status of soil depend on specific characteristics as texture, organic matter content, land use as well as of previous machinery trip over the field (Figures 11, 12).

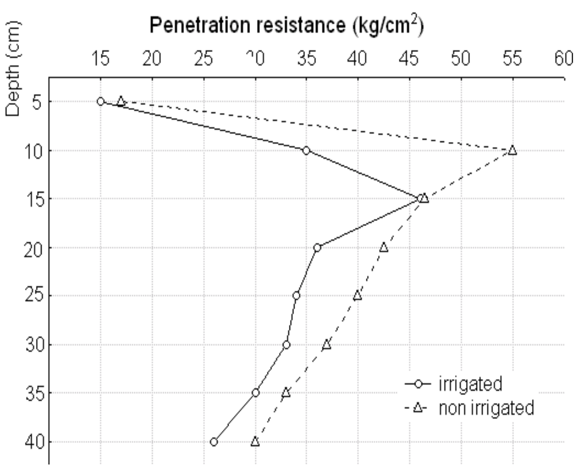


Figure 11. Penetration resistance (kg/cm^3). Haplic Fluvisol (Eutric), village Tselapitsa, 2005. Maise plot areas with and not irrigated.

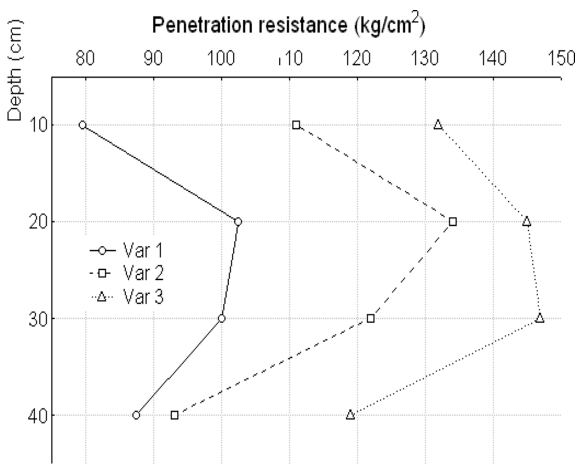


Figure 12. Penetration resistance (kg/cm3). Haplic Fluvisol (Eutric), village Tselapitsa, 2005.

Var. 1) ones tractor furrow running; Var. 2 three times tractor furrow running; Var. 3 five times tractor furrow running.

Pilot methodology

All tillage operations change the structure of the soil caused by the long-term effects pressure of tractor tires. Effects of wheel traffic over the soil compaction is usually not been broken up by subsequent tillage thus compaction gradually increases.

Compilation of soil data and maps for the pilot area

Data for penetration resistance at Test Pilot Area for soil compaction is based on the background of long term data obtained at the experimental station of Nikola Poushkarov Institute of Soil Science in the village Tsalapitsa. Soil survey data (1972), soil map and topographic one at scale 1:10,000 are also used. Information about local tractors and machinery used in the field is of great potential as well as long-term data for land use and crop rotation.

Methodology used for calculation/estimation of parameters and indicators

Data for penetration resistance are presented in table 14.

Table 14. Penetration resistance
MPa (n=10 replicates), Haplic Fluvisol (Eutric),
ENVASSO WP 5: PA Bulgaria, village Tsalapitsa, 2007.

Depth, Cm	Area of Profile1 on the temporary beaten track		Area of profile 2 arable land 20-24cm plough		Area of profile 3 arable land 20-24 cm plough, extremely wet		Area of profile 1 arable land 40cm plough, wet	
	mean	stdev	mean	stdev	mean	stdev	mean	Stdev
0-5	0.74	0.36	0.65	0.18	0.37	0.16	1.55	0.51
5-10	1.80	1.17	0.81	0.25	0.37	0.12	1.97	0.22
10-15	7.36	2.75	0.81	0.20	0.37	0.12	1.62	0.36
15-20	9.09	2.69	1.27	0.88	0.42	0.10	1.62	0.44
20-25	8.17	1.69	1.64	1.19	0.51	0.18	1.67	0.60
25-30	4.65	1.73	3.29	1.86	0.65	0.60	1.94	1.23
30-35	2.87	0.40	3.63	1.82	1.60	0.87	3.29	1.55
35-40	2.20	0.53	3.52	1.89	2.34	0.58	4.21	1.65

Evaluation of pilot result

Method is a reliable source as a quick field test for soil compaction and does not demand certain skills. However the dependence of penetration resistance on soil moisture content should be taken into account when soil compaction is estimated at different meteorological conditions.

Conclusions and recommendations

The selected top three indicators are useable and are well described in the manual of procedures. Some additions to the manual concern:

- relating threshold values of the indicators 1 and 2 to soil texture class.
- restriction of the application of packing density – only for subsoil compaction and as well for estimation of the inherent susceptibility to compaction;

- specification of the method for calculation of potential evapotranspiration and period for determination vulnerability class;
- irrigation must be included / considered for determination vulnerability class

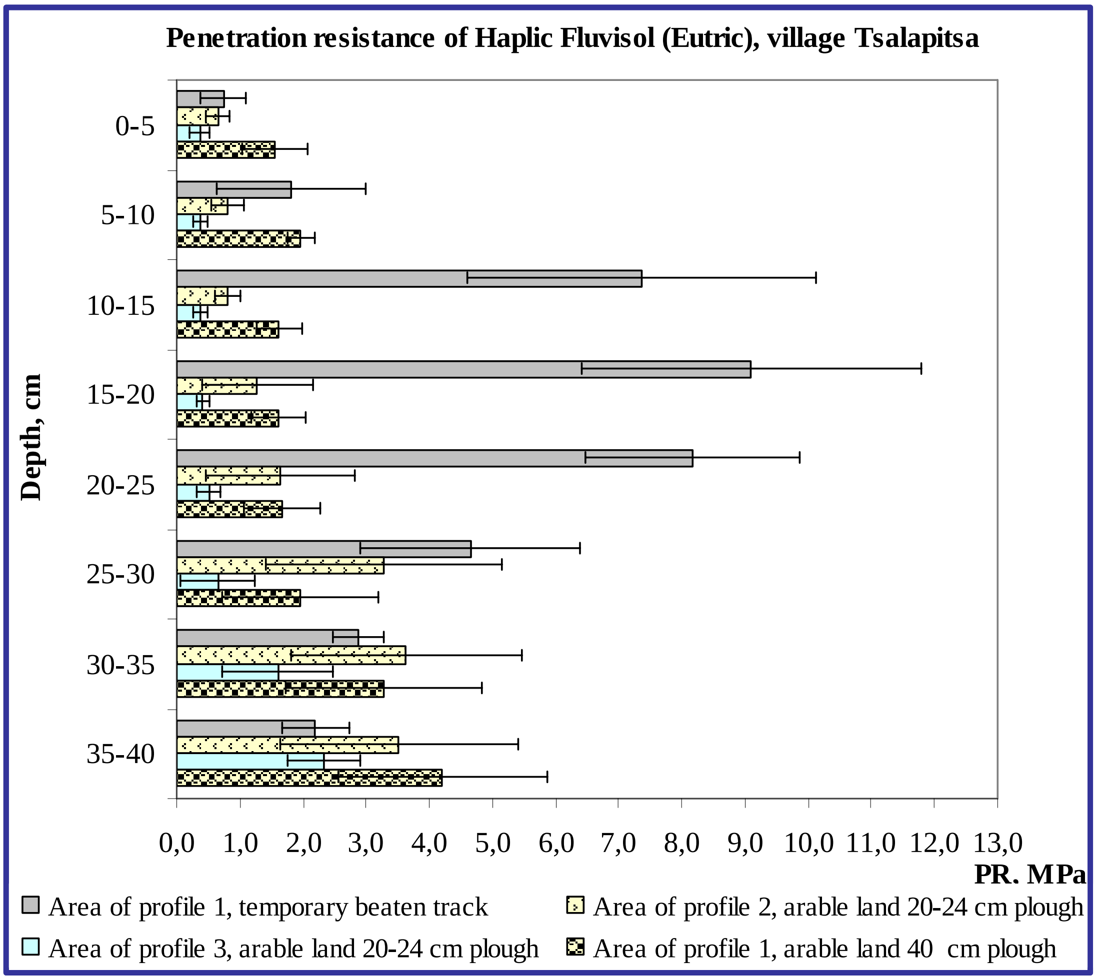


Figure 13. Penetration resistance of Haplic Fluvisol (Eutric),
ENVASSO WP 5: PA Bulgaria, village Tsalapitsa, 2007.

A major problem with CP06 Indicator - (Vulnerability to compaction) is that already compacted subsoils are considered less vulnerable than non-compacted subsoils. So, the more a subsoil is compacted the less susceptible this subsoil becomes for compaction. Of course it is true if compaction is just considered as an increase in bulk density. However, the focus should be on the soil qualities of the subsoil. In a vulnerability assessment it should be considered that:

- The fact that the subsoil is compacted means that the soil was susceptible to compaction (so has an inherent susceptibility for compaction).
- A small increase in density of a dense soil will result in a much higher decrease in soil quality than a small increase in density of a loose soil
- An overcompacted layer can increase in thickness
- The natural recuperation of a soil will decrease strongly the denser the soil becomes (the compacted soil remains wet (so less shrinkage) and the possibilities for rooting and soil fauna are limited)

A solution for this dilemma could be to focus much more on the change of soil quality and soil structure (e.g. expressed in the saturated hydraulic conductivity or the air conductivity at a certain suction). So a soil is considered very vulnerable if a small increase in density results in a strong decrease in required soil properties (as Ksat).

Another solution could be not to consider the actual density, however, a desired density or a baseline density and to use this in the vulnerability assessment methods. So, to consider an inherent vulnerability of the subsoil.

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Pilot area: Brittany, France

Lead partner: University of Rennes
Guénola PERES
Daniel CLUZEAU

Partner A Jérôme CORTET

Partner B Rémi CHAUSSOD

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Description of the pilot area

Name of pilot area		RMQS Biodiv
Names of participating partners	**Lead partner**	**Guénola PERES** **Daniel CLUZEAU**
	Partner A	Jérôme CORTET
	Partner B	Rémi CHAUSSOD
Location and description	Member State(s)	FRANCE (Brittany)
	Coordinates	47° 26' 27" N 2° 28' 46" W 48° 38' 10" N 1° 30' 25" W 48° 38' 55" N 4° 25' 47" W 48°2' 16" N 4° 44' 45" W
	Area of pilot area (km^2)	27,208
	Climate	Oceanic
	Mean temperature (FAO 2006*)	Two contrating areas: **West:** 8.1 to 15°C (mean = 11.4°C) **East:** 7.6 to 15.9°C (mean = 10.4°C)
	Average Annual Precipitation (FAO 2006)	**West:** 1400 mm **East:** 700mm
	Outline description of topography	Brittany reaches 387 m: - In the western part the relief is accentuated with deep hydrographic networks and usually exceeds 250m. - - In the eastern part the relief is less accentuated with large depressions and never exceeds 150m.
	Elevation (m)	20 - 387m
	Vegetation (FAO 2006)	HT, medium grassland (HM), HS, WE, WX
	Major Land Use (FAO 2006)	**AA** (AA1,AA3) [CeWh, CeBa, CeMa, FoCl, FoGr, FoHa, FoLe, FoMa] [PL, MO] **MP,H12, H11**
	Major soils (WRB 2006 RGs**)	Cambisols (CM), Luvisols (LV)

* ftp://ftp.fao.org/agl/agll/docs/guidel_soil_descr.pdf
**ftp://ftp.fao.org/agl/agll/docs/wsrr103e.pdf

Brittany occupies a large peninsula in the northwest of France (see figure 1).

The relief is strongly related to i) the geological substrates (Brioverian schist, Paleozoic granite and Paleozoic schist, sandstone), ii) the action of the large tectonic faults which cross the region, and iii) the erosion of the Armoricain massif, since last 300 millions years. If major soils are Cambisol and Luvisols, other soils are also observed to a lesser extent: Redoxisols, Rankosols, Colluviosols/fluvisols.

Concerning some topsoil characteristics: the pH ranges from 5 to 7 (mean 6) ; the OC (OM%) ranges from 4 to 8% (in the western part) and from 2 to 4 % (in the eastern part).

Agricultural lands in Brittany occupy 83,5% of the region, and are subdivided in permanent crops, pastures and horticulture (truck farming). Crops (cereals as wheat, barley, maize, leguminous plants, and fodder plants) represent 25% of the regional area, whereas pastures (permanent or temporary; pasture or fodder; fertilized or not) and horticulture (truck farming) represent 48,3 %. Forests represent only 8.9%.

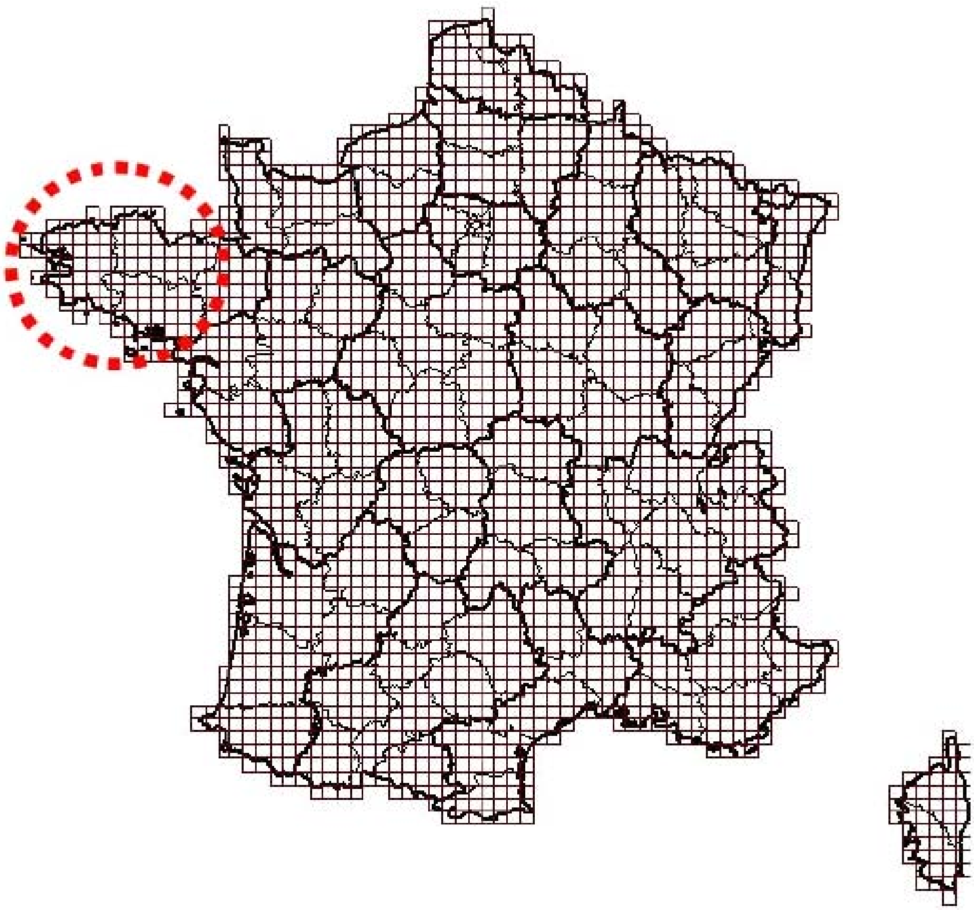


Figure 1. Localization of the Pilot Area (surrounded) and organization of the RMQS grid

Threat and related indicator(s) evaluated in pilot area

Table 2. Top 3 indicators measured in the French PA

Threat	Decline in soil biodiversity
Indicator BI01	Earthworm
Indicator BI02	Collembola
Indicator BI03	Microbial respiration

In the PA, the 3 top indicators defined by WP1 (e.g. earthworm, Collembola and microbial respiration) are analyzed (see table 3) but additional indicators recommended in WP1 are also measured (e.g. total macrofauna, nematodes, bacterial and fungal communities, fauna activity).

Rationale for selection of pilot area

Brittany area is representative of a large part of French soils because of the high heterogeneity of soil substrates (e.g. granite, loam, schist, sandstone) and of various land uses and land managements (pastures, crop rotation, monoculture, forest). Furthermore this area also presents a climate gradient from East to West, related to a strong organic carbon gradient. These pedological, climatic and agricultural characteristics create a large number of situations.

This Pilot Area (called RMQS-Biodiv) where soil biodiversity is assessed is integrated in a larger soil monitoring network developed at national scale (RMQS) which assesses the characteristics of soil in terms of: chemistry, physic, land uses. This French soil monitoring network is based on a 16x16 km grid (the same as EU forest is used) (see maps 1 for the national grid and map 2 for the regional scale). All the data from the RMQS are stored in a data base called “DoneSol” which is still in build.

For the PA “RMQS-Biodiv” 115 sites were sampled (34 points in 2006 and 81 points in 2007, see figure 2); the sampling were managed by two teams working in parallel (Vincent Mercier’s team and Laurence Rougé’s team).

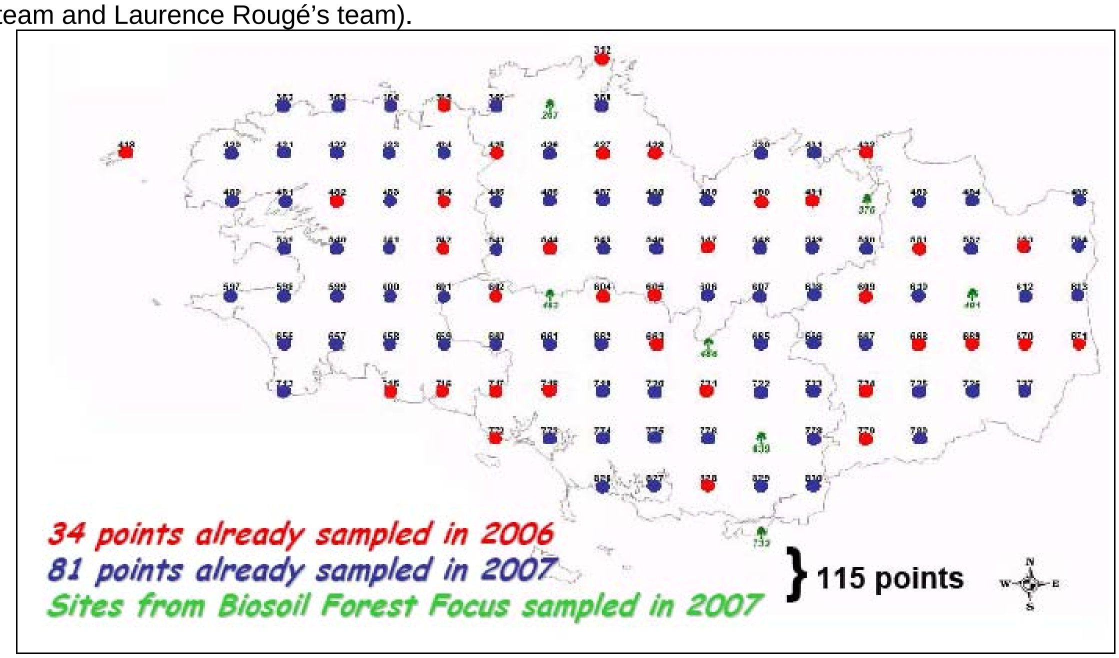


Figure 2. Location of sampling points (RMQS-Biodiv)

Indicator evaluation

This part provides a description of each of the top 3 indicators but also explains how the sampling area is defined and prepared.

Spatial extent and sampling design for each indicator

On each site (from 2ha to 5 ha) of the 115 sites defined according the GPS coordinates given by the RMQS, a sampling area of 102 m² (34 x 3 m) is defined for biodiversity sampling. In order to avoid any disturbance for physico-chemical sampling this area is located 5 m far from classical RMQS area (see figure 3). Localizations of the RMQS-Biodiv areas are also recorded by GPS devices.

The sample area meets the WP1 recommendations

The definition of the sampling area for biodiversity measurements should be carefully made as it should be representative and homogeneous according to the classical RMQS area. The choice is made according to field observations as slope, vegetation…

Inside this RMQS BioDiv area, the location of the sampling sectors for the different biological indicators is clearly identified using different coloured stakes (see figure 4).

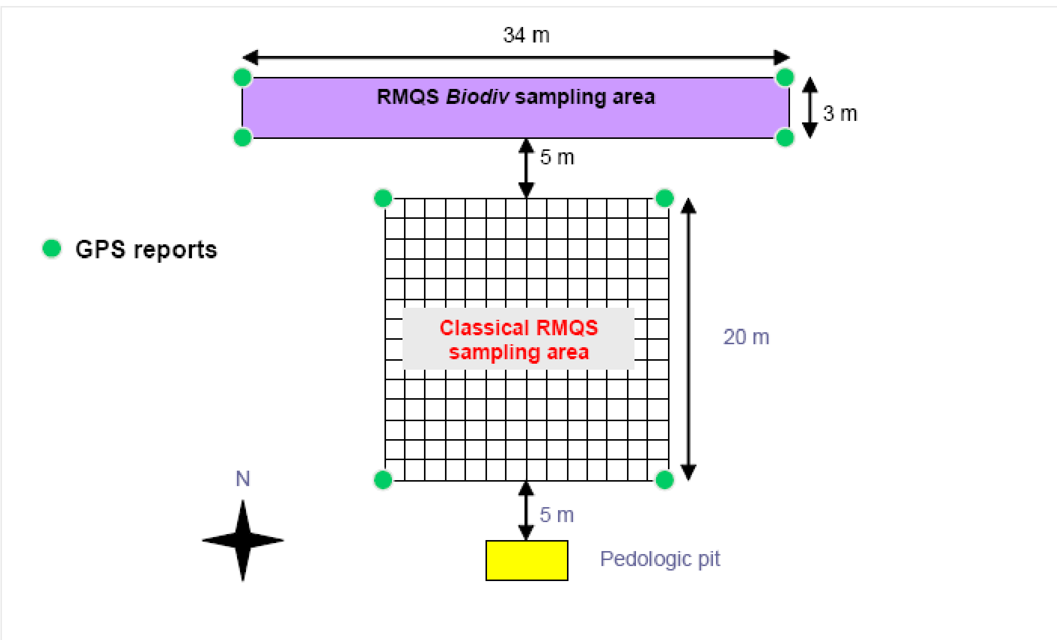


Figure 3. Location of the RMQS BioDiv sampling area with respect tothe classical RMQS composite sample area

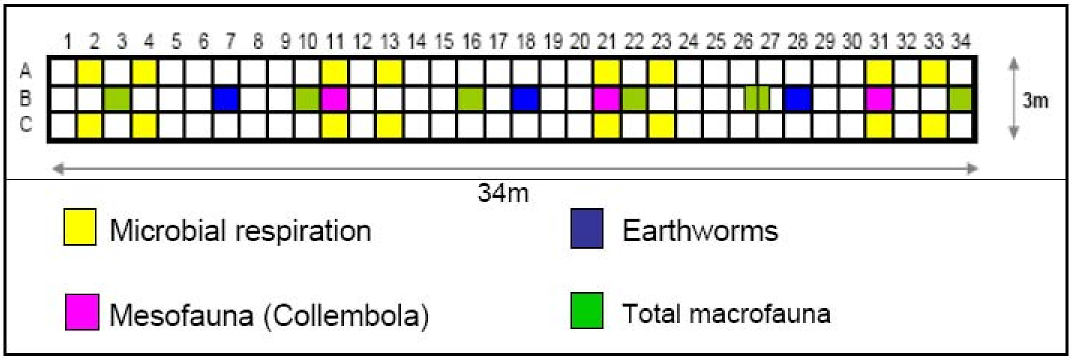


Figure 4. Definition of the sampling sectors for each indicator within the sampling area

Indicator: BI01 – Earthworms

Pilot description

Required parameters

Soil description, soil physico-chemical data and land uses will be obtained thought the national soil monitoring network (RMQS) as the sampling area for indicators is located at the same place. This information will be used to produce maps and any relevant information on the area.

Testing (method of indicator sampling)

Natural earthworm community is extracted using the formaldehyde method (Bouché, 1972; Cluzeau et al., 1999 & 2003) on a 1m² grid, followed at the same place by a hand-sorting on a volume of soil (25x25x20cm) (the detailed procedure is explained in table 4). Three samples are made within the biodiversity sampling area (see figure 4).

Data description and standards

According to ISO 23611-1:2006

a. total abundance (number of individuals per area or volume)
b. total biomass (fresh or dry mass of the earthworms per area or volume)
c. Species richness (number of species)

Methodology used for calculations / estimations of parameters and indicators

Classical additive approaches and statistical analyses will be used to bring out differences in soil indicators depending on soil types, land uses, agricultural practices.

Baseline definition

No baseline defined within WP1.

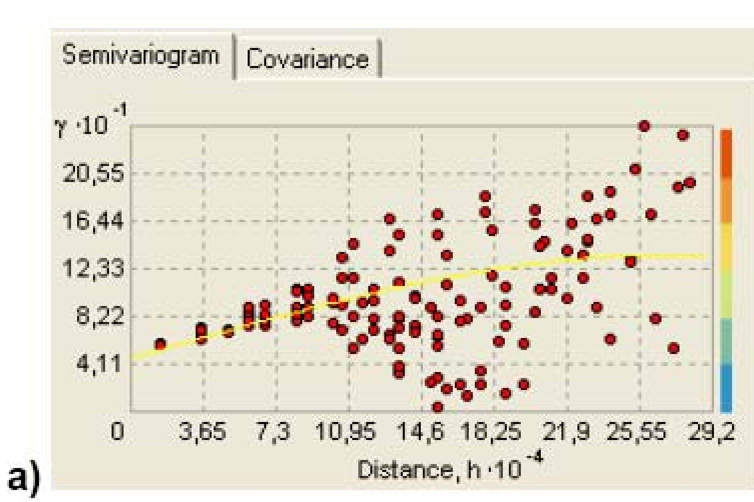
Threshold definition

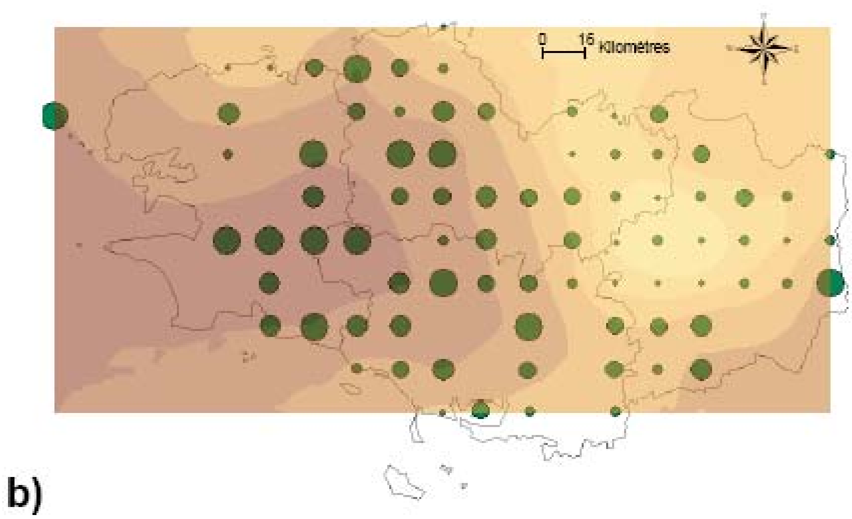
No baseline defined within WP1.

Commentary on original data
All parameters needed to interpret biodiversity values are obtained according to the WP4 P&P.

Pilot methodology
All the sites were sampled and organisms are being identified. A preliminary work can be done on part of the sites in other to present maps and graphs. This is currently being done.

Compilation of soil data and maps for the pilot area
A partial compilation of soil data was performed which allows the presentation of several graphs and maps for the pilot area (e.g. main soil types, main land uses).





a) semi-variogramme, b) map and kriging (test)

Figure 5. Distribution of soil organic carbone content in the PA (DoneSol, INRA Orléans, 2006) .

Method development and application

Step by step procedure

1. Replicate's positioning

    Replicates must be made with a minimum distance of 5 m apart from each other.
    On crops, the replicate must integrate the heterogeneity of rows and inter-rows[3]

2. Description of the vegetation

    -Identify each replicate (site's name, number of the replicate)
    -Take pictures of the replicates surface, for computer interpretation of the vegetation
    -Use a vegetation form to describe the vegetal species present on the replicate
    -Annotate the lombricians form to point out the presence of crop residues, midden, and the soil surface conditions (tire tracks, for example)

3. Soil's surface preparation

    -Locate the grid's positioning with 4 marking plastic stakes on each corner of the grid
    -Take off the grid
    -Short cut the vegetation, without interfering with soil surface conditions
    -Delicately take off the big crop residues
    -Re-position the grid between the 4 stakes

4. Dilutions for formalin watering

    -Fill the watering cans with 10l of water
    -Add 25ml of formalin in 2 watering cans (0,25%), and 40ml in the third (0,4%)

5. Formalin extraction

    -The diluted formalin solution is carefully and evenly applied* on the 1m² (1st watering: 10L of formalin 0,25%) : During 15 minutes, the plot is observed in order to collect all earthworms appearing on the soil surface of the sampling plot.
    -After 15 minutes, this step is repeated applying the same formalin concentration (0.25%, 2nd watering), earthworms are collected during 15 minutes.
    -The last application is realised using a higher formalin concentration (0.4%, 3rd watering): this formalin solution is prepared in an identified watering-can, in order to identify this different concentration.
    -The sampling is finished 45 minutes after the application of the last watering can.
    -Earthworms are collected by forceps. The collected earthworms are immediately fixed in pillboxes half-filled with 4% formalin solution.

6. Hand-sorting

    -Random choice of a 25 x 25 x 20cm volume of soil inside the grid, to core
    -Identify it with 4 marking plastic stakes
    -Take off the grid
    -Remove a single piece of soil by means of spade. The excavated soil is spread out on a plastic tray
    -Cautiously search the soil for earthworms

7. Conservation Earthworms are conserved in the pillboxes until laboratory identification.

** Regular and smooth watering, do not hesitate to apply water to an area larger than the grid.*

---

3 Recommendations:

- Sampling should be done at times of the year where the animals are not forced by the environmental conditions (e.g. low soil moisture and/or high temperatures) into lethargy (e.g. are not reacting to formalin). In temperate regions, such unfavourable sampling times are winter and, in particular, midsummer periods

• Replicates' positioning

    On annual crops: position the grid's left side all along a sowing row

On perpetual crops (vineyards): position a wine row in the left part of the grid, in order to assess both zones: under row and inter-row zones.

Variations are made with respect to ISO 23611-1:2006 to adapt the method to temperate soils (e.g.1m² replicates in order to integrate the spatial variability related to cultivated systems, formalin extraction before hand-sorting). Those variations are in agreement with WP4 procedures and protocols (see annex 1 for the description of the grid to study the effect of the size of the sampling grid).

Statistical and spatial analysis

Data was analysed according to following methods:
-Statistical analysis without spatial approach: Anova, Multivariate analyses (PCA, CA, MCA).
-Spatial analysis:

- autocorrelation method : Geostatistical analysis (kriging), autocorrelation index (Moran I), multivariate approach (Mantel test)
- determination of homogeneous zones: cluster analysis (K-means) with contiguity constraint Statistical analysis

Results are presented in the next 3 figures (Figures 6, 7, 8).

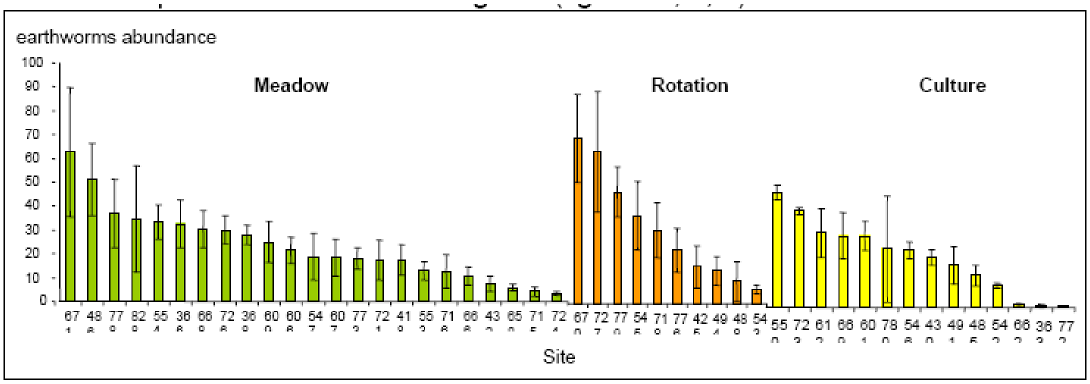


Figure 6. Earthworm abundance (nb. i/m²) depending on the soil use (n=57)

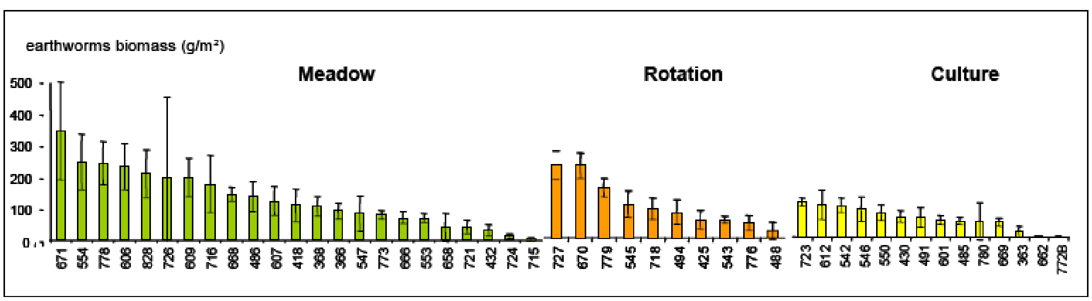


Figure 7. Earthworm biomass (g/m²) depending on the soil use (n=57)

The earthworm abundances and biomasses (Figures 6, 7) are very heterogeneous within each land uses (meadow vs rotation vs culture). Moreover, the earthworm abundances observed under meadow are not higher compared to the abundances observed under cultivated filed (rotation or culture). This result demonstrates that i) land use influence macrofauna state, but in interactions with other parameter as mesologie (OM content, hydromorphic conditions, soil texture, ..) or ii) within each land use, there are many variabilities which interfered as land management (tillage or not), fertilization etc….

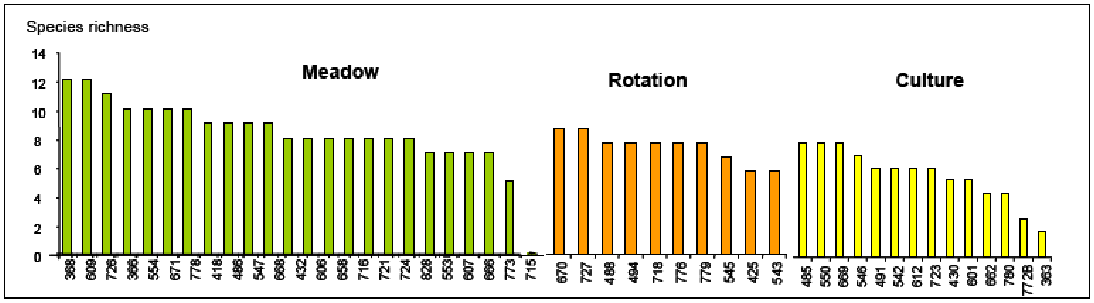


Figure 8. Species richness of earthworm communities depending on the soil use (n=57)

The species richness (Figure 8) is related to the soil use: higher under meadow (from 12 to 6 species) vs rotation (from 9 to 6) or culture (from 9 to 2). This parameter can be used as an indicator of the intensity of the anthropic constraints. It should help us to develop some threshold or baseline.

Spatial approach

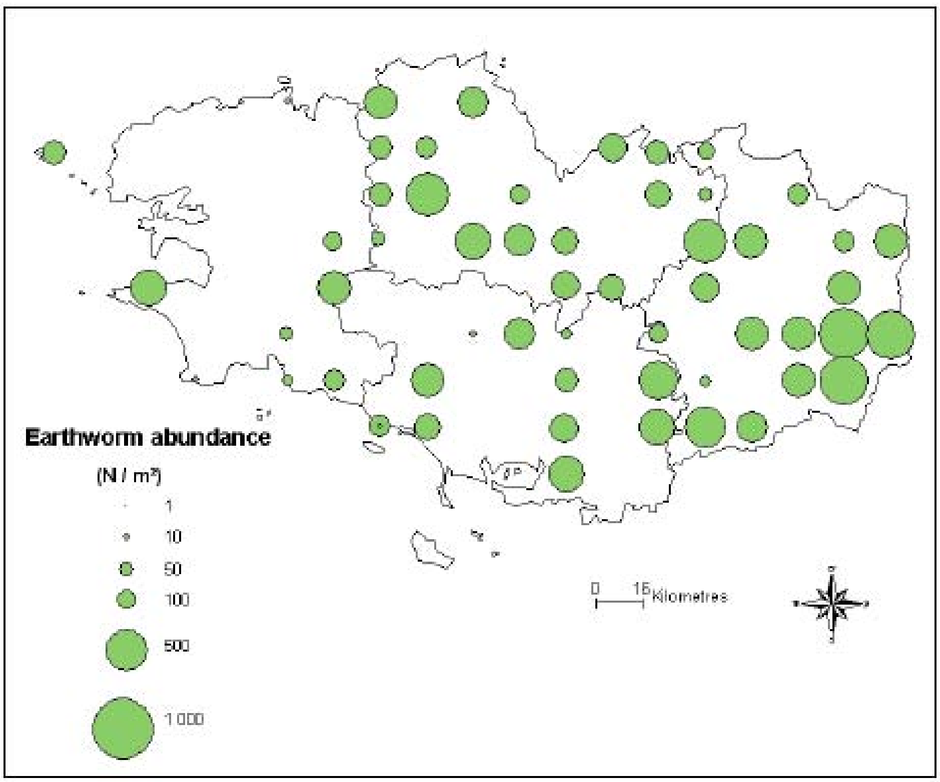


Figure 9. Distribution of earthworm abundance on 57 sites

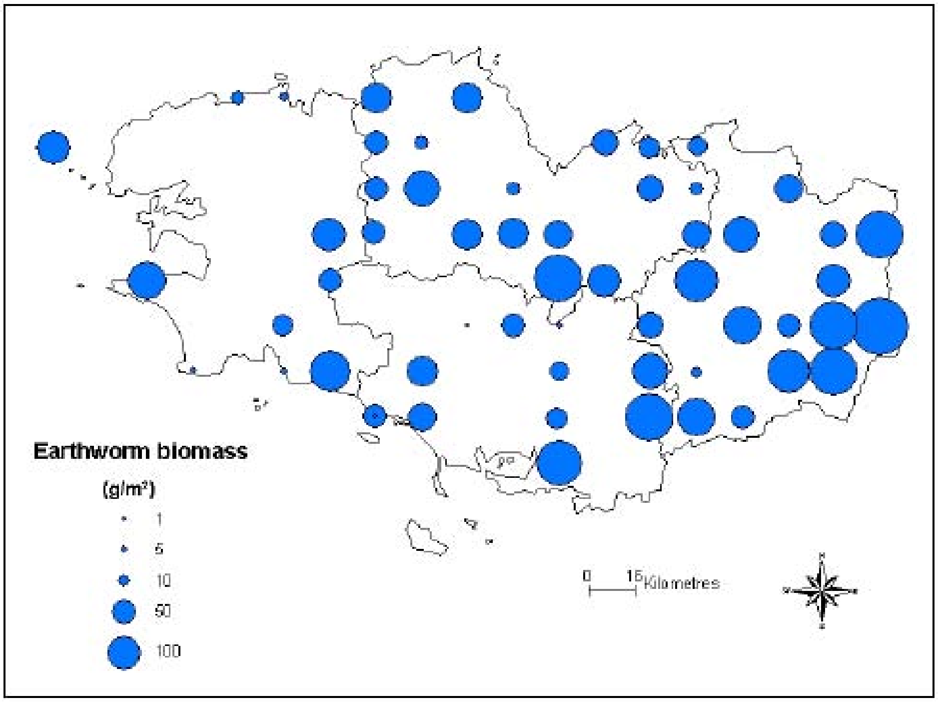


Figure 10. Distribution of earthworm biomass on 57 sites

These first results of earthworm abundance (figure 9), biomass (figure 10) and species richness (figure 11) show the high heterogeneity all over the PA. Till now, no relation to climatic gradient (from East to West) can be clearly observed. More data will be needed to develop a geostatistical approach.

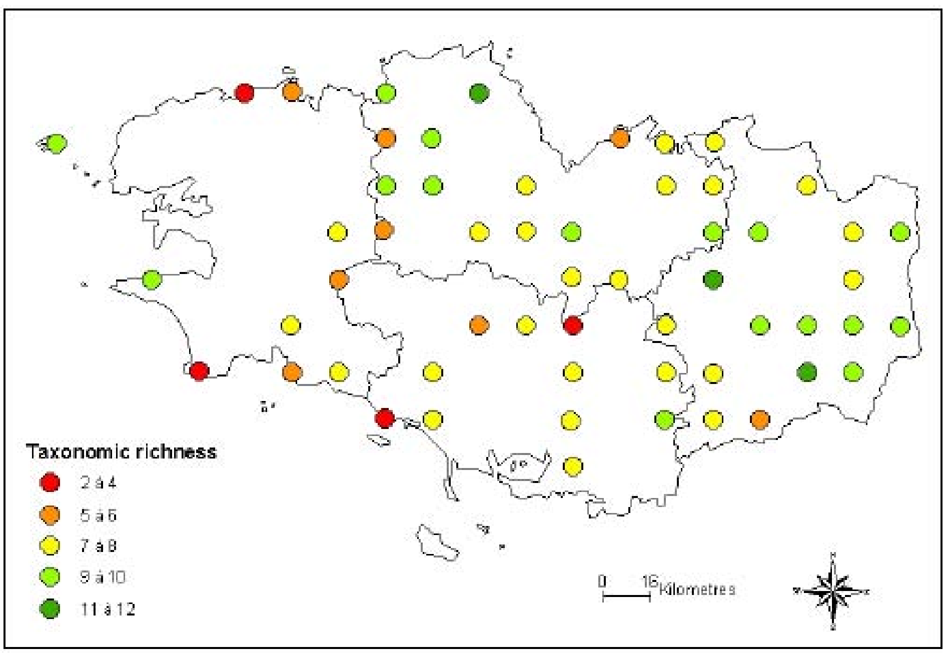


Figure 11. Distribution of earthworm taxonomical richness (i.e. species richness) on 57 sites

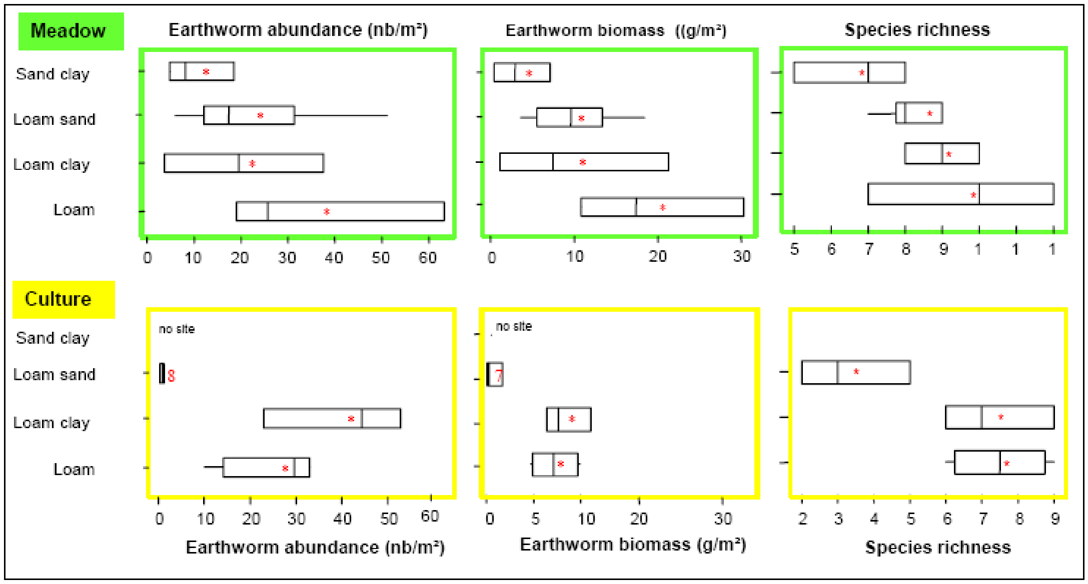


Figure 12. Relation between soil texture and earthworm abundance, earthworm biomass and species richness under meadow (n=19) and under culture (n=10)

The structure of earthworm communities (abundance, biomass, species richness) is influenced by soil texture combined to land use (figure 12). This influence appears more important under culture where a more sandy texture (loam sand) clearly affects the abundance, biomass and species richness of earthworm communities. Under meadow, the loamy texture appears to be the best texture for earthworm communities.

Thus, these first results show the heterogeneity between each land use (meadow vs culture), demonstrate the necessity to assess separately the different land use, in order to define baseline and threshold values. Moreover, the definition and validation of baseline and threshold values sould be done by adding new data (still under analysis) of this Pilot Area.

Methodology used for calculation/estimation of parameters and indicators

For the total biomass (g/m²) and total abundance (nb/m²), two methods are tested:

i) Firstly the number of worms is counted and expressed as individuals per sample (separately for hand-sorting and formalin samples).
Secondly, the number for hand-sorting samples is multiplied by a factor in order to achieve the number of worms per square meter [the factor is 16 when 1/16 m² is used (usually 25cm X 25cm samples)]. Both values are added in order to determine the total abundance of earthworms (according to ISO 23611-1:2006).

ii) Two images of the results are presented separately: one resulting from the hand-sorting extraction, the other one resulting from the formalin extraction. In both case, the earthworm number for samples (hand-sorting or formalin) is multiplied by a factor in order to achieve the number of worms per square meter [the factor is 16 in the case 1/16 m² is used (usually 0,25cm X 0,25cm samples), or is 4 in the case 0,25m² is used (usually 50cm X 50cm samples)].

The species richness is assesses by the number of species.

Part of the data set has been integrated into the SoDa base.

Definition of baselines

As previously described it may be possible to start the definition of baseline values according to land use and soil type (e.g. soil texture). Nevertheless this may be not enough as temporal variations will also be needed. This may be easier for ecosystems as pastures or forests with low human management but for managed systems as crops, depending on the practices (e.g. till, no till), the management (e.g. rotation, monoculture) and inputs (e.g. fertilizers) variations observed may be so important that baselines values have to be defined for specific combinations of agricultural practices.

Definition and application of threshold

Depending on the data, values or percentage can be provide as threshold values (compared to the baseline ones).

Evaluation of pilot results

Feasibility and experience of applying ENVASSO procedures and protocols

The protocol is simple to apply but previous experience in collecting worms is preferable to be quickly operational.

Output performance e.g. Minimum Detectable Change achievable and comparison with WP1 requirements; definition of baselines and application of thresholds

Not tested as any result available yet.

Identified strengths and weaknesses of

a. the estimation of indicator values

- o Strengths: easy to implement especially for total biomass and abundance,
- o Weaknesses:
    - 1- species richness determination will require the help of an expert,
    - 2- biomass and species richness may sometimes not be enough to assess the decline of soil biodiversity function.

b. the interpretation of indicator values

- o Strengths: generally easy to interpret when comparing the influence of land use/soil type on earthworm populations
- o Weaknesses:
    - 1- seasonal variability can influence the earthworm sampling.
    - 2- difficult to compare data collected on other Pilot Areas with different sampling methods.

Conclusions and recommendations

In order to assess the decline of soil biodiversity and soil biodiversity function, biomass and species richness should be completed by other descriptors: it should be relevant to assess abundance and biomass of ecological groups (epigeic, endogeic, anecic) (figure 13), abundance and biomass of species, age structure of the population (e.g. the adult/juvenile ratio). However, these informations are easy to obtain, because they are more or less informed by the species level (if you have the species richness, you also have the abundance and biomass of the species, and also the abundance and biomass of the ecological group). The specific structure could also be completed by some diversity index (ex: Shannon-Wiener index).

Concerning the influence of the seasonal variability, it is necessary:

- i) to realise the soil sampling at the same time of the year (spring or autumn)
- ii) to reduce the sampling period (in our case, the earthworms are sampled between the 15 February to the end of April, moreover all the samplings are realised during the morning time, starting at 8h30),

iii) to associate in the data base (as “SoDa”) the sampling time to each measurement. This information will be analysed as the soil type and/or the soil land use.

Concerning the influence of the different sampling methods, it may be possible to develop a correction index in order to integrate all the data in the SoDa data base.

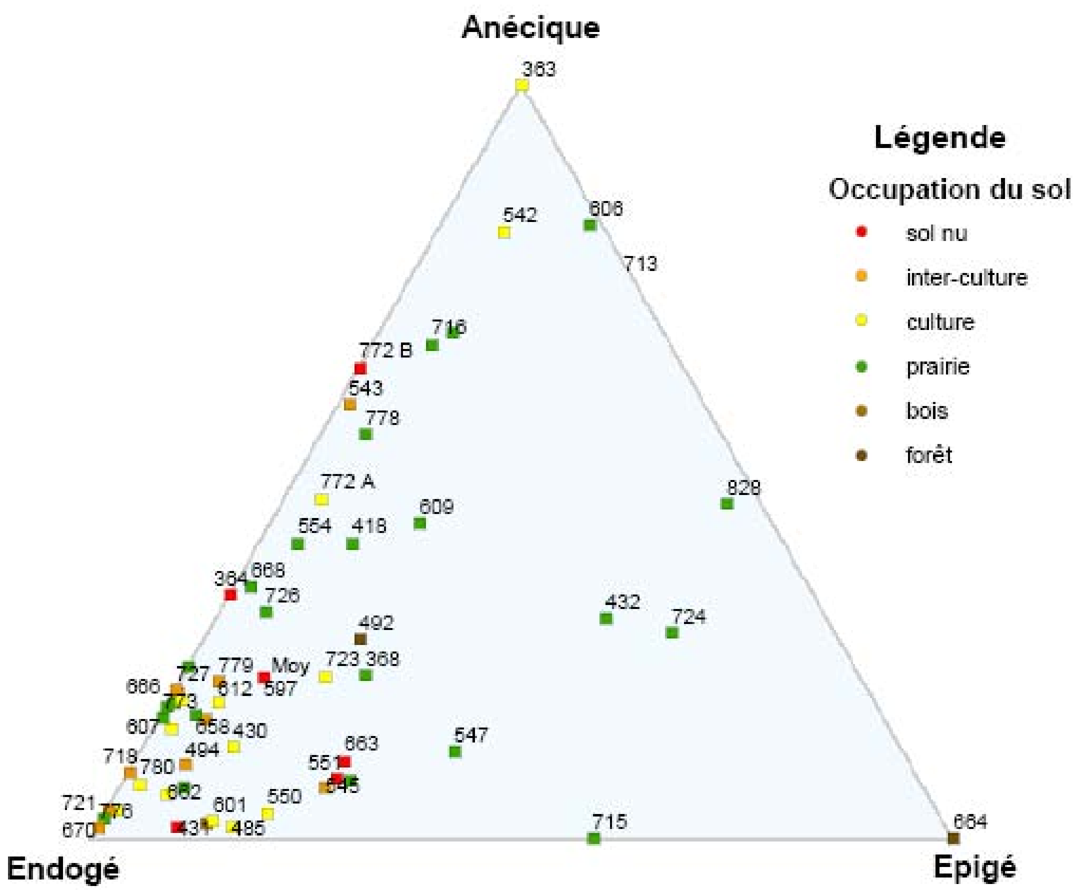


Figure 13. Distribution of ecological group of earthworm depending on the land use

Earthworm communities observed under meadows present higher number of anecic species and epigeic species than communities observed under cultures. Thus, the ecological group (epigeic, endogeic, anecic) can inform more precisely the influence of land use compared to global descriptors as total abundance (nb/m²) or total biomass (g/m²).

Indicator: BI02 – Collembola

Pilot description

Required parameters

Soil description, soil physico-chemical data and land uses will be obtained thought the national soil monitoring network (RMQS) as the sampling area for indicators is located at the same place. This information will be used to produce maps and any relevant information on the area.

Testing

The sampling of Collembola is made according to ISO 23611-2:2006, with advances: 3 soil depths are studied (instead of one in ISO standard). Three soil samples are realized at equal distance and far from the earthworm sampling areas in order to avoid any soil perturbations (see figure 4) (the detailed procedure is explained in table 5).

Data description and standards

The following parameters and indicators will be measured or calculated:

a. Total abundance (number of individuals per area or volume
b. Species richness (number of species)

Part of the data set should be integrated into the SoDa base.

Methodology used for calculations / estimations of parameters and indicators

Classical additive approaches and statistical analyses are used to bring out differences in soil indicators depending on soil types, land uses, agricultural practices.

Baseline definition
No baseline defined within WP1.

Threshold definition
No baseline defined within WP1.

Commentary on original data
All parameters needed to interpret biodiversity values are obtained according to the WP4 P&P.

Pilot method
All the sites were sampled and organisms are being identified. A preliminary work can be done on part of the sites in other to present maps and graphs. This is currently being done.

Compilation of soil data and maps for the pilot area
A partial compilation of soil data was performed which allows the presentation of several graphs for the pilot area (e.g. main soil types, main land uses).

Method development and application

The method used to sample Collembola on the sites and extract Collembola in the laboratory are presented below.

Step Procedure

Table 4. Collembola extraction (according to ISO 23611-2:2006, with some advances)

1. Field sampling	-fill in the split corer with plexiglas tubes (in each split corer introduce 3 plexiglas tubes are in order to collect 3 soil depths) -insert the split corer in the soil and press -open the split corer and extract the soil cores -place the cores in plastic tubes and transport it to the laboratory (on each sample and replicate the depth is clearly identified) -store samples at 5°C, in dark
2. Fresh samples weighing in the laboratory	-weigh the soil samples with their caps -note the fresh weight of each sample -weigh an empty plexiglas tub
3. Positioning of the samples in the extractor	-take off the caps -position each sample on an individual extraction kit -fill the pot below with benzoic acid -open the extractor -position the samples & its kit and pot in their accommodations -position the insulating foam rubber plates -position the temperature captor on the surface of one soil sample -position the insulating wood plates - close the extractor
4. McFayden programming & extraction	-program the apparatus for a 8 days extraction & start it up -standard program (N°2) : 48h/35°C, 48h/40°C, 48h/50°C, 48h/60°C -make sure that apparatus is on automatic mode -press the green button to start extraction
5. Sample recuperation	-take off the samples -separate the sample and its extraction kit -put a drop of liquid soap in each pot, put a cap and note the number of the sample -reposition the caps on each soil samples -weigh the soil samples with their caps -note the dry weight of each sample
6. Sample transfer in alcohol	-put the samples 2 hours in incubator (60°C) -transfer microarthropods in 70°C alcohol by means a micrometric filter : 1-remove the samples from the incubator, empty them towards the filter in a recipient. Animals are retained on the filter 2-turn the filter over & rinse them out with alcohol saving animals and alcohol in a flask 3-throw the benzoic acid solution 4. well note the sample's references on the flask
7. Identification	-abundance (number of animals per area, volume or weight) -number of species or other taxonomically or ecologically defined group -diversity indices (alpha, beta and gamma diversity)

The sampling should be done at times of the year where the animals are not forced by the environmental conditions (e.g. low soil moisture and/or high temperatures). In temperate regions, such unfavourable sampling times are winter and, in particular, midsummer periods.

Collembola are rapidly (within a few days, not much more than one week) extracted by behavioural methods, using a MacFadyen apparatus, and preserved for future identifications.

Statistical and spatial analysis

Data was analysed with classical statistical methods.

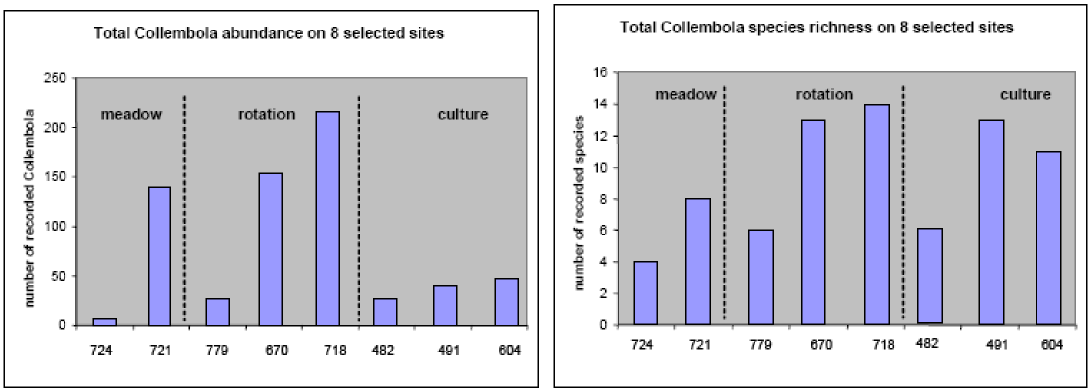


Figure 14. Total abundance and species richness of Collembola on 8 sites.

Total abundances of collembola are heterogeneous within each land uses, nevertheless the lowest abundances are more often observed under culture vs rotation or meadow (figure 14). In contrary, the species richness can reach high value under culture and rotation, more often higher than under meadow. These two parameters (abundance and species richness) give complementary informations.

Methodology used for calculation/estimation of parameters and indicators

Abundance values can be recalculated related to area (usually 1 m²), volume or weight (usually 1 kg).

Definition of baselines

It may be possible to start the definition of baseline values according to land use and soil type. Nevertheless this may be not enough as temporal variations will also be needed. This may be easier for well known ecosystems as pastures or forests with low human management but for managed systems as crops, depending on the practices (e.g. till, no till) and inputs (e.g. fertilizers) variations observed may be so important that baselines values have to be defined for specific combinations of agricultural practices.

Definition and application of threshold

Depending on the data, values or percentage can be provide as threshold values (compared to the baseline ones).

Evaluation of pilot results

Feasibility and experience of applying ENVASSO procedures and protocols

The protocol is simple to apply concerning the field sampling but previous experience and material is needed for the extraction of Collembola (note that the MacFarden extractor can be substitute by other systems as the Tullgreen extractor).

Output performance e.g. Minimum Detectable Change achievable and comparison with WP1 requirements; definition of baselines and application of thresholds

Not tested as any result available yet.

Identified strengths and weaknesses of;

a. the estimation of indicator values

Strengths: easy to implement especially for total abundance,
Weaknesses:

- Taxa approach, especially species identification, will require the help of an expert,
- Total abundance and species richness may sometimes not be enough to assess the decline of soil biodiversity.

b. the interpretation of indicator values

Strengths: generally easy to interpret when comparing the influence of land use/soil type on Collembola populations

Weaknesses: The seasonal variability can influence the Collembola sampling. It is absolutely necessary to avoid very dry sampling periods.

Conclusions and recommendations

It is difficult to compare data collected on other Pilot Areas if sampling was performed according to other methods. It may be possible to develop a correction factors in order to integrate all the data in the SoDa data base.

To assess the decline of soil biodiversity, biomass and species richness should be completed by other descriptors:
-Species abundance (number of individuals per species and area or volume)
-Ecological groups (the definition of ecological groups can be done on several

parameters like habitat see Gisin, 1943).
-species diversity and eveness (easy to calculate using the Shannon index)
-it should also be relevant to assess abundance of ecological groups based on:
-habitat (epi-, hemi-, eu-edaphic species) (Gisin, 1943)
-life history tactics (Siepel, 1994)

- acidophilic species

However, these ecological groups need to be clearly defined before (all the species found have to be classified according to the criteria described for each ecological group, which is not always possible as the ecology of the species are not always known).

Indicator: BI03 – Microbial respiration

Pilot description

Testing

The collection, handling and storage of soil under aerobic conditions for the assessment of microbiological respiration are carried out according to ISO 10381-6. A composite sample (3 kg) is made based on 32 elementary soil cores. The microbial respiration measurement is made in the laboratory according to ISO 16071 (the detailed procedure is explained in table 5).

Data description and standards

Soil description, soil physico-chemical data and land uses will be obtained thought the national soil monitoring network (RMQS) as the sampling area for indicators is located at the same place. This information will be used to produce maps and any relevant information on the area. Part of this data set could also be integrated into the SoDa base.

Methodology used for calculations / estimations of parameters and indicators

Classical approaches and statistical analyses will be used to bring out differences in soil indicators depending on soil types, land uses, agricultural practices.

Baseline definition

No baseline defined within WP1.

Threshold definition

No baseline defined within WP1.

Commentary on original data

All parameters needed to interpret biodiversity values are obtained according to the WP4 P&P.

Pilot methodology

All the sites were sampled and microbial respiration are being measured. A preliminary work can be done on part of the sites in other to present maps and graphs.

Compilation of soil data and maps for the pilot area.

Till now the microbial respiration measurments are still under analysis, thus only the microbial biomass results are presented here.

Method development and application

Table 5 presents the method used to sample soil for microbial respiration determination.

Table 5. Soil sampling (according to ISO 10381-6) and microbial respiration determination (according to ISO 16071)

1. Field sampling [a]	-collect 32 elementary cores (ø 7cm, 15cm depth) across the whole surface of the RMQS Biodiv area (see figure 4) -pass each core through a 6mm-sieve to a plastic[b] tray order to remove any surface vegetation cover, moss-covered litter layer, visible roots, large pieces of plant or woody plant litter and visible soil fauna (this is made to prevent the addition of fresh organic carbon to the soil) -homogenize the soil sample in the plastic tray to end with the composite sample) -place 3kg this composite sample in a plastic9 bag identified with the site's number -store and transport samples to the laboratory at 5°C, in dark
2. Measurement of soil microbial respiration	-place 40g of the soil sample into a glass flask of 575 ml for 28 days at 28°C (soil moisture should be adjust to field capacity) -measure the rate CO2 formation by absorbing the gas in NaOH

a.The sampling should be done at times of the year where the animals are not forced by the environmental conditions (e.g. low soil moisture and/or high temperatures). In temperate regions, such unfavourable sampling times are winter and, in particular, midsummer periods

b.The use of containers which either absorb water from the soil or release into the soil materials, e.g. solvents or plasticizers, should be avoided.

Statistical and spatial analysis

Data will be analysed according to following methods:

-Statistical analysis without spatial approach: Anova, Multivariate analyses (PCA, CA, MCA).
- Spatial analysis:

- autocorrelation method : Geostatistical analysis (kriging), autocorrelation index (Moran I), multivariate approach (Mantel test)
- determination of homogeneous zones: cluster analysis (K-means) with contiguity constraint

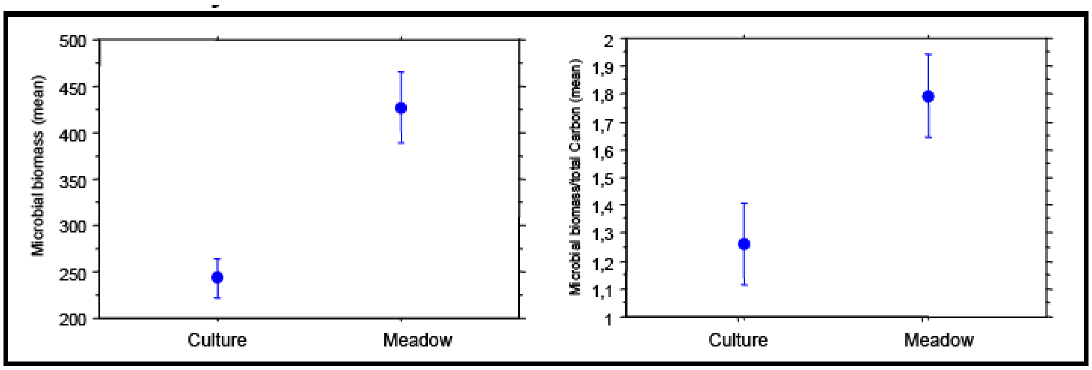


Figure 15. Microbial biomass and ratio microbial biomass/ total soil carbon under culture (n=9) and meadow (n=22) (means)

The microbial biomass, and the ratio microbial biomass/ total soil carbon are strongly influenced by the land use: higher under meadow vs culture (figure 15). The heterogeneity observed within each land use should be explained by the pedological characteristics.

However, these results reflect only 31 data (espciallay, only 9 data under culture), thus these results contribute to increase the knowledge but can not allow some defintive conclusions.

Spatial analysis

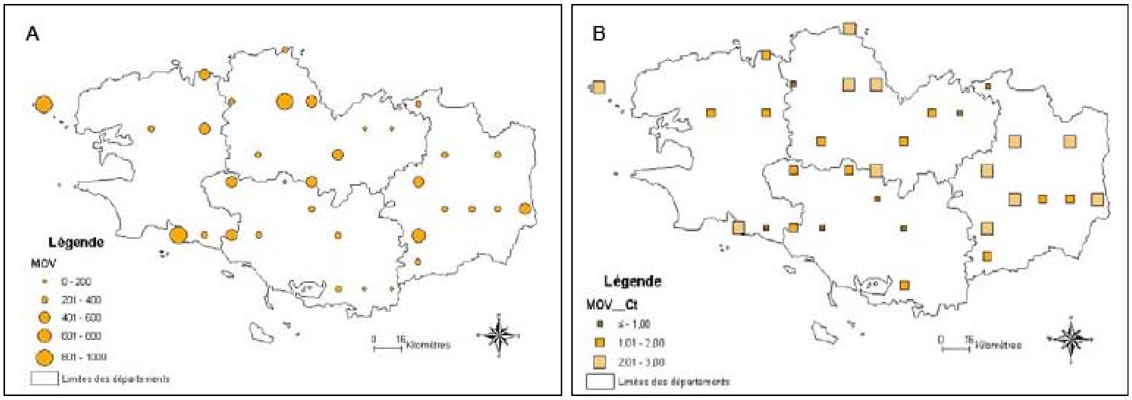


Figure 16. Spatial distribution of microbial biomass (A) and ratio microbial biomass/soil total carbon (B)

Microbial biomass (figure 16 A) or ratio microbial biomass/soil total carbone (figure 16 B) present a high heterogeneity all over the PA, and no link appears between these spatial distribution and a geographical gradient (from est to west). More data will be needed to develop a geostatistical approach.

Relation between microbial biomass and physico-chemical data
The relationship between microbial biomass and total soil carbon is strongly modified depending on the land use (culture vs meadow) (figure 17).

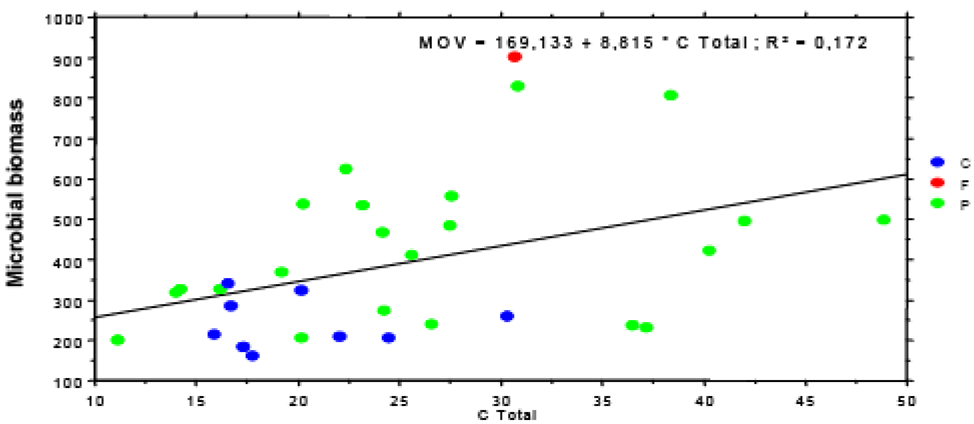


Figure 17. Relationship between microbial biomass (MOV) and soil carbon content (Ct)

Under culture (table 6), there is no significant relation between microbial biomass (MOV) and total soil carbon (Ct), neither between microbial biomass (MOV) and metabolites (MOL); that means that, the culture sites are not balanced in terms of organic state. Microbial biomass appears more related to the clay content.

Under meadows (table 7), the link between MOV and MOL exists, and also the relation with total soil carbon (but not satisticaly significant); whereas there is no impact of the texture.

Table 6. correlation matrix for culture sites (n=9)

Matrice de corrélation

	MOV	MOV%Ct	MOL	MOL%Ct	MOV/MOL	pH K2SO4	Argile	C Total	N total	pH eau	AL_ECH	CEC	Sech/CEC	Sables	Limons	Sab/Lim
MOV	1,000	,818	,067	,241	,863	,200	,568	-,027	-,067	,058	-,415	-,113	,242	-,385	,320	-,477
MOV%Ct	,818	1,000	-,396	,602	,917	,223	,840	-,587	-,585	,144	-,552	-,023	,249	-,533	,431	-,471
MOL	,067	-,396	1,000	-,133	-,441	-,020	-,237	,861	,943	,095	,217	,178	-,027	,134	-,102	-,076
MOL%Ct	,241	,602	-,133	1,000	,246	,280	,882	-,610	-,424	,483	-,501	,466	,247	-,583	,479	-,443
MOV/MOL	,863	,917	-,441	,246	1,000	,191	,602	-,440	-,522	,009	-,475	-,195	,233	-,410	,341	-,395
pH K2SO4	,200	,223	-,020	,280	,191	1,000	,470	-,155	-,028	,836	-,829	,698	,678	-,790	,817	-,729
Argile	,568	,840	-,237	,882	,602	,470	1,000	-,611	-,485	,547	-,747	,431	,497	-,786	,690	-,670
C Total	-,027	-,587	,861	-,610	-,440	-,155	-,611	1,000	,965	-,185	,410	-,103	-,118	,384	-,309	,146
N total	-,067	-,585	,943	-,424	-,522	-,028	-,485	,965	1,000	-,012	,328	,076	-,068	,235	-,164	,006
pH eau	,058	,144	,095	,483	,009	,836	,547	-,185	-,012	1,000	-,834	,932	,799	-,747	,748	-,644
AL_ECH	-,415	-,552	,217	-,501	-,475	-,829	-,747	,410	,328	-,834	1,000	-,706	-,864	,793	-,757	,652
CEC	-,113	-,023	,178	,466	-,195	,698	,431	-,103	,076	,932	-,706	1,000	,772	-,563	,559	-,431
Sech/CEC	,242	,249	-,027	,247	,233	,678	,497	-,118	-,068	,799	-,864	,772	1,000	-,645	,641	-,533
Sables	-,385	-,533	,134	-,583	-,410	-,790	-,786	,384	,235	-,747	,793	-,563	-,645	1,000	-,990	,952
Limons	,320	,431	-,102	,479	,341	,817	,690	-,309	-,164	,748	-,757	,559	,641	-,990	1,000	-,960
Sab/Lim	-,477	-,471	-,076	-,443	-,395	-,729	-,670	,146	,006	-,644	,652	-,431	-,533	,952	-,960	1,000

9 observations ont été utilisées dans ce calcul.

Table 7. correlation matrix for meadow sites (n=22)

Matrice de corrélation

	MOV	MOV%Ct	MOL	MOL%Ct	MOV/MOL	pH K2SO4	Argile	C Total	N total	pH eau	AL_ECH	CEC	Sech/CEC	Sables	Limons	Sab/Lim
MOV	1,000	,585	,759	,616	,388	-,208	,281	,328	,386	-,309	,244	,061	-,139	-,057	-,012	-,088
MOV%Ct	,585	1,000	,191	,762	,682	,109	,194	-,346	-,181	,122	-,191	,128	-,133	-,211	,180	-,158
MOL	,759	,191	1,000	,382	-,265	-,466	,139	,758	,794	-,522	,466	,086	-,151	-,069	,039	-,123
MOL%Ct	,616	,762	,382	1,000	,386	-,244	-,097	-,283	-,160	-,230	,134	-,046	-,290	-,119	,156	-,119
MOV/MOL	,388	,682	-,265	,386	1,000	,382	,162	-,580	-,553	,335	-,290	-,060	-,038	-,014	-,027	-,001
pH K2SO4	-,208	,109	-,466	-,244	,382	1,000	,392	-,395	-,286	,912	-,673	,572	,407	-,152	,063	-,044
Argile	,281	,194	,139	-,097	,162	,392	1,000	,140	,291	,178	-,125	,327	,209	-,455	,235	-,391
C Total	,328	-,346	,758	-,283	-,580	-,395	,140	1,000	,939	-,460	,413	,039	,002	,031	-,071	-,038
N total	,386	-,181	,794	-,160	-,553	-,286	,291	,939	1,000	-,344	,289	,224	,100	-,166	,105	-,212
pH eau	-,309	,122	-,522	-,230	,335	,912	,178	-,460	-,344	1,000	-,784	,631	,466	-,135	,100	-,027
AL_ECH	,244	-,191	,466	,134	-,290	-,673	-,125	,413	,289	-,784	1,000	-,626	-,661	,196	-,181	,102
CEC	,061	,128	,086	-,046	-,060	,572	,327	,039	,224	,631	-,626	1,000	,547	-,103	,026	,010
Sech/CEC	-,139	-,133	-,151	-,290	-,038	,407	,209	,002	,100	,466	-,661	,547	1,000	-,426	,411	-,333
Sables	-,057	-,211	-,069	-,119	-,014	-,152	-,455	,031	-,166	-,135	,196	-,103	-,426	1,000	-,972	,958
Limons	-,012	,180	,039	,156	-,027	,063	,235	-,071	,105	,100	-,181	,026	,411	-,972	1,000	-,943
Sab/Lim	-,088	-,158	-,123	-,119	-,001	-,044	-,391	-,038	-,212	-,027	,102	,010	-,333	,958	-,943	1,000

22 observations ont été utilisées dans ce calcul.

Methodology used for calculation/estimation of parameters and indicators

The end-parameter is x mg CO2.kg-1 dry soil.day-1. Part of the data set should be integrated into the SoDa base.

Definition of baselines

It may be possible to start the definition of baseline values according to land use and soil type. Nevertheless this may be not enough as temporal variations will also be needed. This may be easier for well known ecosystems as pastures or forests with low human management but for managed systems as crops, depending on the practices (e.g. till, no till) and inputs (e.g. fertilizers) variations observed may be so important that baselines values have to be defined for specific combinations of agricultural practices.

Definition and application of threshold

Depending on the data, values or percentage can be provide as threshold values (compared to the baseline ones).

Evaluation of pilot results

Feasibility and experience of applying ENVASSO procedures and protocols
The protocol is simple to apply and well known across Europe.

Output performance e.g. Minimum Detectable Change achievable and comparison with WP1 requirements; definition of baselines and application of thresholds

Not tested as any result available yet.

Identified strengths and weaknesses of

a. the estimation of indicator values

Strengths: robust tool, easy to implement,

Weaknesses: high spatial and temporal variability may be observed.

b. the interpretation of indicator values

Strengths: generally easy to interpret when comparing the influence of land use/soil type on microbial respiration.

Weaknesses: seasonal variability (especially related to hydrologic soil conditions e.g. dryness, freezing) can influence the microbial respiration.

Conclusions and recommendations

In order to monitor soil microbial respiration, it is necessary

i) to realise the soil sampling at the same time of the year (spring or autumn)
ii) to make sure that there was no hydrous stress 15 days before the soil sampling,
iii) to associate in the data base (as “SoDa”) the sampling time to each measurement.

This information will be analysed as the soil type and/or the soil land use.

Pilot area: Szent István University Experimental Farm, Hungary

Lead partner **Szent István University**

Description of the Pilot Area

Name of pilot area		Szent István University Experimental Farm
Names of participating partners	**Lead partner**	**Szent István University**
	Partner A	Hungarian Soil Information and Monitoring System (TIM) for microbial respiration
	Partner B	-
	Partner C	-
Location and description	Member State(s)	Hungary
	Coordinates	GPS N 47 41.730 E 19 36.519
	Area of pilot area (km^2)	270 ha
	Climate	Continental
	Mean temperature (FAO 2006*)	9.5-10 ^{o}C
	Average Annual Precipitation (FAO 2006)	580-610 mm
	Outline description of topography	very diverse, it consists of hills and valleys oriented from northwest to southeast
	Elevation (m)	128-350 m
	Vegetation (FAO 2006)	CeWh, OiSu, CeMa, FoAl
	Major Land Use (FAO 2006)	AA (Annual field cropping)
	Major soils (WRB 2006 RGs**)	Chernozems, Calcisols

* ftp://ftp.fao.org/agl/agll/docs/guidel_soil_descr.pdf
**ftp://ftp.fao.org/agl/agll/docs/wsrr103e.pdf

The pilot area is basically an erosion catena representing different levels of erosion, physical degradation, and organic matter. There are four soil profiles along the catena in the farm. The first two profiles are Chernozems, the one on the top has no erosion (NE – No Erosion), the second has low erosion (LE – Low Erosion). These soils are very fertile, however, according to the inappropriate land use practice, there is very sever soil compaction (plough layer). The third profile is the most eroded one (HE – High Erosion), it is a Calcisol; and the fourth profile at the bottom of the valley is a Cumulic Chernozem (AP – Accumulation Profile).

Threat and related indicator(s) evaluated in pilot area

Threat	Decline in biodiversity
Indicator BI01	Earthworm
Indicator BI02	Collembola
Indicator BI03	Microbial respiration

Rationale for selection of pilot area

The pilot area is representative of the Eastern Central European loess areas with high organic matter content. It also represents the decline in organic matter content and soil biodiversity mainly due to soil erosion.

Most of the agricultural soils in Hungary developed on calcareous loess, which is a favourable parent material for fertile soil formation. Chernozems have been considered very good soils in their natural conditions, but most of these loess derived soils have been cultivated for several centuries. Unfortunately, almost the entire area of Chernozems in the country has experienced erosion and/or structural degradation mainly due to inappropriate land use practice.

The pilot area is located on Szent István University Experimental Farm, in Northern Hungary. This farm area was chosen for pilot area to examine and test the different biological indicators, since it was already examined in detail for general chemical, physical laboratory analyses, and also for enzymatic characterization.

Indicator evaluation

This part provides a description of each of the top 3 indicators but also explains how the sampling area is defined and prepared.

Spatial extent and sampling design for each indicator

The schematic outline of the pilot area is presented. The first three soil profiles have increasing levels of soil erosion (no, low, high erosion), and the forth one is an accumulation profile.

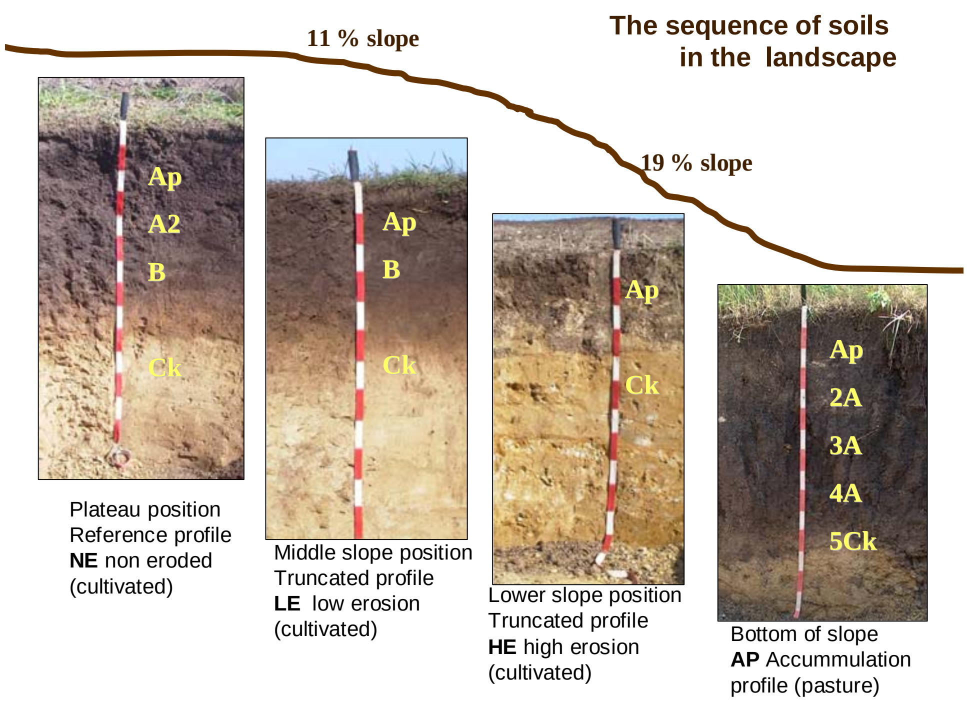


Figure 1. Schematic presentation of the Pilot Area

Using these background data it was convenient to follow and understand the changes and decline in soil biodiversity with the new data we obtained.

BI01 – Earthworms

Pilot area description

Testing

The "ISO 23611-1:2006 (E) – Soil Quality – Sampling of soil invertebrates – Part 1.: Hand-sorting and formalin extraction of earthworms" method was tested on the pilot area for earthworm sampling and determination.

The procedure to extract the earthworms from the soil (ISO 23611-1) is time consuming either by hand-sorting and/or formalin extraction, however the procedure itself is not complicated.
Data description and standards
Soil data were gained from the PhD research project of Balázs Szeder and new data were recorded during testing of the Pilot Area in the frame of the ENVASSO Project. Local maps were provided by the farm and land use description was done using the farm records.

Methodology used for calculations / estimations of parameters and indicators
Basic data were provided and basic statistics were applied.

Baseline definition
No baseline defined within WP1.

Threshold definition
No baseline defined within WP1.

Commentary on original data
All parameters needed to interpret biodiversity values were obtained according to the WP4 Procedures & Protocols.

Pilot methodology

Compilation of soil data and maps for the pilot area

The abundance of earthworms along the erosion catena can be seen in Figures 2 and 3. There were two samplings done for earthworm abundance, one was carried out in May, 2007 (Figure 2), and the other was done in September, 2007 (Figure 3). The reason why the second sampling was carried out in the fall is that sampling in May turned out to be late, since the weather warmed up early this year and there was lower amount of rainfall compared to other years.

The treatments of Figure 2, 3 and 4 are the following:
- Treatment 1: NE – no erosion (soil with a hard plough layer)
- Treatment 2: LE – low erosion
- Treatment 3: HE – high erosion
- Treatment 4: AP – accumulation profile.

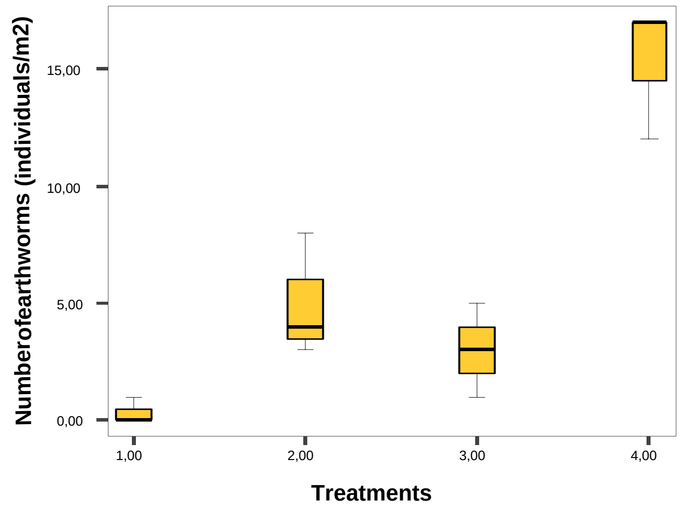


Figure 2. Effect of soil erosion on earthworm abundance investigated by hand-sorting and formalin extraction (May, 2007)

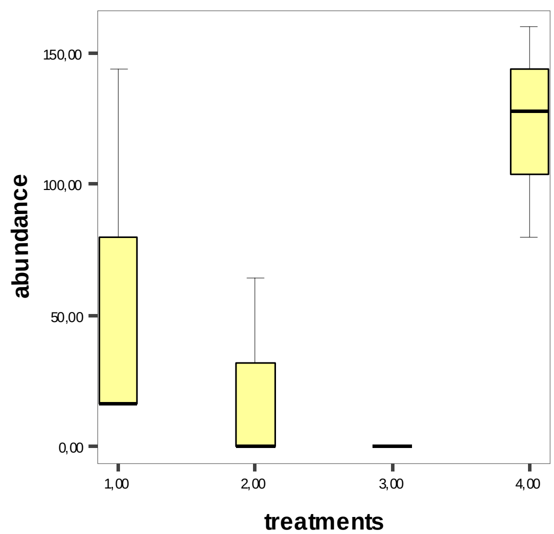


Figure 3. Effect of soil erosion on earthworm abundance investigated by hand-sorting (Sept, 2007)

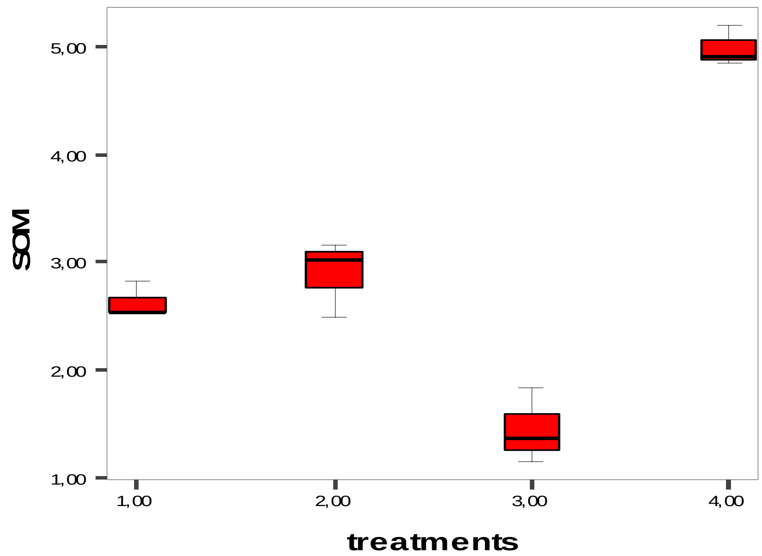


Figure 4. Effects of soil erosion on soil organic matter content (%)

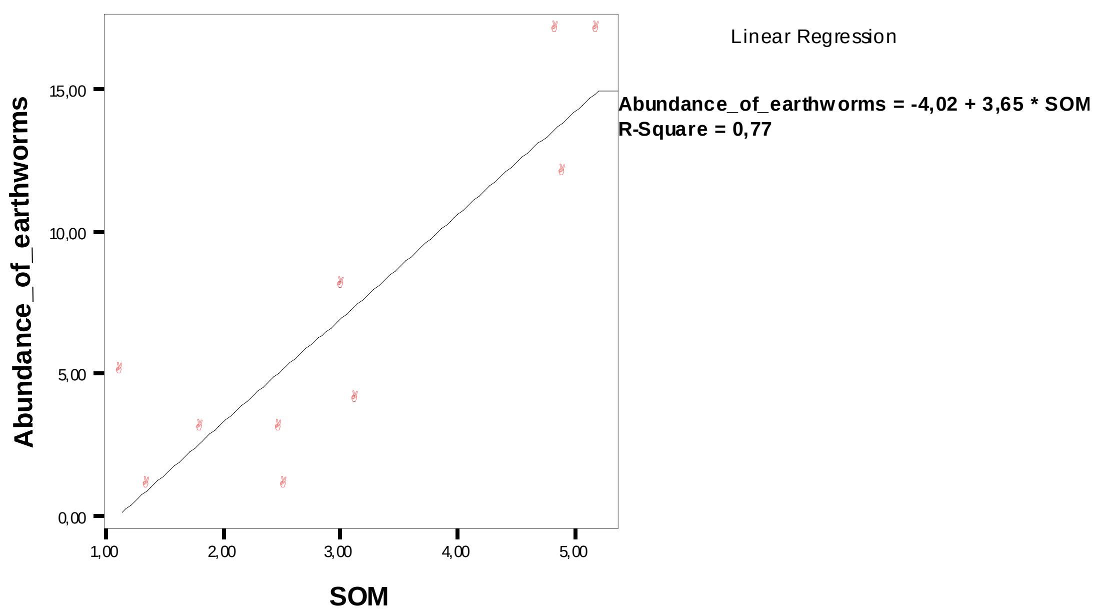


Figure 5. Correlation between soil organic matter content (%) and the abundance of earthworms

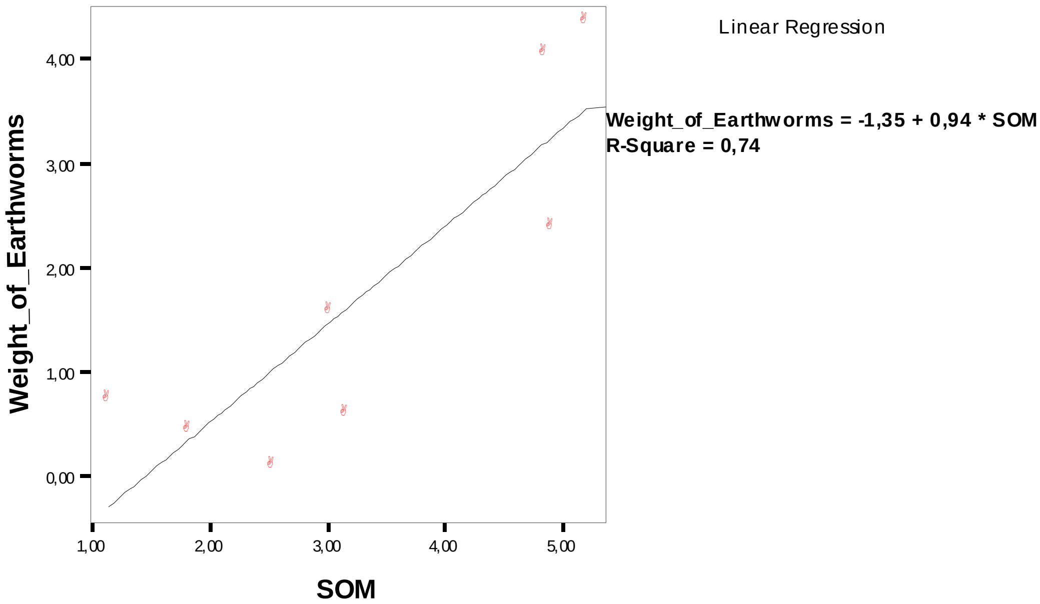


Figure 6. Correlation between soil organic matter content (%) and the weight of earthworms

Method development and application

The following sampling design was applied for the earthworm sampling along the four soil profiles (Figure 7). Each sampling area was 1 m^2, and there were three replicates, 5 meters away from each soil profiles.

All the steps were followed according to the “ENVASSO Procedures and Protocols” during the sampling for earthworm diversity, with the following differences:

- Step 1: We applied the formalin extraction method on 1 m^2 area first and then the hand-sorting. However, the amount and concentrations of the formalin solutions we applied was different: 20 l of formalin solution (50 ml 37% formalin in 10 l water) was only given onto 1 m^2 area. As for the hand-sorting, we chose a sub-square (25x25 cm) right in the middle of the 1 m^2 square, not by random approach, as it was written.
- Step 2: Species determination: it has not been done yet since we are in the learning process. The determination of the earthworm biomass was done according to the suggested protocol.

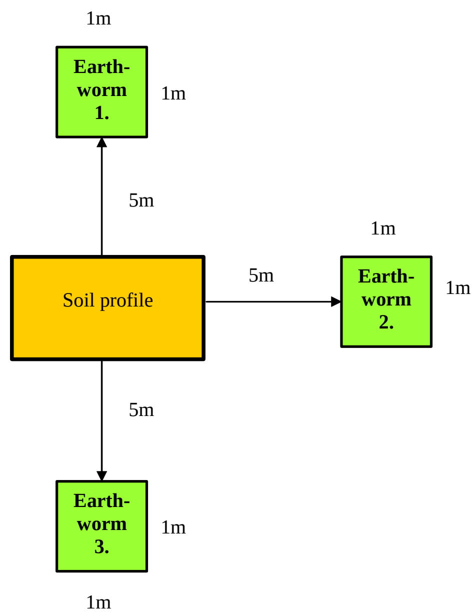


Figure 7. Sampling design for earthworm collection

Statistical and geo-statistical analysis

Data was stored in MS Excel and loaded for statistics in "Statistica" and SPSS. ANOVA, LSD Post Hoc tests and linear regressions were carried out.

Methodology used for calculation/estimation of parameters and indicators Definition of baselines

Definition and application of threshold

Depending on the data, values or percentage can be provided as threshold values (compared to the baseline ones).

BI02 – Collembola

Pilot description

Testing

The "ISO 23611-2:2006 (E) – Soil Quality – Sampling of soil invertebrates – Part 2.: Sampling and extraction of micro-arthropods (Collembola and Acarina)" method was tested on the pilot area for Collembola sampling and determination.

Data description and standards

Soil data were gained from the PhD research project of Balázs Szeder and new data were obtained during testing on the Pilot Area in the frame of ENVASSO Project. Local maps were provided by the farm and the land use was followed by the farm records.

Methodology used for calculations / estimations of parameters and indicators

Basic data were provided and basic statistics were applied.

Baseline definition

No baseline defined within WP1.

Threshold definition

No baseline defined within WP1.

Commentary on original data

All parameters needed to interpret biodiversity values are obtained according to the WP4 Procedures & Protocols.

Pilot methodology

Compilation of soil data and maps for the pilot area

Several data treatments have been applied for statistics as following:

- the abundance of Collembola (**Figure 8**),
- the correlation of Collembola biodiversity parameters with the soil characteristics (**Table 4** and **Figure 9** and **10**),
- the density of species (**Table 5**).

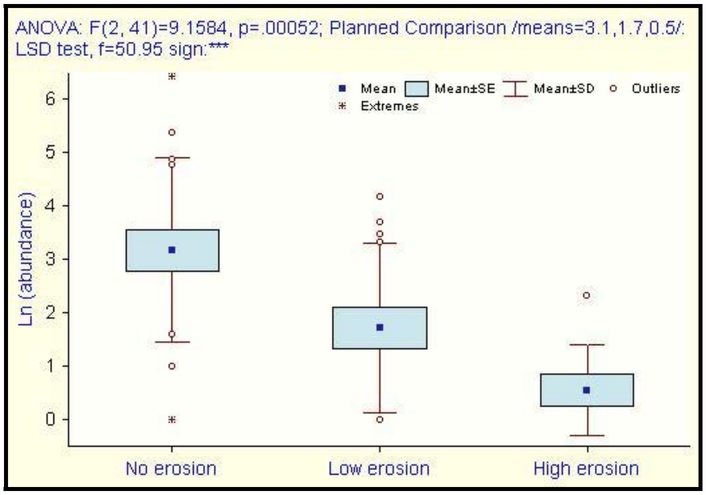


Figure 8. Abundance of Collembola species on the PA

Table 4. Correlation of Collembola and Acari with soil characteristics

	R-Square				
	SOM %	**Depth of humus layer**	**pH (H_2O)**	**pH (KCl)**	**Acari abundance**
Collembola abundance	0,81	0,43	0,38	0,4	-
Species number	0,42	0,22	-	-	0,59
Acari abundance	0,51	0,2	-	-	-

$r^2 < 0{,}04$	no correlation
$0{,}04 < r^2 < 0{,}16$	slight correlation
$0{,}16 < r^2 < 0{,}36$	moderately strong correlation
$0{,}36 < r^2 < 0{,}64$	medium strong correlation
$0{,}64 < r^2 < 0{,}81$	strong correlation
$0{,}81 < r^2$	very strong correlation

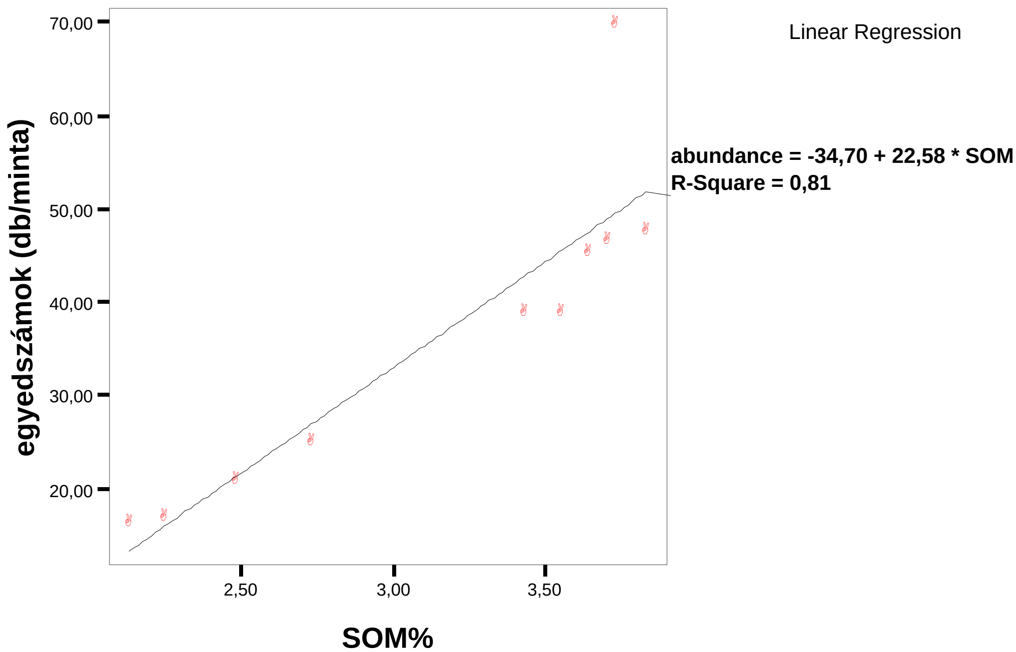


Figure 9. Correlation between SOM% and abundance of Collembola

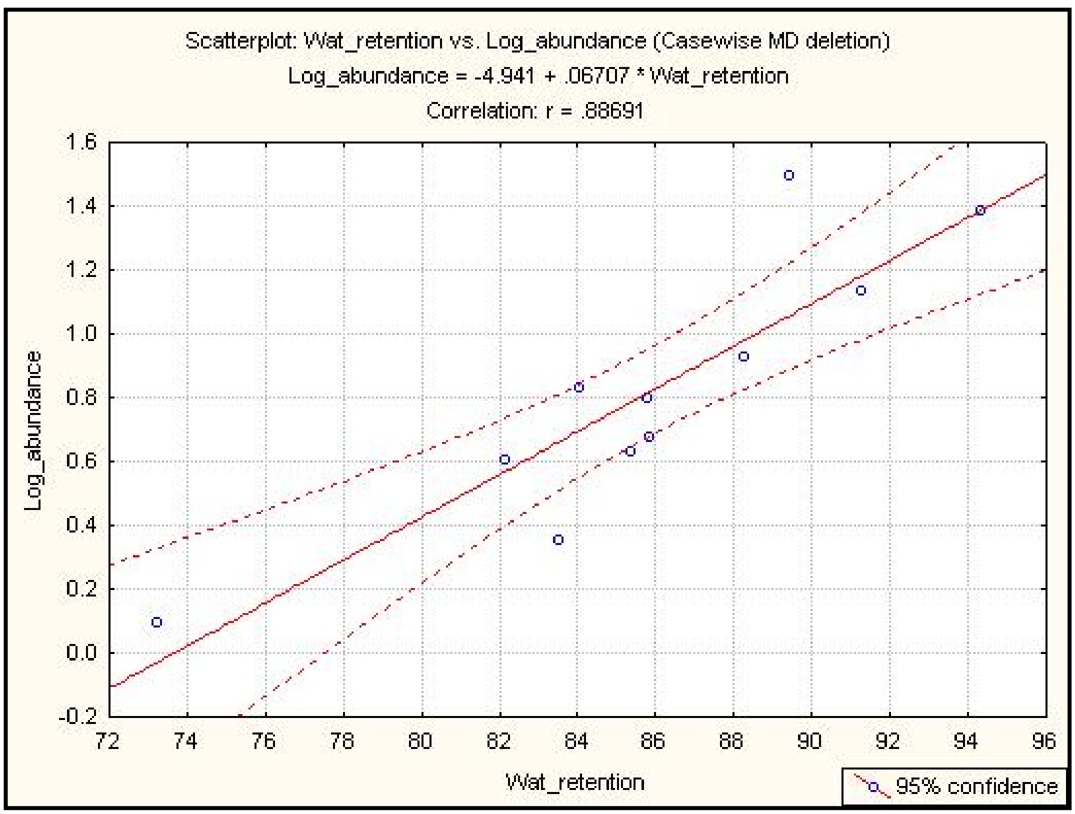


Figure 10. Correlation between water retention and abundance of Collembola

Table 5. The density of springtails

	Density of springtails				
	reference	no erosion 1	no erosion 2	highly eroded	sedimented
Ceratophysella cf. armata	130	89	55	18	19
Entomobrya handshini	21	12	41	33	14
Entomobrya multifasciata	2	0	0	0	3
Folsomia cf. penicula	16	37	25	15	12
Folsomides parvulus	1	8	3	1	1
Heteromurus nitidus	36	36	68	18	15
Heteromurus tetrophthalmus	6	1	7	0	5
Lepidocyrtus cf. arabonicus	33	73	91	13	31
Lepidocyrtus paradoxus	0	0	1	0	5
Onychiurus rectospinatus	3	2	2	0	1
Orchesella cincta	4	10	27	8	15
Orchesella sp.	1	2	1	4	1
Sminthurus aureus	0	3	0	0	0
Sminthurus elegans	2	4	3	0	2

Method development and application

The same farm with the same four soil profiles was the Pilot Area for the Collembola diversity determination as for the earthworms.

The following sampling design was applied for the Collembola sampling along the four soil profiles (see **Figure 11**). There were three replicates (Coll1, Coll2, and Coll3) 2 meters away from the earthworm sampling area and 8 meters away from each soil profiles.

Basically all the steps were followed according to the “ENVASSO Procedures and Protocols” during the sampling for Collembola diversity, with the following differences:

- Step 1. We did not take the samples with split corer but the volume of the soil was about the same as it is written in the ISO Standard (23611-2:2006(E)). Three individual replicates were taken. We only took samples from the top 5 cm of soil.
- Step 2. Diversity analysis: Collembola species were determined the instructed way.
- Step 3. The conservation was carried out the instructed way.

Apart from these changes, we exactly followed the “ENVASSO Procedures and Protocols”.

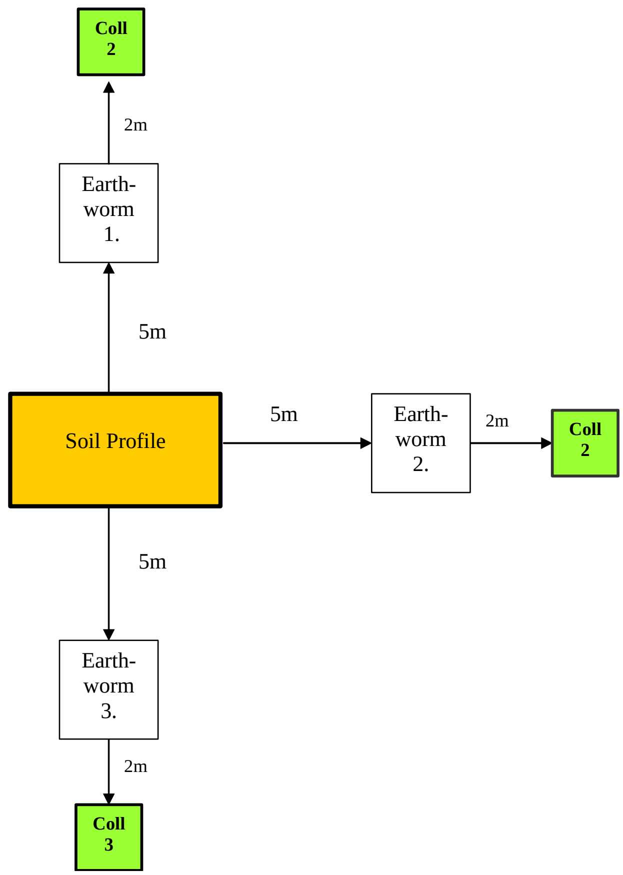


Figure 11. Sampling design for Collembola

Statistical and geo-statistical analysis

Data was stored in MS Excel and loaded for statistics in "Statistica" and SPSS. ANOVA, LSD Post Hoc tests and linear regressions were carried out.

Methodology used for calculation/estimation of parameters and indicators Definition of baselines

Definition and application of threshold

BI03 – Microbial respiration

Pilot description

Testing

The "ISO 16072:2002 (E) – Soil Quality – Laboratory methods for determination of microbial soil respiration" method was tested on the pilot area for soil microbial respiration determination.

Data description and standards

Soil data we show in **Figure 12** and **13** were gained from the TIM (Hungarian Soil Information and Monitoring System) database only to have insight into the already existing Hungarian database for soil microbial respiration.

The data that we perform in this report (**Figure 14** and **15**) were obtained from the Pilot Area testing in the frame of the ENVASSO Project. Local maps were provided by the farm and the land use was followed by the farm records.

Methodology used for calculations / estimations of parameters and indicators

Basic data were provided and basic statistics were applied.

Baseline definition

No baseline defined within WP1.

Threshold definition

No baseline defined within WP1.

Commentary on original data

All parameters needed to interpret biodiversity values are obtained according to the WP4 Procedures & Protocols.

Pilot methodology

Compilation of soil data and maps for the pilot area

Several data treatments have been made as mapping the national data (**Figure 12**) or making correlations between microbial respiration and soil characteristics (**Figure 13**).

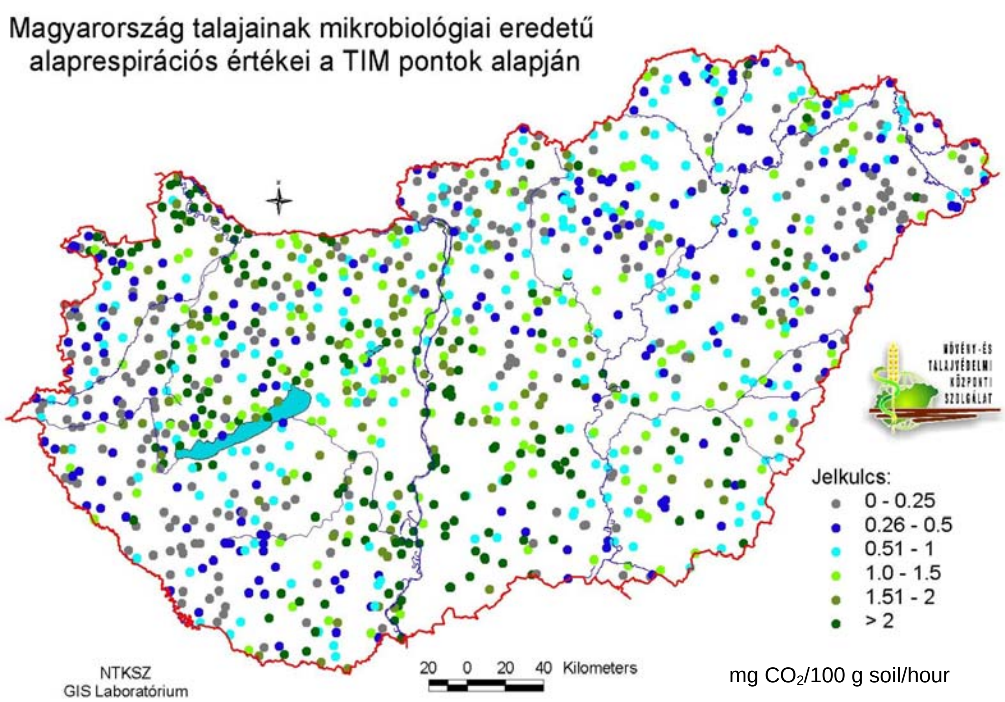


Figure 12. Basal respiration on TIM points in Hungary

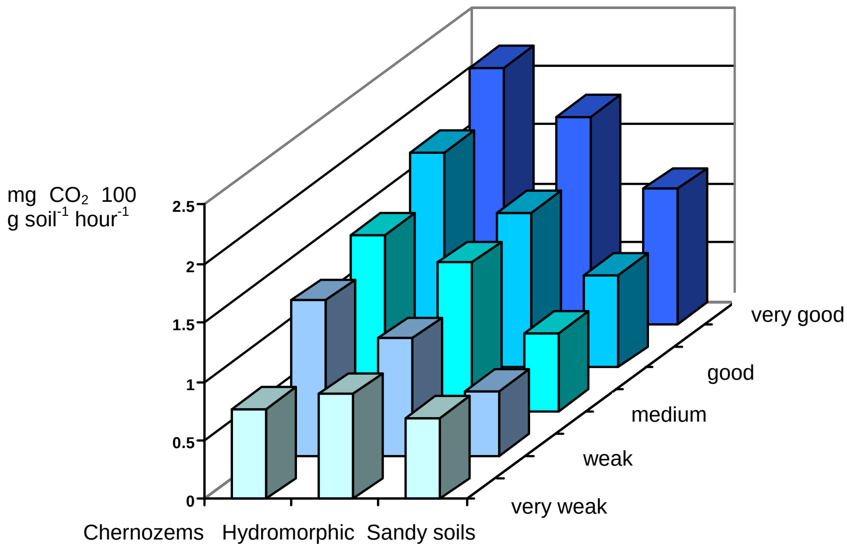


Figure 13 Basal respiration (mg CO_2 100g soil^{-1} hour^{-1}) vs soil organic matter content (%)

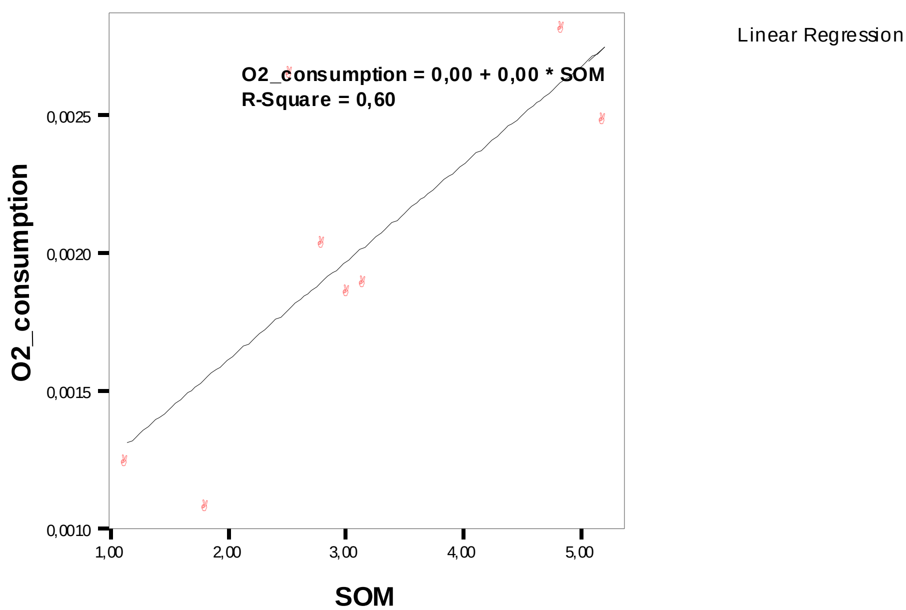
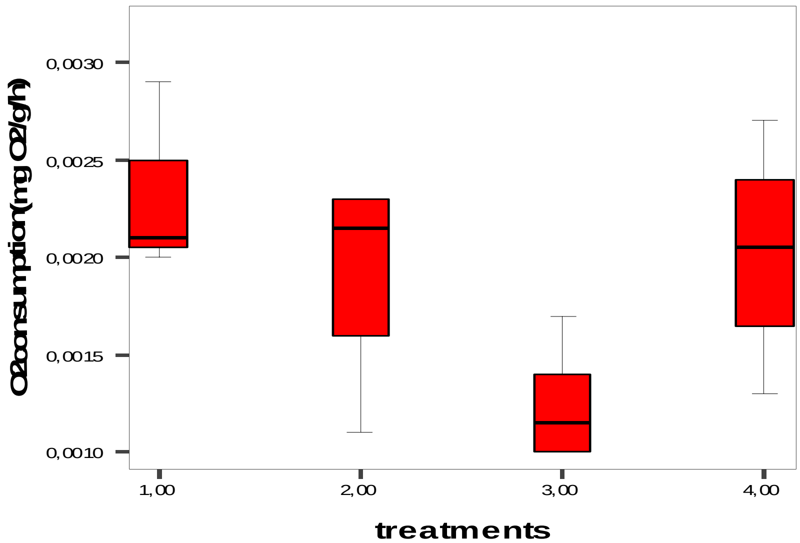


Figure 14. Correlation between soil organic matter content (%) and O_2 consumption



(Treatments: 1. No erosion, 2. Low erosion, 3. High erosion, 4. Accumulation profile)

Figure 15. O_2 consumption at the erosion catena

Method development and application

Two sampling campaigns are reported:

- The first one from the Hungarian Soil Information and Monitoring System (TIM) which is a national soil database. It has been providing basic chemical, physical and biological data for the whole area of Hungary since 1992. It carries out the sampling and the laboratory analyses for the soil microbial respiration the following way:
    - Sampling. Soil organic matter content (%) and soil microbial respiration are measured every 3rd year (mg CO_2 / 100 g soil / 1 hour)
    - Sampling for microbial respiration. 1 kg soil from „A horizon" stored at +4°C until measurement (less than 3 weeks)
    - Laboratory analysis:
        - o determination of soil moisture content (%) (The samples were taken at field-moist state.)
        - o aerobic incubation of the soil with known weight on 18°C for 100 hours
        - o analysis with infrared analyzer
        - o basal + induced respiration (with C, N, C + N source)

- The second one from the Pilot Area where sampling was performed according to the outline reported in **Figure 16**. There were three replicates around the area where the Collembola and earthworm samples were taken, about 9 meters away from each soil profiles. At each sampling point 10 samples were taken from 10 cm depth and composited. Roots were removed from the sample that was passed through a 6 mm sieve. Stones were not present in the soil so it was not necessary to determine their weight. Three kg of the composited sample was then saved and stored at 4 °C for respiration measurement in the laboratory (within one month of sampling). Separate samples were taken for determination of moisture content. The determination of CO_2 release was carried out by pressure measurement in a static system (ISO 16072:2002(E)). After incubation time to reach the constant temperature under the thermostat the respiration measurement run for 14 days at 20 °C.

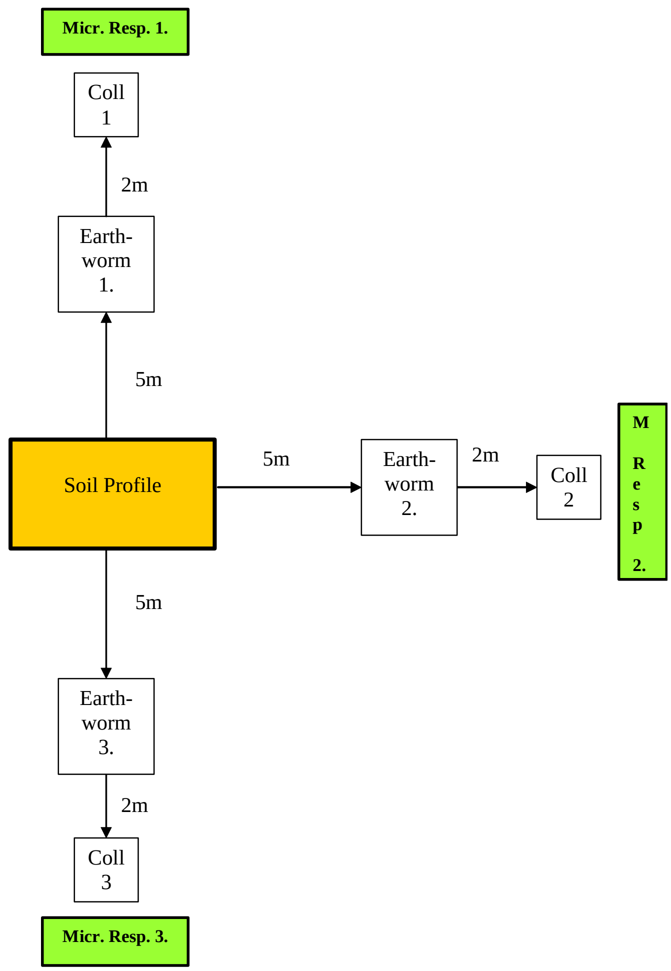


Figure 16. Sampling design for Microbial Respiration

Statistical and geo-statistical analysis

Data was stored in MS Excel and loaded for statistics in "Statistica" and SPSS. ANOVA, LSD Post Hoc tests and linear regressions were carried out.

Methodology used for calculation/estimation of parameters and indicators

Calculation of microbial respiration as O_2 consumption (mg O_2/g/h) was done according to the equations determined by the ISO 16072:2002(E) standard 5.6.

Definition of baselines
Definition and application of threshold

Evaluation of pilot results

Feasibility and experience of applying ENVASSO procedures and protocols

Feasibility and applicability of ENVASSO Procedures & Protocols was good. The recommended ISO standards are well written and clearly described.

a. In case of the Collembola sampling, it was easy and quick to sample, the extraction and the determination was also carried out in a fairly easy and fast way. It did not depend much on the weather conditions.

b. As for the soil microbial respiration, the sampling was carried out easily and quickly, but the determination of the soil microbial respiration was time consuming and required more organisation concerning sample storing and treatment. It did not depend much on the weather conditions either.

c. However, the earthworm sampling is generally very season sensitive. Since most of the species move further down the soil profile or go into an inactive state as soon as the weather conditions (moisture, temperature) are not favourable. Our original thought was to sample the earthworms in May, 2007, however we knew that timing was late, since the temperature in May warmed up faster than other years, and the moisture conditions were not proper anymore. Thus, we repeated the earthworm sampling in September, 2007, but we still did not experience too much earthworm activity, because of the dry summer. Despite these conditions, we found that with increasing level of erosion and soil degradation the number of earthworms decreased.

d. In general, we can state that the procedures to extract the earthworms from the soil (ISO 23611-1) was easy either by hand-sorting and/or formalin extraction, however it is quite time consuming. The determination to the species level has to be learned and needs a lot of experience.

Output performance e.g. Minimum Detectable Change achievable and comparison with WP1 requirements; definition of baselines and application of thresholds

Identified strengths and weaknesses of

a. the estimation of indicator values (for earthworms)
   - Strengths. easy to implement especially for total biomass and abundance,
   - Weaknesses. species richness determination will require the help of an expert

b. the interpretation of indicator values
   - Strengths.
   - Weaknesses.

Conclusions and recommendations

Sampling on the Hungarian Pilot Area for earthworms, springtails, and soil microbial respiration was comparable with standards determined by ISO and methods in ENVASSO Procedures & Protocols. Our results showed that ENVASSO indicators BI01 (earthworms), BI02 (springtails) and BI03 (microbial respiration) were useful to detect deterioration of soil properties as loss of organic matter and degree of erosion along a catena.

Evaluation of pilot areas results

The following questions were identified at the start of the Evaluation exercise (with some answers):

- Are the procedures in the manual clearly described?
  - ⇒ *To be discussed later*
- Are the indicators measured / measurable? (including soil characterization)
  - ⇒ *Yes they are measurable and measured in several soil monitoring networks*
  - ⇒ *The main problem for all these groups is that a taxonomic expertise is needed.*
- Are the suggested methods and actual methods compatible?
  - ⇒ *Yes methods used in soil monitoring networks are compatible with the ones recommended (ISO methods)*
- Are the sampling densities close to the recommended?
  - ⇒ *There is no prescription for the sampling densities.*
- Is the database specification efficient?
  - ⇒ *To be discussed later*
- Is the WRB applicable to harmonize profile data base / classification?
  - ⇒ *Yes but to be discussed later*
- Are the top 3 indicators easy to implement?
  - ⇒ *Experience and data from the Hungarian PA will provide an answer to this question.*
- Are the top 3 indicators well chosen and defined?
  - ⇒ *German data are available on earthworms, Collembola, Enchytaeids and other indicators to see if these indicators can be used as surrogate for other groups.*
  - ⇒ *May be also completed by French data obtained on the RMQS.*
- Are the top 3 indicators able to discriminate between different soil types, land-uses, land management?
  - ⇒ *German, Irish and French data are available to discuss these aspects.*
- Can the top 3 indicators detect decline in soil biodiversity?
  - ⇒ *Data from time series measurements are available in Germany.*
- Are we able to start the definition of B&T values?
  - ⇒ *Data treatment, already done on the Dutch soil monitoring system may be used to define reference values.*

Annex 1. Assessing the minimal sampling surface area

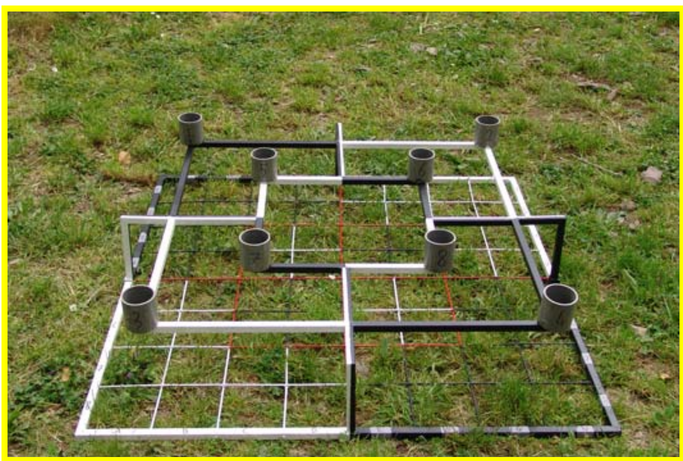
Current methodological validation's stage

In order to assess the relevance of the sampling methodology (especially the minimal sampling surface area), **t**he 1m² grid is subdivided in 64 pixels (8 columns: A to H, and 8 lines: 1 to 8, like a chess grid), to allow the evaluation of the intra-m² spatial variability. Inside this grid, 8 zones are currently defined:

- 4 central sub-squares (1/16 m²) are distributed around the central point of the 1m² square (hand sorting will be realized on one of these sub-squares; moreover, in order to relate hand-sorting to formalin extraction, the earthworms sampled on this zone using formalin, are collected in a pillbox clearly identified).
- 4 other zones complete the 1/16m² squared-subdivisions in order to obtain 1/4m² quantifications (see figures 3) (only formalin extraction will be realized on these zones).

The number of zones into the m² could be reduced to 4, 2 or 1 according to the environment heterogeneity or the study aims.

A support for the pillboxes has been developed and is fixed on the grid in order to be more efficient to collect earthworms on the field (see figure).



Support for 8 pillboxes half-filled with formalin 4%, in which are conserved earthworms, according to the position in the grid from where they are extracted

1m² grid subdivided in 64 squares like a chess grid

Figure Lombricians extraction's grid & pillboxes' support
- Presentation -

The data analyse is realised by increasing the sampling area (from ¼ m² to 1 m²) to assess the best surface area needed to assess earthworm biodiversity, and to assess if this minimal surface area is the same whatever the land use and soil surface heterogeneity.

Pilot area: Republic of Ireland

Lead partner TEAGASC
Partner A University College Dublin
Partner B University College Cork
Partner C Cranfield University

Description of the Pilot Area

Name of pilot area		Republic of Ireland
Names of participating partners	Lead partner	TEAGASC Ireland
	Partner A	University College Dublin
	Partner B	University College Cork
	Partner C	Cranfield University
Location and description	Member State(s)	Republic of Ireland
	Coordinates	53° N 8° W
	Area of pilot area (km^2)	69 902
	Climate	Temperate maritime
	Mean temperature (FAO 2006*)	East: 9 °C West: 10,5 °C
	Average Annual Precipitation (FAO 2006)	East: 750-1000 mm West: 1000-1250 mm
	Outline description of topography	36% of the area is „Flat to Undulating Lowland", mostly below 100 m, with slopes less then 3°. 31% of the area is „Rolling Lowland" mainly below 150 m, with slopes ranging between 2 and 6°. „Mountain and Hill" covers 15%, occurs mostly above 500 m, with very steep (16-23°) and steep (12-16°) slopes. 11% is „Drumlins", and 6% is „Hill" – elevation is between 150-365 m, with slopes usually less then 12°.
	Elevation (m)	0 – 1041 m
Location and description	Vegetation (FAO 2006)	Medium grassland (HM), Rainwater-fed bog peat (M), Deciduous forest (FD), Coniferous forest (FC)
	Major Land Use (FAO 2006)	Non-irrigated cultivation (AP1), Animal production (HI1), Extensive grazing (HE), Plantation forestry(FP), Not used and not managed (U)
	Major soils (WRB 2006 RGs**)	Histosols (HS), Gleysols (GL), Luvisols (LV), Podzols (PZ), Cambisols (CM), Leptosols (LP)

You can down load the related info from:
* ftp://ftp.fao.org/agl/agll/docs/guidel_soil_descr.pdf
**ftp://ftp.fao.org/agl/agll/docs/wsrr103e.pdf

Ireland is an island in northwest Europe in the North Atlantic Ocean. Its main geographical features are low central plains surrounded by a ring of coastal mountains.

The large central lowland is of limestone covered with glacial deposits of clay and sand, with widespread bogs and lakes. The coastal mountains vary greatly in geological structure. In the south, the mountains are composed of old red sandstone with limestone river valleys. In Galway, Mayo, Donegal, Down and Wicklow, the mountains are mainly granite, while much of the north-east of the country is a basalt plateau.

The soils of the north and west tend to be poorly drained Histosols and Gleysols, including peaty Podzols. In contrast, in the south and east the soils are free-draining Cambisols, Luvisols and Podzols. This is reflected in the rainfall distribution on the island, with the poorly-drained regions being those with the highest rainfall.

4.3 million ha (62%) of the 6.9 million ha country is used for agriculture: 3.4 million ha (49%9 is in grass, hay and silage, 0.5 million ha (7,2%) is in rough grazing, and 0.4 million (5.8%) is in crop production. Forests represent 710,000 ha, 10,3%.

Threat and related indicator(s) evaluated in pilot area

For the harmonized inventory and monitoring of the decline in soil biodiversity the following three indicators were selected in the project.

THREAT	DECLINE OF SOIL BIODIVERSITY
Indicator BI01	Earthworm
Indicator BI02	Collembola
Indicator BI03	Microbial respiration

The Irish pilot area provides data for Indicator 1 (Earthworm) and Indicator 2 (Collembola).

Rationale for selection of pilot area

Ireland is representative of the temperate maritime areas of Europe. In order to evaluate the decline in soil organic matter in this region it is necessary to include the major soil type / land use combinations. Given the large variation in climatic and soil conditions thoughout the country it was decided that pilot area should include the entire country.

The pilot area contains 60 sites (50 mineral soil sites and 10 peat sites, 0 to 50 cm depth) which are representative of the major land uses and soil types of Ireland, and have a geographic spread. These 60 sites were selected by the “SoilC” (“Measurement and modelling of soil carbon stocks and stock changes in Irish soils”) and “CréBeo” (“A national project on soil biodiversity”**)** projects and were sampled in 2006.

The projects are based on the sites of the Irish National Soil Database (NSD), containing 1310 sites in all land uses. All NSD sites were sampled once (the south eastern region in 1995-96, the other areas of the country in 2002), to a depth of 10 cm, on a predetermined defined positions on the national grid (two samples per 100 km^2). All 1310 samples were analysed for a number of chemical parameters (list of it can be found in Table 1), but it has no data for soil biodiversity. For the microbial analysis, just nucleic acids (DNA) archive was subsequently generated from subsamples collected during the 2003-2005 NSD sampling campaign.

Hence, a new national project on soil biodiversity, the “CréBeo” has been established, to provide baseline data, response to pressures, functions and conservation of keystone micro- and macro-organisms in Irish soils.

Using the background data of NSD, and the new, more detailed data from SoilC project, it was convenient to use the same pilot area, with the same 60 representative NSD points as SoilC Project.

The 60 sites for the pilot study were selected from the dominant soil type/land use combinations of the NSD. Finally the 60 sites are within 15 different categories of land-use/soil-type combinations, with a minimum of three sites in the selected soil type/ land use combination. The sites are a random selection from the NSD sites.

Table 1. List of parameters measured for NSD sites with associated abbreviations

Al	aluminium	**Nb**	niobium
As	arsenic	**Ni**	nickel
Avail_K	available potassium	**P**	phosphorus
Avail_Mg	available magnesium	**pH**	soil acidity

Avail_P	available phosphorous	**Pb**	lead
Ba	barium	**Rb**	rubidium
Ca	calcium	**S**	sulphur
Cd	cadmium	**Sb**	antimony
Ce	cerium	**Sc**	scandium
Co	cobalt	**Se**	selenium
Cr	chromium	**SOC**	soil organic carbon
Cu	copper	**Sn**	tin
Fe	iron	**Sr**	strontium
Ga	gallium	**Ta**	tantalum
Ge	germanium	**Th**	thorium
Hg	mercury	**Ti**	titanium
K	potassium	**Tl**	thallium
La	lanthanum	**U**	uranium
Li	lithium	**V**	vanadium
Mg	magnesium	**W**	tungsten
Mn	manganese	**Y**	yttrium
Mo	molybdenum	**Zn**	zinc
Na	sodium		

Indicator Evaluation

Indicator BI01 – Earthworms

Earthworms are very important soil animals, very well studied. They have several important and advantageous influences on soil properties. They influence soil structure, aeration, water holding capacity, litter decomposition, and nutrient cycling, etc (Lavelle, 2002). They increase soil fertility and help to build up good soil structure. Therefore they are very good indicators for soil degradation in most soils.

Pilot description

Spatial extent

Pilot area and the 60 sampling sites are shown in Figure 1.

On each of the 60 sites according the GPS coordinates given by the NSD, a sampling area of 400 m² (20 x 20 m) centred on the site's GPS point was defined for biodiversity sampling. In order to avoid any disturbance, the sampling points are at least 3m apart from each other. Localizations of the "CreBeo" biodiversity areas are also recorded by GPS devices.

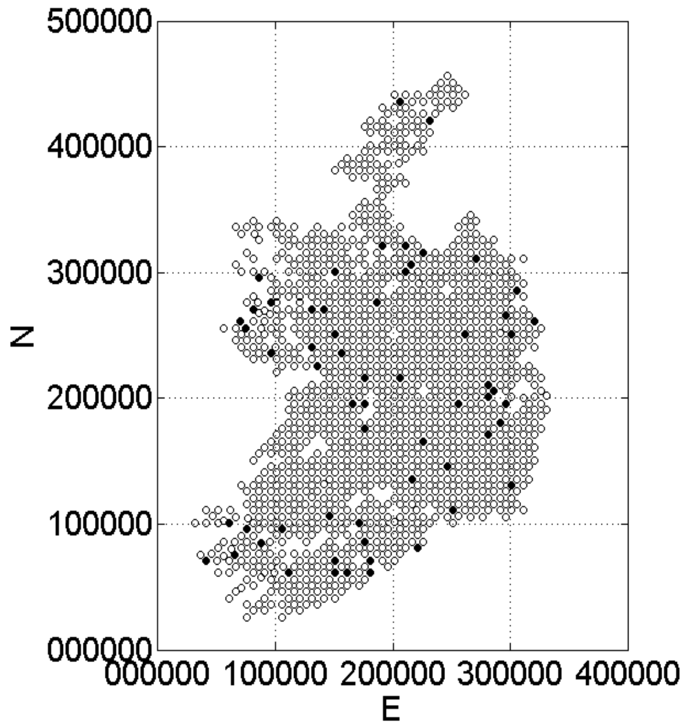


Figure 1. The 60 representative site of the pilot study from the NSD sites

Data

Sampling design

Two approaches were employed for sampling earthworms, where feasible, at each study site:

Hand-sorting: 25x25 cm square soil blocks will be excavated to a depth of 25 cm at each of four cardinal points 10 m from GPS point, or at corners of site if GPS point is at an edge. These soil blocks will be sorted through by hand to collect earthworms, which will be placed in plastic bottles in the field, and kept cool (4°C) until worms can be weighed and processed in the lab. The four subsamples will be kept separate throughout the sorting and identification process.

Chemical expellant: After removal of vegetation with hand shears, 50x50 cm (0,25 m²) frames will be placed on the soil and pressed in to a depth of 1-2 cm, a few meters distance from the hand-sorting plots. Dilute mustard oil (2 mL allyl isothiocyanate [Aldrich 37,743-0] dispersed in 40 mL isopropanol [2-propanol], then added to 20 L water) will be applied with a watering can to run-off and expelled earthworms collected with forceps as they emerge. Application of the mustard oil solution will be repeated after 10-15 minutes for each of the four subsample sites, adding approximately 5 L solution total to each location. Collected worms will be placed in plastic jars containing a small amount of water to rinse off the irritant. After worms have stopped emerging, the rinse water will be poured off, and the jars closed and kept cool until return to the laboratory.

In the laboratory, each subsample of worms will be rinsed with tap water, blotted on paper towels and weighed *en masse* for total biomass. After weighing, worms will be fixed in 4% formalin until they can be identified.

Testing

Natural earthworm community is extracted using the mustard oil method (Zaborski, 2003) on a 0,25 m² grid, and hand-sorting on a volume of soil (25x25x25cm). Four samples are made within the biodiversity sampling area, the mustard oil extraction and hand-sorting a few meters away from each other.

Data description and standards

Soil data and map data

Archieved soil physico-chemical data are provided by the Irish National Soil Database (NSD), and new data will be obtained from the SoilC Project, as the sampling area for indicators is located at the same place. Irish soil classification data is obtained from the "General Soil Map of Ireland" (second edition) at a scale 1:575000 (Gardiner and Radford, 1980). On the map 10 Great Soil Groups are identified and are represented in the form of soil associations -which are not suited for correlation with WRB. Detailed soil survey (AFT County maps at soil series level, at scale of 1:126,720) is available just for 44% of the country.

Expert judgement may be possible in possession of SoilC data (available from 2008) at Reference Soil Group level.

Described and correlated WRB classification will be available from a new project of „Digital Soil Database at 1:250000 scale for Ireland" by 2009.

This information will be used to produce maps and any relevant information on the area.
The data set will be integrated into the SoDa base.

Methodology used for calculations / estimations of parameters and indicators

Classical additive approaches and basic statistical analyses will be used to bring out differences in soil indicators depending on soil types, and land uses.

Baseline definition

No baseline defined within WP1.

Threshold definition

No threshold defined within WP1.

Commentary on original data

The pilot area data / methodology is compatible to ENVASSO procedures and protocols.

Pilot method

All the sites were sampled and organisms are being identified.
Total biomass results are available, total abundance and species richness result will be available end of 2007.

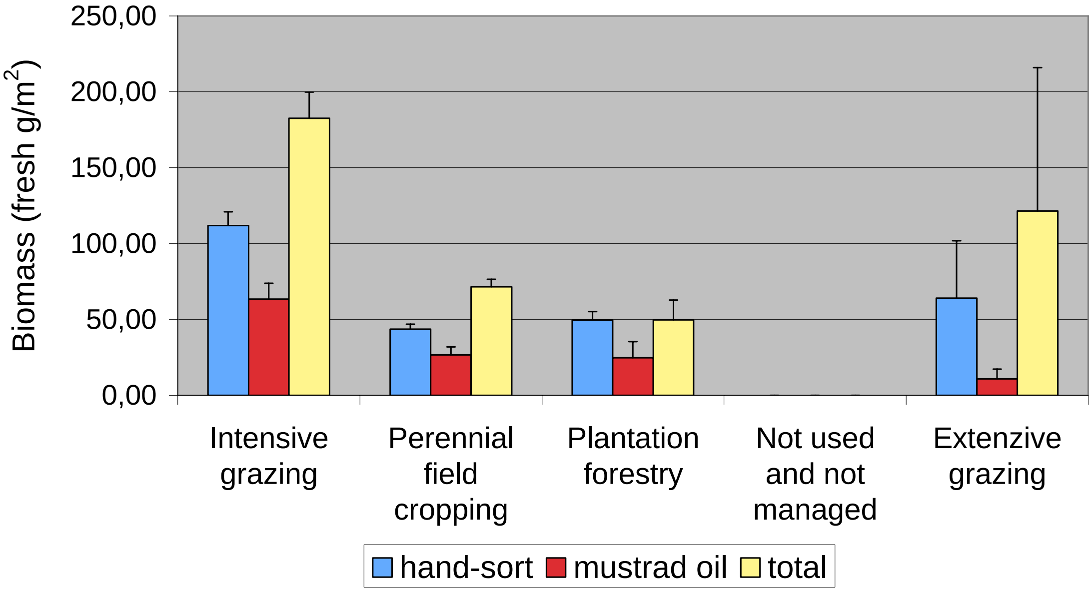


Figure 2. Earthworm biomass by land use on the PA

The compilation will be completed with results.

Method development and application

Two approaches were employed for sampling earthworms:

I. Passive methods: Hand sorting of soil blocks (n=4)
II. Dynamic method: Mustard oil extraction (n=4)

For detailed method descriptions see „Sampling design" chapter.

Variations are made with respect to ISO 23611-1:2006: We recommend the alternative method of mustard oil extraction rather than formaline because of health safety and active farm management in private lands at the sampling sites.

Those variations are in agreement with ENVASSO procedures and protocols.

Statistical and geo-statistical analysis *(to be completed with results)*

Data is stored in MS Excel and will be loaded for statistics in SPSS. ANOVA, LSD Post Hoc tests and linear regressions will be carried out.

Methodology used for calculations / estimations of parameters and indicators, including interpolations.

The following parameters (optional parameters are shown in italics) will be measured or calculated:

a. Total abundance (number of individuals per area or volume)
b. Total biomass (fresh or dry mass of the earthworms per area or volume)
c. Species richness (number of species)
d. Abundance/biomass of ecological groups (epigeic, endogeic, anecic)
e. Abundance/biomass of species
f. Age structure of the population (e.g. the adult/juvenile ration)
g. Morphological alteration in individuals

The data set will be integrated into SoDa base.

Definition of baselines

It may be possible to start the definition of baseline values according to land use.

Definition and application of thresholds

Depending on the data, values or percentage can be provide as threshold values (compared to the baseline ones).

Evaluation of pilot results

Feasibility and experience of applying ENVASSO procedures and protocols

The protocol is simple to apply but previous experience in collecting worms is preferable to be quickly operational.

We recommend the alternative method of mustard oil extraction rather than formaline because of health safety and and active farm management in private lands at the sampling sites.
Baselines and thresholds are hard to apply.

Output performance e.g. Minimum Detectable Change achievable and comparison with WP1 requirements; definition of baselines and application of thresholds

Not tested as no results available at time of testing.

Identified strengths and weaknesses of

> **the estimation of indicator values**
> Strenghts: Easy to implement especially for total biomass and abundance
> Weaknesses: Species richness determination will require the help of an expert
>
> **the interpretation of indicator values**
> Strenghts:
> Weaknesses: Natural variation between seasons and years can influence the results

Conclusions and recommendations

Indicator BI02 – Collembola

Collembola are one of the most studied groups in soil ecology since they have very high abundance and diversity in the soil and in litter as well. They take part in organic matter decomposition and mostly feed on fungal hyphae, due to this fact they play an important role in soil respiration (Larink, 1997). They are sensitive to physical degradation since they cannot make their own burrows, thus they depend on the pore space provided by the soil. In this sense they can indicate soil compaction by the decrease of their abundance and diversity (Dittmer and Schrader, 2000).

Pilot description

Spatial extent

Pilot area and the 60 sampling sites are shown in Figure 1.

On each of the 60 sites according the GPS coordinates given by the NSD, a sampling area of 400 m² (20 x 20 m) centred on the site's GPS point was defined for biodiversity sampling. In order to avoid any disturbance, the sampling points are at least 3m apart from each other.
Localizations of the "CreBeo" biodiversity areas are also recorded by GPS devices.

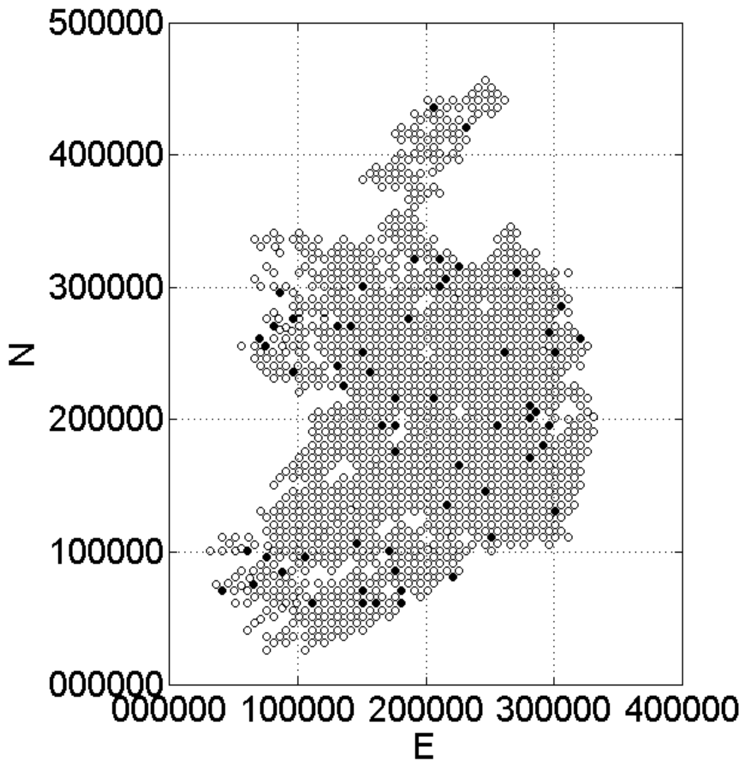


Figure 1. The 60 representative site of the pilot study from the NSD sites

Data

Sampling design

The following sampling design was applied for the Collembola:

- Four cores per site, one at each of 4 cardinal points 10 m from the GPS point, or situated at corners of site if the GPS point is at the edge.
- Cores were taken to a depth of 5 cm with a serrated coring device (approx. 5 cm in diameter). Cores were placed in screen-bottomed sample cups, inside plastic screw-cap jars, and transported to the laboratory.
- Samples are conserved in 5 °C, in dark.
- Collembola are rapidly extracted by behavioural methods, using a MacFadyen apparatus, and preserved for future identifications.

Testing

The sampling of Collembola is made according to ISO 23611-2:2006.
Four replicates are taken per site, with equal distance between them.

Data description and standards
Soil data and map data

Archived soil physico-chemical data are provided by the Irish National Soil Database (NSD), and new data will be obtained from the SoilC Project, as the sampling area for indicators is located at the same place. Irish soil classification data is obtained from the "General Soil Map of Ireland" (second edition) at a scale 1:575000 (Gardiner and Radford, 1980). On the map 10 Great Soil Groups are identified and are represented in the form of soil associations -that are not suited for correlation with WRB. Detailed soil survey (AFT County maps at soil series level, at scale of 1:126,720) is available for only 44% of the country.

Expert judgement may be possible in possession of SoilC data (available from 2008) at Reference Soil Group level.

Described and correlated WRB classification will be available from a new project of „Digital Soil Database at 1:250000 scale for Ireland" by 2009.

This information will be used to produce maps and any relevant information on the area.
The data set will be integrated into the SoDa base.

Methodology used for calculations / estimations of parameters and indicators

Classical additive approaches and basic statistical analyses will be used to bring out differences in soil indicators depending on soil types, and land uses.

Baseline definition

No baseline defined within WP1.

Threshold definition

No threshold defined within WP1.

<u>Commentary on original data</u>

The pilot area data / methodology is compatible to ENVASSO procedures and protocols (WP4).

Pilot methodology

All the sites were sampled and organisms are extracted.
Samples will be sent to an expert for determination, results will be available next year.

Compilation of soil data and maps for the pilot area *(to be completed with results)*

The compilation will be done with results.

Method development and application

The following approach was employed for sampling collembola:
High-gradient extraction of soil cores (n=4)
For detailed method descriptions see "Sampling design" chapter.
The methodology is compatible to those outlined in ENVASSO procedures and protocols (WP4).

Statistical and geo-statistical analysis *(to be completed with results)*

Data is stored in MS Excel and will be loaded for statistics in SPSS. ANOVA, LSD Post Hoc tests and linear regressions will be carried out.

Methodology used for calculations / estimations of parameters and indicators, including interpolations.

The following parameters (optional ones are shown in italics) will be measured or calculated according to ISO 23611-2:2006:

a. Total abundance (number of individuals per area or volume)
b. Species richness (number of species)
c. Species abundance (number of individuals per species and area or volume)
d. Ecological groups. The definition of ecological groups can be done on several parameters like habitat (Gisin, 1943).

The data set will be integrated into SoDa base.

Definition of baselines

It may be possible to start the definition of baseline values according to land use.

Definition and application of thresholds

Depending on the data, values or percentage can be provide as threshold values (compared to the baseline ones).

Evaluation of pilot results

Feasibility and experience of applying ENVASSO procedures and protocols

The protocol is simple to apply concerning the field sampling but previous experience and material is needed for the extraction of Collembola.
Baselines and thresholds are hard to apply.

Output performance e.g. Minimum Detectable Change achievable and comparison with ENVASSO procedure requirements; definition of baselines and application of thresholds

Not tested as no results available yet.

Identified strengths and weaknesses of

the estimation of indicator values
Strengths: easy to implement especially for total abundance
Weaknesses: species richness determination will require the help of an expert

the interpretation of indicator values
Strengths: generally easy to interpret when comparing the influence of land use/soil type on Collembola populations
Weaknesses: seasonal variability can influence the Collembola sampling

References

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Pilot area: Brandenburg, Germany

Lead partner: Brandenburg
Jörg RÖMBKE
Werner KRATZ

Description of the Pilot Area

Name of pilot area		**Brandenberg**
Names of participating partners	**Lead partner**	**Brandenburg State**
	Partner A	**Jörg RÖMBKE and Werner KRATZ**
Location and description	Member State(s)	Germany (State of Brandenburg)
	Coordinates	Weizgrund (No. 1204) N 50°56,3' E 11°20,4' Beerenbusch (No. 1202) N 52°24,1' E 13°05,9' Kienhorst (No. 1203) N 52°38,4' E 13°38,6'
	Area of pilot area (km2)	Not known
	Climate	Continental Mean temperature (FAO 2006*) 10°C (estimated) Average Annual Precipitation 500 – 600 mm (FAO 2006)
	Elevation (m)	30 m – 150 m
	Vegetation (FAO 2006)	Coniferous forests
	Major Land Use (FAO 2006)	Forestry
	Major soils (WRB 2006 RGs**)	Poor sandy soils

* *ftp://ftp.fao.org/agl/agll/docs/guidel_soil_descr.pdf* ***ftp://ftp.fao.org/agl/agll/docs/wsrr103e.pdf*

Other descriptive information
Please note that the respective standard methods (e.g. FAO 2006) have NOT been used. Since these three sites belong to the monitoring network of the State of Brandenburg other (and more detailed) parameter could be provided, if needed.

The Monitoring Areas (MA) of Brandenburg are situated in the mid of the Northern German lowlands which in fact runs from the Netherlands to Poland. Because of the influence of the ice ages the whole area is flat. The soils are sandy, very poor in nutrients, low in organic matter content and acid (pH: 2.8 – 3.4). The soil surface is usually covered by a thick layer of needle litter. The whole area is used for commercial forestry, meaning that most of the area is covered by pine plantations (Figure. 1).

Three sites were selected which are located in the central part of the state of Brandenburg, either on the Southern (Weizgrund) or Northern (Beerenbusch, Kienhorst) side of Berlin.

Figure 1. One of the three monitoring areas (Weizgrund)

Threat and related indicator(s) evaluated in pilot area

Table 2. Indicators measured in the Brandenburg MA

Threat	Decline in soil biodiversity
Indicator 1	BI02 Enchytraeids (no earthworms)

In the Brandenburg MA, only one out of the 3 top indicators defined by WP1 (i.e. earthworm, collembola and microbial respiration) was analyzed (see table 3). Because of the acidity of the soils, earthworms are almost completely lacking in this region. Following the recommendation of Workpackage 1 on how to proceed in such a case enchytraeids were sampled instead.

Rationale for selection of monitoring area

Coniferous forests on sandy, poor soils are typical for the State of Brandenburg (in fact wide areas of the Northern German Lowlands). Therefore, about 40 individual sites were selected by the responsible authorities in order to get data describing the quality of these sites in time and space. Sampling for soil chemistry and physics as well as forestry (e.g. yield, nutrients) is performed on a regular scale (every five years). These sampling activities are not co-ordinated on a national scale in Germany. However, soil biological parameters are rarely measured sine they are not (yet) required by law. The three sites described here were selected in order to get an idea about the biological status of the soil by using an organism group (enchytraeids) which is known to be the most important one in terms of abundance and biomass for such acid soils.

However, due to financial constraints sampling was possible twice so far (November 2001, March 2003). Further sampling is planned but no details are fixed until now. In particular, the aim of this sampling was to check the representativity of one sampling (November 2001) by comparing the results with sampling in the next year (March 2002).

Indicator evaluation

This part provides a description of that top indicator which was actually sampled but also explains how the sampling area is defined and prepared.

Spatial extent and sampling design for each indicator

On each of the three sites a sampling area of about 0.51 ha (100 x 50 m) was already defined for non-biological sampling (coloured sticks were used to identify the borders). Since the use of split-corers does not heavily impact the site it was decided to take ten enchytraeid samples arranged in two rows of five each. The distance between the two rows as well as between the individual samples was 10 m each. With few exceptions (e.g. because of a path or a tree) this scheme was strictly followed.

Indicator BI 02 – Enchytraeids
Pilot description

Testing

The enchytraeid community was sampled extracted using the wet extraction method (ISO 23611-2, 2007) (the detailed procedure is explained in table 4). Ten samples are made within the biodiversity sampling area.

Data description and standards

Soil description, soil physico-chemical data and land uses can be obtained from the LUA Brandenburg, Potsdam (the local authority responsible for running the monitoring sites). This information can be used to produce maps and any relevant information on the area. Part of this data set could also be integrated into the SoDa base.

Methodology used for calculations / estimations of parameters and indicators

Classical additive approaches and statistical analyses will be used to bring out differences in soil indicators depending on soil types, land uses, agricultural practices.

Baseline definition

No baseline defined within WP1.

Threshold definition

No baseline defined within WP1.

Pilot methodology

All the sites were sampled and organisms are being identified. A preliminary work can be done on part of the sites in other to present maps and graphs. A first evaluation is provided here.

Compilation of soil data and maps for the pilot area

Soil data and maps can be obtained from the LUA Brandenburg, Potsdam (the local authority responsible for running the monitoring sites). However, since the monitoring activities described here were performed within the decade before the ENVASSO project started, only earthworms and enchytraeids were considered. Other organism groups, belonging to Level II of the ENVASSO recommendations (e.g. oribatid and gamasid mites, or macrofauna), were sampled but are not reported here.

Method development and application

Table 4 presents the method used to sample enchytraeids on the sites. No variations of the ISO method have been made. However, it should be not each sample was divided into four sub-samples: vegetation layer (varying depth: 1 – 4 cm), plus three layers of mineral top soil (each 2.5 cm thick).

Table 3. Procedure for enchytraeid collection

Sampling and soil extraction of enchytraeids	
Guideline	Committee Draft ISO/CD 23611-3
Species	Natural enchytraeid field community
Principle	Extraction of animals from soil samples using behavioural methods (duration 2 – 4 days)
Method	Collecting of soil samples with a soil-corer in the field; extraction of the worms in a simple wet-extraction method according to Graefe; microscopical species determination
Parameters	Abundance, species composition, dominance spectrum, biomass

Statistical and spatial analysis

Data was analysed according to classical statistical analyses without spatial approach (e.g. Anova, Multivariate analyses (PCA, CA, MCA))

Methodology used for calculation/estimation of parameters and indicators

The following parameters and indicators were measured or calculated:

a. Total abundance (number of individuals per area or volume)
b. Species richness (number of species)
c. Abundance/biomass of species
d. Age structure of the population (e.g. the adult/juvenile ratio)

Part of the data set should be integrated into the SoDa base.

Evaluation of pilot results

Pilot results

Enchytraeids were found in high numbers at all three sites and both sampling dates (on average: 50.000 – 110.000 ind/m2). The following enchytraeid species were found at the three sites: *Achaeta sp., A. abulba, A. cf. affinoides, A. cf. bohemica, A. urbana, Bryodrilus ehlersi, Cognettia sphagnetorum, Enchytraeus norvegicus, Enchytronia parva, Fridericia striata, Marionina clavata, Mesenchytraeus pelicensis, Oconnoriella cambrensis*.

This study had two aims:

- to characterize the three sites (which are quite similar regarding region, soil properties, vegetation, climate etc,.) in terms of their enchytraeid communities;
- to compare the results of two samplings performed in two consecutive years and different seasons (but considered to be optimal for enchytraeid sampling).

Referring to the first aim, several parameters important for the description of enchytraeid communities are given in Table 5. While there has no statistical comparison been made so far, the overall impression is that there are no consistent differences between the enchytraeid communities at the three sites.

Table 5: Comparison of the enchytraeid communities of three forest sites in Brandenburg (each as mean of the two sampling dates)

Parameter	Weizgrund	Beerenbusch	Kienhorst
Abundance (Ind/m 2)	85357	63086	65133
Age structure (ratio of juveniles	70 : 30 %	62 : 38 %	74 : 26 %
to adults (%))			
Vertical distribution	44 : 372: 18 : 5 %	53 : 26 : 14 : 7	58 : 28 : 11 : 3 %
Number of species	9	12	11
Most abundant species	*A. affinoides, C. sphagnetorum, M. clavata*	*A. affinoides, C. sphagnetorum, M. Clavata*	*M. clavata, C. sphagnetorum, A. cf. affinoides*

Referring to the second aim, the differences in the same parameter are separately given for the three sites and the two sampling dates in Tables 6-8. In addition, the so-called indicator values according to Graefe (based on the pH preference of the individual species) and the outcome of the BBSK evaluation are given. The latter two numbers describe the community composition (for details see Graefe & Schmelz 1999; Ruf et al. 2003). Without going into details it can be stated that there are no differences between sampling dates. However, it is obvious that abundance is more variable than other parameters, in particular those depending on the community structure (e.g. species composition). While this conclusion is preliminary for the Brandenburg sites, other studies have found the same outcome. This example has been chosen because the ISO method has been used, while in other, older studies, other methods were used.

Table 6: Comparison of the enchytraeid communities of the Weizgrund site at the two sampling dates

Parameter	November 2001	März 2002
Abundance (Ind/m 2)	55920 ± 52444	110793 ± 97799
Age structure (ratio of juveniles to adults (%))	63 : 27 %	68 : 32 %
Vertical distribution	48 : 32 : 15 : 4 %	40 : 32 : 21 : 6 %
Number of species	9	10
Most abundant species	*C. sphagnetorum, A. affinoides*	*A. affinoides, C. sphagnetorum*
Indicator value (pH) according to Graefe	3.1	3.3
BBSK evaluation	22 %	16 %

Table 7: Comparison of the enchytraeid communities of the Beerenbusch site at the two sampling dates

Parameter	November 2001	März 2002
Abundance (Ind/m 2)	71.617 ± 34.533	54.555 ± 31.634
Age structure (ratio of juveniles to adults (%))	56 : 44 %	67 : 33 %
Vertical distribution	58 : 24 : 13 : 5 %	48 : 27 : 15 : 10 %
Number of species	12	12
Most abundant species	*A. affinoides, C. sphagnetorum*	*A. affinoides, C. sphagnetorum*
Indicator value (pH) according to Graefe	3.1	3.2
BBSK evaluation	20 %	20 %

Table 8: Comparison of the enchytraeid communities of the Kienhorst site at the two sampling dates

Parameter	November 2001	März 2002
Abundance (Ind/m 2)	75.394 ± 70.214	54.873 ± 36.907
Age structure (ratio of juveniles to adults (%))	75 : 25 %	72 : 28 %
Vertical distribution	56 : 37 : 5 : 2 %	60 : 20 : 17 : 4 %
Number of species	9	11
Most abundant species	*M. clavata, C. sphagnetorum*	*M. clavata, C. sphagnetorum*
Indicator value (pH) according to Graefe	2.9	3.0
BBSK evaluation	22 %	16 %

Between 1978 and 1984, the enchytraeid community of a beech forest (Schluttenbach) in Southern Germany was sampled bimonthly, using a non-standard method (combination of hand-sorting and floating). Considerable differences in abundance and biomass were found when they are presented as mean annual values (Figure 2); for example because of a severe draught in 1983 (Römbke 1989). However, when calculating the mean monthly values (n = 8) it becomes clear that there is an obvious annual cycle, with highest values in October, December and February (Table 9). Biomass is even more pronounced than abundance, which can be explained by the big individual differences in biomass between the species living at that site.

These experiences support the recommendation to sample enchytraeids in the winter, which, due to practical reasons, means late autumn or early spring. In this context it must be remembered that this recommendation is not a fixed law: in other regions of Europe as well as in years with "extreme" climatic events, adaptations of the sampling scheme may become necessary.

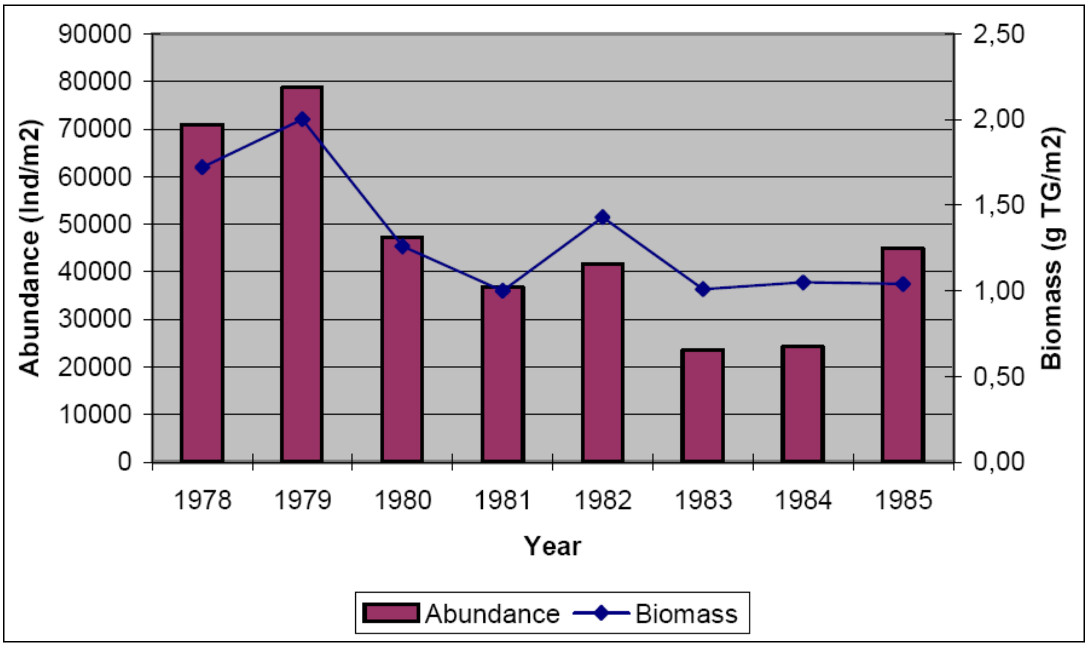


Figure 2. Mean annual values of enchytraeid abundance and biomass at the Schluttenbach forest (Germany)

Table 9: Mean monthly (n = 8) values of enchytraeid abundance and biomass at the Schluttenbach forest (Germany)

Parameter	Abundance (Individuals m^2)	Biomass (g fresh weight m^2)
February	57.500	10.70
April	35.800	6.94
June	31.200	5.10
August	39.600	4.74
October	56.400	9.02
December	58.700	16.04

Feasibility and experience of applying ENVASSO procedures and protocols

The protocol is simple to apply but previous experience in collecting worms is preferable to be quickly operational.

Output performance

e.g. Minimum Detectable Change achievable and comparison with WP1 requirements; definition of baselines and application of thresholds
Not tested as no result available yet.

Identified strengths and weaknesses of

a. the estimation of indicator values
Strengths: easy to implement especially for total abundance,

Weaknesses: 1-species richness determination will require the help of an expert, 2-abundance and species richness may sometimes not be enough to assess the decline of soil biodiversity function.

b. the interpretation of indicator values

Strengths: generally easy to interpret when comparing the influence of land use/soil type on enchytraeid populations

Weaknesses: 1-seasonal variability can influence the enchytraeid sampling. 2-difficult to compare data collected on other Pilot Areas with different sampling methods.

Conclusions and recommendations

In order to assess the decline of soil biodiversity and soil biodiversity function, abundance and species richness should be completed by other descriptors: it should be relevant to assess abundance of species, age structure of the population (e.g. the adult/juvenile ratio). However, these informations are easy to obtain, because they are more or less informed by the species level (if you have the species richness, you also have the abundance of the species. The specific structure could also be completed by some diversity index (ex: Shannon-Wiener index).

Concerning the influence of the seasonal variability, it is necessary:

i) to realise the soil sampling at the same time of the year (spring or autumn)

ii) ii) to reduce the sampling period (here: the enchytraeids were sampled either in autumn (October, November) or in spring (March, April), usually within one day per site),

iii) iii) to associate in the data base (as “SoDa”) the sampling time to each measurement. This information will be analysed as the soil type and/or the soil land use.

References

Graefe, U., Schmelz, R. (1999): Indicator values, strategy types and life forms of terrestrial Enchytraeidae. Newsletter on Enchytraeidae 6: 5967. Römbke, J. (1989): Zur Biologie eines Buchenwaldbodens. 12. Die Enchytraeidae. Carolinea 47: 5592.

Ruf, A., Beck, L., Dreher, P., HundRinke, K., Römbke, J. & Spelda, J. (2003): A biological classification concept for the assessment of soil quality: „biological soil classification scheme“ (BBSK). Agriculture, Ecosystems and Environment 98: 263271.

Pilot area: North Rhine-Westphalia, Germany

Lead partner LANUV NRW Germany

Partner A IFAB Institute for Applied Soil Biology Germany
Ulfert Graefe

Description of the Pilot Area

Name of pilot area		**Soil Monitoring Sites of the federal state North Rhine-Westphalia (BDF NRW)**
Names of participating partners	**Lead partner**	**Landesamt für Natur, Umwelt und Verbraucherschutz Nordrhein-Westfalen (LANUV NRW)**
	Partner A	IFAB Institute for Applied Soil Biology
Location and description	Member State(s)	Germany (North Rhine-Westphalia)
	Coordinates	Geographical centre point E 7°33' 40" N 51°34' 13"
	Area of pilot area (km2)	34 085 km²
	Climate	Oceanic
	Elevation (m)	16 m – 675 m
	Vegetation (FAO 2006)	FC, FS, FD, HS
	Major Land Use (FAO 2006)	FN1, HI, SC [N, VM, MU, PO]
	Major soils (WRB 2006)	Cambisols, Planosols, Podzols, Arenosols, Gleysols, Luvisols

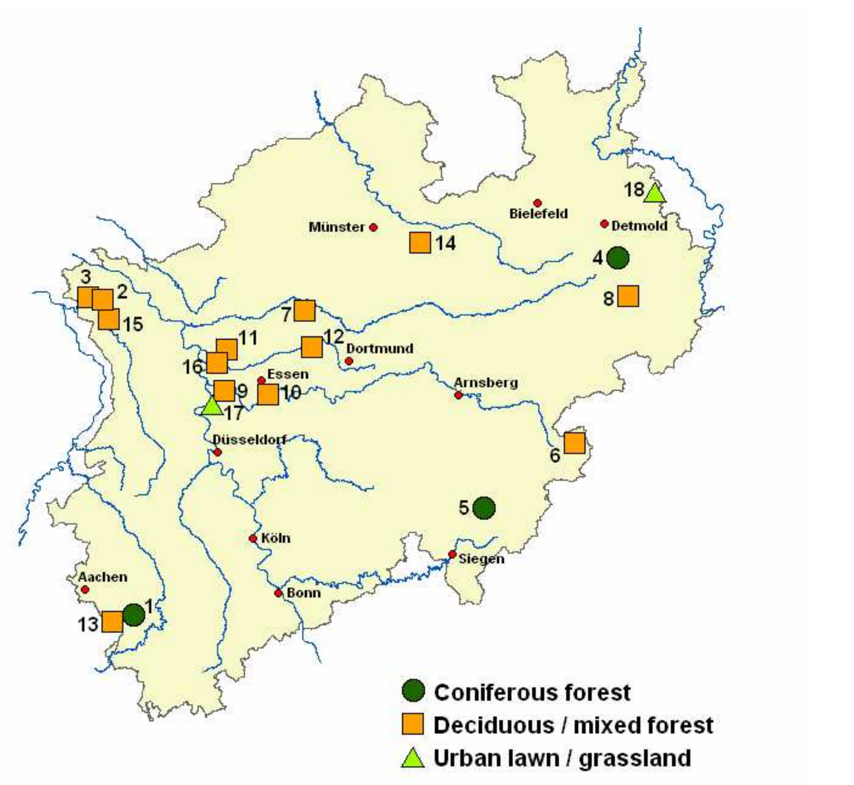


Figure 1. Location of the 18 Soil Monitoring Sites in the German PA North Rhine-Westphalia

Table 2. Descriptions of the individual Soil Monitoring Sites

BDF 01 LAF Lammersdorf Fichte: 570 m a.s.l., 7,7 °C , 1113 mm a.r., spruce forest, Stagnic Cambisol, Mormoder
BDF 02 KLT Kleve Tannenbusch: 28 m a.s.l., 9,6 °C, 754 mm a.r., beech-oak forest, Gleyic Cambisol, Moder
BDF 02 KLR Kleve Rehsol: 35 m a.s.l., 9,6 °C, 754 m m a.r., beech forest, Gleyic Cambisol, Moder
BDF 04 VEL Velmerstot: 400 -425 m a.s.l., 9,0 °C, 1259 mm a.r., spruce forest, (Cambi-)Haplic Podzol, Mormoder
BDF 05 ELB Elberndorf: 675 m a.s.l., 6,4 °C, 1323 m m a.r., spruce forest, Gleyic Cambisol, Mormoder
BDF 06 GLI Glindfeld: 545 m a.s.l., 6,4 °C, 790 mm a.r., beech forest, Skeletic Cambisol, Moder
BDF 07 HAA Haard: 75 m a.s.l., 9,5 °C, 814 mm a.r., mixed pine-beech forest, (Cambi-)Haplic Podzol, Mormoder
BDF 08 SCH Schwaney: ca. 370 m a.s.l., 7 -8 °C, 10 00 -1100 mm a.r., deciduous forest, Cambisol, F-Mull and Mullmoder
BDF 09 DUW Duisburg Wald: 81 m a.s.l., 11,0 °C, 748 mm a.r., beech forest, Dystric Arenosol, Mormoder, partly changed to F-Mull through liming
BDF 10 ESS Essen Süd: 137 m a.s.l., 9,6 °C, 883 mm a.r., mixed spruce-beech forest, Gleyic Cambisol, Mormoder
BDF 11 BOT Bottrop: 63 m a.s.l., 9,6 °C, 882 mm a.r ., beech forest, Stagnic Arenosol, Mormoder, changed through liming
BDF 12 CAR Castrop-Rauxel: 71 m a.s.l., 9,8 °C, 785 mm a.r., beech forest, Arenic Planosol, Mormoder, changed through liming
BDF 13 LAB Lammersdorf Buche: 448 m a.s.l., 6 -7 °C, 1100 mm a.r., beech forest, Haplic Planosol, Mormoder
BDF 14 EWI Everswinkel: 64 m a.s.l., 9,3 °C, 750 mm a.r., deciduous forest, Arenic Planosol, Mullmoder
BDF 15 GOC Goch: 16 m a.s.l., 9,6 °C, 696 mm a.r., deciduous forest, Dystric Gleysol, Moder
BDF 16 DUM Duisburg Mattlerbusch: 30 m a.s.l., 11,0 °C, 748 mm a.r., deciduous forest, Gleyic Cambisol, Mullmoder
BDF 17 DUB Duisburg Biegerhof: 39 m a.s.l., 11,0 °C , 748 mm a.r., grassland (urban lawn), Haplic Cambisol, L-Mull, heavy metal pollution
BDF 18 LÜK Lütkenberg: 239 m a.s.l., 9,3 °C, 846 mm a.r., grassland (pasture), Haplic Luvisol, L-Mull

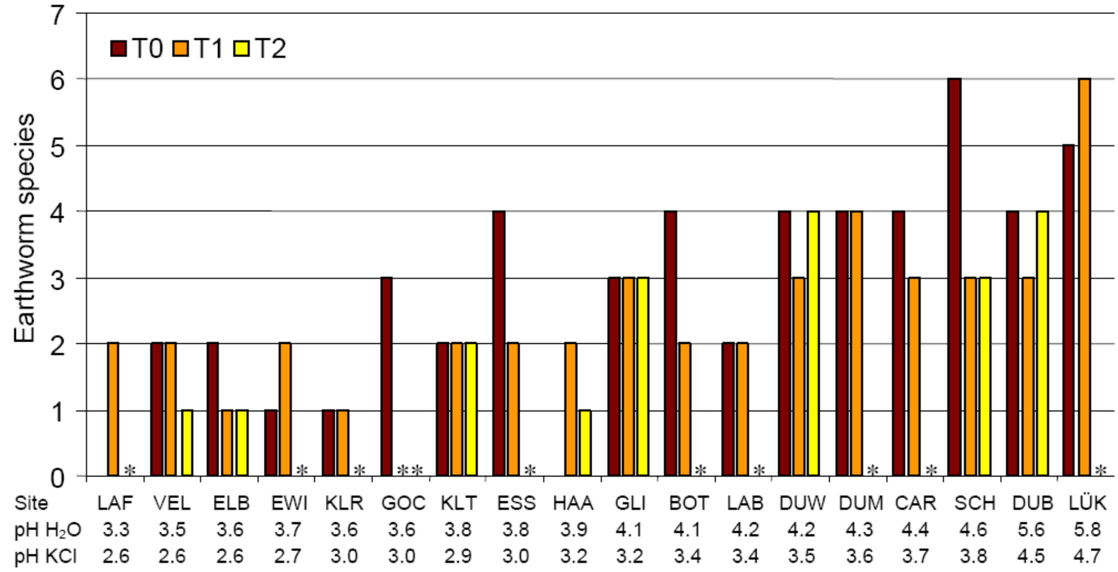
(additional data are available from LUA 2005*/LUA 2005a**)
*http://www.lanuv.nrw.de/boden/boschu-lua/Bericht_BDF_Druckversion.pdf
**http://www.lanuv.nrw.de/boden/boschu-lua/Anhang_BDF_Internet.pdf

Threat and related indicators evaluated in the pilot area

Table 3. Top 3 indicators measured in the German PA

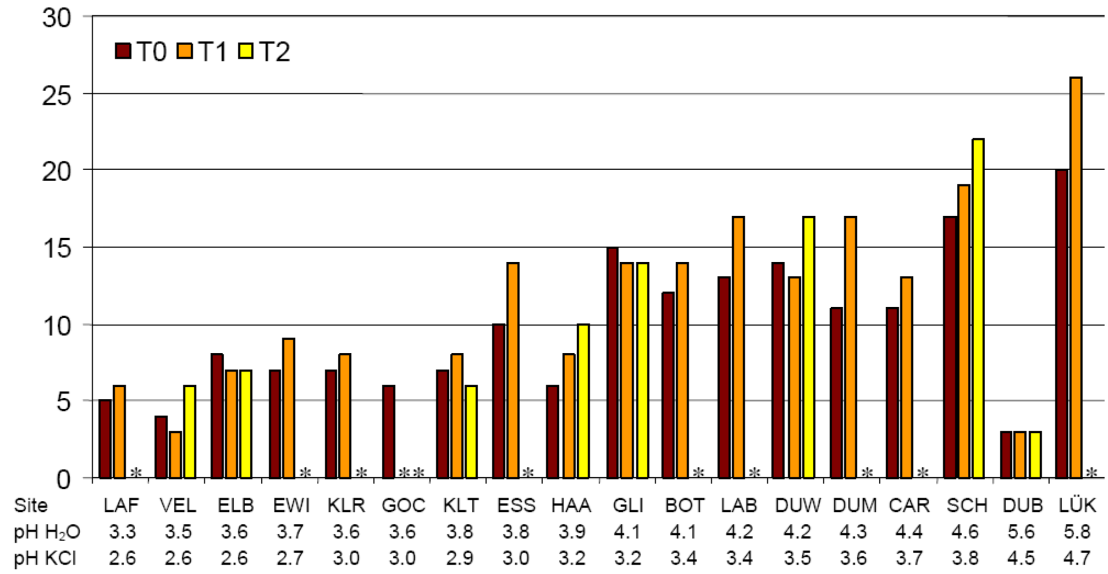
Threat	Decline in soil biodiversity
Indicator 1	BI01 Earthworms
Indicator 2	BI02 Enchytraeids
Indicator 3	BI03 Microbial respiration

Additional data from the pilot area



T0 : 1995 or 1996 // T1 : 2000 or 2001 // T2 : 2005 or 2006

Figure 2. Effect of pH on Earthworms species diversity at 3 sampling dates



T0 : 1995 or 1996 // T1 : 2000 or 2001 // T2 : 2005 or 2006

Figure 3. Effect of pH on Enchytaied species diversity at 3 sampling dates

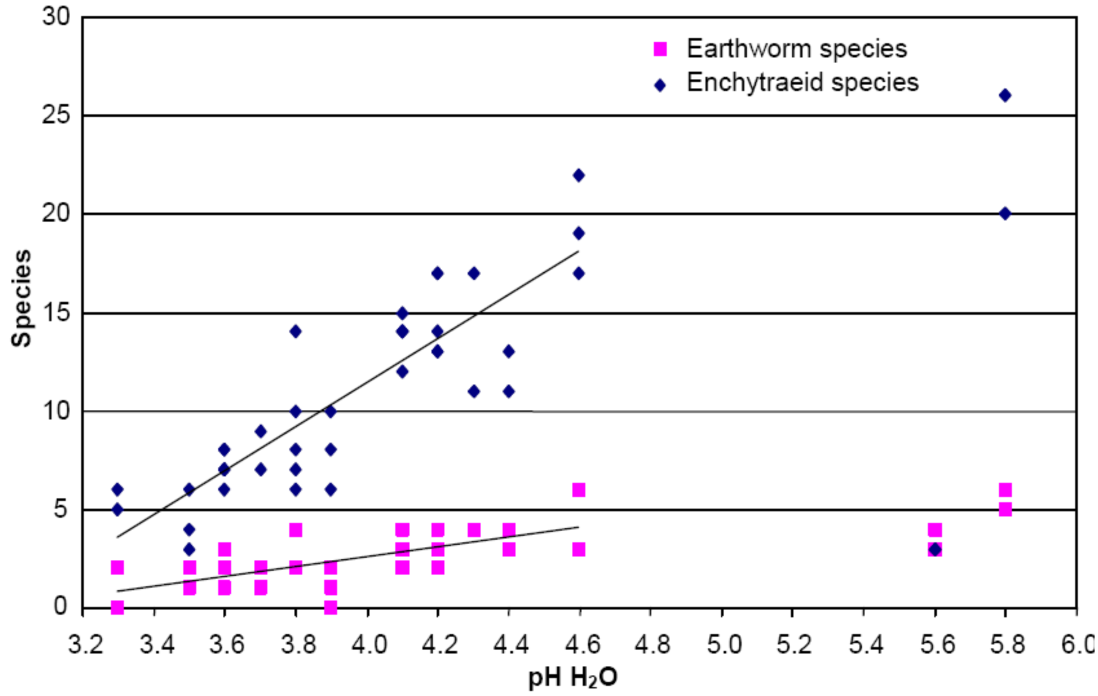


Figure 4. Correlation between pH and number of Indicator species on the sites of the BDF NRW pilot area

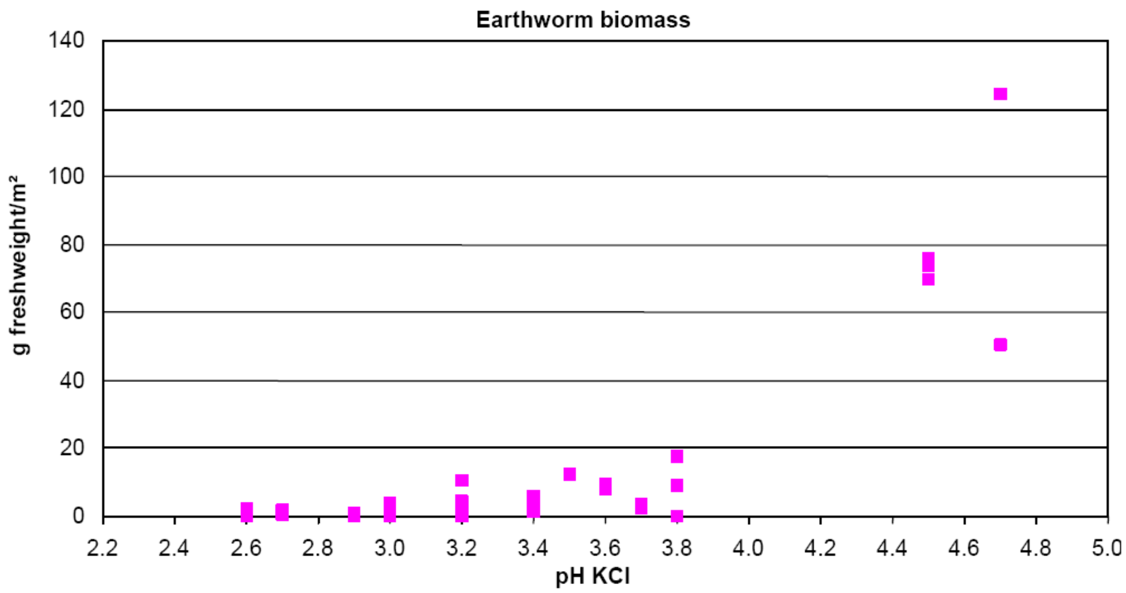


Figure 5. Correlation between pH and Earthworm biomass on the sites of the BDF NRW pilot area

Effect of heavy metal content on the number of species on the sites of the BDF NRW pilot area

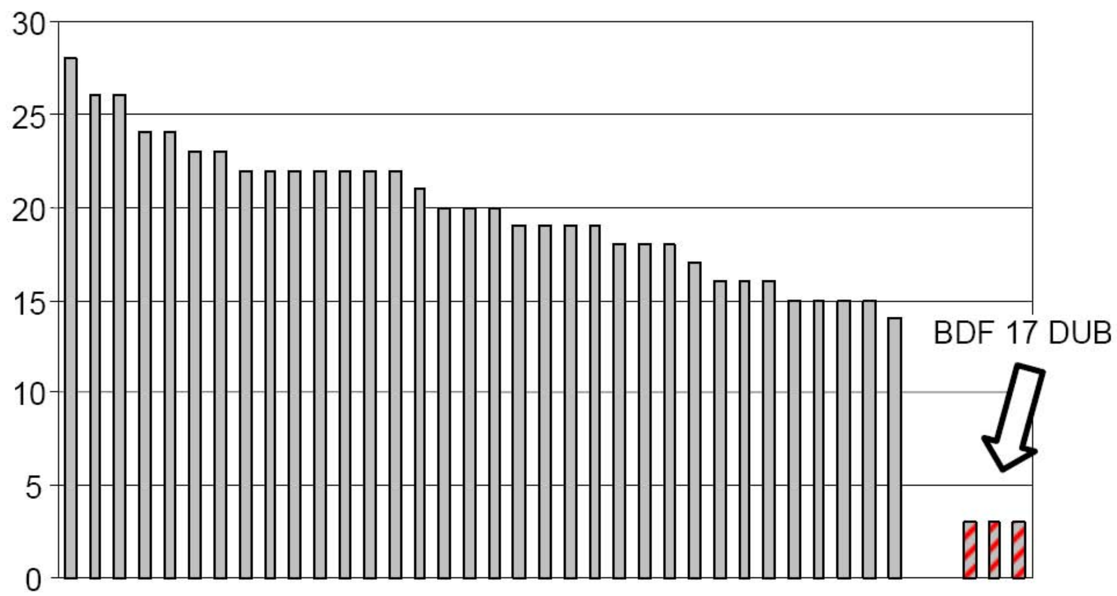


Figure 6. Decline in species diversity due to heavy metal contamination at grassland monitoring sites cf. Duisburg Biegerhof.

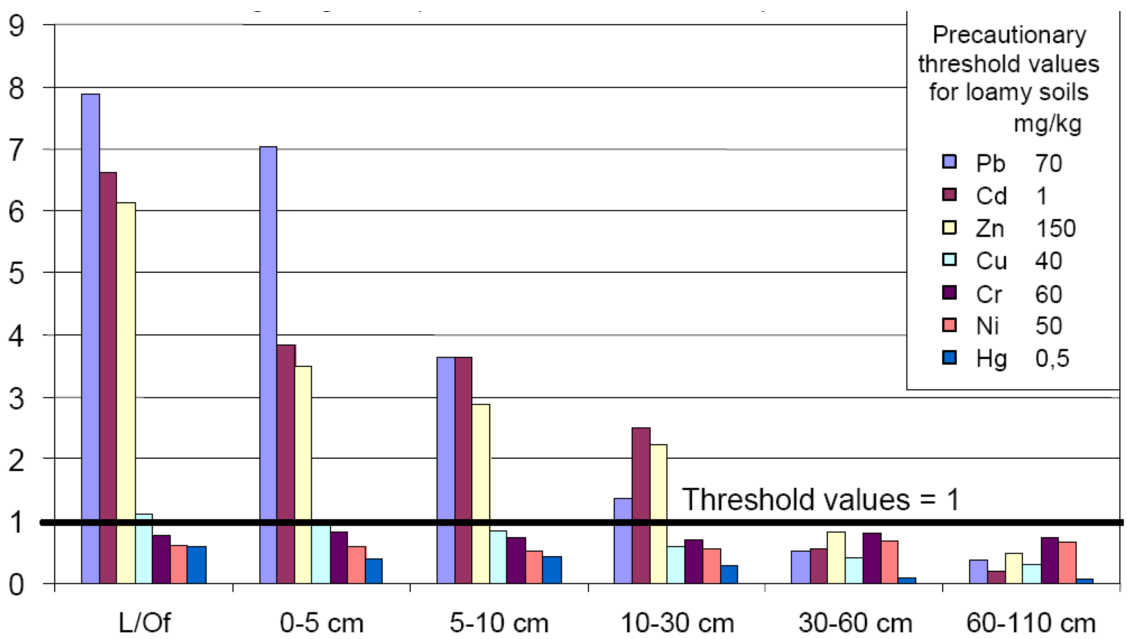


Figure 7. Exceedance of heavy metal thresholds at Duisburg Biegerhof (BDF 17 DUB, urban lawn)

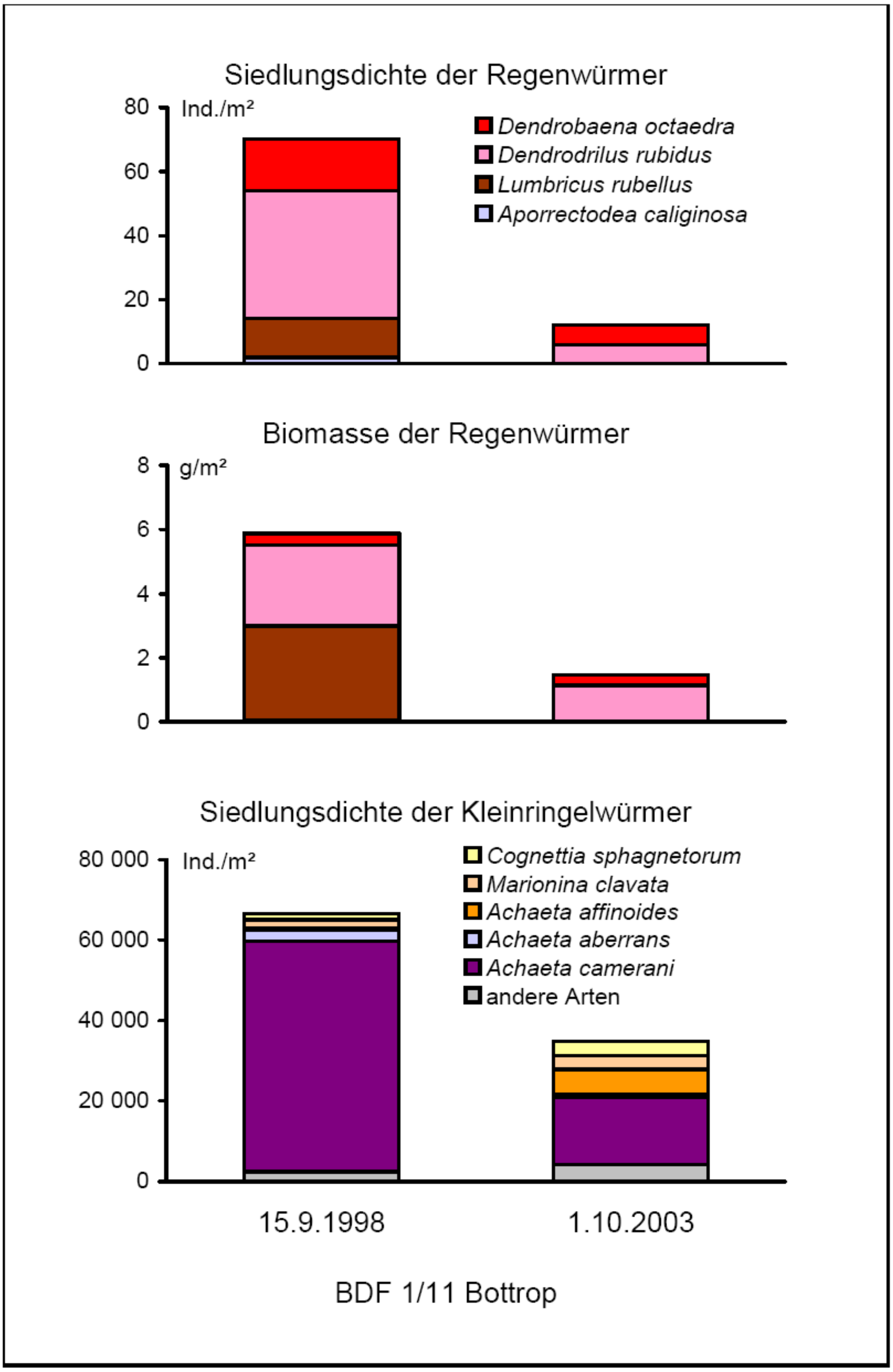


Figure 8.Temporal variation of Indicator 1 species on Bottrop area (Decline in diversity, abundance and biomass after 2 samplings)

Pilot area: Level I Forest sites, Portugal

Lead partner **Universidade de Coimbra, PORTUGAL**
José Paulo SOUSA

Partner A **Direcção Geral de Recursos Florestais. Portugal**
Maria CONCEIÇÃO-BARROS

Description of Pilot Area

Note that the respective standard methods (e.g. FAO 2006) have not been used.

Name of Monitoring Area		**Level I Forest sites (Portugal)**
Names of participating partners	**Lead partner**	**José Paulo SOUSA** **Universidade de Coimbra**
	Partner A	Maria CONCEIÇÃO-BARROS Direcção Geral de Recursos Florestais (DGRF)
Location and description	Member State(s)	PORTUGAL
	Coordinates :	Can be obtained in the national focal point
	Area of pilot area (km 2)	(DGRF) see also Figure 1 Variable according to the site and type of forest stand. Minimum of 1 ha
	Climate:	
	Gontim (Fafe) Sever do Vouga Lousã	Atlantic Atlantic Atlantic
	Idanha-a-Nova	Mediterranean
	Almeirim	Mediterranean
	Alcochete	Mediterranean
	Monchique	Sub-tropical moist
	Mean temperature (FAO 2006*)	
	Gontim (Fafe)	15ºC
	Sever do Vouga	15ºC
	Lousã	14ºC
	Idanha-a-Nova	16ºC
	Almeirim	16ºC
	Alcochete	16ºC
	Monchique	15ºC
	Average Annual Precipitation (FAO 2006)	
	Gontim (Fafe)	1700mm / year
	Sever do Vouga	2100mm / year
	Lousã	960mm / year
	Idanha-a-Nova Almeirim	400mm / year 400-500mm /year
	Alcochete	400-500mm / year
	Monchique	1000-1500mm /year
	Outline description of topography	
	Gontim (Fafe)	Hilly area with smooth slopes
	Sever do Vouga Lousã	Mountain area with steep slopes Mountain area with steep slopes
	Idanha-a-Nova	Hilly area near a dam
	Almeirim	Flat area with smooth topography
	Alcochete	Flat area with smooth topography
	Monchique	Mountain area

	Elevation (m)	
	Gontim (Fafe)	350m
	Sever do Vouga	300m
	Lousã	550m
	Idanha-a-Nova	300m
	Almeirim	40m
	Alcochete	10m
	Monchique	500m
	Vegetation (FAO 2006)	
	Gontim (Fafe)	Quercus robur /Q. pyrenaica forest Eucalyptus globulus plantation
	Sever do Vouga	Pinus pinaster plantation Eucalyptus globulus plantation
	Lousã	Pinus pinaster plantation Eucalyptus globulus plantation
	Idanha-a-Nova	Quercus ilex stand Eucalyptus globulus plantation
	Almeirim	Quercus suber stand Eucalyptus globulus plantation
	Alcochete	Quercus suber stand Eucalyptus globulus plantation
	Monchique	Quercus suber / Q. canariensis stand Eucalyptus globulus plantation
	Major Land Use (FAO 2006)	Forest
	Major soils (WRB 2006 RGs**)	Can be obtained in the national focal point (DGRF) mean soil characteristics are presented in table 3.

* ftp://ftp.fao.org/agl/agll/docs/guidel_soil_descr.pdf
**ftp://ftp.fao.org/agl/agll/docs/wsrr103e.pdf

Other descriptive information:

The sites reported here are included in a wider monitoring area composing the Level I ICP Forests monitoring plots from Portugal. These sites were chosen because previous monitoring of soil Collembola was done. However all Level I sites will start to be monitored on a regular basis for forest biodiversity (including ENVASSO top 3 indicators) from 2008. Since several sites were considered, more detailed information about each site (e.g., soil type and soil characterization, climate) can be obtained from the local focal point.

Threat and related indicator(s) evaluated in pilot area

Table 2. Indicators measured in the Portuguese monitoring areas

Threat	Decline in soil biodiversity
Indicator 1	BI02 Collembola

However, since the monitoring activities described here were performed several years before the ENVASSO project (although using methodologies adopted by ENVASSO), only Collembola were considered. In some of the sites, also some other organisms, belonging to Level II of the ENVASSO recommendations (i.e., macrofauna), were sampled but are not reported here.

Rationale for selection of monitoring area

The main objective of the monitoring study reported here was to evaluate the effects of replacing natural forests by Eucalyptus plantations on biodiversity patterns of Collembola. Therefore, within the Level I plots, the sites were selected using two basic criteria:

i) being in regions where the percentage cover area of Eucalyptus plantations were representative in terms of total area of forest in the region;

ii) have represented the most important autochthonous forest types;
iii) select sites where the previous soil use of the eucalyptus area was a forest dominated by the respective autochthonous tree species (Fig. 1)

This is the reason why, at each site there is always an area covered with autochthonous tree species and a neighbouring area with a Eucalyptus plantation.

Indicator evaluation

This part provides a description of that top indicator which was actually sampled but also explains how the sampling area is defined and prepared.

Spatial extent and sampling design for each indicator

At each one of the sites two forest areas were sampled, one representing the autochthonous forest and another representing the Eucalyptus plantation. At each stand four sampling plots of 64m2 were randomly chosen and, inside each plot, 4 sampling points were selected also randomly. At each sampling point a soil core was taken, making a total of 16 soil samples for each stand (and a total of 32 for each site).

BI02 – Collembola

Pilot description

Testing

The Collembola community at each site was sampled and extracted using a method similar to the ISO 23611-2 method (at each sampling point, the litter layer and the first 5cm of the soil layer were sampled).

Data description and standards

Rough soil description and measurement of several soil parameters were done with samples collected simultaneously to the Collembola sampling (Table 4). Detailed soil characterization should be obtained from the DGRF.

Methodology used for calculations / estimations of parameters and indicators

Classical additive approaches and statistical analyses will be used to bring out differences in soil indicators depending mainly on forest type.

Baseline definition

No baseline defined within WP1.

Threshold definition

No baseline defined within WP1.

Pilot methodology

All the sites were sampled and organisms were being identified. A summary evaluation (taking into account species richness only) is done here.

Compilation of soil data and maps for the pilot area

Table 3 presents a brief soil characterization of the sampling points at each area. Detailed soil characterization should be obtained from the DGRF.

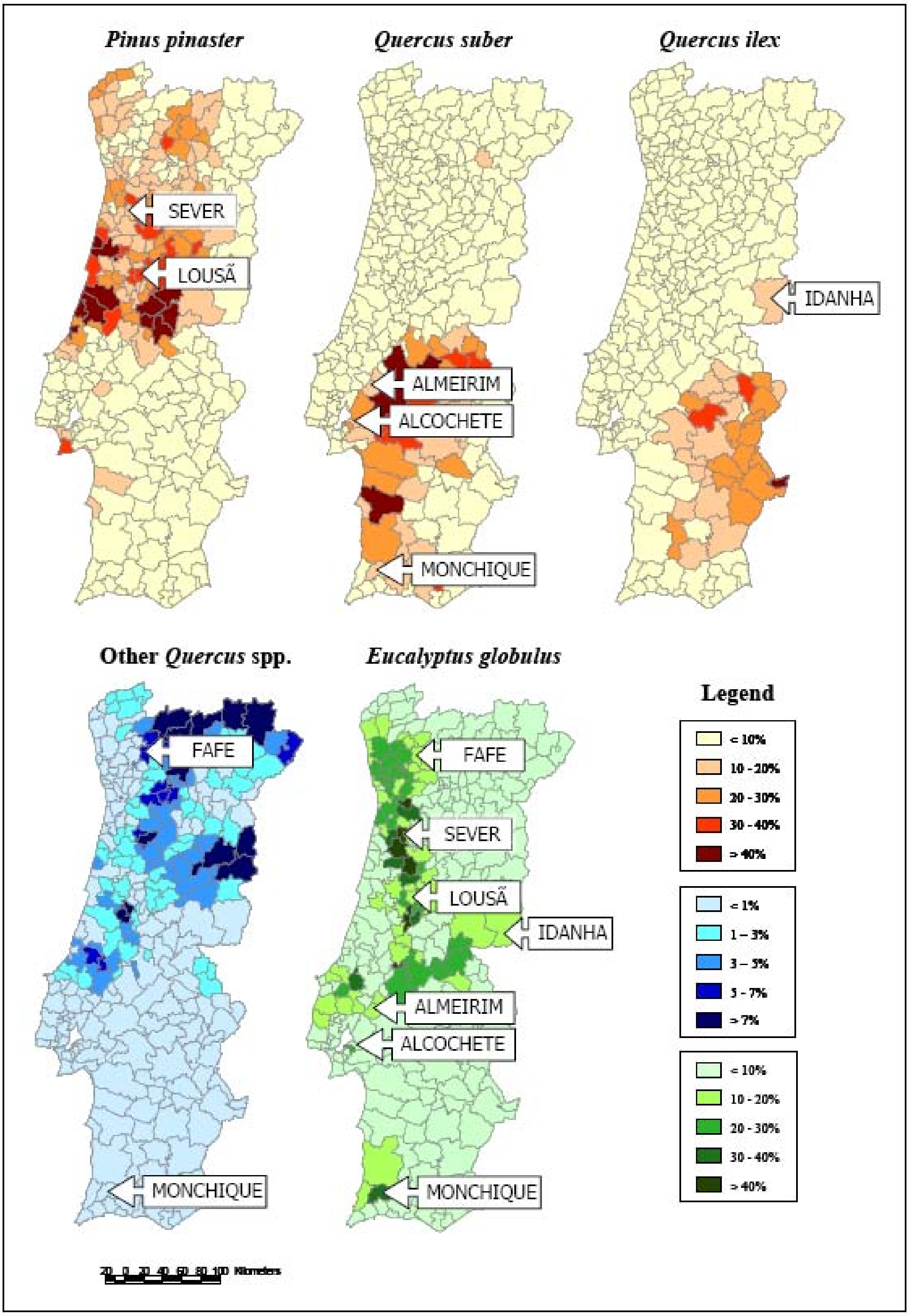


Figure 1. Location of study sites showing percentage forest coverage at regional administrative level

Table 3 – Soil parameters measured on sampling points at each area.

	Litter Thickness	Carbon	Nitrogen	C/N	OM
Idanha					
Quercus ilex	2.25 (0.91)	4.71 (1.23)	0.34 (0.11)	14.52 (3.19)	11.76 (2.67)
Eucalyptus globulus	1.88 (0.47)	1.98 (0.84)	0.13 (0.06)	16.79 (5.07)	5.18 (1.56)
Fafe					
Quercus pyrenaica	3.28 (0.73)	33.37 (5.73)	1.68 (0.31)	19.99 (2.01)	57.93 (8.82)
Eucalyptus globulus	1.84 (0.57)	27.37 (10.65)	1.26 (0.55)	23.27 (7.06)	45.41 (12.51)
Almeirim					
Quercus suber	0.88 (0.44)	15.57 (10.57)	0.67 (0.42)	24.91 (14.84)	31.45 (23.63)
Eucalyptus globulus	0.57 (0.34)	32.13 (11.19)	0.92 (0.36)	36.27 (11.74)	53.27 (17.58)
Alcochete					
Quercus suber I	3.91 (1.34)	21.37 (13.83)	0.29 (0.09)	72.95 (38.13)	29.87 (22.00)
Quercus suber II	2.00 (1.41)	19.37 (4.72)	0.23 (0.04)	85.00 (22.01)	23.48 (9.68)
Quercus suber III	2.61 (1.29)	22.98 (9.36)	0.32 (0.12)	75.28 (29.07)	27.58 (11.23)
Eucalyptus globulus	n.a.	n.a.	n.a.	n.a.	n.a.
Monchique					
Quercus suber	4.72 (1.72)	39.32 (7.94)	1.12 (0.29)	37.22 (14.61)	60.35 (11.34)
Quercus canariensis	4.81 (1.28)	26.04 (7.85)	0.92 (0.31)	30.30 (9.57)	42.85 (12.39)
Eucalyptus globulus I	2.25 (0.65)	46.10 (4.66)	1.19 (0.17)	39.62 (9.52)	74.38 (5.00)
Eucalyptus globulus II	2.38 (1.11)	49.92 (1.57)	1.28 (0.09)	39.10 (3.55)	75.50 (2.27)
Eucalyptus globulus III	3.63 (0.48)	39.19 (7.16)	1.32 (0.23)	29.86 (2.80)	60.15 (9.18)
Sever do Vouga					
Pinus pinaster	1.25 (0.26)	30.05 (9.77)	1.26 (0.29)	23.60 (4.84)	53.75 (16.85)
Eucalyptus globulus	1.72 (0.63)	31.79 (7.59)	1.39 (0.36)	23.86 (5.97)	56.75 (13.10)
Lousã					
Pinus pinaster	2.50 (0.10)	n.a.	n.a.	n.a.	n.a.
Eucalyptus globulus	2.00 (0.10)	n.a.	n.a.	n.a.	n.a.

	Soil pH	Carbon	Nitrogen	C/N	OM
Idanha					
Quercus ilex	6.66 (0.38)	2.29 (0.64)	0.20 (0.05)	11.77 (3.36)	6.37 (1.23)
Eucalyptus globulus	5.63 (0.18)	1.78 (0.60)	0.13 (0.07)	15.73 (5.02)	4.81 (1.04)
Fafe					
Quercus pyrenaica	5.83 (1.11)	17.51 (4.14)	0.81 (0.15)	21.89 (4.25)	28.82 (6.19)
Eucalyptus globulus	5.41 (0.64)	13.45 (4.31)	0.58 (0.26)	25.04 (6.10)	20.04 (6.23)
Almeirim					
Quercus suber	6.19 (0.79	4.42 (2.00)	0.22 (0.11)	22.06 (6.12	8.20 (4.14)
Eucalyptus globulus	6.25 (0.89)	2.30 (0.52)	0.13 (0.14)	23.72 (9.80)	4.03 (1.04)
Alcochete					
Quercus suber I	4.56 (0.63)	1.73 (1.11)	0.06 (0.03)	33.68 (24.39)	3.38 (2.57)
Quercus suber II	4.76 (0.45)	2.21 (1.18)	0.06 (0.02)	44.11 (33.04)	4.26 (3.30)
Quercus suber III	4.58 (0.61)	2.48 (1.95)	0.06 (0.03)	43.44 (37.33)	4.96 (3.90)
Eucalyptus globulus	n.a.	n.a.	n.a.	n.a.	n.a.
Monchique					
Quercus suber	6.10 (0.29)	14.60 (4.96)	0.61 (0.20)	24.31 (5.10)	26.47 (6.30)
Quercus canariensis	6.16 (0.23)	8.95 (1.54)	0.38 (0.08)	24.51 (5.78)	17.00 (2.80)
Eucalyptus globulus I	6.10 (0.29)	20.22 (4.85)	0.56 (0.27)	44.21 (23.78)	38.44 (9.86)
Eucalyptus globulus II	6.24 (0.19)	29.71 (11.06)	0.75 (0.31)	44.12 (26.50)	50.61 (14.53)
Eucalyptus globulus III	6.38 (0.33)	13.82 (4.76)	0.49 (0.16)	28.41 (5.23)	21.77 (4.24)
Sever do Vouga					
Pinus pinaster	4.72 (0.37)	7.61 (2.89)	0.32 (0.13)	24.04 (2.76)	12.51 (4.99)
Eucalyptus globulus	4.48 (0.49)	8.64 (2.72)	0.34 (0.13)	26.97 (7.45)	14.37 (5.45)
Lousã					
Pinus pinaster	4.15 (0.35)	8.84 (2.66)	0.23 (0.06)	39.29 (9.78)	n.a.
Eucalyptus globulus	4.11 (0.16)	6.88 (1.67)	0.16 (0.07)	44.43 (11.68)	n.a.

Method development and application

Table 4 presents the method used to sample collembolan at each site. No variations of the ISO method have been made.

Table 4. Procedure for collembola collection

Sampling and soil extraction of collembola	
Guideline:	Committee Draft ISO/CD 23611-2
Species:	Natural collembola field community
Principle:	Extraction of animals from soil samples using behavioural methods (duration 7-10 days)
Method:	Collecting of soil samples with a soil-corer in the field
Parameters:	Abundance, species composition

Statistical and spatial analysis

Since a rough analysis is presented here, and only dealing with abundance and species richness, only ANOVA methods will be used.

Methodology used for calculation/estimation of parameters and indicators

The following parameters and indicators were measured or calculated:

a. Total abundance (number of individuals per area or volume)
b. Species richness (number of species)
c. Abundance for each species

Collembola abundances ranged from 29.000 ind m^2 to over 700.000 ind m^2 varying according not only to soil type and land-use cover, but also climate conditions (Table 5). The lowest density was obtained on a Eucalyptus plantation in a very dry year. However species density values were not useful to detect any patterns between natural vs. exotic tree forest cover nor between the different management regimes adopted.

Species richness varied between 19 species (identified in the same eucalyptus plantation on the same year) to 47 species obtained in a rich forest canary oak forest (Table 5). A general decrease (over 20%) was observed mainly on those areas where the introduction of the exotic tree species and/or the forest management adopted in the site introduced changes in habitat configuration mainly on the organic horizon level and on the understory vegetation cover (sites: Idanha, Fafe, Alcochete and Monchique) (Figure 2). Those sites where a low decrease or even an increase in species richness was observed (changes around 10% or lower) (sites: Almeirim, Sever and Lousã), correspond to areas where the Eucalyptus plantations were low not intensively managed and where a resemblance on habitat configuration was observed (Figure 2).

Table 5. Abundance and species richness of Collembola for the sampled areas (Portugal)

Sites	Tree Species	Management	Nº Ind /m2	Nº Taxa
Idanha	*Quercus ilex*	Not managed	156.200 (*)	43 (*)
	Eucalyptus globulus	High management	39.600	26
Fafe	*Quercus pyrenaica*	Not managed	411.700	42 (*)
	Eucalyptus globulus	Low management	456.900	34
Almeirim	*Quercus suber*	Not managed	60.400 (*)	19
	Eucalyptus globulus	Low management	29.100	21
Alcochete	*Quercus suber I*	Not managed	56.1751 (*)	35 (*)
	Quercus suber II	Low management	138.528	25
	Quercus suber III	Low management	311.179	28
	Eucalyptus globulus	Low management	158.900	11
Monchique	*Quercus suber*	Not managed	410.300 (a)	47 (*)
	Quercus canariensis	Not managed	205.600 (1)	45 (*)
	Eucalyptus globulus I	High management	173.000 (b, 1)	19
	Eucalyptus globulus II	High management	380.400 (a, 2)	21
	Eucalyptus globulus III	High management	97.200 (b, c)	23
Sever do Vouga	*Pinus pinaster*	Low management	93.500 (*)	46
	Eucalyptus globulus	Low management	419.700	41
Lousã	*Pinus pinaster*	Low management	713.100 (*)	37
	Eucalyptus globulus	Low management	136.200	40

Note: (*), (1) and (a) indicate significant differences between the autochthonous forest vs. the corresponding eucalyptus plantation or the managed autochthonous forest (in Alcochete site)

When plotting species richness data according to the degree of management and separating into forest tree types, the decrease on managed sites is quite visible (Figure 3).

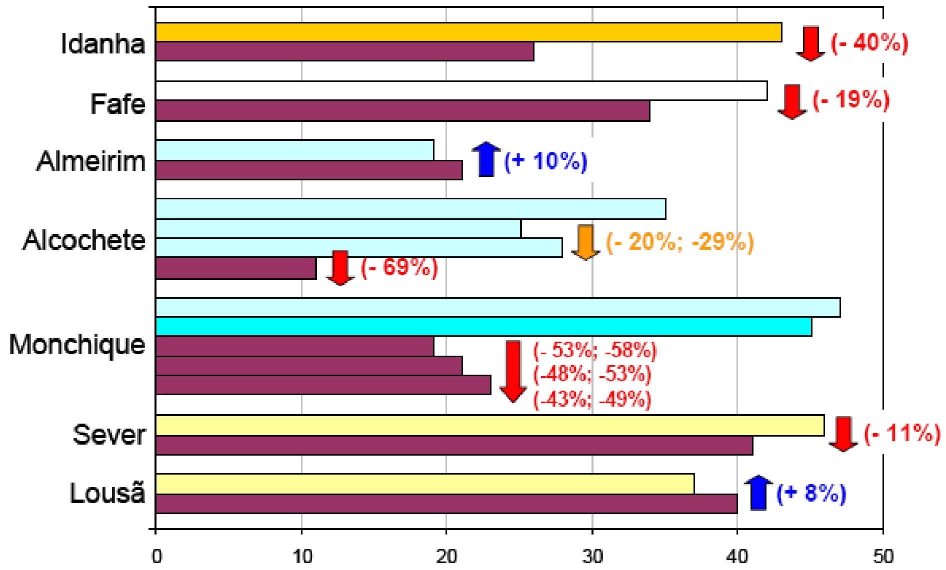
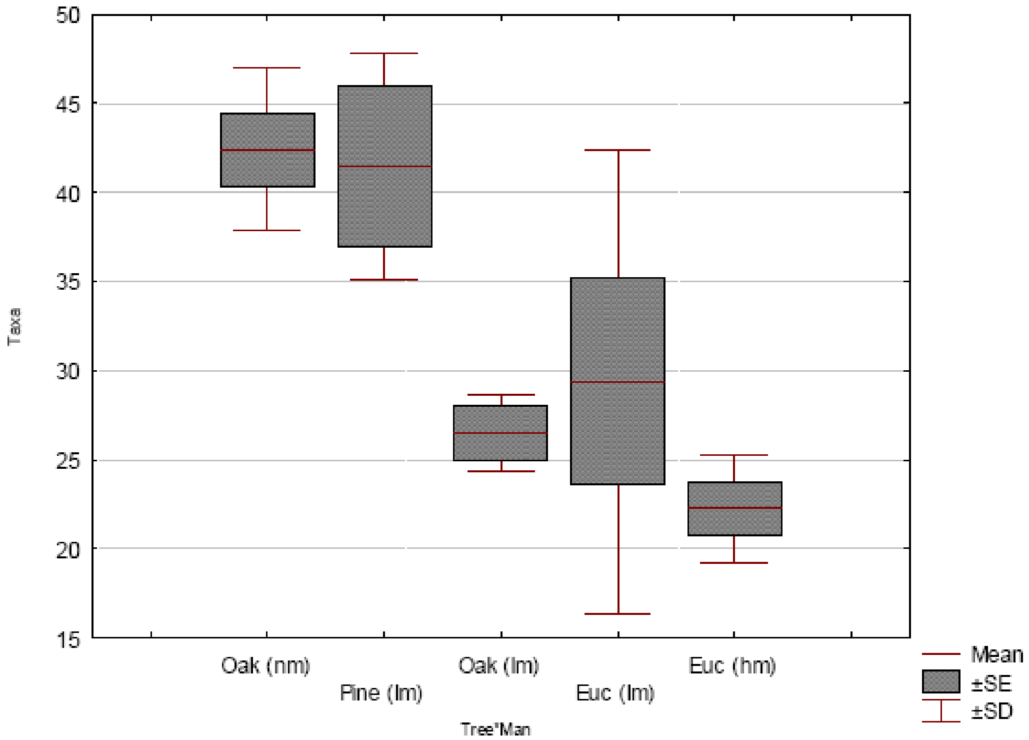


Figure 2. Species richness of Collembola at each sampled area (Portugal). Arrows indicate percentage change when shifting from natural to exotic forest tree covers

Thus, according to the major aim of the study (i.e., indicate changes in biodiversity of soil mesofauna on autochthonous tree forests after reforestation with eucalyptus), the data showed that the method adopted and the indicator chosen was able to successfully detect a decrease in biodiversity due to changes of soil quality / habitat configuration under the exotic tree plantations (mainly those managed) or under the managed natural forests.



Oak: the several oak forests sampled; Pine (Pinus pinaster plantations); Euc: Eucalyptus globulus plantations; nm: not managed; lm: low management intensity; hm: high management intensity.

Figure 3. Species richness (average + SE + SD) of Collembola according to tree and management intensity (Portugal).

Definition of baselines

The definition of baseline values is dependent from soil type and, most relevant for Collembola, according to the bionomial land-use cover / management options. Although it is still a bit premature to talk about baseline values for forest types in Portugal, since more data is necessary covering not only more reference situations and an extended temporal variation, the data presented here is promising regarding this issue.

From Table 5 and Figure 3 it is possible to see that average richness on areas with a natural tree cover, with no or low management activities, is similar among different tree species, with values around 40 species or higher. The only exception was a case where sampling was done under extreme dry conditions. Since the data presented is based on several projects, sampled over different years, values of this magnitude can be expected for this type of forest systems with this sampling effort.

Definition and application of threshold

The definition of threshold values should be done even more carefully than the definition of baseline values. Not only natural fluctuations should be taken into account, but also the meaning of a defined percentage decrease should be perceived.

However, for the data shown in this report (see Figure 2), a decrease of species richness around 20% or higher seems to be associated to changes in habitat quality for Collembola. Changes of this magnitude could be, after validation with more information, be indicative of a threshold value for Collembola richness under this type of forest systems with this sampling effort.

Evaluation of pilot results

Feasibility and experience of applying ENVASSO procedures and protocols

The protocol is simple to apply but previous experience in collecting worms is preferable to be quickly operational.

Output performance

e.g. Minimum Detectable Change achievable and comparison with WP1 requirements; definition of baselines and application of thresholds
Not tested as any result available yet.

Identified strengths and weaknesses

a. the estimation of indicator values

Strengths: easy to implement especially for total abundance,

Weaknesses:
species richness determination will require the help of an expert,
abundance and species richness may sometimes not be enough to assess the decline of soil biodiversity function.

b. the interpretation of indicator values

Strengths:
generally easy to interpret when comparing the influence of land use/soil type on collembola populations

Weaknesses :
seasonal variability can influence the collembola sampling

Conclusions and recommendations

In order to assess the decline of soil biodiversity and soil biodiversity function, abundance and species richness could be completed with other biodiversity descriptor (other indices). Moreover: (1) abundance of each species should be mandatory and not optional; (2) classification into morphotypes can be useful to understand changes in functional diversity and make a link to soil processes. However, this type of information is relatively easy to obtain once the species are identified.

Concerning the influence of the seasonal variability, it is necessary:

i) to perform the soil sampling at the same time of the year, and chosing a season where a peak in diversity is expected (usually spring or autumn), taking always into attention some key soil parameters like soil moisture.

ii) to reduce the sampling period (here: the collembola were always sampled in spring – April-May -and within one day per site),

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Pilot area: Körös-Berettyó Basin, Hungary

Lead partner **RISSAC, Hungary**

Partner A **ICPA, Romania**

Description of the Pilot Area

Name of pilot area		Körös-Berettyó Basin
Names of participating partners	**Lead partner**	**RISSAC, Hungary**
	Partner A	ICPA, Romania
	Partner B	-
	Partner C	-
Location and description	Member State(s)	Hungary
	Coordinates (WGS84)	46.956237; 20.915119 47.097851; 21.220088
	Area of pilot area (km^2)	370 km^2
	Climate	dry continental
	Mean temperature (FAO 2006*)	10.4 °C
	Average Annual Precipitation (FAO 2006)	540-570 mm
	Outline description of topography	Flat, alluvial plain (LP)
	Elevation (m)	82-86 m
	Vegetation (FAO 2006)	Short grass
	Major Land Use (FAO 2006)	Arable land, pasture
	Major soils (WRB 2006 RGs**)	Solonetz, Vertisols, Phaeozems, Cambisols

Other descriptive information
The selected region is dry and warm. The depth of groundwater is about 2 m, strongly affected by the net of canals. The evapotranspiration exceeds the precipitation, the aridity index is between 1.24-1.30, which represents dry conditions. The composition of the groundwater characterized by sodium and hydro-carbonate. The interval of the extreme temperature values: -16°C to +33°C.

Threat and related indicator(s) evaluated in pilot area

Threat	Salinisation/sodification/Potential salinisation/sodification
Indicator 1	Salt profile
Indicator 2	pH, ESP
Indicator 3	Potential salt sources

Rationale for selection of pilot area

The selected area (yellow rectangle on Figure 1a) represents a transnational pilot area close to the Hungarian-Romanain boundary. The same geological evolution and geographical position on both side of the Körös (Krisu) Basin represents a quite homogenous bio-geographical unit, with similar land use systems (arable lands and pasture mainly). Because of the climatic and pedological definiteness (e.g. dry conditions, high evaporation, negative water balance) it is covered primary by salt-affected soils. The deep groundwater level (as a consequent of canalization and /or less precipitation in the recent past) results a part of this soils turning into steppe formation. Detection of these changes can be successful with monitoring. Some sites inside the pilot area are members of the Hungarian Monitoring Network. Because of the monitoring system existing since 1992, data available in time series. 1:100000 and 1:25000 scale soil maps and available data are also presented on the pilot area.

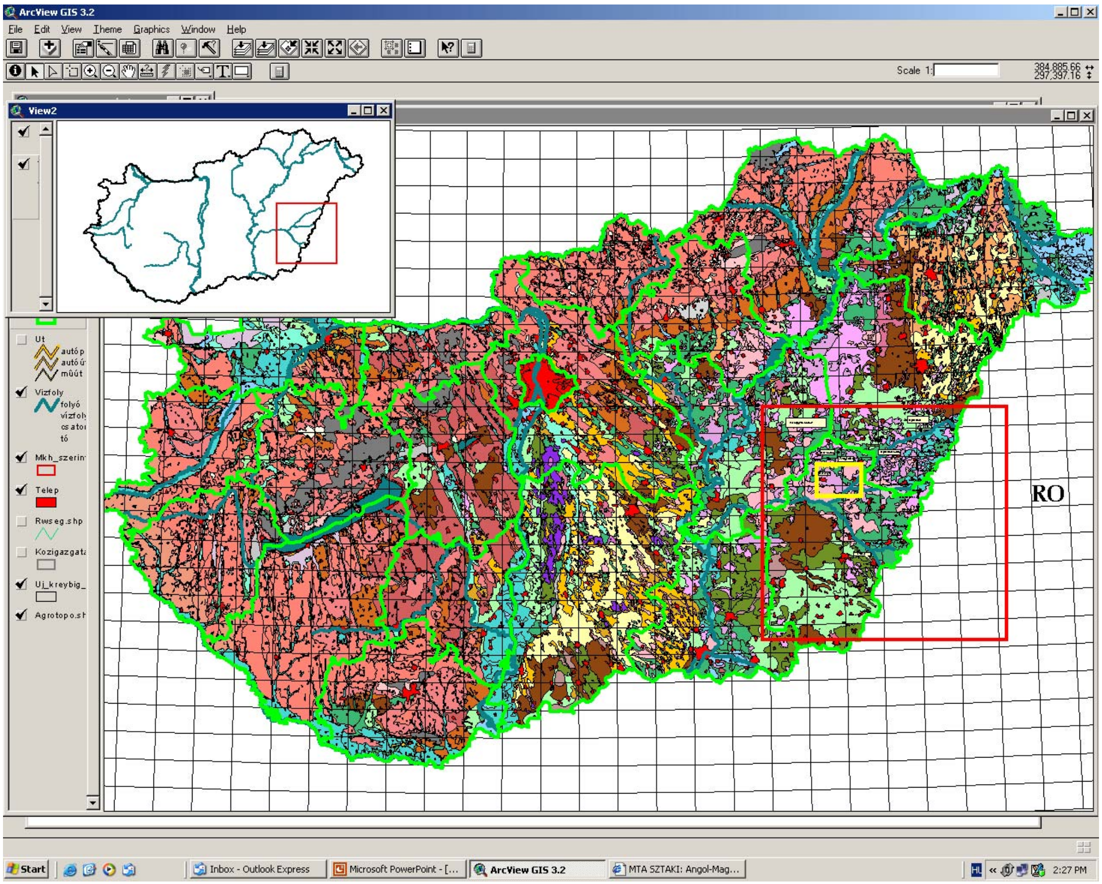


Figure 1a. Localization of the Pilot Area (yellow rectangle) with the 1:100000 scale soil map of Hungary in the background.

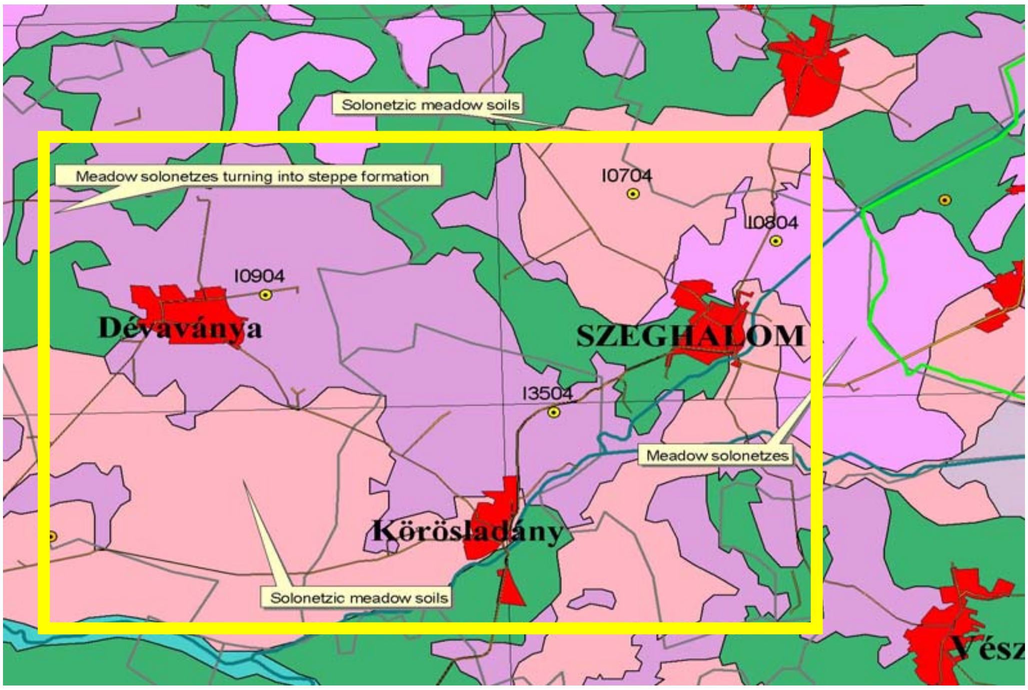


Figure 1b. Localization of the Pilot Area (inside the yellow rectangle) with the 1:100000 scale soil map of Hungary in the background with the position of the selected profiles.

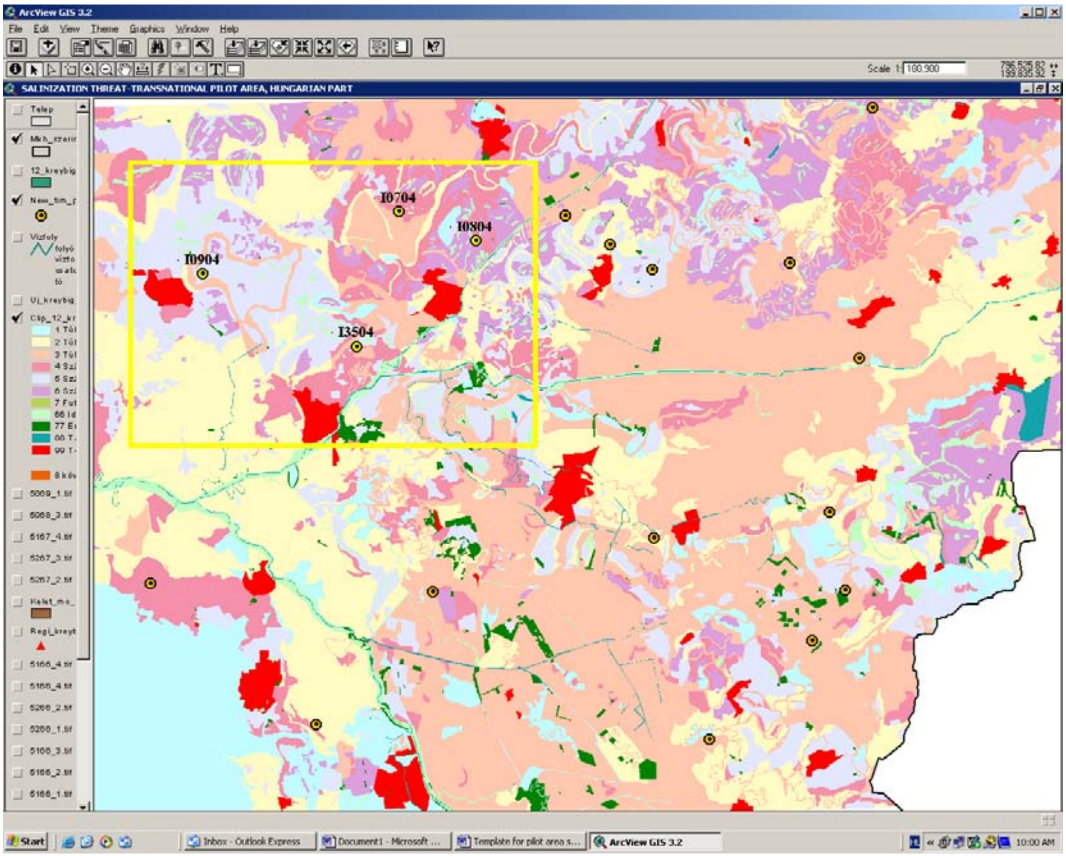


Figure 1c. Localization of the Pilot Area (towards the Romanian boundary) with the1:25000 scale soil map of Hungary in the background with the position of the selected profiles.

Indicator Evaluation

The top 3 indicators chosen by WP1 were:

SL01
Salt profile – selected as indicator for key issue Salinisation – gives a complete picture on the salinity/sodicity state of the soil, or more exactly the salt-affected area. On its basis we may receive three-dimensional information on the existing salts, on their vertical and horizontal distribution and chemical composition, which are extremely important data regarding the unfavorable impacts of salinisation/alkalisation/sodification.

SL02
Exchangeable sodium percentage (ESP)- the most important indicator selected for Sodification. ESP and SAR (Sodium Adsorption Ratio) are the key issues of solonetz formation, resulting in unfavorable changes in the physical/hydrophysical soil properties and moisture regime of the affected areas, increasing the hazard (frequency, duration and ecological consequences) of extreme moisture situations.

SL03
Potential salt sources - Potential salinisation/sodification is the risk of saline or brackish irrigation water not combined with proper irrigation practice; salt accumulation from the rising water table with high salt content and unfavorable ion composition; the salt movement from the deeper horizons to upper layers or to the active root zone by capillary transport; salt water inundation or subsurface intrusion from the sea. Consequently, we have selected potential salt sources (groundwater or irrigation water) and the vulnerability of soils to salinisation/sodification as indicator.

Indicator: SL01 Salt profile
Pilot description

Sampling design

The aim of the pilot area study was testing the *in situ* EC and pH measurements. The sampling was made from soil augering, where the EC was tested at 10 cm depth increments to the depth of the salt accumulation layer using a hand-held EC device. Parallel with the augering a soil profile was sampled also, but from the representative diagnostic horizons. We recorded the location of the sampling positions with a GPS device. One soil sampling and measurement was carried out on both (Hungarian and Romanian) side of the Pilot Area.

Some sites sampled are members of the Hungarian Monitoring Network and these historical data exists since 1992 and it is available in time series.

Procedure
We used 1:2.5 soil:water suspension for field-test method.

Soil and map data
The soil description based on WRB 2006 system, the soil physical and chemical data concerning the soil profiles are obtained thought the Hungarian Soil Monitoring Network (TIM). The monitoring sites give relevant information on the area, but the database have not got direct connection to mapsheets as output. The detailed soil map of the area based on a 1:25 000 scale map (Digital Kreybig Soil Information System). A test-part of the data could also be integrated into the SoDa base.

Land use
CORINE CLC50 database is available for the area.

Methodology used for calculations / estimations of parameters and indicators

<u>For laboratory measurements</u>, according to the Procedures:

Perform sample pre-treatment: ISO 11464:2006
Perform EC analysis: ISO 11265:1994
Perform pH analysis: ISO 10390:2005
Perform ion composition analysis: ISO 13536:1996

<u>For field-test</u>
Based on the measured EC from 1:2.5 suspension we used a rough estimation for predicting EC_e value, based on soil texture classes.

Baseline definition
Background value for normal" soil without any specific influence of salts and sodium
- For total amount of soluble salts < 0.05%, or
- EC in saturated soil paste < 2 dS//m

Threshold definition
Above threshold values soil fertility is (severely) reduced and there are problems with one or more soil functions
- Total amount of soluble salts > 0.15%, or
- EC in saturated soil paste: > 4* dS//m

**In Hungary and Romania this value in practice is 6 dS/m, but the value 4 is harmonizing with the FAO Guidelines, 2006.*

Commentary on original data for each indicator

The aim of the field work was testing the WP4 Procedures and Protocols concerning the Salinisation threat. 4 soil profiles were selected, which are representative sites for the pilot area but not enough for mapping this region. To characterize the pilot area we could use a 1:25000 scale soil map as background.

Pilot methodology

Compilation of soil data and maps for the pilot area *for SL01 and SL02 indicators*

<u>Source of point data:</u>
Hungarian Soil Information and Monitoring System (TIM), a national soil database. It has been collecting basic chemical, physical and biological data for the whole territory of Hungary since 1992 at about 1200 sites.

Laboratory analysis for salt-affected soils:
Yearly, in a period between 15^{th} Sept. and 15^{th} Oct.
- determination of pH, soluble salt content, organic matter content, $CaCO_3$ content,

Every sixth year:
- exchangeable cations, BS, CEC

On the Hungarian side of the Pilot Area the following profile's were investigated: I0704, I0804, I3504, I0904. For each profile data is available from 1992.

<u>Source of maps:</u>
1: 100000 scale soil map of Hungary, compiled in the 1980's year (using the Hungarian classification system)

1:25000 scale soil map, compiled in the 1950's year (with the physico-chemical properties of the soil, focusing on data requirements of farming)

Statistical and geo-statistical analysis

Not tested as any result available yet.

Method development and application

The WP4 procedures and protocols describe the laboratory methods for EC, pH measurements (above a threshold value), but there is no detailed description for a field method. We used the 1:2.5 soil:water suspension as field method.

Steps for $EC_{2.5}$ field-test:

Step 1. Preparation of 1:2.5 volume:volume suspension
- put ca 10 ml water to measuring tube. Add soil to increase with 10 ml. Complement with water to 35 ml. (soil=10 ml, water=25 ml)

Step 2. Calibrate hand-held field EC and Na meter

Step 3. Measure $EC_{2.5}$ (dS/cm) and $pH_{2.5}$. According to the soil textural classes recalculate $EC_{2.5}$ to EC_e (EC in saturation extract) value, with the factor using the

Methodology used for calculations / estimations of parameters and indicators

For estimating EC_e based on the field-mesurements:

Table 1. Factors to multiply ECfield_method to get ECe value. The subscripted 5 or 2.5 values show the ratio of the original soil: water suspension.

Soil textural class	EC_5	$EC_{2.5}$	[1]$EC_{sat.\ paste}$ (if it is >1dS/m)
Sand	23	11.5	5.7
Sandy loam	14	7	3.1
Loam	10	5	2.3
Clay loam	9	4.5	2
Light clay	7.5	3.75	1.8
Heavy clay	6	3	1.3

The following mean SP (saturation percentage) values were used for calculation:
Sand 20; Sandy loam 35; Loam 50; Clay loam 55; Light clay 65; Heavy clay 85.

Example:
Loam with measured $EC_{2.5}$ =0.5 dS/m is equivalent to EC_e 2.5 dS/m.

The measured and estimated values of soil profiles are presented in **Appendix Ia.**

Average results from historical data are presented in the following graphs:

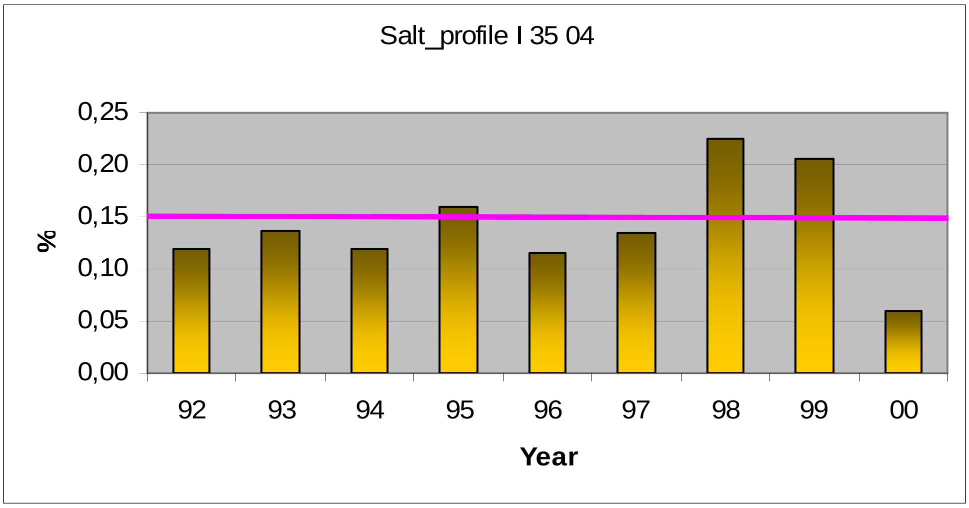


Figure 2a. Historical data of the salt profile number I_35_04.

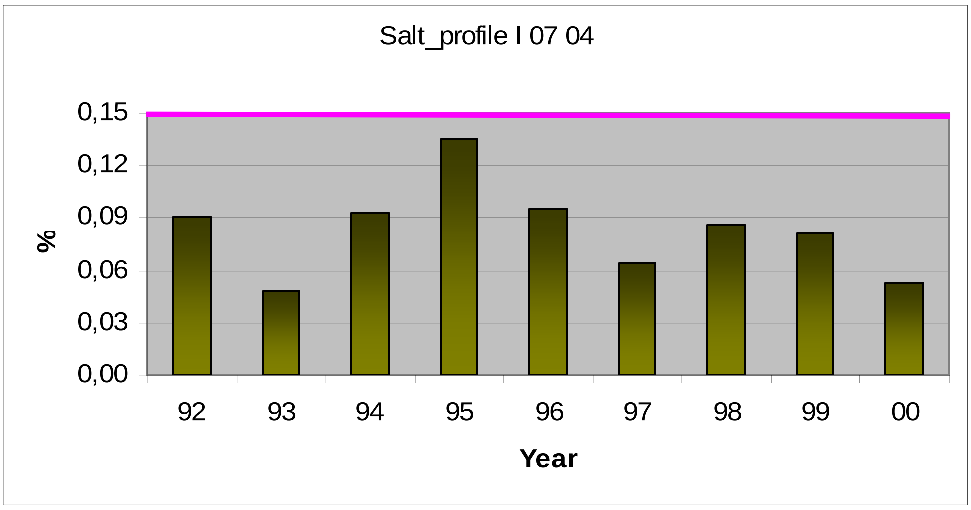


Figure 2b. Historical data of the salt profile number I_07_04.

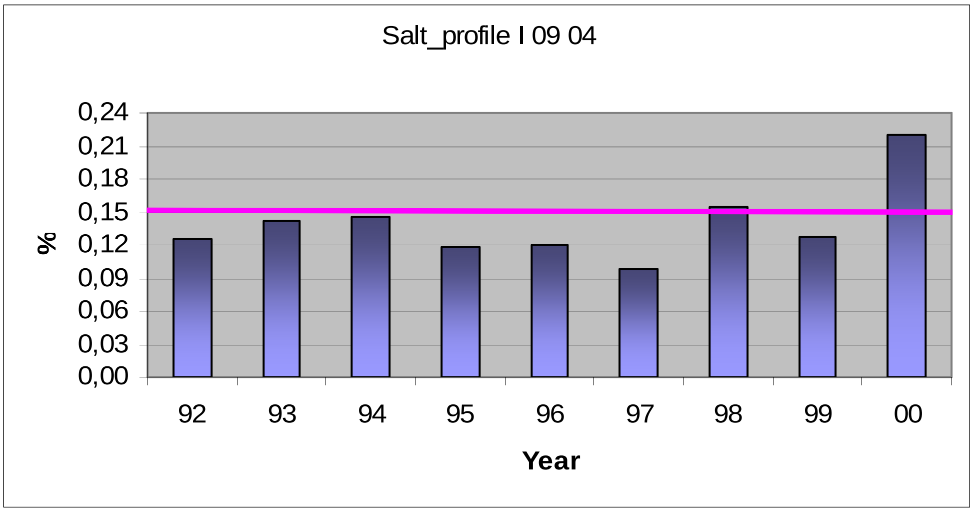


Figure 2c. Historical data of the salt profile number I_09_04.

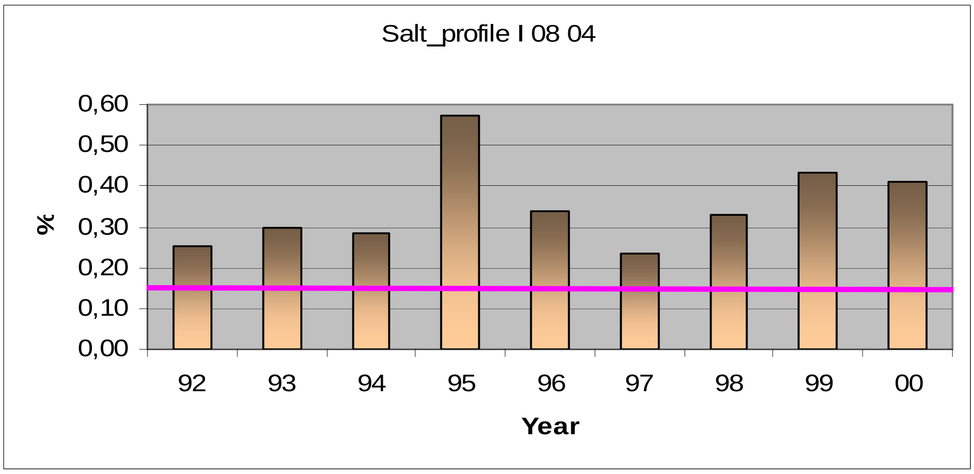


Figure 2d. Historical data of the salt profile number I_08_04.

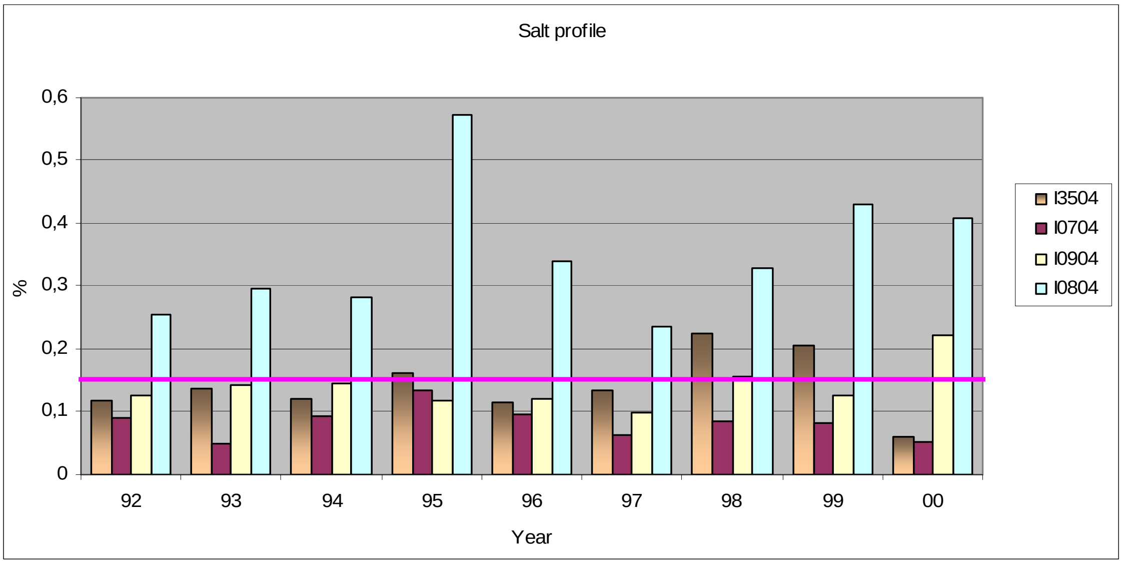


Figure 3. Summary of the historical data of all profiles.

The results before are obtained using the following calculations:

- In each depth ,or horizon, of the profile the SAR is calculated:

$$SAR_h = \frac{SAR \cdot e}{D}$$, where

SAR_h is the weighted up SAR of the horizon;
SAR is the SAR of the horizon;
e is the horizon's thickness and
D is the total depth of the profile.

later the total profile SAR should be calculated as follows, $SAR = \sum_{i=1}^{i=n} SAR_{h\,i}$,

where SAR is the SAR all profile, SAR_h is the SAR in horizon or in interval of depth.

Evaluation of pilot results

Feasibility and experience of applying ENVASSO procedures and protocols

The procedures and protocols concerning the field *in-situ* method for salt content measurement should be specify more detailed. The *in-situ* EC measurement from saturation paste is very time consuming.

Output performance

Not tested as no result available yet.

Identified strengths and weaknesses of the estimation of indicator values (SL01)

Strengths

- For the salt profile the 1:2.5 suspension method means a simple implementation and rapid determination,
- Time saving and small amount of requested sample

Weaknesses

- The measured EC from saturated paste or saturation extract more reliable, than the result from 1:2.5 suspension method.
- The reliability depends upon the kind of salts present, e.g. sulphate or carbonate salts, which have relatively low solubility.

The interpretation of indicator values

Strengths
Generally easy to interpret in a profile, the spatial extension could be questionable
Weaknesses
Seasonal variability can influence the salt profile, time series are necessary,
Difficult to compare data collected with different sampling methods, the 1:2.5 suspension method available only for estimating salinity and encountering the threatened areas

Indicator: SL02 ESP
Pilot description

Sampling design

The aim of the pilot area study was testing the *in situ* Na (SAR) measurements. The sampling was made from soil augering, where the Na was tested at 10 cm depth increments to the depth of the salt accumulation layer using a hand-held Na device. Parallel with the augering a soil profile was sampled also, but from the representative diagnostic horizons. We recorded the location of the sampling positions with a GPS device. One soil sampling and measurement was carried out on both (Hungarian and Romanian) side of the Pilot Area.

Procedure
We used 1:2.5 soil:water suspension for field-test method.

Data description and standards

Soil and map data
The soil description based on WRB 2006 system, the soil physical and chemical data in concerning the soil profiles are obtained thought the Hungarian Soil Information and Monitoring Network (TIM). The monitoring sites give relevant information on the area, but the database have not got direct connection to mapsheets as output. The detailed soil map of the area based on a 1:25 000 scale map (Digital Kreybig Soil Information System). Part of the profile data could also be integrated into the SoDa base.

Land use
CORINE CLC50 database is available for the area.

Methodology used for calculations / estimations of parameters and indicators

For laboratory measurements, according to the Procedures:
Perform sample pre-treatment: ISO 11464:2006
Perform cation concentration analysis: ISO 13536:1995
Perform pH analysis: ISO 10390:2005

For field-test
Based on the measured Na from 1:2.5 suspension we used a rough estimation for predicting Na_e value, based on soil texture classes.

Exchangeable sodium percentage (meq): $ESP = \frac{Na^+}{Ca^{2+} + Mg^{2+} + Na^+ + K^+} \cdot 100$

Sodium adsorption ratio in water or saturation extract: $SAR = \frac{Na^+}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}}$

For sodicity hazard prediction the following empirical relation is used between SAR and ESP:

$$ESP = \frac{100 \cdot (-0.0126 + 0.01475SAR)}{1 + (-0.0126 + 0.01475SAR)}$$

Baseline definition
Background value for normal" soil without any specific influence of salts and sodium

- PH: 5-8,
- ESP < 5%, or SAR < 4

Threshold definition
Above threshold values soil fertility is (severely) reduced and there are problems with one or more soil functions

- pH >8.5,
- ESP > 15%, or SAR > 10

Pilot methodolgy

Method development and application

The WP4 procedures and protocols describe the laboratory methods for Na (SAR) measurements. We tested the 1:2.5 soil:water suspension as field method for Na-determination.

Statistical and geo-statistical analysis

Not tested as any result available yet.

Methodology used for calculations / estimations of parameters and indicators, including interpolations. Minimum detectable change (?) etc
Steps for $Na_{2.5}$ (SAR, ESP) field-test:

Step 1. Preparation of 1:2.5 volume:volume suspension
- put ca 10 ml water to measuring tube. Add soil to increase with 10 ml. Complement with water to 35 ml. (soil=10 ml, water=25 ml)

Step 2. Calibrate hand-held field Na meter

Step 3. Measure $Na_{2.5}$ (ppm) and recalculate $Na_{2.5}$ to SAR and ESP value (using EC_e), according to the following:

EC_e x 10 = $Total\_Cation_e$ (me/l)

Na_e (ppm)/23=Na_e (me/l)

$cc_{e(Ca+Mg)}$ = $Total\_Cation_e$ - Na_e **

$$SAR_e = \frac{Na_e}{\sqrt{\frac{cc_{e(Ca+Mg)}}{2}}}$$

*(**remark: if the estimated value of Na_e **>** $Total\_Cation_e$ get $cc_{e(Ca+Mg)}$ =1)*

Example

EC_e = 8.5; multiply by 10 = $Total\_Cation_e$ 85 me/l

Na_e = 1500 ppm (=mg/l) /23 = **65** me/l

$cc_{e(Ca+Mg)}$ = 85-65 = **20** me/l

$$SAR_e = \frac{Na_e}{\sqrt{\frac{cc_{e(Ca+Mg)}}{2}}} = 20$$

Definition of baselines

Hard to define, depends on location:
PH: 5-8,
ESP < 5%, or SAR < 4

Definition and application of thresholds -for practical purposes:

ESP value:

ESP < 5	no sodification symptom
ESP 5-15	slightly sodic (solonetzic) soil
ESP 15-25	strongly sodic (solonetzic) soil
ESP > 25	sodic (solonetz) soil

Depth of ESP accumulation

< 7 cm	shallow sodic soil (solonetz)
7-15 cm	medium sodic soil (solonetz)
> 15 cm	deep sodic soil (solonetz)

Practical classification" of Hayward, 1954

Soil	*EC_e*	*ESP or SAR_e*	*pH_e*
(Nonsaline) nonsodic	<4dS/m	<15	(<8.5)
Saline (nonsodic)	>4dS/m	<15	(<8.5)
(Nonsaline) sodic	<4dS/m	>15	(>8.5)
Saline sodic	>4dS/m	>15	(>8.5)

Evaluation of pilot results

Feasibility and experience of applying ENVASSO procedures and protocols

Concerning this indicator (ESP) the feasibility and applicability of ENVASSO procedures and protocols were good and well described.

Output performance e.g. Minimum Detectable Change achievable and comparison with WP1 requirements
Not tested as any result available yet.

Identified strengths and weaknesses: the estimation of indicator values (SL02)

Strengths
ESP value can indicate the sodification process very well

Weaknesses
There is not suggested *in-situ* method for this indicator, determine in laboratory only

The interpretation of indicator values
Strengths
generally easy to interpret in a profile, the spatial extension could be questionable
Weaknesses
difficult to compare data collected with different sampling methods,

Indicator: SL03 Potential salt sources

Sampling design

In the sampling design we should take into consideration the salinity in the deeper horizons, the groundwater dynamics and the irrigation practice to define that conditions, which lead to, became a territory as threatened area.
Definition of baselines

	Irrigation. w. Groundwater
Salt concentration	< 500 mg/l
EC	< 0.5 dS/m
SAR	< 4

Definition of thresholds
Generally if the groundwater-quality is above the baseline level, its use for irrigation is not recommended.

Identified strengths and weaknesses of

the estimation of indicator values (SL03)
Strengths
The quality of the irrigation or groundwater

Weaknesses
There is not suggested *in-situ* method for this indicator, determine in laboratory only.

the interpretation of indicator values
Strengths
generally easy to interpret with spatial extension (if the dense of sampling is satisfactory)
Weaknesses
The groundwater dynamics is season sensitive that influences the interpretation of changes.

Conclusions and recommendations

SL01:
For the field in situ method the following description is proposed:
Step 1: drill subsampling sites

- i) For about 5 ha: drill 12 randomly positioned subsampling points (auger) in the monitoring site to the depth of the salt accumulation layer or ground water level or 150 cm depth, whichever is shallower.
- ii) Record the location of each subsampling position with a differential GPS device

Step 2: Test the EC

- i) At each of the 12 subsampling points (holes): test the EC at 10 cm depth increments using a hand-held EC device

If one or more subsampling points show EC values above the threshold value (4 dS·m-1), then:

Step 3: dig soil profile (pit) and sample soil

- i) In the threatened area dig a soil pit and collect soil samples from the representative diagnostic horizons (recommended) or from every 20 cm depth increment (0/20/40/60 etc.) from the soil surface down to the salt accumulation layer or the ground water level.
- ii) Record the location of the soil profile position with a differential GPS device
- iii) Store each individual sample in labelled, double plastic bags.

Step 4: Perform sample pre-treatment

- i) ISO 11464:2006

Step 5: Perform EC analysis

- i) ISO 11265:1994

Step 6: Perform pH analysis

- i) ISO 10390:2005

Step 7: Perform ion composition analysis

- i) ISO 13536:1996
- i) Ca2+, Mg2+, K+, Na+ cations, and $CO3^{2-}$, $HCO3^{-}$, Cl^{-} and $SO4^{2-}$ anions

Other comments
Because the results of the procedures are season sensitive ones (e.g. the depth of the maximum salt accumulation) it would be necessary to specify the period for investigate salt content of the soils (e.g. early autumn).

Appendix Ia: Record of salt profile description for salt affected soils

ENVASSO WP5 PA Workshop, Hungary, 18–20 July, 2007

Profile ID	HUN_I0804	Sampling method	from profile **hand auger** gouge auger	
Profile depth	*2 m*	Field measurements (*fm)	saturation paste 1:5 solution **1:2.5 solution X**	
Depth of groundwat	*< 2 m*	Author and date	*PA workshop*	*19/07/2007*

Depth (cm)	Texture class	Moisture	measured $pH_{(H2O)}$	measured $*EC_{fm}$ (mS/cm)	estimated EC_e (dS/m)	measured $*Na_{fm}$ (ppm)	estimated Na_e (ppm)	estimated SAR_e	estimated ESP_e	ESP_e **For genetic horizons
0-10	SC	very dry	5	0.31	1.55	77	385	24	25	8
10-20	SC	very dry	5	0.5	2.5	140	700	43	38	8
20-30	SC	dry	7	1.1	**5.5**	270	1350	83	55	21
30-40	SC	dry	8.7	0.86	**4.3**	200	1000	61	47	21
40-50	SC	dry	8.7	0.86	**4.3**	200	1000	61	47	21
50-60	SC	dry	8.8	0.87	**4.35**	220	1100	68	50	28
60-70	SC	slightly moist	8.9	1.85	**9.26**	390	1950	42	38	28
70-80	SC	slightly moist	8.7	1.5	**7.5**	350	1750	108	61	28
80-90	SC	slightly moist	9	1.6	**8**	380	1900	117	63	27
90-100	SC	slightly moist	9	1.5	**7.5**	380	1900	117	63	27
Combined samples										
0-20	SC	very dry		0.7	3.5	90	450	7	8	8
20-50	SC	dry		0.37	1.85	110	550	34	33	21
					Factor =5		Factor =5			

$*EC_{fm}$ and Na_{fm} : measured electric conductivity and Na-content using the assigned field method; dimensions: mS/cm equal to S/m
EC_e , Na_e, SAR_e : EC, Na and SAR values in the saturation extract
*** data from the monitoring database, combined samples for genetic horizons*

Site:
Settlement: Szeghalom (Hungary)
Location: 47°3.022082' N, 21°11.788382' E
Elevation= 86,7 m
Parent material: clay with loess, alluvial deposit

WRB classification:

Bathygleyic, Calcic, Epistagnic, Salic, Vertic Solonetz (Humic, Clayic)

Appendix Ib: Record of salt profile description for salt affected soils

ENVASSO WP5 PA Workshop, Hungary, 18–20 July, 2007

Profile ID	RO_Szalonta_18	Sampling method	from profile **hand auger** gouge auger	
Profile depth	*2 m*	Field measurements (*fm)	saturation paste 1:5 solution **1:2.5 solution X**	
Depth of groundwater	*< 2 m*	Author and date	*PA workshop*	*20/07/2007*

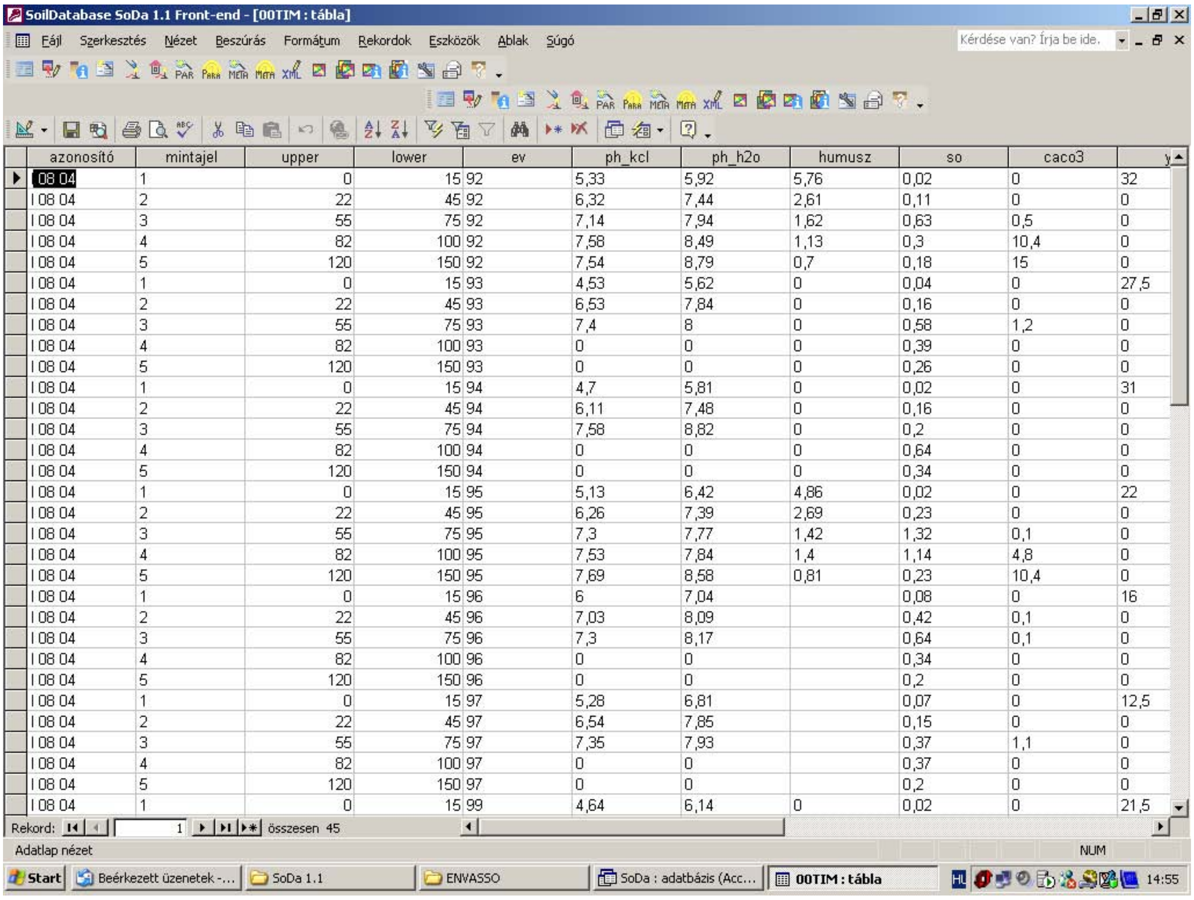
Depth (cm)	0-10	44105	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100			
Texture class	L	CL	CL	C	C	C	C	C	C	CL			
Moisture	very dry	dry	dry	dry	dry	dry	slightly moist moist	slightly moist	slightly moist	slightly moist			
Measured $pH_{(H2O)}$	-	-	-	-	-	-	-	-	-	-			
measured *ECfm (mS/cm)	0.15	0.42	1.35	0.49	0.52	0.98	0.51	1.23	0.57	0.59			
estimated ECe (dS/m)	0.75	1.89	**6.08**	1.84	1.95	3.68	1.91	**4.61**	2.14	2.66	Factors L=5	CL=4.5	C=3.75
measured $*Na_{fm}$ (ppm)	46	170	420	220	210	460	190	360	250	270			
estimated ECe (dS/m)	230	765	1890	825	788	1725	713	1350	938	1215	Factors L=5	CL=4.5	C=3.75
estimated ECe (dS/m)	14	47	116	51	48	106	44	83	58	75			
estimated ECe (dS/m)	16	41	63	42	41	61	39	55	46	52			
ESP_e **For genetic horizons	-	-	-	29	29	29	33	33	20	20			

*EC_{fm} and Na_{fm} : measured electric conductivity and Na-content using the assigned field method; dimensions: mS/cm equal to S/mEC_e , Na_e, SAR_e : EC, Na and SAR values in the saturation extract
** data from the monitoring database, combined samples for genetic horizons

Site:
Settlement: Szalonta (Romania)

WRB classification:

Bathygleyic, Calcic, Epistagnic, Vertic Solonetz (Albic, Clayic)



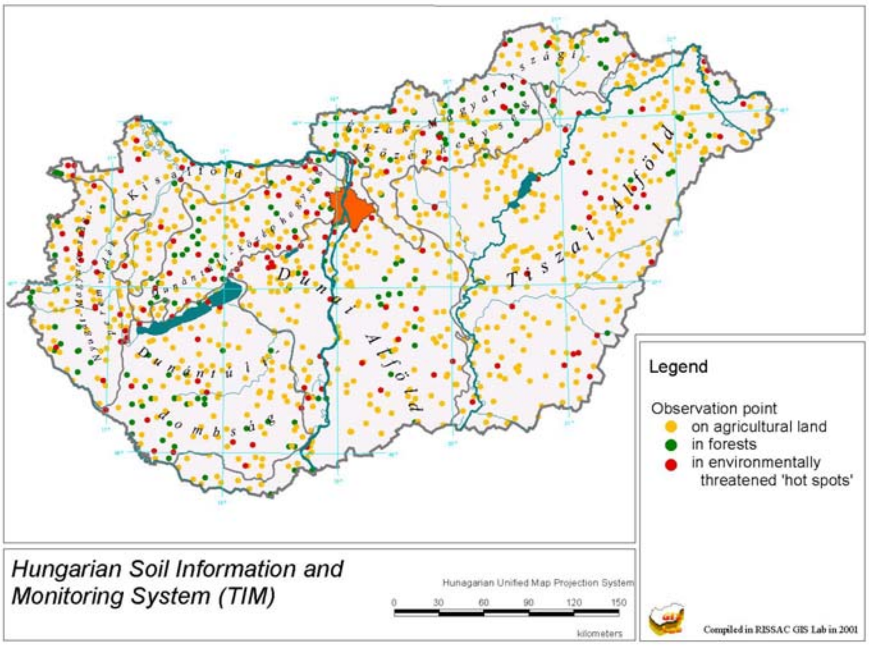
azonosító	mintajel	upper	lower	ev	ph_kcl	ph_h2o	humusz	so	caco3	y
08 04	1	0	15	92	5,33	5,92	5,76	0,02	0	32
I 08 04	2	22	45	92	6,32	7,44	2,61	0,11	0	0
I 08 04	3	55	75	92	7,14	7,94	1,62	0,63	0,5	0
I 08 04	4	82	100	92	7,58	8,49	1,13	0,3	10,4	0
I 08 04	5	120	150	92	7,54	8,79	0,7	0,18	15	0
I 08 04	1	0	15	93	4,53	5,62	0	0,04	0	27,5
I 08 04	2	22	45	93	6,53	7,84	0	0,16	0	0
I 08 04	3	55	75	93	7,4	8	0	0,58	1,2	0
I 08 04	4	82	100	93	0	0	0	0,39	0	0
I 08 04	5	120	150	93	0	0	0	0,26	0	0
I 08 04	1	0	15	94	4,7	5,81	0	0,02	0	31
I 08 04	2	22	45	94	6,11	7,48	0	0,16	0	0
I 08 04	3	55	75	94	7,58	8,82	0	0,2	0	0
I 08 04	4	82	100	94	0	0	0	0,64	0	0
I 08 04	5	120	150	94	0	0	0	0,34	0	0
I 08 04	1	0	15	95	5,13	6,42	4,86	0,02	0	22
I 08 04	2	22	45	95	6,26	7,39	2,69	0,23	0	0
I 08 04	3	55	75	95	7,3	7,77	1,42	1,32	0,1	0
I 08 04	4	82	100	95	7,53	7,84	1,4	1,14	4,8	0
I 08 04	5	120	150	95	7,69	8,58	0,81	0,23	10,4	0
I 08 04	1	0	15	96	6	7,04		0,08	0	16
I 08 04	2	22	45	96	7,03	8,09		0,42	0,1	0
I 08 04	3	55	75	96	7,3	8,17		0,64	0,1	0
I 08 04	4	82	100	96	0	0		0,34	0	0
I 08 04	5	120	150	96	0	0		0,2	0	0
I 08 04	1	0	15	97	5,28	6,81		0,07	0	12,5
I 08 04	2	22	45	97	6,54	7,85		0,15	0	0
I 08 04	3	55	75	97	7,35	7,93		0,37	1,1	0
I 08 04	4	82	100	97	0	0		0,37	0	0
I 08 04	5	120	150	97	0	0		0,2	0	0
I 08 04	1	0	15	99	4,64	6,14	0	0,02	0	21,5

Intermediate status of the Hungarian data into the SoDa database…

Appendix Ic: Soil Information and Monitoring System (TIM) of Hungary

The Soil Information and Monitoring System (TIM) is an independent subsystem of the Integrated Environmental Information and Monitoring System (KIM), which is under elaboration.

Based on physiographical–soil–ecological units 1200 „representative" observation points were selected (and exactly defined by geographical coordinates using GPS): 800 points on agricultural land, 200 points in forests and 200 points in environmentally threatened „hot spot" regions [representing 12 different types of environmental hazards or particularly sensitive areas, such as: degraded soils; ameliorated soils; drinking water supply areas; watersheds of important lakes and reservoirs; protected areas with particularly sensitive ecosystems; „hot spots" of industrial, agricultural, urban and transport pollution; military fields; areas affected by (surface) mining; waste (water) disposal affected spots].



The regional soil experts selected the „representative" sampling sites on the basis of all available soil information (profile descriptions, results of laboratory analysis, long-term field observations, maps, etc.) and on their local experiences. The forest and the „hot spot" sampling sites were selected in cooperation with regional forest land-site experts, environmentalists and experts of the given environmental hazards.

The sampling date is September 15–October 15 each year. The first sampling was in 1992. In the monitoring system some soil parameters are measured every year, some others every 3 years or every 6 years depending on their changeability (stability) *(based on Gy. Várallyay: ESB Report, 2002)*

Soil Characteristics Table

Soil characteristics determined for the basic observation points [I, M] of the soil information and monitoring system for environmental control TIM [HUNGARY]

Soil characteristics		at start t_o	yearly	3 yearly	6 yearly	Remarks
Morphological description of the soil profile		+				
Particle-size distribution		+				
Texture (SP)		+				
Hygroscopic moisture content (hy_1)		+				
Total water storage capacity (WC_T –pF_0)		+				
Field capacity (FC– pF 2.5)		+				on undis-
Wilting percentage (WP – pF 4.2)		+				turbed soil
Available moisture range (AMR = FC–WP)		+				cores
Saturated hydraulic conductivity		+				
$CaCO_3$ content	if > 5 %	+			+	
	if 1 - 5 %	+		+		
	if < 1 %	+	+			
pH(H_2O)	if $CaCO_3$ > 1 %	+		+		
	if $CaCO_3$< 1 %	+	+			
pH(KCl)	if $CaCO_3$ > 1 %	+		+		
	if $CaCO_3$ < 1 %	+	+			
Hydr. acidity (y_1) if $CaCO_3$% = 0		+	+			
Exch. acidity (y_2) if $CaCO_3$ % = 0		+	+			
Total water-soluble salts (in salt-affected soils (sas))		+	+			
1:5 water extract analysis [pH, EC; CO_3^{2-}, HCO_3^-, Cl^-, SO_4^{2-}, Ca^{2+}, Mg^{2+}, Na^+, K^+] (in sas)		+			+	
Phenolphtalein alkalinity(in sas)		+		+		
Depth of the humus horizon		+			+	profile
Organic matter content		+	+			
CEC (cation exchange capacity)		+			+	
Exchangeable cations (Ca^{2+}, Mg^{2+}, Na^+, K^{2+})		+			+	
Total N		+		+		
NO_3-NO_2		+	+			
"Available" plant nutrients [P, K, Ca, Mg; NO_2-NO_3; Fe, Cu, Zn, S, Mn]		+		+		
Potentially toxic elements [Al, As, B, Cd, Co, Cr, Cu, Hg, Mn, Mo, Ni, Pb, Se, Sn, Sr, Zn]		+		+		
	"total"	+				
	"mobile"	+		+		
Cellulose-test	as indicators	+		+		
Dehydrogenase activity	of soil "bio-logical" activ-	+		+		
CO_2 production	ity	+		+		
Natural radioactivity		+		+		
"Average depth" to the groundwater table		+	+			
Chemical composition of the groundwater [pH, EC, CO_3^{2-}, HCO_3^-, Cl^-, SO_4^{2-}, NO_3^-, PO_4^{3-}, Ca^{2+}, Mg^{2+}, Na^+, K^+] [micronutrients] [micropollutants]		+	+			

Appendix Id: Historical data of the profile number I 35 04

TIM_ID	upper_depth	lower_depth	depth	year	pH_KCl	pH_H2O	salt_sum	mean_Salt_horitzon	salt_profile	CaCO3	soda	ESP%	ESP_horitzo%	ESP_total%	BS%	CEC
I 35 04	0	30	30	92	7,05	8,11	0,03	0,01	0,12	1,20	0,021	**1,93**	**0,39**	**9,37**	97,85	46,52
I 35 04	30	50	20	92	6,92	8,28	0,08	0,01		0,50	0,021	**4,49**	**0,90**		97,27	54,98
I 35 04	50	80	30	92	7,09	8,38	0,11	0,02		2,20	0,021	**7,76**	**1,55**		97,77	44,87
I 35 04	80	115	25	92	7,25	8,04	**0,23**	0,04		10,00	0,053	**13,18**	**2,64**		96,48	42,63
I 35 04	115	150	25	92	7,49	8,54	**0,25**	0,04		11,00	0,032	**19,46**	**3,89**		96,34	40,95
I 35 04	0	30	30	93	-	-	0,00	0,00	0,14	0,00	0,000	-			-	-
I 35 04	30	50	20	93	6,75	8,38	0,00	0,00		0,00	0,000	-			-	-
I 35 04	50	80	30	93	-	-	**0,26**	0,05		0,00	0,000	-			-	-
I 35 04	80	115	25	93	-	-	**0,23**	0,04		0,00	0,000	-			-	-
I 35 04	115	150	25	93	-	-	**0,28**	0,05		0,00	0,000	-			-	-
I 35 04	0	30	30	94	-	-	0,00	0,00	0,12	0,00	0,000	-			-	-
I 35 04	30	50	20	94	6,92	8,08	0,00	0,00		1,70	0,000	-			-	-
I 35 04	50	80	30	94	-	-	**0,23**	0,05		0,00	0,000	-			-	-
I 35 04	80	115	25	94	-	-	**0,18**	0,03		0,00	0,000	-			-	-
I 35 04	115	150	25	94	-	-	**0,26**	0,04		0,00	0,000	-			-	-
I 35 04	0	30	30	95	7,04	8,04	0,08	0,02	0,16	0,70	0,016	-			-	-
I 35 04	30	50	20	95	7,06	8,41	0,08	0,01		1,00	0,053	-			-	-
I 35 04	50	80	30	95	7,06	7,78	**0,26**	0,05		2,70	0,011	-			-	-
I 35 04	80	115	25	95	7,31	8,19	**0,26**	0,04		3,60	0,027	-			-	-
I 35 04	115	150	25	95	7,35	8,39	**0,23**	0,04		5,90	0,048	-			-	-
I 35 04	0	30	30	96	-	-	0,00	0,00	0,12	0,00	0,000	-			-	-
I 35 04	30	50	20	96	6,63	8,29	0,00	0,00		0,00	0,000	-			-	-
I 35 04	50	80	30	96	-	-	0,11	0,02		0,00	0,000	-			-	-
I 35 04	80	115	25	96	-	-	**0,26**	0,04		0,00	0,000	-			-	-
I 35 04	115	150	25	96	-	-	**0,30**	0,05		0,00	0,000	-			-	-
I 35 04	0	30	30	97	-	-	0,00	0,00	0,13	0,00	0,000	-			-	-
I 35 04	30	50	20	97	6,78	8,01	0,00	0,00		0,00	0,000	-			-	-
I 35 04	50	80	30	97	-	-	**0,26**	0,05		0,00	0,000	-			-	-
I 35 04	80	115	25	97	-	-	**0,23**	0,04		0,00	0,000	-			-	-
I 35 04	115	150	25	97	-	-	**0,26**	0,04		0,00	0,000	-			-	-
I 35 04	0	30	30	98	6,91	8,46	0,09	0,02	0,22	0,80	0,032	**6,11**	**1,22**	**14,32**	95,68	41,42
I 35 04	30	50	20	98	6,98	8,41	0,10	0,01		1,70	0,042	**6,04**	**1,21**		96,72	36,60
I 35 04	50	80	30	98	6,99	7,99	**0,35**	0,07		2,50	0,000	**11,67**	**2,33**		98,03	40,54

TIM_ID	upper_depth	lower_depth	depth	year	pH_KCl	pH_H2O	salt_sum	mean_Salt_horitzon	salt_profile	CaCO3	soda	ESP%	ESP_horitzo%	ESP_total%	BS%	CEC
I 35 04	80	115	25	98	7,33	8,52	**0,30**	0,05		7,90	0,032	**22,62**	**4,52**		98,05	36,48
I 35 04	115	150	25	98	7,37	8,27	**0,44**	0,07		5,50	0,021	**25,19**	**5,04**		97,10	34,54
I 35 04	0	30	30	99	-	-	0,00	0,00	0,21	0,00	0,000	-			-	-
I 35 04	30	50	20	99	6,83	8,47	0,00	0,00		0,80	0,000	-			-	-
I 35 04	50	80	30	99	-	-	**0,39**	0,08		0,00	0,000	-			-	-
I 35 04	80	115	25	99	-	-	**0,41**	0,07		0,00	0,000	-			-	-
I 35 04	115	150	25	99	-	-	**0,36**	0,06		0,00	0,000	-			-	-
I 35 04	0	30	30	00	-	-	0,00	0,00	0,06	0,00	0,000	-			-	-
I 35 04	30	50	20	00	6,63	8,09	0,00	0,00		0,10	0,000	-			-	-
I 35 04	50	80	30	00	-	-	**0,09**	0,02		0,00	0,000	-			-	-
I 35 04	80	115	25	00	-	-	**0,12**	0,02		0,00	0,000	-			-	-
I 35 04	115	150	25	00	-	-	**0,13**	0,02		0,00	0,000	-			-	-

Appendix Ie: Historical data of the profile number I 07 04

TIM_ID	upper_depth	lower_depth	depth	year	pH_KCl	pH_H2O	salt_sum	mean_Salt_horitzon	salt_profile	CaCO3	soda	ESP%	ESP_horitzo%	ESP_total%	BS%	CEC
I 07 04	0	25	25	92	6,02	6,90	0,07	0,0117	0,09	0,00	0,00	**3,38**	**0,56**	**4,54**	86,49	37,02
I 07 04	25	55	30	92	5,78	6,68	0,07	0,0140		0,00	0,00	**3,94**	**0,79**		84,82	38,86
I 07 04	55	100	45	92	6,55	7,61	0,09	0,0270		0,00	0,00	**5,36**	**1,61**		93,91	41,04
I 07 04	100	130	30	92	7,09	8,18	0,10	0,0200		13,00	0,03	**5,04**	**1,01**		97,20	35,72
I 07 04	130	150	20	92	7,05	8,00	0,13	0,0173		9,20	0,03	**4,32**	**0,58**		97,12	34,76
I 07 04	0	25	25	93	5,63	6,74	0,00	0,0000	0,05	0,00	0,00	-			-	-
I 07 04	25	55	30	93	5,41	6,53	0,00	0,0000		0,00	0,00	-			-	-
I 07 04	55	100	45	93	6,59	7,46	0,10	0,0300		0,00	0,00	-			-	-
I 07 04	100	130	30	93	0,00	0,00	0,09	0,0180		0,00	0,00	-			-	-
I 07 04	130	150	20	93	0,00	0,00	0,00	0,0000		0,00	0,00	-			-	-
I 07 04	0	25	25	94	5,63	6,61	0,00	0,0000	0,09	0,00	0,00	-			-	-
I 07 04	25	55	30	94	5,28	6,48	0,00	0,0000		0,00	0,00	-			-	-
I 07 04	55	100	45	94	6,18	7,33	0,11	0,0330		0,00	0,00	-			-	-
I 07 04	100	130	30	94	0,00	0,00	**0,30**	0,0600		0,00	0,00	-			-	-
I 07 04	130	150	20	94	0,00	0,00	0,00	0,0000		0,00	0,00	-			-	-
I 07 04	0	25	25	95	6,15	7,20	0,05	0,0083	0,13	0,00	0,00	-			-	-
I 07 04	25	55	30	95	5,48	6,87	0,06	0,0120		0,00	0,00	-			-	-
I 07 04	55	100	45	95	6,35	7,75	0,11	0,0330		0,00	0,00	-			-	-
I 07 04	100	130	30	95	7,23	7,72	**0,30**	0,0600		3,50	0,00	-			-	-
I 07 04	130	150	20	95	7,32	8,17	**0,16**	0,0213		8,80	0,03	-			-	-
I 07 04	0	25	25	96	6,20	7,31	0,00	0,0000	0,10	0,00	0,00	-			-	-
I 07 04	25	55	30	96	6,61	7,66	0,00	0,0000		1,00	0,00	-			-	-
I 07 04	55	100	45	96	7,26	8,24	**0,15**	0,0450		10,40	0,00	-			-	-
I 07 04	100	130	30	96	0,00	0,00	**0,25**	0,0500		0,00	0,00	-			-	-
I 07 04	130	150	20	96	0,00	0,00	0,00	0,0000		0,00	0,00	-			-	-
I 07 04	0	25	25	97	5,53	6,46	0,00	0,0000	0,06	0,00	0,00	-			-	-
I 07 04	25	55	30	97	6,01	7,12	0,00	0,0000		0,00	0,00	-			-	-
I 07 04	55	100	45	97	6,86	7,75	0,08	0,0240		0,10	0,00	-			-	-
I 07 04	100	130	30	97	0,00	0,00	**0,20**	0,0400		0,00	0,00	-			-	-
I 07 04	130	150	20	97	0,00	0,00	0,00	0,0000		0,00	0,00	-			-	-
I 07 04	0	25	25	98	6,64	7,60	0,10	0,0167	0,09	0,00	0,00	**5,69**	**0,95**	**5,26**	95,47	32,86
I 07 04	25	55	30	98	5,17	6,50	0,04	0,0080		0,00	0,00	**3,33**	**0,67**		93,57	24,89

TIM_ID	upper_depth	lower_depth	depth	year	pH_KCl	pH_H2O	salt_sum	mean_Salt_horitzon	salt_profile	CaCO3	soda	ESP%	ESP_horitzo%	ESP_total%	BS%	CEC
I 07 04	55	100	45	98	6,09	7,10	0,08	0,0240		0,00	0,00	**1,42**	**0,42**		94,02	28,26
I 07 04	100	130	30	98	7,51	8,72	0,10	0,0200		8,40	0,04	**8,75**	**1,75**		99,33	30,05
I 07 04	130	150	20	98	7,38	8,76	0,13	0,0173		8,20	0,06	**11,02**	**1,47**		98,96	28,85
I 07 04	0	25	25	99	6,79	7,75	0,00	0,0000	0,08	0,50	0,00	-			-	-
I 07 04	25	55	30	99	6,02	7,55	0,00	0,0000		0,00	0,00	-			-	-
I 07 04	55	100	45	99	6,52	8,14	0,11	0,0330		0,50	0,00	-			-	-
I 07 04	100	130	30	99	0,00	0,00	**0,24**	0,0480		0,00	0,00	-			-	-
I 07 04	130	150	20	99	0,00	0,00	0,00	0,0000		0,00	0,00	-			-	-
I 07 04	0	25	25	00	5,83	7,16	0,00	0,0000	0,05	0,00	0,00	-			-	-
I 07 04	25	55	30	00	5,43	7,00	0,00	0,0000		0,00	0,00	-			-	-
I 07 04	55	100	45	00	6,72	7,99	0,09	0,0270		2,90	0,00	-			-	-
I 07 04	100	130	30	00	0,00	0,00	0,13	0,0260		0,00	0,00	-			-	-
I 07 04	130	150	20	00	0,00	0,00	0,00	0,0000		0,00	0,00	-			-	-

Appendix If: Historical data of the profile number I 09 04

TIM_ID	upper_depth	lower_depth	depth	year	pH_KCl	pH_H2O	OM	salt_sum	mean_Salt_horitzon	salt_profile	CaCO3	soda	ESP%	ESP_horitzo%	ESP_total%	BS%	CEC
I 09 04	0	30	30	92	7,20	8,03	2,31	0,05	0,01	0,13	2,80	0,016	**3,21**	**0,64**	**21,37**	86,92	26,75
I 09 04	30	70	40	92	7,59	9,11	1,27	0,11	0,03		3,80	0,053	**17,06**	**4,55**		95,42	32,77
I 09 04	70	100	30	92	7,79	9,48	0,72	0,13	0,03		2,00	0,080	**33,67**	**6,73**		95,32	32,08
I 09 04	100	150	50	92	7,95	9,52	0,38	**0,18**	0,06		27,00	0,138	**28,34**	**9,45**		94,76	38,18
I 09 04	0	30	30	93	-	-	-	0,00	0,000	0,14	0,00	0,000	-			-	-
I 09 04	30	70	40	93	-	-	-	**0,15**	0,04		0,00	0,000	-			-	-
I 09 04	70	100	30	93	-	-	-	**0,18**	0,04		0,00	0,000	-			-	-
I 09 04	100	150	50	93	-	-	-	**0,20**	0,07		0,00	0,000	-			-	-
I 09 04	0	30	30	94	-	-	-	0,00	0,00	0,15	0,00	0,000	-			-	-
I 09 04	30	70	40	94	-	-	-	0,11	0,03		0,00	0,000	-			-	-
I 09 04	70	100	30	94	-	-	-	**0,20**	0,04		0,00	0,000	-			-	-
I 09 04	100	150	50	94	-	-	-	**0,23**	0,08		0,00	0,000	-			-	-
I 09 04	0	30	30	95	7,24	8,74	2,35	0,04	0,01	0,12	1,50	0,011	-			-	-
I 09 04	30	70	40	95	7,72	8,92	1,27	0,09	0,02		4,50	0,064	-			-	-
I 09 04	70	100	30	95	8,01	9,65	0,77	**0,16**	0,03		10,30	0,106	-			-	-
I 09 04	100	150	50	95	8,03	9,58	0,46	**0,16**	0,05		15,00	0,159	-			-	-
I 09 04	0	30	30	96	-	-	-	0,00	0,00	0,12	0,00	0,000	-			-	-
I 09 04	30	70	40	96	-	-	-	0,09	0,02		0,00	0,000	-			-	-
I 09 04	70	100	30	96	-	-	-	**0,15**	0,03		0,00	0,000	-			-	-
I 09 04	100	150	50	96	-	-	-	**0,20**	0,07		0,00	0,000	-			-	-
I 09 04	0	30	30	97	-	-	-	0,00	0,00	0,10	0,00	0,000	-			-	-
I 09 04	30	70	40	97	-	-	-	0,09	0,02		0,00	0,000	-			-	-
I 09 04	70	100	30	97	-	-	-	**0,15**	0,03		0,00	0,000	-			-	-
I 09 04	100	150	50	97	-	-	-	0,13	0,04		0,00	0,000	-			-	-
I 09 04	0	30	30	98	8,00	9,68	0,77	**0,16**	0,03	0,16	1,70	0,032	**39,93**	**7,99**	**26,11**	93,55	26,37
I 09 04	30	70	40	98	7,79	9,48	0,96	0,11	0,03		3,80	0,058	**22,46**	**5,99**		93,51	26,18
I 09 04	70	100	30	98	7,25	9,29	2,37	0,07	0,01		1,70	0,017	**3,76**	**0,75**		95,96	24,73
I 09 04	100	150	50	98	7,86	9,54	0,36	**0,24**	0,08		9,60	0,095	**34,14**	**11,38**		97,80	31,37
I 09 04	0	30	30	99	-	-	-	0,00	0,00	0,13	0,00	0,000	-			-	-
I 09 04	30	70	40	99	-	-	-	0,09	0,02		0,00	0,000	-			-	-
I 09 04	70	100	30	99	-	-	-	**0,20**	0,04		0,00	0,000	-			-	-
I 09 04	100	150	50	99	-	-	-	**0,19**	0,06		0,00	0,000	-			-	-

TIM_ID	upper_depth	lower_depth	depth	year	pH_KCl	pH_H2O	OM	salt_sum	mean_Salt_horitzon	salt_profile	CaCO3	soda	ESP%	ESP_horitzo%	ESP_total%	BS%	CEC
I 09 04	0	30	30	00	-	-	-	0,00	0,00	0,22	0,00	0,000	-			-	-
I 09 04	30	70	40	00	-	-	-	**0,20**	0,05		0,00	0,000	-			-	-
I 09 04	70	100	30	00	-	-	-	**0,27**	0,05		0,00	0,000	-			-	-
I 09 04	100	150	50	00	-	-	-	**0,34**	0,11		0,00	0,000	-			-	-

Appendix Ig: Historical data of the profile number I 08 04

TIM_ID	upper_depth	lower_depth	depth	year	pH_KCl	pH_H2O	salt_sum	mean_Salt_horitzon	salt_profile	CaCO3	soda	ESP%	ESP_horitzo%	ESP_total%	BS%	CEC
I 08 04	0	20	20	92	5,33	5,92	0,02	0,00	0,25	0,00	0,000	**2,84**	**0,38**	**22,66**	50,67	25,34
I 08 04	20	50	30	92	6,32	7,44	0,11	0,02		0,00	0,000	**19,45**	**3,89**		85,44	37,78
I 08 04	50	80	30	92	7,14	7,94	**0,63**	0,13		0,50	0,000	**30,25**	**6,05**		93,32	44,93
I 08 04	80	105	25	92	7,58	8,49	**0,30**	0,05		10,40	0,095	**28,87**	**4,81**		95,49	44,33
I 08 04	105	150	45	92	7,54	8,79	**0,18**	0,05		15,00	0,127	**25,10**	**7,53**		97,49	39,92
I 08 04	0	20	20	93	4,53	5,62	0,04	0,01	0,30	0,00	0,000	-			-	-
I 08 04	20	50	30	93	6,53	7,84	**0,16**	0,03		0,00	0,000	-			-	-
I 08 04	50	80	30	93	7,40	8,00	**0,58**	0,12		1,20	0,000	-			-	-
I 08 04	80	105	25	93	-	0,00	**0,39**	0,07		0,00	0,000	-			-	-
I 08 04	105	150	45	93	-	0,00	**0,26**	0,08		0,00	0,000	-			-	-
I 08 04	0	20	20	94	4,70	5,81	0,02	0,00	0,28	0,00	0,000	-			-	-
I 08 04	20	50	30	94	6,11	7,48	**0,16**	0,03		0,00	0,000	-			-	-
I 08 04	50	80	30	94	7,58	8,82	**0,20**	0,04		0,00	0,000	-			-	-
I 08 04	80	105	25	94	-	-	**0,64**	0,11		0,00	0,000	-			-	-
I 08 04	105	150	45	94	-	-	**0,34**	0,10		0,00	0,000	-			-	-
I 08 04	0	20	20	95	5,13	6,42	0,02	0,00	0,57	0,00	0,000	-			-	-
I 08 04	20	50	30	95	6,26	7,39	**0,23**	0,05		0,00	0,000	-			-	-
I 08 04	50	80	30	95	7,30	7,77	**1,32**	0,26		0,10	0,000	-			-	-
I 08 04	80	105	25	95	7,53	7,84	**1,14**	0,19		4,80	0,000	-			-	-
I 08 04	105	150	45	95	7,69	8,58	**0,23**	0,07		10,40	0,122	-			-	-
I 08 04	0	20	20	96	6,00	7,04	0,08	0,01	0,34	0,00	0,000	-			-	-
I 08 04	20	50	30	96	7,03	8,09	**0,42**	0,08		0,10	0,000	-			-	-
I 08 04	50	80	30	96	7,30	8,17	**0,64**	0,13		0,10	0,000	-			-	-
I 08 04	80	105	25	96	-	-	**0,34**	0,06		0,00	0,000	-			-	-
I 08 04	105	150	45	96	-	-	**0,20**	0,06		0,00	0,000	-			-	-
I 08 04	0	20	20	97	5,28	6,81	0,07	0,01	0,24	0,00	0,000	-			-	-
I 08 04	20	50	30	97	6,54	7,85	**0,15**	0,03		0,00	0,000	-			-	-
I 08 04	50	80	30	97	7,35	7,93	**0,37**	0,07		1,10	0,000	-			-	-
I 08 04	80	105	25	97	-	-	**0,37**	0,06		0,00	0,000	-			-	-
I 08 04	105	150	45	97	-	-	**0,20**	0,06		0,00	0,000	-			-	-
I 08 04	0	20	20	98	4,27	5,85	0,02	0,00	0,33	0,00	0,000	**7,92**	**1,06**	**23,40**	81,02	12,12
I 08 04	20	50	30	98	6,46	7,54	**0,17**	0,03		0,00	0,000	**20,85**	**4,17**		94,91	33,19
I 08 04	50	80	30	98	7,41	8,42	**0,71**	0,14		3,20	0,027	**27,94**	**5,59**		97,37	38,47

TIM_ID	upper_depth	lower_depth	depth	year	pH_KCl	pH_H2O	salt_sum	mean_Salt_horitzon	salt_profile	CaCO3	soda	ESP%	ESP_horitzo%	ESP_total%	BS%	CEC
I 08 04	80	105	25	98	7,81	8,86	**0,33**	0,06		11,00	0,064	**26,83**	**4,47**		98,51	40,21
I 08 04	105	150	45	98	7,77	8,94	**0,32**	0,10		14,00	0,074	**27,05**	**8,12**		99,06	31,79
I 08 04	0	20	20	99	4,64	6,14	0,02	0,00	0,43	0,00	0,000	-			-	-
I 08 04	20	50	30	99	6,40	7,94	**0,29**	0,06		0,00	0,000	-			-	-
I 08 04	50	80	30	99	7,19	8,12	**1,01**	0,20		0,80	0,000	-			-	-
I 08 04	80	105	25	99	-	-	**0,47**	0,08		0,00	0,000	-			-	-
I 08 04	105	150	45	99	-	-	**0,30**	0,09		0,00	0,000	-			-	-
I 08 04	0	20	20	00	4,51	6,24	0,02	0,00	0,41	0,00	0,000	-			-	-
I 08 04	20	50	30	00	5,86	7,19	**0,15**	0,03		0,00	0,000	-			-	-
I 08 04	50	80	30	00	6,86	7,81	**0,92**	0,18		0,10	0,000	-			-	-
I 08 04	80	105	25	00	-	-	**0,61**	0,10		0,00	0,000	-			-	-
I 08 04	105	150	45	00	-	-	**0,30**	0,09		0,00	0,000	-			-	-

Pilot area: Oradea region (Bihor county), Romania

Lead partner **ICPA, Romania**

Description of the Pilot Area

Name of pilot area		Oradea region (Bihor county), Romania
Names of participating partners	**Lead partner**	**ICPA, Romania**
Location and description	Member State(s)	Romania
	Coordinates	46°40' - 47°00' N, 21°30' - 21°49'E
	Area of pilot area (km^2)	360 km^2
	Climate	Temperate *Soil moisture regime* = ustic *Soil temperature regime* = mesic
	Mean temperature	10 - 11°C
	Average Annual Precipitation	550 - 600 mm
	Outline description of topography	Plain (flat)
	Elevation (m)	95 – 100 m
	Vegetation	- Steppe-Silvosteppe replaced by cultivated plants - Hallophyle in saline area (*Statice gmelini*, *Festuca sulcata*, *Artemisia monogina)*
	Major Land Use	- Arable land (non-irrigated) - Pasture (manly in saline area)
	Major soils	Chernozems, Phaeozems, Fluvisols, Gleysols and Solonetz

Depth of groundwater: 150 – 200 cm

Threat and related indicator(s) evaluated in pilot area

Threat	Soil salinisation
Indicator 1	**TSC** (total salt content)
Indicator 2	**ESP** (exchangeable sodium percentage)
Indicator 3	**pH**
	Soil salinity
Indicator 1	**EC** (electrical conductivity)

Rationale for selection of pilot area

The salt affected soils are, generally, distributed as sporadic patches, especially in the low plains. This is the case of the Panonic Plain where, the salt affected soils patches are located, into the Tisa low plain (on the Romanian and Hungarian territory, near the border). That is why, the plots were located in this area and comprise two areas: a Romanian one (Oradea region, Bihor county – Figure 1) and a Hungarian one.

The pilot area is representative for salt affected soil threat, due to the presence, in the area of a high variety of salinisation-/sodification soil types, and also to a various land use practices. This area is integrated in the national soil monitoring network; that is why many data on salt affected soils are available.

Figure 1. Location of the plot area in Oradea region, Bihor County – Romania.

Indicator evaluation

Indicators

Soil salinity is characterized by 3 indicators: **TSC** (total salt content); **ESP** (exchangeable sodium percentage); **pH,** while ***soil salinity*** is characterized by 1 indicators: **EC** (electrical conductivity).

TSC (Total Salt Content - mg/100g soil)
The total salt content (mg/100g soil) calculated on the basis of EC (in situ, or saturation paste or saturation extract); the KCl-calibrated values for EC and the temperature determine the salt content (summarized in a table)

ESP (Exchangeable Sodium Percentage) or **SAR** (Sodium Adsorption Ratio).
ESP is the most important indicator selected for Sodification, and together with SAR represents the key issue of Solonetz formation. **ESP** is a widely accepted indicator of sodic/alkali soils and sodification processes, due to the high negative influence of exchangeable sodium when accumulate in high quantity, on soil characteristics.
ESP is calculated with the relation:

$$ESP = \frac{Na^+}{Ca^{2+} + Mg^{2+} + Na^+ + K^+} \cdot 100$$

SAR (Sodium Adsorption Ratio – in solution extract). The Na^+, Ca^{++} and Mg^{++} cations (meq l^{-1}) values, extracted from the water saturated soil, are use to calculate the SAR values with the equation:

$$SAR = \frac{Na}{\sqrt{\frac{Ca + Mg}{2}}}$$

pH (in soil water 1:2.5)

Soil salinity:
ECe (Electrical conductivity of the extracted from the water saturated paste– in dS m^{-1}).

Pilot area description

Spatial extent

The pilot area covers 360 km^2 (Figure 2) and it is located in a region with steppe-sylvosteppe vegetation.
The major land use is arable while in saline area the land use is pasture, with halophyte vegetation (*Statice gmelini*, *Festuca sulcata*, *Artemisia monogina)*. The natural vegetation was replaced by cultivated plants.

The major soils are: Chernozems, Phaeozeoms, Fluvisols, Gleysols and Solonetz (WRB RGs).

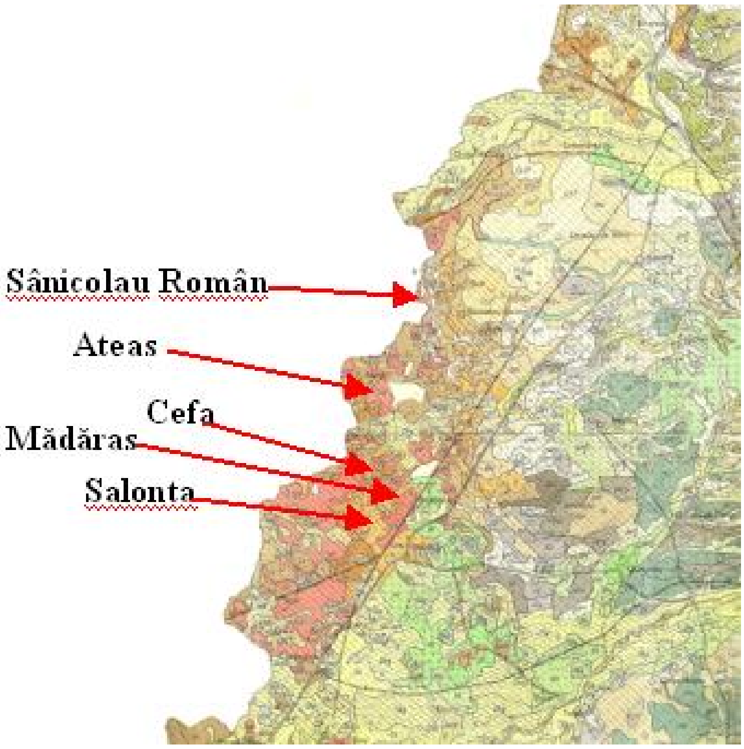


Figure 2. The soil profile location in the plot area
Data

Sampling design

The ***sampling method*** comprises:

1st sample, year 2005:
- drilling of soil
- description of soil profile and mainly the " salt profile"
- sampling genetic horizons.
- registration of the coordinates of the site soil profile by GPS.

2nd sample, year 2007:
- description of soil profile and mainly the "salt profile".
- sampling genetic horizons.
- registration of the coordinates of the site soil profile by GPS.

Data description and standards

Profile-18: *Salonta region*

Batygleic calcic epistagnic vertic Solonetz (Albic, Clayic) (WRB)

(Pelic Solonetz) (SRTS)

Location*: 46^{o}51'10,2''N, 21^{o}35'52,9''E*

Elevation = 100 m
Topography: **Flat**
Landform: **Riverine plain**
Land use: **Pasture**

Annual precipitation = 589,2 mm
Aridity index =
Temperature regime: **Mesic**
Soil moisture regime: **Ustic**
Parent material: riverine deposits
Depth of the ground water table: **150 – 200 cm**

Vegetation: *Puccinelia distans, Festuca pseudovina, Artemisia maritima*

Profile Description

E	medium loam, grayish brown (10YR 5/2) when moist, light brown gray (10YR 6/2) when dry, small granular structure, firm when moist, hard when dry, plastic, sticky, slightly compact when dry, clear boundary.
Btn	medium loamy clay, dark grayish brown (10YR 4/2) when moist, grayish brown (10YR 5/2) when dry, coarse columnar structure, very firm when moist, very hard when dry, plastic, sticky, moderate compact, when dry, weak effervescence, clear boundary.
BCn	loamy clay, dark brown (10YR 3/3) when moist, yellowish brown (10YR 4/3) when dry, coarse columnar structure, very firm when moist, very hard when dry, very plastic, very sticky, moderate compact, strong effervescence, smooth boundary.
CBn	loamy clay silty, brown (10YR 4/4) when moist, yellowish brown (10YR 5/4) when dry, subangular blocky structure, firm when moist, hard when dry, plastic, sticky, moderate compact when moist, strong effervescence, smooth boundary.
Cln	silty clay loam, brown (10YR 4/6) when moist, yellowish brown (10YR 5/6) when dry, wet, structureless, firm when moist, hard when dry, plastic, sticky, moderate compact, strong effervescence.

Diagnostic horizons: Natric horizon, Vertic horizon, Calcic horizon

Analytical data

Genetic layer	Depth	pH(H_2O)	OC	$CaCO_3$	y1	CEC	B	Σ Salt	*ESP*
	(cm)		(%)	(%)		cmol(+) kg^{-1}	%	(%)	(%)
E	0-9	6.35	3.6	0	-		-	0.082	
Btn	9-28	7.45	1,6	0	-		-	0.070	
BCn	28-64	9.25	n.a	0.9	-	39.5	-	0.152	29.1
CBn	64-87	9.45	n.a	0.2	-	37.0	-	0.132	33.5
Cln	87-130	9.40		7.9	-	31.0	-	0.140	20.3

Genetic layer	Depth	% Sand	% Clay	Texture	Bulk Density	Field Capacity (pF 2.3)	Wilting Point (pF 4.2)	Available Water (Δ pF 2.3-pF 4.2)
	(cm)	2-0.02 mm	<0.002 mm	FAO	(g cm^{-3})	(v v^{-1} %)	(v v^{-1} %)	(v v^{-1} %)
E	0-9	47.0	23.5					
Btn	9-28	37.1	39.1					
BCn	28-64	31.7	48.6					
CBn	64-87	26.6	46.6					
Cln	87-130	24.4	38.9					

Abbreviations: *WRB-World Reference Base, ST-Soil Taxonomy, SRTS-Romanian Sistem of Soil Taxonomy, OC-Organic Carbon, y1-hydrolytic acidity, CE -Cation Exchange Capacity, B% -Base Saturation, ESP-Exchangeable Sodium Percentage*

Profile-21: *Mădăras village*

Batygleic calcic epistagnic vertic Solonetz (Albic, Clayic) (WRB)

(***Salinic Solonetz***) *(SRTS)*

Location*: 46°51'19,0''N, 21°39'12,0''E*
Elevation = 100 m
Topography: **Flat**
Landform: **Riverine plain**
Land use: **Pasture**

Annual precipitation = 589,2 mm
Aridity index =
Temperature regime: **Mesic**
Soil moisture regime: **Ustic**
Parent material : riverine deposits
Depth of the ground water table: **150 – 200 cm**

Vegetation: *Puccinelia distans, Festuca pseudovina, Artemisia maritima*

Profile Description

A	medium loam, light grayish brown (10YR 6/2) when moist, light gray (10YR 7/2) when dry, dry, granular very friable, firm when moist, angular-subangular blocky when dry, moderate plastic, moderate sticky, moderate compact, sharp wavy boundary.
Btnz$_1$	medium loam, dark brown (10YR 3/3) when moist, yellowish brown (10YR 5/3) when dry, dry, columnar structure, very firm when moist, very hard when dry, very plastic, very sticky, very compact when dry, rare fine roots, wavy boundary.
Btnz$_2$	medium loam, yellowish brown (10YR 5/3) when moist, yellowish brown (10YR 5/4) when dry, columnar structure, very firm when moist, very hard when dry, very plastic, very sticky, very compact, smooth boundary.
BCnlz	medium sandy loam, yellowish brown (10YR 5/4) when moist, light yellowish brown (10YR 6/4) when dry, slight moist, subangular blocky structure, firm when moist, hard when dry, moderate plastic, moderate sticky, moderate compact when moist, smooth boundary..
Cnlz	medium sandy loam, grayish brown (5Y 4/3) when moist, grey (5Y 5/4) when dry, slight moist, subangular blocky structure, firm when moist, hard when dry, moderate plastic, moderate sticky, moderate compact.

Diagnostic horizons: Natric horizon, Vertic horizon, Calcic horizon

Analytical data

Genetic layer	Depth	pH (H_2O)	OC	$CaCO_3$	y1	CEC	B	Σ Salt	ESP
	(cm)		(%)	(%)		cmol(+) kg^{-1}	%	(%)	(%)
A	0-12	7.10	1.91	0	-				
$Btnz_1$	12-40	9.10	0.91	0	-	23.50		0.160	13.06
$Btnz_2$	40-72	9.40	0.54	0	-	26.11		0.140	15.70
BCnlz	72-98	9.45		0	-	25.24		0.090	11.50
Cnlz	98-130	9.40		0		26.11		0.110	10.20

Genetic layer	Depth	% Sand	% Clay	Texture	Bulk Density	Field Capacity (pF 2.3)	Wilting Point (pF 4.2)	Available Water (Δ pF 2.3-pF 4.2)
	(cm)	2-0.02 mm	<0.002 mm	FAO	(g cm^{-3})	(v v^{-1} %)	(v v^{-1} %)	(v v^{-1} %)
A	0-12	44.7	31.6					
$Btnz_1$	12-40	43.4	31.5					
$Btnz_2$	40-72	42.7	29.4					
BCnlz	72-98	60.6	19.3					
Cnlz	98-130	58.2	19.5					

Abbreviations: *WRB-World Reference Base, ST-Soil Taxonomy, SRTS-Romanian Sistem of Soil Taxonomy, OC-Organic Carbon, y1-hydrolytic acidity, CE -Cation Exchange Capacity, B% -Base Saturation, ESP-Exchangeable Sodium Percentage*

Baseline definition

The values of the indicators of a "normal" soil without any specific influence of salts and sodium are:

For salinisation (0-150cm)

Total amount of soluble salts < 0.05%, or
EC in saturated soil paste < 2 mmhos/cm

For sodification

pH 5-8,
ESP < 5%, or SAR < 4

<u>The Potential of salinisation/sodification soils</u>

Into the irrigated area could be influenced by the irrigation water quality and also by the influence of irrigation on the groundwater level.

The indicators should be: - Salt concentration < 500 mg/l
- EC < 0.5 mmhos/cm
- SAR < 4

Threshold definition

Above threshold values soil fertility is (severely) reduced and there are problems with one or more soil functions

For salinisation (0-50cm)

Total amount of soluble salts > 0.15%, or
EC in saturated soil paste: > 6 mmhos/cm

For sodification (in the accumulation horizon)

pH >8.5,
ESP > 15%, or SAR > 10

Potential salinisation/sodification (risk)
Salt concentration (mg/l) 500-2000 > 1000
EC (mmhos/cm) 0.5-5
SAR >10

Thresholds for practical purposes
ESP < 5 no sodification symptom
ESP 5-15 slightly sodic (solonetzic) soil
ESP 15-25 strongly sodic (solonetzic) soil
ESP > 25 sodic (solonetz) soil***Depth of ESP accumulation***
< 7 cm shallow sodic soil (solonetz)
7-15 cm medium sodic soil (solonetz)
> 15 cmdeep sodic soil (solonetz)**Commentary on original data**

The RISSA monitoring data were used for the pilot area, but some required data could be not provided by the existing data base, as for example SAR indicator, that is why it was estimated on the base of a diagram (widely used during the time).

Pilot method

The sampling method comprise:
- open the soil profile (with auger at max. 10 m from the profile site in the following years),
- description of soil profile and mainly the „salt profile" according to procedures and protocols,
- sampling genetic horizons, soil sample bank (frequency of measurements for selected parameters: 1, 3 or 6 years in the following years),
- GPS coordinates of the sites

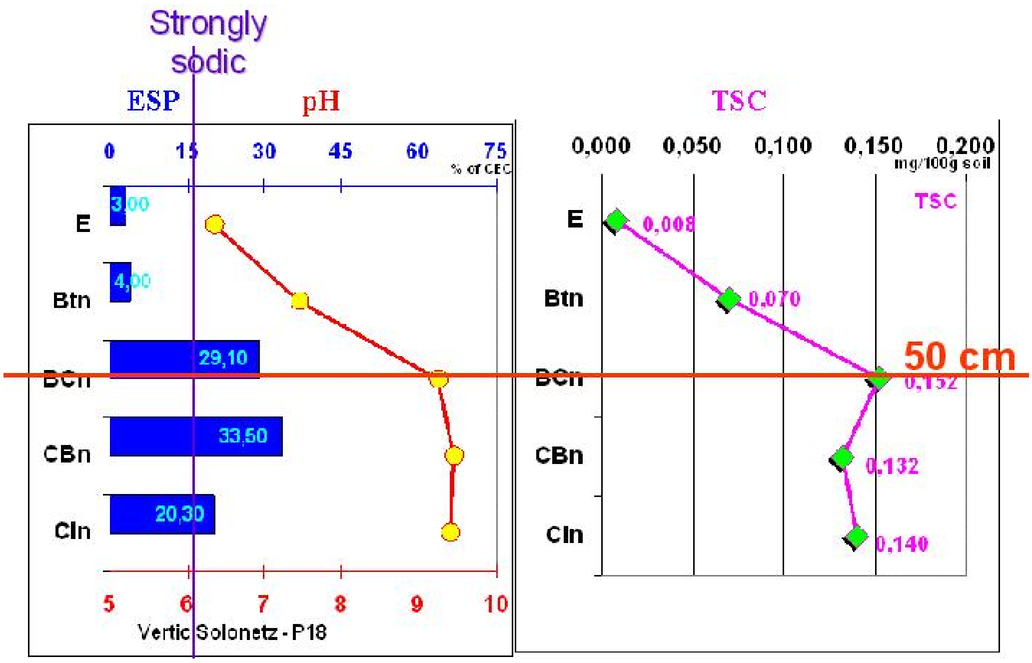
Compilation of soil data and maps for the pilot area
Profile-18: Salonta region
Indicators for salt affected soils OF Profile No. 18 SALONTA

HORIZON HORIZON DEPTH	UM cm	E 0-9	Btn 9-28	BCn 28-64	CBn 64-87	Cln 87-130
TSC	mg/100g soil	0.0082	0.070	0.152	0.132	0.140
ESP	% of CEC			29.1	33.5	20.3
SAR	-			28.0	36.0	18.0
pH in water	-	6.35	7.45	9.25	9.45	9.40

Profile-21: Mădăras village
Indicators for salt affected soils
OF Profile No. 21 Mădăraş

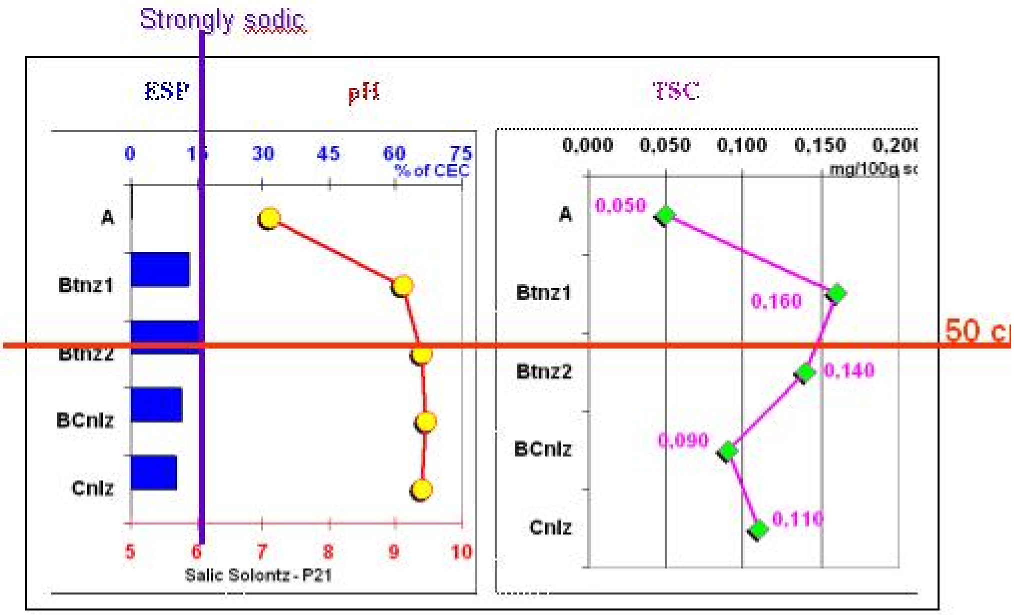
HORIZON HORIZON DEPTH	UM cm	A	$Btnz_1$	$Btnz_2$	BCnlz	Cnlz
TSC	mg/100g soil	0.000	0.160	0.140	0.090	0.11
ESP	% of CEC		13.06	15.70	11.50	10.20
SAR	-					
pH in water	-	6.10	6.75	8.75	9.60	9.70

Method development and application



Profile-18: Salonta region

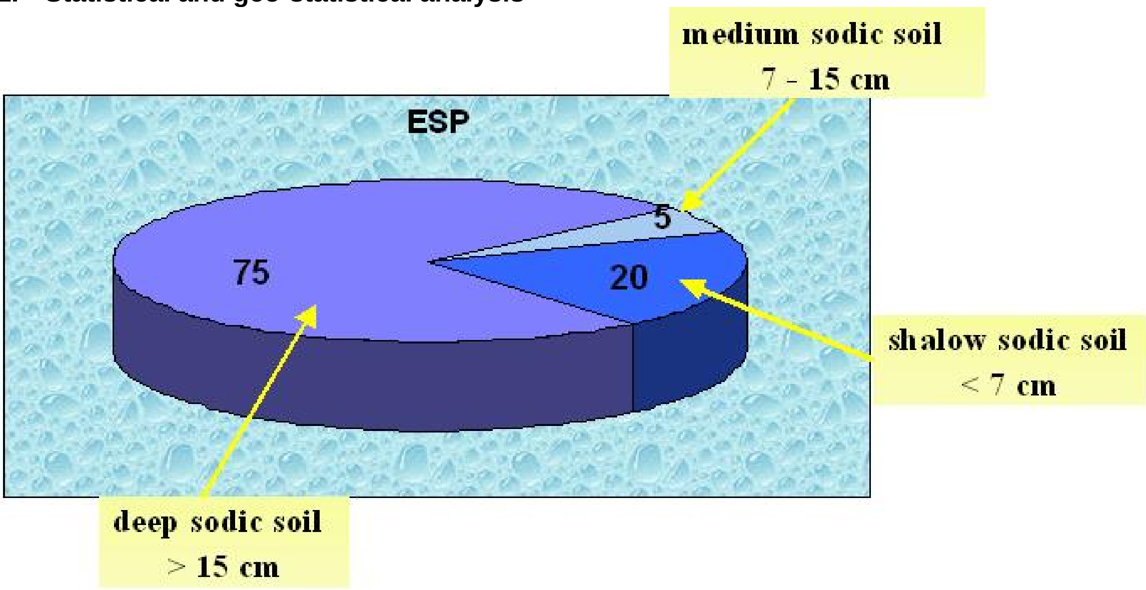
The data obtained from the soil salinity indicators showed that the soil profile is strongly sodic, the exchangeable Na being very high (29.10 % of CEC), double comparing with the limit of sodification (15 % of CEC), while the TSC is at the limit of salinisation (0.15 mg/100 g soil).



Profile-21: Mădăras village

The data showed that the soil profile is at the limit of sodification (15 % of CEC), even if the morphological characteristics (in the field) showed specific columnar structure and salt efflorescence on some aggregate faces. The data also emphasize that maximum accumulation of exchangeable Na is upper the firs 50 cm, strongly influencing plant roots. Also, the TSC is at the limit of salinisation (0.15 mg/100 g soil).

1. **Statistical and geo-statistical analysis**



Evaluation of pilot results

Feasibility and experience of applying ENVASSO procedures and protocols

The data of salt affected soils are feasible with ENVASSO procedures and protocols because of the indicators required by these protocols which are widely used and accepted to characterized the sodic and alkali soils as well as sodification processes. Also, our monitoring data fit to the indicator and parameter list and are appropriate for further survey.

Output performance e.g. Minimum Detectable Change achievable and comparison with WP1 requirements; definition of baselines and application of thresholds

The indicators of soil Salinity and Sodicity were tested during the time on soil samples collected in various climatic, vegetation conditions and showed very satisfactory to emphasize soil salinity threat.

Identified strengths and weaknesses of

c. the estimation of indicator values
d. the interpretation of indicator values

Strengths:
-Representative sites,
-Georeferenced points,
-Precise sampling strategy,
-Repeated measurements, sampling in the same season of the year.

Weakness:
-The same season does not mean the same moisture condition, which influences the salt profile,
-Standard sampling strategy cannot specify the spatial (horizontal and vertical) variability and time dynamism in threatened areas.

Conclusions and recommendations

- **pH**.

In sodic soils the pH in the eluvial A horizon can be neutral or even acidic, but the illuvial B horizon is always alkaline, averaged 0-10/20/40/50/80 cm sampling (over genetic horizons cannot shows it clearly due to the changing in soil classification and also the development of soil profiles).

- Salt profile.
The graphic of salt profile drawing on the base of salt content; vertical distribution; salt composition; quantity and ion composition of salts could be an other good indicator to emphasize the salinity threats.

- **EC** (Electrical Conductivity)
The measurements of EC on soil surface could be important and quick information about salt dynamics, but it needs modern techniques and apparatus which could be use by all the laboratories which monitors soil salinity.

For the monitoring of soil and land evolution of pilot area, it is necessary to select several points of soil and ground water sampling. For this purpose it is useful to establish some criteria to chose the soil profiles location tacking into account, at least few characteristics: parent material; hydrological conditions and land drainage; vegetation; land use.

Appendix IIa:Profiles described in the pilot area of Romania.

Profile-1: *Cefa village*

Gleyic Solonetz (WRB)

*(**Solonet Gleic**) (SRTS, 2003)*

Elevation = 100 m

Topography: **Flat**
Landform: **Riverine plain**
Land use: **Pasture**
Vegetation: *Hordeum sp., Scorzonera laciniata, Camphorosma ovata*

Annual precipitation = 589,2 mm
Aridity index = 1.3 -1.38
Temperature regime: **Mesic**
Soil moisture regime: Ustic
Parent material: **Riverine deposits**
Depth of the ground water table: **150 – 200 cm**

Profile Description

A 0-2	sandy loam, grayish brown (10YR 5/2) when moist, light brownish gray (10YR 6/2) when dry, granular structure, slightly developed, very friable when moist, slightly cohesive when dry, slightly plastic, slightly adhesive, frequent pores, fine grass roots, abrupt boundary.
Btn 2-14	silty loam, grayish brown (10YR 5/2) when moist, light brownish gray (10YR 6/2) when dry, columnar structure, hard when moist, very hard when dry, very compact, rare pores, fine frequent roots, medium plastic, very adhesive, gradual wavy boundary.
$Btnz_1$ 14-25	clay loam, dark grayish brown - brown (10YR 4/2-3) when moist, grayish brown (10YR 5/2) when dry, columnar structure, very hard when moist, extreme firm when dry, very compact, moderate plastic, very adhesive, weak effervescence, rare pores, rare fine roots, gradual wavy boundary.
$Btnz_2$ 25-42	clay loam, yellowish brown (10YR 5/6) when moist, brownish yellow (10YR 6/6) when dry, coarse blocky angular structure, hard when moist, very firm when dry, moderate compact, medium plastic, very adhesive, moderate effervescence, rare pores, rare fine roots, gradual wavy boundary.
$Clnz_1$ 42-66	clay loam, dark grayish brown (10YR 4/2) when moist, grayish brown (10YR 5/2) when dry, coarse blocky angular structure, hard when moist, firm when dry, moderate compact, medium plastic, very adhesive, moderate effervescence, rare pores, gradual wavy boundary.
$Clnz_2$ 66-100	medium clay loam, grayish brown (10YR 5/2) when moist, light brownish gray (10YR 6/2) when dry, coarse blocky angular structure, hard when moist, firm when dry, moderate compact, medium plastic, very adhesive, moderate effervescence, rare pores.

Diagnostic horizons: Natric horizon, Gleyic horizon

Analytical data

Genetic layer	Depth	pH(H_2O)	OC	$CaCO_3$	y1	CEC	B	Σ Salt	*ESP*
	(cm)		(%)	(%)		cmol(+) kg^{-1}	%	(%)	(%)
A	0-2				-				
Btn	2-14	8.05	1.98	0	-	29.0	100	0.065	21.0
Btnz$_1$	14-25	9.50	1.22	1.7	-	38.0	100	0.236	31.4
Btnz$_2$	25-42	9.70	0.87	7.4	-	36.0	100	0.384	49.2
Clnz$_1$	42-66	9.80		6.5	-	35.0	100	0.436	50.9
Clnz$_2$	66-100	9.80		13.3	-	35.0	100	0.366	

Genetic layer	Depth	% Sand	% Clay	Texture	Bulk Density	Field Capacity (pF 2.3)	Wilting Point (pF 4.2)	Available Water (Δ pF 2.3-pF 4.2)
	(cm)	2-0.02 mm	<0.002 mm	FAO	(g cm^{-3})	(v v^{-1} %)	(v v^{-1} %)	(v v^{-1} %)
A	0-2							
Btn	2-14	27.7	27.9					
Btnz$_1$	14-25	34.5	36.7					
Btnz$_2$	25-42	34.4	39.3					
Clnz$_1$	42-66	40.2	38.4					
Clnz$_2$	66-100	49.4	35.1					

Abbreviations: *WRB-World Reference Base, ST-Soil Taxonomy, SRTS,2003-Romanian Soil Taxonomy, OC-Organic Carbon, y1-hydrolytic acidity, CE -Cation Exchange Capacity, B% -Base Saturation, ESP-Exchangeable Sodium Percentage*

Indicators for salt affected soils
OF Profile No. 1 CEFA

HORIZON HORIZON DEPTH	UM cm	Btn 0-14	Btnz$_1$ 14-23	Btnz$_2$ 23-42	Clnz$_1$ 42-66	Clnz$_2$ 66-100
TSC*	mg/100g sol	0.065	0.236	0.384	0.486	0.366
ESP**	% of CEC	21.0	31.4	49.2	50.9	
SAR***	-	16	31	67	71	
pH in water	-	8.05	9.50	9.70	9.80	9.80

* *TSC = Total salt content.*
** *ESP = Exchangeable Na percentage.*
*** *SAR = Sodium adsorption ratio: was estimated from the diagram of SAR-ESP correlation.*

Profile-2: *Ateas village*

Gleyic Solonetz (WRB)

*(**Solonet Gleic**) (SRTS, 2003)*

Elevation = 100 m

Topography: **Flat**
Landform: **Riverine plain**
Land use: **Pasture**
Vegetation: *Festuca sulcata, Artemisia monogyna, Scorzonera lacini*

Annual precipitation = 589,2 mm
Aridity index = 1.3 -1.38
Temperature regime: **Mesic**
Soil moisture regime: **Ustic**
Parent material: **Riverine deposits**
Depth of the ground water table: **150 – 200 cm**

Profile Description

A **0-3**	silty clay loam, grayish brown (10YR 5/2) when moist, light brownish gray (10YR 6/2) when dry, dry, granular structure, slightly developed, very friable when moist, slightly cohesive when dry, fine roots, frequent pores, medium plastic, medium adhesive, abrupt boundary.
Btn 3-13	medium clay loam, grayish brown (10YR 5/2) when moist, light brownish gray (10YR 6/2) when dry, coarse columnar structure, well developed, very hard when moist, extremely firm when dry, rare thin roots, very compact, rare pores, medium plastic, medium adhesive, wavy boundary.
Btnz 13-28	medium clay loam, dark yellowish brown (10YR 4/4) when moist, yellowish brown (10YR 5/4) when dry, coarse prismatic structure, very hard when moist, very firm when dry, very compact, medium plastic, medium adhesive, slightly moist, weak effervescence, rare pores, rare thin roots, gradual wavy boundary.
BCnz 28-46	medium clay loam, yellowish brown (10YR 5/6) when moist, brownish yellow (10YR 6/6) when dry, coarse blocky angular structure, very hard when moist, very firm when dry, very compact, medium plastic, medium adhesive, moderate effervescence, $CaCO_3$ efflorescence, rare pores, wavy boundary.
Cl_1nz 46-62	medium clay loam, brownish yellow (10YR 6/6) when moist, yellow (10YR 7/6) when dry, slightly moist, coarse blocky angular structure, hard when moist, firm when dry, medium compact, rare pores, medium plastic, medium adhesive, $CaCO_3$ efflorescence, moderate effervescence, wavy boundary.
Cl_2nz 62-86	medium clay loam, yellow (10YR 7/6) when moist, yellow (10YR 8/8) when dry, slightly moist, medium blocky angular structure, hard when moist, firm when dry, medium compact, medium plastic, medium adhesive, $CaCO_3$ efflorescence, moderate effervescence, rare pores.

Diagnostic horizons: Natric horizon, Gleyic horizon

Analytical data

Genetic layer	Depth	pH (H_2O)	OC	$CaCO_3$	y1	CEC	B	Σ Salt	*ESP*
	(cm)		(%)	(%)		cmol(+) kg^{-1}	%	(%)	(%)
A	**0-3**								
Btn	**3-13**	8.90	1.90	-	-	29.3	94	0.139	21.2
Btnz	13-28	9.25	1.45	3.1	-	30.2	100	0.273	36.4
BCnz	28-46	9.40	0.83	5.1	-	30.8	100	0.364	51.3
Cl_1nz	46-62	9.40	-	9.0	-	28.6	100	0.367	65.7
Cl_2nz	62-86	9.45	-	24.3	-	28.6	100	0.2559	70.3

Genetic layer	Depth	% Sand	% Clay	Texture	Bulk Density	Field Capacity (pF 2.3)	Wilting Point (pF 4.2)	Available Water (Δ pF 2.3-pF 4.2)
	(cm)	2-0.05 mm	<0.002 mm	FAO	(g cm^{-3})	(v v^{-1} %)	(v v^{-1} %)	(v v^{-1} %)
A	**0-3**							
Btn	**3-13**	27.7	37.9					
Btnz	13-28	34.5	39.8					
BCnz	28-46	34.4	40.2					
Cl_1nz	46-62	40.2	37.6					
Cl_2nz	62-86	49.4	30.4					

Abbreviations: *WRB-World Reference Base, ST-Soil Taxonomy, SRTS,2003-Romanian Soil Taxonomy, OC-Organic Carbon, y1-hydrolytic acidity, CE -Cation Exchange Capacity, B% -Base Saturation, ESP-Exchangeable Sodium Percentage*

Indicators for salt affected soils
Profile No. 2 ATEAş

HORIZON	UM	Btn	Btnz	BCnz	Cl_1nz	Cl_2nz
HORIZON DEPTH	**cm**	**3-13**	**13-28**	**28-46**	**46-62**	**62-86**
TSC*	mg/100g sol	0.139	0.273	0.364	0.367	0.252
ESP**	% of CEC	21.2	36.4	51.3	65.7	70.3
SAR	-	19	40	71	130	160
pH in water	-	8.90	9.25	9.40	9.40	9.45

* *TSC = Total salt content.*
** *ESP = Exchangeable Na percentage.*
*** *SAR = Sodium adsorption ratio: was estimated from the diagram of SAR-ESP correlation.*

Profile-3: *Cefa village*

Gleyic Solonetz (WRB)

*(**Solonet Gleic**) (SRTS, 2003)*

Elevation = 100 m

Topography: **Flat**
Landform: **Riverine plain**
Land use: **Pasture**
Vegetation: *Festuca sulcata, Statice gmelini*

Annual precipitation = 589,2 mm
Aridity index = 1.3 -1.38
Temperature regime: **Mesic**
Soil moisture regime: **Ustic**
Parent material: **Riverine deposits**
Depth of the ground water table: **200 – 300 cm**

Profile Description

A 0-6	medium loam, grayish brown (10YR 5/2) when moist, light gray (10YR 7/2) when dry, complex structure: granular (very friable, small) and massive structure, very firm when moist, extremely firm when dry, sticky-very sticky, small and medium iron-manganese concretions, fine pores, fine and frequent roots, abrupt boundary.
AB 6-12	medium loam, grayish brown (10YR 5/2) when moist, light gray (10YR 7/2) when dry, massive structure, very-extremely firm when moist, extremely firm when dry, plastic-very plastic, very sticky, small and medium iron-manganese concretions, fine and frequent roots, fine pores, gradual wavy boundary.
Btn_1 12-40	medium loam, dark grayish brown (10YR 4/2) when moist, grayish brown (10YR 5/2) when dry, columnar structure, extremely firm when moist, extremely firm when dry, very plastic, very sticky, small and medium iron-manganese concretions, weak effervescence, rare and fine roots, gradual wavy boundary.
Btn_2 40-60	medium loamy clay, dark grayish brown-dark brown (10YR 4/2-3) when moist, brown- yellowish brown (10YR 5/3-4) when dry, columnar structure, extremely firm when moist, extremely hard when dry, very plastic, very sticky, very compact when dry, small and medium iron-manganese concretions, strong effervescence, fine and frequent roots, fine pores, gradual wavy boundary.
BCn 60-78	medium loam, yellowish brown (10YR5/4) when moist, light yellowish brown (10YR 6/4) when dry, columnar structure, $CaCO_3$ concretions, firm when moist, very hard when dry, very plastic, very sticky, very compact, strong effervescence, gradual wavy boundary.
Cln 78-95	medium loam, yellow (10YR 7/6) when moist, yellow (10YR 8/6) when dry, moist, structureless, firm when moist, hard when dry, plastic, sticky, very compact, strong effervescence, $CaCO_3$ concretions.

Diagnostic horizons: Natric horizon, Gleyic horizon

Analytical data

Genetic layer	Depth	pH (H_2O)	OC	$CaCO_3$	y1	CEC	B	Σ Salt	*ESP*
	(cm)		(%)	(%)		cmol(+) kg^{-1}	%	(%)	(%)
A	0-6	6.92	2.67	0	-	29.3		0.061	11.9
AB	6-12	9.00	1.16	0	-	18.8		0.128	22.3
Btn1	12-29	9.50		0.9	-	28.5		0.228	27.4
	29-40	9.65		3.8	-	27.2		0.249	36.0
Btn2	40-60	9.70		7.1		28.1		0.235	34.5
BCn	60-78	9.72		13.4		27.3		0.219	41.8

Genetic layer	Depth	% Sand	% Clay	Texture	Bulk Density	Field Capacity (pF 2.3)	Wilting Point (pF 4.2)	Available Water (Δ pF 2.3-pF 4.2)
	(cm)	2-0.02 mm	<0.002 mm	FAO	(g cm^{-3})	(v v^{-1} %)	(v v^{-1} %)	(v v^{-1} %)
A	0-6	54.0	21.1					
AB	6-12	57.2	20.5					
Btn1	12-29	47.3	32.0					
	29-40	49.0	32.1					
Btn2	40-60	45.8	33.5					
BCn	60-78	52.0	28.4					

Abbreviations: *WRB-World Reference Base, ST-Soil Taxonomy, SRTS,2003-Romanian Soil Taxonomy, OC-Organic Carbon, y1-hydrolytic acidity, CE -Cation Exchange Capacity, B% -Base Saturation, ESP-Exchangeable Sodium Percentage*

Indicators for salt affected soilsProfile No. 3 CEFA

HORIZON **HORIZON DEPTH**	**UM** **cm**	**A** **0-6**	**AB** **6-12**	**Btn_1** **29-40**		**Btn_2** **40-60**	**BCn** **60-78**
TSC	mg/100g sol	0.061	0.128	0.228	0.249	0.235	0.219
ESP	% of CEC	11.9	22.3	27.4	36.0	34.5	41.8
SAR	-	14	20	26	40	36	49
pH in water	-	6.92	9.00	9.50	9.65	9.70	9.72

* *TSC = Total salt content.*
** *ESP = Exchangeable Na percentage.*
*** *SAR = Sodium adsorption ratio: was estimated from the diagram of SAR-ESP correlation.*

Profile-4: *Sînicolau Roman village*

Gleyic Solonetz (WRB)

*(**Solonet Gleic**) (SRTS, 2003)*

Elevation = 100 m

Topography: **Flat**
Landform: **Riverine plain**
Land use: **Grass land**
Vegetation: *Festuca sulcata, Statice gmelini*

Annual precipitation = 589,2 mm
Aridity index = 1.3 -1.38
Temperature regime: **Mesic**
Soil moisture regime: **Ustic**
Parent material: **Riverine deposits**
Depth of the ground water table: **150 cm**

Profile Description

An 0-13	medium loam, grayish brown (10YR 5/2) when moist, light gray-light brownish gray (10YR 6/1 – 6/2) when dry, blocky, iron-manganese concretions and spots, rare roots, firm to very firm when moist, very hard when dry, very plastic, very sticky, very compact, abrupt boundary.
ABtnz13 -22	medium loam, light brownish gray (10YR 6/2) when moist, light gray (10YR 7/2) when dry, iron-manganese concretions and separations, rare roots, very firm when moist, very hard when dry, very plastic, very sticky, very compact, gradual wavy boundary.
Btnz$_1$ 22-30	medium clay loam, grayish brown (10YR 5/2) when moist, light brownish gray (10YR 6/2) when dry, columnar structure, very firm when moist, extremely hard when dry, very plastic, very sticky, very compact, iron-manganese concretions and separations, moderate effervescence, gradual wavy boundary
Btnz$_2$ 30-44	medium clay loam, grayish brown (10YR 5/2) when moist, light brownish gray (10YR 6/2) when dry, columnar structure, very firm when moist, extremely hard when dry, plastic-very plastic, very sticky, very compact, small iron-manganese concretions and separations, moderate effervescence, gradual wavy boundary.
Btnz$_3$ 44-62	medium clay loam, grayish brown (10YR 5/2) when moist, light brownish gray (10YR 6/2) when dry, columnar structure, very firm when moist, extremely hard when dry, plastic-very plastic, very sticky, very compact, small iron-manganese concretions and separations, moderate effervescence, clear smooth boundary.
Cln$_1$ 62-80	medium clay loam, grayish brown (10YR 5/2) when moist, light brownish gray (10YR 6/2) when dry, columnar structure, very firm when moist, extremely hard when dry, plastic-very plastic, very sticky, very compact, moderate effervescence, gradual wavy boundary.
Cln$_2$ 80-110	medium clay loam, grayish brown (10YR 5/2) with yellowish brown (10YR 5/6) spots when moist, light gray (10YR 7/1) with yellow (10YR 7/6) when dry, very firm when moist, very hard when dry, plastic to very plastic, very sticky, very compact, moderate effervescence.

Diagnostic horizons: Natric horizon, Gleyic horizon

Analytical data

Genetic layer	Depth	pH(H_2O)	OC	$CaCO_3$	y1	CEC	B	Σ Salt	ESP
	(cm)		(%)	(%)		cmol(+) kg^{-1}	%	(%)	(%)
An	0-13	8.85	1.16	0	-	36.6		0.147	20.8
ABtnz	13-22	9.40	1.13	0	-	32.5	100	0.224	37.2
$Btnz_1$	22-30	9.60	0.95	0	-	34.6	100	0.249	41.9
$Btnz_2$	30-44	9.60	-	0	-	36.2	100	0.261	47.2
$Btnz_3$	44-62	9.60	-	0	-	33.9	100	0.249	46.6
Cln_1	62-80	9.60	-	0	-	30.4	100	0.133	51.6
Cln_2	80-110								

Genetic layer	Depth	% Sand	% Clay	Texture	Bulk Density	Field Capacity (pF 2.3)	Wilting Point (pF 4.2)	Available Water (Δ pF 2.3-pF 4.2)
	(cm)	2-0.02 mm	<0.002 mm	FAO	(g cm^{-3})	(v v^{-1} %)	(v v^{-1} %)	(v v^{-1} %)
An	0-13	44,8	30.0					
ABtnz	13-22	41,7	32.3					
$Btnz_1$	22-30	35,7	35.5					
$Btnz_2$	30-44	39,9	38.1					
$Btnz_3$	44-62	35,4	34.2					
Cln_1	62-80							
Cln_2	80-110							

Abbreviations: *WRB-World Reference Base, ST-Soil Taxonomy, SRTS,2003-Romanian Soil Taxonomy, OC-Organic Carbon, y1-hydrolytic acidity, CE -Cation Exchange Capacity, B% -Base Saturation, ESP-Exchangeable Sodium Percentage*

Indicators for salt affected soils
Profile No. 4 SÎNICOLAU ROMAN

HORIZON HORIZON DEPTH	UM cm	An 0-13	ABtnz 13-22	$Btnz_1$ 22-30	$Btnz_2$ 30-44	$Btnz_3$ 44-62	Cln_1 62-80
TSC	mg/100g sol	0.147	0.224	0.249	0.261	0.249	0.133
ESP	% of CEC	20.8	37.2	41.9	47.2	46.6	51.6
SAR	-	19	40	50	60	58	72
pH in water	-	8.85	9.40	9.60	9.60	9.60	9.60

** TSC = Total salt content.*
*** ESP = Exchangeable Na percentage.*
**** SAR = Sodium adsorption ratio: was estimated from the diagram of SAR-ESP correlation.*

Profile-5: *Ateas village*

Gleyic Solonetz (WRB)

*(**Solonet Gleic**) (SRTS, 2003)*

Elevation = 100 m

Topography: **Flat**
Landform: **Riverine plain**
Land use: **Pasture**
Vegetation: *Statice gmelini, Festuca sulcata*

Annual precipitation = 589,2 mm
Aridity index = 1.3 -1.38
Temperature regime: **Mesic**
Soil moisture regime: **Ustic**
Parent material: **Riverine deposits**
Depth of the ground water table: **150 – 200 cm**

Profile Description

A 0-3	medium loam, dark grayish brown (10YR 4/2) when moist, grayish brown (10YR 5/2) when dry, slightly developed granular structure, very friable when moist, medium cohesive when dry, slightly compact, non plastic, non sticky, frequent pores, fine roots, abrupt – gradual wavy boundary.
En 3-7	medium loam, grayish brown (10YR 5/2) when moist, light brownish gray (10YR 6/2) when dry, slightly developed granular structure, very friable when moist, slightly cohesive when dry, slightly compact, non plastic, non sticky, fine roots, frequent pores, gradual wavy boundary.
Btnz 7-21	medium clay loam, dark grayish brown (10YR 4/2) when moist, grayish brown (10YR 5/2) when dry, large columnar structure, very firm when moist, extremely hard when dry, plastic, sticky, rare fine roots, gradual wavy boundary.
BCnz 21-43	medium clay loam, very dark gray (5Y 3/1) when moist, dark gray (5Y 4/1) when dry, large angular blocky structure, very firm when moist, extremely hard when dry, very compact, very plastic, very sticky, weak effervescence, rare pores, gradual wavy boundary.
Clnz 43-62	medium clay loam, olive gray (5Y 4/2) when moist, olive gray (5Y 5/2) when dry, large angular blocky structure, very firm when moist, extremely hard when dry, very plastic, very sticky, moderate effervescence, gradual wavy boundary.
GClnz 62-85	medium clay loam, greenish gray (5 GY 5/1) when moist, greenish gray (5 GY 6/1) when dry, large angular blocky structure, very firm when moist, extremely hard when dry, very plastic, very sticky, moderate effervescence, very rare $CaCO_3$ concretions, gradual wavy boundary.
Clnz 85-100	medium loam, greenish gray (5 GY 6/1) when moist, light greenish gray (5 GY 7/1), large angular blocky structure, firm when moist, hard when dry, plastic, sticky, moderate effervescence, very rare $CaCO_3$ concretions.

Diagnostic horizons: Natric horizon, Gleyic horizon

Analytical data

Genetic layer	Depth	pH(H_2O)	OC	$CaCO_3$	y1	CEC	B	Σ Salt	*ESP*
	(cm)		(%)	(%)		cmol(+) kg^{-1}	%	(%)	(%)
A	0-3				-				
En	3-7	7.65	3.65		-	23.0		0.139	19.1
Btnz	7-21	9.40	2.13		-	30.3	100	0.621	40.9
BCnz	21-43	8.95	2.19		-	29.4	100	0.375	57.1
Clnz	43-62	9.75			-	30.2	100	0.718	59.6
GClnz	62-85	9.90			-	26.8	100	0.683	61.6
Clnz	85-100	9.85			-	20.0	100	0.672	73.0

Genetic layer	Depth	% Sand	% Clay	Texture	Bulk Density	Field Capacity (pF 2.3)	Wilting Point (pF 4.2)	Available Water (Δ pF 2.3-pF 4.2)
	(cm)	2-0.02 mm	<0.002 mm	FAO	(g cm^{-3})	(v v^{-1} %)	(v v^{-1} %)	(v v^{-1} %)
A	0-3							
En	3-7	49,9	23.0					
Btnz	7-21	40,6	37.9					
BCnz	21-43	40,4	34.2					
Clnz	43-62	38,2	39.5					
GClnz	62-85	46,3	33.3					
Clnz	85-100	51,4	29.8					

Abbreviations: *WRB-World Reference Base, ST-Soil Taxonomy, SRTS,2003-Romanian Soil Taxonomy, OC-Organic Carbon, y1-hydrolytic acidity, CE -Cation Exchange Capacity, B% -Base Saturation, ESP-Exchangeable Sodium Percentage*

Indicators for salt affected soils
Profile No. 5 Ates

HORIZON **HORIZON DEPTH**	**UM** **cm**	**En** **3-7**	**Btnz** **7-21**	**BCnz** **21-43**	**Clnz** **43-62**	**GClnz** **62-85**	**Clnz** **85-100**
TSC	mg/100g sol	0.139	0.621	0.375	0.718	0.683	0.672
ESP	% of CEC	19.1	40.9	57.1	59.6	61.6	73.0
SAR	-	17	48	90	100	110	171
pH in water	-	7.65	9.40	8.95	9.75	9.90	9.85

* *TSC = Total salt content.*
** *ESP = Exchangeable Na percentage.*
*** *SAR = Sodium adsorption ratio: was estimated from the diagram of SAR-ESP correlation.*

Profile-6: *Sînicolau Roman village*

Gleyic Solonetz (WRB)

*(**Solonet Gleic**) (SRTS, 2003)*

Elevation = 100 m

Topography: **Flat**
Landform: **Riverine plain**
Land use: **Grass land**
Vegetation: *Festuca sulcata, Statice gmelini, Artemisia monogyna*

Annual precipitation = 589,2 mm
Aridity index = 1.3 -1.38
Temperature regime: **Mesic**
Soil moisture regime: **Ustic**
Parent material: **Riverine deposits**
Depth of the ground water table: **100 cm**

Profile Description

Ah 0-10	medium loamy clay, grayish brown (10YR 5/2) when moist, light brownish gray (10YR 6/2) when dry, dry, massive structure, very firm when moist, very hard when dry, plastic-very plastic, sticky-very sticky, medium-very compact, iron manganese concretions, fine and frequent roots, gradual wavy boundary.
Ahz 10-20	medium loamy clay, grayish brown (10YR 5/2) when moist, light brownish gray (10YR 6/2) when dry, columnar structure, very firm when moist, very hard when dry, plastic-very plastic, very sticky, very compact, iron-manganese concretions, weak effervescence, fine and frequent roots, gradual wavy boundary.
Btnz 20-37	medium loamy clay, dark grayish brown (10YR 4/2) when moist, grayish brown (10YR 5/2) when dry, massive - columnar structure, very firm when moist, very hard when dry, very plastic, very sticky, very compact, iron and manganese concretions, weak effervescence, fine and rare roots, gradual wavy boundary.
Btnlz$_1$ 37-57	medium clay loam, grayish brown (10YR 5/2) when moist, light brownish gray (10YR 6/2) when dry, columnar structure, very firm when moist, extremely hard when dry, plastic-very plastic, very sticky, very compact, small iron-manganese concretions, moderate effervescence, gradual wavy boundary.
Btnlz$_2$ 57-80	medium clay loam, grayish brown (10YR 5/2) when moist, light brownish gray (10YR 6/2) when dry, columnar structure, very firm when moist, extremely hard when dry, plastic-very plastic, very sticky, very compact, small iron-manganese concretions, moderate effervescence, clear smooth boundary.
Btnlz$_3$ 80-100	medium loamy clay, dark greenish gray (5GY 4/1) when moist, dark gray (5Y 4/1) when dry, columnar structure, extremely firm when moist, extremely hard when dry, very plastic, very sticky, very compact, strong effervescence, slightly moist.

Diagnostic horizons: Natric horizon, Gleyic horizon

Analytical data

Genetic layer	Depth	pH(H_2O)	OC	$CaCO_3$	y1	CEC	B	Σ Salt	*ESP*
	(cm)		(%)	(%)		cmol(+) kg^{-1}	%	(%)	(%)
Ah	**0-10**	7.60	5.49	0.1	-	51.5		0.130	15.1
Ahz	**10-20**	8.50	1.78	0.4	-	35.7		0.211	24.6
Btnz	**20-37**	9.05	1.23	3.3	-	32.4	100	0.374	32.4
$Btnlz_1$	**37-57**	9.30		5.7	-	35.3	100	0.301	34.8
$Btnlz_2$	**57-80**	9.30		5.9	-	36.5	100	0.260	32.6
$Btnlz_3$	**80-100**								

Genetic layer	**Depth**	**% Sand**	**% Clay**	**Texture**	**Bulk Density**	**Field Capacity (pF 2.3)**	**Wilting Point (pF 4.2)**	**Available Water (Δ pF 2.3-pF 4.2)**
	(cm)	**2-0.02 mm**	**<0.002 mm**	**FAO**	**(g cm^{-3})**	**(v v^{-1} %)**	**(v v^{-1} %)**	**(v v^{-1} %)**
Ah	**0-10**	3.9	36.9					
Ahz	**10-20**	2.4	37.4					
Btnz	**20-37**	41.1	37.4					
$Btnlz_1$	**37-57**	40.8	37.5					
$Btnlz_2$	**57-80**	37.6	38.1					
$Btnlz_3$	**80-100**							

Abbreviations: *WRB-World Reference Base, ST-Soil Taxonomy, SRTS,2003-Romanian Soil Taxonomy, OC-Organic Carbon, y1-hydrolytic acidity, CE -Cation Exchange Capacity, B% -Base Saturation, ESP-Exchangeable Sodium Percentage*

Indicators for salt affected soils
Profile No. 6 SÎNICOLAU ROMAN

HORIZON **HORIZON DEPTH**	**UM** **cm**	**Ah** **0-10**	**Ahz** **10-20**	**Btnz** **20-37**	**$Btnlz_1$** **37-57**	**$Btnlz_2$** **57-80**
TSC	mg/100g sol	0.130	0.211	0.374	0.301	0.260
ESP	% of CEC	15.1	24.6	32.4	34.8	32.6
SAR	-	13	22	33	38	34
pH in water	-	7.6	8.5	9.05	9.3	9.3

* *TSC = Total salt content.*
** *ESP = Exchangeable Na percentage.*
*** *SAR = Sodium adsorption ratio: was estimated from the diagram of SAR-ESP correlation.*

Profile-7: *Sînicolau Roman village*

Gleyic Solonetz (WRB)

*(**Solonet Gleic**) (SRTS, 2003)*

Elevation = 100 m

Topography: **Flat**
Landform: **Riverine plain**
Land use: **Pasture**
Vegetation: *Festuca sulcata, Statice gmelini, Artemisia monogyna*

Annual precipitation = 589,2 mm
Aridity index = 1.3 -1.38
Temperature regime: **Mesic**
Soil moisture regime: **Ustic**
Parent material: **Riverine deposits**
Depth of the ground water table: **150-200 cm**

Profile Description

Ah 0-10	medium loam, grayish brown (10YR 5/2) when moist, light brownish gray (10YR 6/2) when dry, granular weel developed, firm when moist, hard when dry, slightly plastic, slightly sticky, medium compact, small iron and manganese concretions, fine and frequent roots, frequent pores, gradual wavy boundary.
Ahn 10-25	medium loamy clay, dark grayish brown (10YR 4/2) when moist, grayish brown (10YR 5/2) when dry, dry, massive to granular, fine and frequent roots, firm to very firm when moist, hard to very hard when dry, plastic, sticky, medium compact, small iron and manganese concretions, weak effervescence, frequent pores, gradual wavy boundary.
ABtnz 25-38	medium loamy clay, very dark grayish brown (10YR 3/2) when moist, dark grayish brown (10YR 4/2) when dry, dry, angular blocky, very firm when moist, very hard when dry, plastic, sticky, very compact, fine pores, weak effervescence, gradual wavy boundary.
Btnz$_1$ 38-57	medium loamy clay, grayish brown very dark (10YR 3/2) when moist, dark grayish brown (10YR 4/2) when dry, slightly moist, columnar structure, very firm when moist, very hard-extremely hard when dry, very plastic, very sticky, very compact, fine pores, moderate effervescence, gradual wavy boundary.
Btnz$_2$ 57-70	medium loamy clay, very dark grayish brown (10YR 3/2) when moist, dark grayish brown (10YR 4/2) when dry, slightly moist, columnar structure, very firm when moist, extremely hard when dry, very plastic, very sticky, very compact, fine pores, moderate effervescence, gradual wavy boundary.
BClnz 70-80	medium loamy clay, dark grayish brown (2.5Y 4/2) when moist, grayish brown (2.5Y 5/2) when dry, slightly moist, moist, medium developed angular blocky structure, firm, very hard when dry, very plastic, very sticky, very compact, moderate effervescence, fine pores, gradual wavy boundary.
Clnz$_1$ 80-95	medium loamy clay, olive brown (2.5Y 4/4) when moist, light olive brown (2.5Y 5/4) when dry, slightly moist, weak developed angular blocky, firm when moist, very hard when dry, very plastic, very sticky, very compact, moderate effervescence, fine pores, gradual wavy boundary.
Clnz$_2$ 95-110	medium loamy clay, light olive brown (2.5Y 5/6) when moist, olive yellow (2.5Y 6/6) when dry, structureless, friable when moist, very hard when dry, very plastic, very sticky, very compact, moderate effervescence, fine pores.

Diagnostic horizons: Natric horizon, Gleyic horizon

Analytical data

Genetic layer	Depth	pH(H_2O)	OC	$CaCO_3$	y1	CEC	B	Σ Salt	ESP
	(cm)		(%)	(%)		cmol(+) kg^{-1}	%	(%)	(%)
Ah	**0-10**	7.48	3.72	0.1	-	39.0		0.075	10.3
Ahn	**10-25**	8.75	1.33	0.7	-	35.8		0.132	15.0
ABtnz	**25-38**	8.80	1.23	2.0	-	36.3	100	0.253	17.6
$Btnz_1$	**38-57**	8.90		7.9	-	35.0	100	0.317	28.3
$Btnz_2$	**57-70**	9.00		7.1	-	32.5	100	0.284	31.7
BClnz	**70-80**	9.15		7.2	-	37.0	100	0.235	28.4
$Clnz_1$	**80-95**	9.25		11.8	-	30.4	100	0.211	37.2
$Clnz_2$	**95-110**								

Genetic layer	Depth	% Sand	% Clay	Texture	Bulk Density	Field Capacity (pF 2.3)	Wilting Point (pF 4.2)	Available Water (Δ pF 2.3-pF 4.2)
	(cm)	**2-0.02 mm**	**<0.002 mm**	**FAO**	**(g cm^{-3})**	**(v v^{-1} %)**	**(v v^{-1} %)**	**(v v^{-1} %)**
Ah	**0-10**	35.8	32.7					
Ahn	**10-25**	35.5	38.9					
ABtnz	**25-38**	38.0	40.9					
$Btnz_1$	**38-57**	32.8	43.7					
$Btnz_2$	**57-70**	32.7	43.5					
BClnz	**70-80**	31.8	37.1					
$Clnz_1$	**80-95**	41.7	34.2					
$Clnz_2$	**95-110**							

Abbreviations: *WRB-World Reference Base, ST-Soil Taxonomy, SRTS,2003-Romanian Soil Taxonomy, OC-Organic Carbon, y1-hydrolytic acidity, CE -Cation Exchange Capacity, B% -Base Saturation, ESP-Exchangeable Sodium Percentage*

Indicators for salt affected soils
PROFILE NO. 7 Sînicolau Roman

HORIZON **HORIZON DEPT**	**UM** **cm**	**Ah** **0-10**	**Ahn** **10-25**	**ABtnz** **25-38**	**$Btnz_1$** **38-57**	**$Btnz_2$** **57-70**	**BClnz** **70-80**	**$Clnz_1$** **80-95**
TSC	mg/100g sol	0.075	0.132	0.253	0.317	0.284	0.235	0.211
ESP	% of CEC	10.3	15.0	17.6	28.3	31.7	28.4	37.2
SAR	-	8.0	13	15.3	27.5	31.0	27.5	42.0
pH in water	-	7.48	8.75	8.80	8.90	9.00	9.15	9.25

* *TSC = Total salt content.*
** *ESP = Exchangeable Na percentage.*
*** *SAR = Sodium adsorption ratio: was estimated from the diagram of SAR-ESP correlation.*

Profile-8: *Sînicolau Roman village*

Gleyic Solonetz (WRB)

*(**Solonet Gleic**) (SRTS, 2003)*

Elevation = 100 m

Topography: **Flat**
Landform: **Riverine plain**
Land use: **Pasture**
Vegetation: *Agropyron repens, Agrostis tenuis, Beckmannia eruciformis*

Annual precipitation = 589,2 mm
Aridity index = 1.3 -1.38
Temperature regime: **Mesic**
Soil moisture regime: **Ustic**
Parent material: **Riverine deposits**
Depth of the ground water table: **150 cm**

Profile Description

An 0-4	medium loam, grayish brown (10YR 5/2) when moist, light brownish gray (10YR 6/2) when dry, well developed granular structure, friable moist, hard when dry, very plastic, very sticky, very compact, iron-manganese concretions, weak effervescence, fine pores, frequent roots, gradual wavy boundary.
$Btnz_1$ 4-17	medium loam, grayish brown (10YR 5/2) with olive yellow (2.5 Y 6/6) mottles when moist, light brownish gray (10YR 6/2) with yellow (2.5 Y 7/6) spots when dry, columnar structure, very hard when dry, very firm when moist, very plastic, very sticky, very compact, iron-manganese concretions, fine frequent roots, fine pores, gradual wavy boundary.
$Btnz_2$ 17-30	medium loam, grayish brown (10YR 5/2) with grayish brown (2.5Y 5/2) spots when moist, light brownish gray (10YR 6/2) with light olive brown (2.5 Y 5/6) spots when dry, columnar structure, very firm when moist, very hard when dry, very plastic, very sticky, very compact, iron-manganese concretions, strong effervescence, fine pores, medium and fine roots, smooth boundary.
$Btnz_3$ 30-53	medium loamy clay, dark grayish brown (10YR 4/2) with grayish brown (2.5Y 5/2) spots when moist, very dark grayish brown (10YR 3/2) with light olive brown (2.5 Y 5/6) spots when dry, slightly moist, columnar structure, very hard when dry, very plastic, very sticky, very compact, strong effervescence, $CaCO_3$ concretions, fine pores, gradual wavy boundary.
BClnz 53-72	medium loam, dark grayish brown (10YR 4/2) with light olive brown (2.5 Y5/6) spots when moist, grayish brown (10 YR5/2) with light olive brown (2.5Y5/6) spots when dry, slightly moist, columnar structure, very firm when moist, very hard when dry, very plastic, very sticky, very compact, strong effervescence, $CaCO_3$ concretions, fine pores, gradual wavy boundary.
$Clnz_1$ 72-83	medium loam, grayish brown (10YR 5/2) with light olive brown (2.5Y 5/6) spots when moist, light brownish gray (10YR 6/2) with yellow (2.5Y 6/6) spots when dry, slightly moist, angular blocky, friable moist, hard when dry, plastic, sticky, very compact, fine pores, strong effervescence, $CaCO_3$ concretions, gradual wavy boundary.
$Clnz_2$ 83-100	white (10YR 8/2) with yellow (2.5Y 7/6) spots when moist, white (10YR 8/2) when dry, slightly moist, structureless, medium loamy clay, strong effervescence, $CaCO_3$ concretions, friable when moist, hard when dry, very plastic, very sticky, very compact, fine pores, strong effervescence.

Diagnostic horizons: Natric horizon, Gleyic horizon

Analytical data

Genetic layer	Depth	pH(H_2O)	OC	$CaCO_3$	y1	CEC	B	Σ Salt	*ESP*
	(cm)		(%)	(%)		cmol(+) kg^{-1}	%	(%)	(%)
An	0-4	8.48	2.81		-	28.4		0.133	22.9
$Btnz_1$	4-17	9.55	1.26		-	30.6		0.249	42.2
$Btnz_2$	17-30	9.88			-	29.7	100	0.294	48.1
$Btnz_3$	30-53	9.92			-	32.0	100	0.401	55.0
BClnz	53-72	9.95			-	30.2	100	0.366	59.6
$Clnz_1$	72-83	9.90			-	32.7	100	0.317	61.8
$Clnz_2$	83-100	9.90			-	33.9	100	0.233	67.0

Genetic layer	Depth	% Sand	% Clay	Texture	Bulk Density	Field Capacity (pF 2.3)	Wilting Point (pF 4.2)	Available Water (Δ pF 2.3-pF 4.2)
	(cm)	2-0.02 mm	<0.002 mm	FAO	(g cm^{-3})	(v v^{-1} %)	(v v^{-1} %)	(v v^{-1} %)
An	0-4	55.3	22.2					
$Btnz_1$	4-17	48.3	30.7					
$Btnz_2$	17-30	46.8	27.0					
$Btnz_3$	30-53	39.7	35.5					
BClnz	53-72	45.7	32.0					
$Clnz_1$	72-83	45.9	30.6					
$Clnz_2$	83-100	34.1	40.2					

Abbreviations: *WRB-World Reference Base, ST-Soil Taxonomy, SRTS,2003-Romanian Soil Taxonomy, OC-Organic Carbon, y1-hydrolytic acidity, CE -Cation Exchange Capacity, B% -Base Saturation, ESP-Exchangeable Sodium Percentage*

Indicators for salt affected soils
PROFILE NO. 8 Sînicolau Roman

HORIZON **HORIZON DEPT**	**UM** **cm**	**An** **0-4**	**$Btnz_1$** **4-17**	**$Btnz_2$** **17-30**	**$Btnz_3$** **30-53**	**BClnz** **53-72**	**$Clnz_1$** **72-83**	**$Clnz_2$** **83-100**
TSC	mg/100g sol	0.133	0.249	0.294	0.401	0.366	0.317	0.233
ESP	% of CEC	22.9	42.2	48.1	55.0	59.6	61.8	67.0
SAR	-	21.0	50.1	63.0	95.2	102.0	110.0	140.0
pH in water	-	8.48	9.55	9.88	9.92	9.95	9.90	9.90

* *TSC = Total salt content.*
** *ESP = Exchangeable Na percentage.*
*** *SAR = Sodium adsorption ratio: was estimated from the diagram of SAR-ESP correlation.*

Profile 9: *Ateas village*

Gleyic Solonetz (WRB)

*(**Solonet Gleic**) (SRTS, 2003)*

Elevation = 100 m

Topography: **Flat**
Landform: **Riverine plain**
Land use: **Pasture**
Vegetation: *Festuca sulcata, Statice gmelini, Artemisia monogyna*

Annual precipitation = 589,2 mm
Aridity index = 1.3 -1.38
Temperature regime: **Mesic**
Soil moisture regime: **Ustic**
Parent material: **Riverine deposits**
Depth of the ground water table: **150-200 cm**

Profile Description

An 0-3	medium loam, grayish brown (10YR 5/2) when moist, light gray (10YR 7/2) when dry, slightly developed granular structure, very friable when moist, soft when dry, non plastic, non sticky, fine roots, abrupt boundary.
Btn 3-22	medium clay loam, very dark brown (10YR 2/2) when moist, dark grayish brown (10YR 4/2) when dry, well developed columnar structure, very firm when moist, extremely hard when dry, compact, very plastic, very sticky, rare pores, rare fine roots, very gradual wavy boundary.
Btnz$_1$ 22-36	medium clay loam, very dark brown (10YR 2/2) when moist, dark grayish brown (10YR 4/2) when dry, medium angular blocky structure, very firm when moist, very hard when dry, very compact, very plastic, very sticky, weak effervescence, rare pores, rare fine roots, gradual wavy boundary.
Btnz$_2$ 36-59	medium clay loam, dark yellowish brown (10YR 3/4) when moist, dark brown - dark yellowish brown (10YR 4/3 – 4/4) when dry, medium angular blocky structure, firm when moist, hard when dry, moderate compact, plastic, sticky, moderate effervescence, rare $CaCO_3$ concretions, rare pores, gradual wavy boundary.
BClnz 59-81	medium clay loam, dark olive gray (5Y 3/2) when moist, olive (5Y 5/3), medium angular blocky structure, firm when moist, hard when dry, moderate compact, plastic, sticky, moderate effervescence, rare calcareous concretions, rare pores, gradual wavy boundary.
Clnz$_1$ 81-94	medium clay loam, olive (5Y 4/4) when moist, olive (5Y 5/4) when dry, medium angular blocky structure, firm when moist, hard when dry, moderate compact, rare pores, plastic, sticky, moderate effervescence, many $CaCO_3$ concretions, gradual wavy boundary.
Clnz$_2$ 94-110	medium clay loam, olive (5Y 4/3) when moist, olive (5Y 5/3) when dry, medium angular blocky structure, firm when moist, hard when dry, moderate compact, plastic, sticky, moderate effervescence, many $CaCO_3$ concretions, rare pores.

Diagnostic horizons: Natric horizon, Gleyic horizon

Analytical data

Genetic layer	Depth	pH(H_2O)	OC	$CaCO_3$	y1	CEC	B	Σ Salt	*ESP*
	(cm)		(%)	(%)		cmol(+) kg^{-1}	%	(%)	(%)
An	0-3								
Btn	3-22	8.35	2.34		-	35.6		0.134	20.8
$BCnz_1$	22-36	9.20	1.76		-	36.6	100	0.204	33.1
$BClnz_2$	36-59	9.45	1.29		-	35.5	100	0.227	37.2
Cl_1n	59-81	9.40			-	32.2	100	0.199	42.2
Cl_2n	81-94	9.30			-	29.7	100	0.167	48.5
Cl_3n	94-110								

Genetic layer	Depth	% Sand	% Clay	Texture	Bulk Density	Field Capacity (pF 2.3)	Wilting Point (pF 4.2)	Available Water (Δ pF 2.3-pF 4.2)
	(cm)	2-0.05 mm	<0.002 mm	FAO	(g cm^{-3})	(v v^{-1} %)	(v v^{-1} %)	(v v^{-1} %)
An	0-3							
Btn	3-22	34.0	37.0					
$BCnz_1$	22-36	30.7	42.1					
$BClnz_2$	36-59	31.9	40.3					
Cl_1n	59-81	38.2	36.4					
Cl_2n	81-94	44.9	31.3					
Cl_3n	94-110							

Abbreviations: *WRB-World Reference Base, ST-Soil Taxonomy, SRTS,2003-Romanian Soil Taxonomy, OC-Organic Carbon, y1-hydrolytic acidity, CE -Cation Exchange Capacity, B% -Base Saturation, ESP-Exchangeable Sodium Percentage*

Indicators for salt affected soils
OF Profile No. 9 SÎNICOLAU ROMAN

HORIZON **HORIZON DEPTH**	**UM** **cm**	**Bn** **3-22**	**$BCnz_1$** **22-36**	**$BClnz_2$** **36-59**	**Cl_1n** **59-81**	**Cl_2n** **81-94**
TSC	mg/100g sol	0.134	0.204	0.227	0.199	0.167
ESP	% of CEC	20.8	33.1	37.2	42.2	48.5
SAR	-	18.5	34.0	42.0	50.0	65.0
pH in water	-	8.35	9.20	9.45	9.40	9.30

** TSC = Total salt content.*
*** ESP = Exchangeable Na percentage.*
**** SAR = Sodium adsorption ratio: was estimated from the diagram of SAR-ESP correlation.*

Profile-10: *Sînicolau Roman village*

Gleyic Solonetz (WRB)

*(**Solonet Gleic**) (SRTS, 2003)*

Elevation = 100 m

Topography: **Flat**
Landform: **Riverine plain**
Land use: **Pasture**
Vegetation: *Festuca sulcata, Statice gmelini, Artemisia monogyna*

Annual precipitation = 589,2 mm
Aridity index = 1.3 -1.38
Temperature regime: **Mesic**
Soil moisture regime: **Ustic**
Parent material: **Riverine deposits**
Depth of the ground water table: **150-200 cm**

Profile Description

An 0-15	medium loamy clay, light brownish gray (10YR 6/2) when moist, light gray (10YR 7/2) when dry, massive to granular structure, firm when moist, very hard when dry, very plastic, very sticky, very compact, strong effervescence, iron and manganese nodules, fine pores, frequent fine roots, gradual wavy boundary.
Bng_1 15-37	medium loamy clay, dark grayish brown (10YR 4/2) with dark greenish gray (5GY 4/1) spots when moist, grayish brown (10YR 5/2) with greenish gray (5YG 5/1) when dry, massive to prismatic-columnar structure, very firm when moist, very hard when dry, very plastic, very sticky, very compact, strong effervescence, iron and manganese nodules, fine pores, rare fine roots, gradual wavy boundary.
Bng_2 37-58	medium loamy clay, dark grayish brown (10YR 4/2) with dark greenish gray (5GY 4/1) spots when moist, grayish brown (10YR 5/2) with greenish gray (5YG 5/1) when dry, prismatic-columnar structure, very firm when moist, very hard when dry, very plastic, very sticky, very compact, strong effervescence, small iron and manganese nodules, fine pores, rare fine roots, gradual wavy boundary.
Ckl_1n 58-75	medium loam, olive gray (5Y 4/2) when moist, olive gray (5Y 5/2) when dry, medium developed coarse angular blocky structure, small iron and manganese nodules, very firm when moist, very hard when dry, very plastic, very sticky, very compact, strong effervescence, fine pores, rare fine roots, gradual wavy boundary.
Ckl_2n 75-92	medium loam, olive yellow (5Y 6/6) when moist, yellow (5Y 7/6) when dry, slightly developed angular blocky structure, firm when moist, very hard when dry, plastic, sticky, strong effervescence, $CaCO_3$ nodules, gradual wavy boundary.
Ckl_3n 92-110	medium loam, olive yellow (5Y 6/6) when moist, yellow (5Y 7/6) when dry, angular blocky structure, firm when moist, very hard when dry, plastic, moderate compact, sticky, strong effervescence, $CaCO_3$ nodules, rare pores.

Diagnostic horizons: Natric horizon, Gleyic horizon

Analytical data

Genetic layer	Depth	pH (H_2O)	OC	$CaCO_3$	y1	CEC	B	Σ Salt	*ESP*
	(cm)		(%)	(%)		cmol(+) kg^{-1}	%	(%)	(%)
An	0-15	9.28	2.12	9,6	-	39.0	100	0.133	27.7
Bng_1	15-37	-	-	-	-	-	-	-	-
Bng_2	37-58	9.90	-	17.3	-	33.1	100	0.296	63.1
Ckl_1n	58-75	10.00	-	22.5	-	29.5	100	0.249	66.4
Ckl_2n	75-92	10.02	-	29.5	-	27.1	100	0.221	69.4
Ckl_3n	92-110								

Genetic layer	Depth	% Sand	% Clay	Texture	Bulk Density	Field Capacity (pF 2.3)	Wilting Point (pF 4.2)	Available Water (Δ pF 2.3-pF 4.2)
	(cm)	2-0.02 mm	<0.002 mm	FAO	(g cm^{-3})	(v v^{-1} %)	(v v^{-1} %)	(v v^{-1} %)
An	0-15	52.4	29.4					
Bng_1	15-37	-	-					
Bng_2	37-58	47.1	36.4					
Ckl_1n	58-75	49.7	31.0					
Ckl_2n	75-92	57.1	25.0					
Ckl_3n	92-110							

Abbreviations: *WRB-World Reference Base, ST-Soil Taxonomy, SRTS,2003-Romanian Soil Taxonomy, OC-Organic Carbon, y1-hydrolytic acidity, CE -Cation Exchange Capacity, B% -Base Saturation, ESP-Exchangeable Sodium Percentage*

Indicators for salt affected soils
OF Profile No. 10 SÎNICOLAU ROMAN

HORIZON HORIZON DEPTH	UM cm	An 0-15	Bng_1 15-37	Bng_2 37-58	Ckl_1n 58-75	Ckl_2n 75-92
TSC	mg/100g sol	0.133		0.296	0.249	0.221
ESP	% of CEC	27.7		63.1	66.4	69.4
SAR	-	26.0		112.0	130.0	150.0
pH in water	-	9.28		9.90	10.00	10.02

* TSC = Total salt content.
** ESP = Exchangeable Na percentage.
*** SAR = Sodium adsorption ratio: was estimated from the diagram of SAR-ESP correlation.

Profile-11: *Sînicolau Roman village*

Salic Solonetz (WRB)

*(**Solonet Salinic**) (SRTS)*

Elevation = 90 - 100 m

Topography: **Flat**
Landform: **Riverine plain**
Land use: **Pasture**
Vegetation: *Festuca sulcata, Statice gmelini*

Annual precipitation = 589,2 mm
Aridity index = 1.3 -1.38
Temperature regime: **Mesic**
Soil moisture regime: **Ustic**
Parent material : **Riverine deposits**
Depth of the ground water table: **100 cm**

Profile Description

Anz 0-9	medium loamy clay, dark grayish brown (10YR 4/2) when moist, light brownish gray (10YR 6/2) when dry, massive granular, iron and manganese nodules, fine pores, firm when moist, very hard when dry, slightly plastic, slightly sticky, very compact, slightly when moist, gradual wavy boundary.
ABnz 9-20	medium loamy clay, dark grayish brown (10YR 4/2) with olive gray (5Y 5/2) spots when moist, grayish brown (10YR 5/2) with light olive gray (5Y 6/2) spots when dry, columnar structure, iron and manganese nodules, very firm when moist, extremely hard when dry, very plastic, very sticky, very compact, slightly when moist, rare fine pores, weak effervescence, gradual wavy boundary.
Btnz 20-33	medium loam, dark grayish brown (10YR 4/2) with dark greenish gray (5GY 4/1) spots when moist, grayish brown (10YR 5/2) with greenish gray (5YG 5/1) spots when dry, prismatic-columnar structure, iron and manganese nodules, white NaCl efflorescence, extremely firm when moist, extremely hard when dry, very plastic, very sticky, very compact, slightly when moist, rare roots, rare pores, weak effervescence, gradual wavy boundary.
Btlnz 33-59	medium loam, very dark grayish brown (10YR 3/2) with olive gray (5Y 4/2) spots when moist, dark grayish brown (10YR 4/2) with olive gray (5Y 5/2) spots when dry, prismatic-columnar structure, iron and manganese nodules, white NaCl efflorescence, very firm when moist, very hard when dry, plastic, sticky, slightly when moist, very compact, rare roots, rare pores, weak effervescence, gradual wavy boundary.
$Clnz_1$ 59-85	loamy clay silty, yellowish brown (10YR 5/6) with olive (5Y 5/3) spots when moist, brownish yellow (10YR 6/6) with olive (5Y 5/6) spots when dry, small prismatic slightly developed, white NaCl efflorescence when dry, very firm when moist, very hard when dry, plastic, sticky, very compact, weak effervescence, slightly when moist, rare roots, rare pores, gradual wavy boundary.
$Clnz_2$ 85-100	medium loamy clay, olive (5Y 5/6) when moist, olive yellow (5Y 6/6) when dry, slightly developed small angular blocky structure, white NaCl efflorescence when dry, firm when moist, very hard when dry, plastic, sticky, very compact, rare pores, weak effervescence, $CaCO_3$ nodules, gradual wavy boundary.
$Clnz_3$ 100-125	olive yellow (5Y 6/6) when moist, yellow (5Y 7/6) when dry, angular blocky structure, medium loamy clay, white NaCl efflorescence when dry, firm when moist, very hard when dry, plastic, sticky, very compact, slightly when moist, weak effervescence, $CaCO_3$ nodules, rare pores.

Diagnostic horizons: Natric horizon, Salic horizon

Analytical data

Genetic layer	Depth	pH (H_2O)	OC	$CaCO_3$	y1	CEC	B	Σ Salt	*ESP*
	(cm)		(%)	(%)		cmol(+) kg^{-1}	%	(%)	(%)
Anz	0-9	8.90	2.17		-	26.4	100	0.415	55.7
ABnz	9-20	9.25	1.11		-	33.3	100	0.979	64.3
Btnz	20-33	9.35	1.13		-	32.4	100	1.316	75.9
Btlnz	33-59	9.50			-	36.9	100	0.741	71.0
Clnz$_1$	59-85	9.50			-	37.0	100	0.617	62.2
Clnz$_2$	85-100	9.50			-	36.6	100	0.610	61.2

Genetic layer	Depth	% Sand	% Clay	*Texture*	Bulk Density	Field Capacity (pF 2.3)	Wilting Point (pF 4.2)	Available Water (Δ pF 2.3-pF 4.2)
	(cm)	2-0.02mm	<0.002 mm	FAO	(g cm^{-3})	(v v^{-1} %)	(v v^{-1} %)	(v v^{-1} %)
Anz	0-9	38.6	37.0					
ABnz	9-20	39.9	36.1					
Btnz	20-33	47.7	24.2					
Btlnz	33-59	46.1	31.3					
Clnz$_1$	59-85	22.2	40.7					
Clnz$_2$	85-100	40.3	36.1					

Abbreviations: *WRB-World Reference Base, ST-Soil Taxonomy, SRTS,2003-Romanian Soil Taxonomy, OC-Organic Carbon, y1-hydrolytic acidity, CE -Cation Exchange Capacity, B% -Base Saturation, ESP-Exchangeable Sodium Percentage*

Indicators for salt affected soils
OF Profile No. 11 SÎNICOLAU ROMAN

HORIZON HORIZON DEPTH	UM cm	Anz 0-9	ABnz 9-20	Btnz 20-33	Btlnz 33-59	Clnz$_1$ 59-85	Clnz$_2$ 85-100
TSC	mg/100g sol	0.415	0.979	1.316	0.741	0.617	0.613
ESP	% of CEC	55.7	64.3	75.9	71.0	62.2	61.2
SAR	-	85.0	120.0	205.0	167.0	112.0	108.0
pH in water	-	8.90	9.25	9.35	9.50	9.50	9.50

** TSC = Total salt content.*
*** ESP = Exchangeable Na percentage.*
**** SAR = Sodium adsorption ratio: was estimated from the diagram of SAR-ESP correlation.*

Profile-12: *Cefa village*

Gleyic Solonetz (WRB)

*(**Solonet Gleic**) (SRTS, 2003)*

Elevation = 100 m

Topography: **Flat**
Landform: **Riverine plain**
Land use: **Pasture**
Vegetation: *Statice gmelini*

Annual precipitation = 589,2 mm
Aridity index = 1.3 -1.38
Temperature regime: **Mesic**
Soil moisture regime: **Ustic**
Parent material: **Riverine deposits**
Depth of the ground water table: **100-150 cm**

Profile Description

Ah-sc **0-9**	medium loam, olive (5Y 5/3) when moist, pale yellow (5Y 7/3) when dry, slightly granular, firm when moist, very hard when dry, slightly plastic, slightly sticky, compact when dry, slightly when moist, iron and manganese nodules, fine and frequent roots, frequent pores, gradual wavy boundary.
E 9-16	medium loam, pale olive (5Y 6/4) when moist, pale yellow (5Y 8/4) when dry, complex structure: well developed granular; and massive, firm when moist, hard when dry, slightly plastic, slightly sticky, compact, slightly when moist, fine pores, gradual wavy boundary.
Btnz₁ 16-27	medium loamy clay, olive gray (5Y 4/2) when moist, light olive gray (5Y 6/2) when dry, prismatic-columnar structure, extremely firm when moist, extremely hard when dry, plastic, sticky, very compact, when dry, slightly when moist, iron and manganese nodules, fine and frequent roots, fine pores, effervescence, gradual wavy boundary.
Btnz₂ 27-41	medium loamy clay, olive gray (5Y 4/2) when moist, olive gray (5Y 5/2) when dry, prismatic-columnar structure, extremely firm when moist, extremely hard when dry, plastic, sticky, very compact, slightly when moist., iron and manganese nodules, rare and fine roots, fine pores, effervescence, gradual wavy boundary.
Btnz₃ 41-58	medium loamy clay, olive (5Y 5/3) when moist, pale olive (5Y 6/4) when dry, prismatic-columnar structure, extremely firm when moist, extremely hard when dry, plastic, sticky, very compact, iron and manganese nodules, rare and fine roots, fine pores, effervescence, slightly when moist, gradual wavy boundary.
BCln 58-75	medium loamy clay, olive (5Y 5/3) when moist, pale olive (5Y 6/3) when dry, columnar (with rounded top)-prismatic structure, extremely firm when moist, extremely hard when dry, plastic, sticky, very compact, slightly when moist, iron and manganese nodules, rare and fine roots, fine pores, effervescence, gradual wavy boundary.
Cln ₁ 75-88	medium loamy clay, dark brown-brown (7,5YR 4/2) when moist, dark brown-brown (7,5YR 4/4) when dry, angular blocky, extremely firm when moist, extremely hard when dry, plastic, sticky, very compact, slightly when moist, iron and manganese nodules, fine pores, white NaCl efflorescence when dry, effervescence, $CaCO_3$ nodules, gradual wavy boundary.
Cln ₂ 88-110	medium loamy clay, brown (7,5YR 5/2) when moist, brown (7,5YR 5/4) when dry, angular blocky structure, firm when moist, very hard when dry, plastic, sticky, very compact, iron and manganese nodules small, fine pores, effervescence.

Diagnostic horizons: Natric horizon, Gleyic horizon

Analytical data

Genetic layer	Depth	pH (H_2O)	OC	$CaCO_3$	y1	CEC	B	Σ Salt	*ESP*
	(cm)		(%)	(%)		cmol(+) kg^{-1}	%	(%)	(%)
Ah-sc	**0-9**	8.35	3.55	0	-	35.6	100	0.132	10.4
E	**9-16**	9.20	1.63	0	-	28.5	100	0.155	8.4
$Btnz_1$	**16-27**	9.70		7.5	-	27.0	100	0.290	39.6
$Btnz_2$	27-41				-				
$Btnz_3$	41-58	9.80		7.5	-	29.2	100	0.295	43. 4
BCln	58-75				-				
Cln_1	75-88				-				
Cln_2	88-110	9.65		19.0	-	29.9	100	0.213	43.1

Genetic layer	Depth	% Sand	% Clay	Texture	Bulk Density	Field Capacity (pF 2.3)	Wilting Point (pF 4.2)	Available Water (Δ pF 2.3-pF 4.2)
	(cm)	2-0.02 mm	<0.002 mm	FAO	(g cm^{-3})	(v v^{-1} %)	(v v^{-1} %)	(v v^{-1} %)
Ah-sc	**0-9**	46.4	32.0					
E	**9-16**	41.8	30.8					
$Btnz_1$	16-27	43.8	33.1					
$Btnz_2$	27-41							
$Btnz_3$	41-58	42.0	35.5					
BCln	58-75							
Cln_1	75-88							
Cln_2	88-110	51.1	28.3					

Abbreviations: *WRB-World Reference Base, ST-Soil Taxonomy, SRTS,2003-Romanian Soil Taxonomy, OC-Organic Carbon, y1-hydrolytic acidity, CE -Cation Exchange Capacity, B% -Base Saturation, ESP-Exchangeable Sodium Percentage*

Indicators for salt affected soils
OF Profile No. 12 CEFA

HORIZON **HORIZON DEPTH**	**UM** **cm**	**Ah** **0-9**	**E** **9-16**	**$Btnz_1$** **16-27**	**$Btnz_3$** **41-58**	**Cln** **88-110**
TSC	mg/100g sol	0.132	0.155	0.290	0.295	0.213
ESP	% of CEC	10.4	8.4	39.6	43. 4	43.1
SAR	-	9.0	7.5	46.0	53.0	53.0
pH in water	-	8.35	9.20	9.70	9.80	9.65

** TSC = Total salt content.*
*** ESP = Exchangeable Na percentage.*
**** SAR = Sodium adsorption ratio: was estimated from the diagram of SAR-ESP correlation.*

Profile-13: *Ateaş village*

Albic Gleyic Solonetz *(WRB)*

*(**Solonet Albic Gleic**) (SRTS, 2003)*

Elevation = 100 m

Topography: **Flat**
Landform: **Riverine plain**
Land use: **Pasture**
Vegetation: *Festuca sulcata, Plantago sp.*

Annual precipitation = 589,2 mm
Aridity index = 1.3 -1.38
Temperature regime: **Mesic**
Soil moisture regime: **Ustic**
Parent material: **Riverine deposits**
Depth of the ground water table: **100-150 cm**

Profile Description

A 0-2	medium loam, dark grayish brown (10YR 4/2) when moist, light brownish gray (10YR 6/2) when dry, slightly developed granular structure, very firm when moist, medium cohesive when dry, slightly compact, non plastic, non sticky, very frequent pores, fine roots, gradual wavy boundary.
En 2-13	medium loam, grayish brown (10YR 5/2) when moist, light gray (10YR 7/2) when dry, granular structure slightly developed, very firm when moist, slightly cohesive when dry, slightly compact, frequent pores, non plastic, non sticky, iron and manganese mottles, fine roots, gradual wavy boundary.
EBtnz 13-20	medium loamy clay, dark grayish brown (10YR 4/2) when moist, grayish brown (10YR 5/2) when dry, angular blocky well developed, moderate compact, plastic, sticky, iron and manganese mottles, rare pores, frequent fine roots, gradual wavy boundary.
Btnz 20-39	medium loamy clay, coarse columnar structure, dark yellowish brown (10YR 4/4) when moist, yellowish brown (10YR 5/4) when dry, well developed, very firm when moist, extremely hard when dry, very compact, plastic, medium cohesive, iron and manganese mottles, rare pores, rare fine roots, gradual wavy boundary.
$BCnz_1$ 39-53	loamy clay, yellowish brown (10YR 5/4) when moist, brownish yellow (10YR 6/6) when dry, coarse prismatic structure, very firm when moist, extremely hard when dry, very compact, very plastic, very sticky, rare pores, weak effervescence, gradual wavy boundary.
$BCnz_2$ 53-75	medium loamy clay, coarse prismatic structure, light yellowish brown (10YR 6/4) when moist, very pale brown (10YR 7/4) when dry, well developed coarse prismatic structure, firm when moist, very hard when dry, very compact, plastic, sticky, rare pores, weak effervescence, gradual wavy boundary.
BCln 75-93	medium loamy clay, olive (5Y 5/4) when moist, pale olive (5Y 6/4) when dry, well developed prismatic structure, firm when moist, very hard when dry, very compact, plastic, sticky, rare pores, weak effervescence, gradual wavy boundary.
Cln_1 93-122	medium loam, olive (5Y 5/4) when moist, pale olive yellow (5Y 7/4) when dry, angular blocky structure, well developed, firm when dry, moderate compact, plastic, sticky, rare pores, medium effervescence, gradual wavy boundary.
Cln_2 122-150	medium loamy clay, pale olive (5Y 6/4) when moist, well developed coarse angular blocky structure, firm when moist, hard when dry, moderate compact, plastic, sticky, rare pores, medium effervescence.

Diagnostic horizons: Natric horizon, Albic horizon, Gleyic horizon

Analytical data

Genetic layer	Depth	pH (H_2O)	OC	$CaCO_3$	y1	CEC	B	Σ Salt	*ESP*
	(cm)		(%)	(%)		cmol(+) kg^{-1}	%	(%)	(%)
A	**0-2**								
En	**2-13**	7.40	1.89		-	27.2		0.087	16.2
EBtnz	**13-20**	8.45	1.13		-	32.4	100	0.243	36.7
Btnz	20-39	8.85	0.80		-	37.7	100	0.440	41.1
$BCnz_1$	39-53	9.30		2.3	-	37.4	100	0.380	44.4
$BCnz_2$	53-75	9.35		2.2	-	35.5	100	0.287	43.1
BCln	75-93	9.35		1.1	-	36.0	100	0.225	38.6
Cln_1	93-122	9.30		20.1	-	30.1	100	0.153	47.8
Cln_2	122-150	9.35		10.3	-	32.3	100	0.108	33.7

Genetic layer	Depth	% Sand	% Clay	Texture	Bulk Density	Field Capacity (pF 2.3)	Wilting Point (pF 4.2)	Available Water (Δ pF 2.3-pF 4.2)
	(cm)	2-0.02 mm	<0.002 mm	FAO	(g cm^{-3})	(v v^{-1} %)	(v v^{-1} %)	(v v^{-1} %)
A	**0-2**							
En	**2-13**	51.8	21.2					
EBtnz	**13-20**	39.1	36.2					
Btnz	20-39	32.9	42.7					
$BCnz_1$	39-53	31.8	46.9					
$BCnz_2$	53-75	32.4	45.4					
BCln	75-93	32.5	43.8					
Cln_1	93-122	45.7	31.1					
Cln_2	122-150	43.9	35.4					

Abbreviations: *WRB-World Reference Base, ST-Soil Taxonomy, SRTS,2003-Romanian Soil Taxonomy, OC-Organic Carbon, y1-hydrolytic acidity, CE -Cation Exchange Capacity, B% -Base Saturation, ESP-Exchangeable Sodium Percentage*

Indicators for salt affected soils
OF Profile No. 13 Ateaş

HORIZON HORIZON DEPTH	UM cm	En 2-13	EBtn 13-20	Btnz 20-39	$BCnz_1$ 39-53	$BCnz_2$ 53-75	BCln 75-93	Cln_1 93-122	Cln_2 122-150
TSC	mg/100g soil	0.087	0.243	0.410	0.380	0.287	0.225	0.153	0.108
ESP	% of CEC	16.2	36.7	41.1	44.4	43.1	38.6	47.8	33.7
SAR	-	14.0	40.0	48.0	55.0	52.0	44.0	65.0	42.0
pH in water	-	7.40	8.45	8.85	9.30	9.35	9.35	9.30	9.35

* *TSC = Total salt content.*
*** ESP = Exchangeable Na percentage.*
**** SAR = Sodium adsorption ratio: was estimated from the diagram of SAR-ESP correlation.*

Profile-14: Cefa village

Albic Gleyic Solonetz (WRB)

(**Solonet Albic Gleic**) (SRTS, 2003)

Elevation = 100 m

Topography: **Flat**
Landform: **Riverine plain**
Land use: **Pasture**
Vegetation: Statice gmelini

Annual precipitation = 589,2 mm
Aridity index = 1.3 -1.38
Temperature regime: **Mesic**
Soil moisture regime: **Ustic**
Parent material : riverine deposits
Depth of the ground water table: **150 cm**

Profile Description

Ah 0-7	medium loam, olive (5Y 5/3) when moist, pale yellow (5Y 8/3) when dry, fine granular structure, firm when moist, hard when dry, slightly sticky, slightly plastic, slightly compact when dry, iron and manganese nodules, fine and frequent roots, frequent pores, gradual wavy boundary.
En 7-12	medium loam, pale olive (5Y 6/4) when moist, pale yellow (5Y 8/3,5) when dry, monogranular and massive structure, firm when moist, hard when dry, slightly plastic, slightly sticky, compact, iron and manganese nodules, fine and frequent roots, frequent pores, gradual wavy boundary.
Btn_1 12-24	medium loamy clay, olive gray (5Y 4/2) when moist, olive (5Y 5/4) when dry, prismatic-columnar structure, extremely firm when dry, plastic, very compact, very sticky, small iron and manganese nodules, fine and frequent roots, fine pores, gradual wavy boundary.
Btn_2 24-40	medium loamy clay, dark olive gray (5Y 3/2) when moist, olive gray (5Y 4/2) when dry, prismatic-columnar structure, extremely firm when moist, extremely hard when dry, plastic, very compact, very sticky, iron and manganese nodules, fine and frequent roots, fine pores, gradual wavy boundary.
Btn_3 40-60	medium loamy clay, olive (5Y 4/3) when moist, olive (5Y 5/4) when dry, columnar (with rounded top)- prismatic structure, extremely firm when moist, extremely hard when dry, iron and manganese nodules, rare and fine roots, fine pores, plastic, very compact, very sticky, gradual wavy boundary.
BCn 60-80	medium loamy clay, dark olive gray (5Y 3/2) when moist, olive gray (5Y 4/2) when dry, coarse angular blocky structure, extremely firm when moist, extremely hard when dry, plastic, sticky, very compact, iron and manganese nodules fine pores, weak effervescence, gradual wavy boundary.
Cl_1n 80-116	medium loamy clay, dark brown-brown (7,5Y 4/2) when moist, dark brown-brown (7,5Y 4/4) when dry, angular blocky structure, extremely firm when moist, extremely hard when dry, iron and manganese nodules, fine pores, plastic, sticky, very compact, slightly, when moist, low effervescence, gradual wavy boundary.
Cl_2n 116-137	medium loamy clay, brown (7,5YR 5/4) when moist, light brown (7,5YR 6/4) when dry, coarse angular blocky structure, very firm when moist, very hard when dry, plastic, sticky, very compact, iron and manganese nodules, weak effervescence, gradual wavy boundary.
Cl_3n 137-158	light brown (7,5YR 6/4) when moist, light brown (7,5YR 6/4) when dry, plastic, sticky, very compact, effervescence, gradual wavy boundary.
Cl_4n 158-200	grayish brown (10YR 5/2) when moist, light brownish gray (10YR 6/2) when dry, very firm when moist, very hard when dry, plastic, sticky, moderate compact, effervescence.

Diagnostic horizons: Natric horizon, Albic horizon, Gleyic horizon

Analytical data

Genetic layer	Depth	pH (H_2O)	OC	$CaCO_3$	y1	CEC	B	Σ Salt	*ESP*
	(cm)		(%)	(%)		cmol(+) kg^{-1}	%	(%)	(%)
Ah	0-7	6.35	3.92	0	-	37.9	-	-	8.2
En	7-12	7.65	1.88	0	-	24.2	-	-	18.2
Btn_1	12-24	8.50		0	-	29.4	-	-	14.6
Btn_2	24-40	9.10		0	-	29.7	-	-	27.6
Btn_3	40-60	9.10		0	-	29.7	-	-	27.6
BCn	60-80	9.45		0	-	31.0	-	-	39.4
Cl_1n	80-116	9.30		0	-	32.7	-	-	27.5
Cl_2n	116-137	9.35		0	-	31.1	-	-	24.1
Cl_3n	137-158	9.10		0	-	33.4	-	-	17.7
Cl_4n	158-200	9.00		0	-	33.7	-	-	13.9

Genetic layer	Depth	% Sand	% Clay	Texture	Bulk Density	Field Capacity (pF 2.3)	Wilting Point (pF 4.2)	Available Water (Δ pF 2.3-pF 4.2)
	(cm)	2-0.02 mm	<0.002 mm	FAO	(g cm^{-3})	(v v^{-1} %)	(v v^{-1} %)	(v v^{-1} %)
Ah	0-7	46.5	24.6					
En	7-12	41.2	23.4					
Btn_1	12-24	42.4	33.4					
Btn_2	24-40	33.1	36.0					
Btn_3	40-60	33.1	36.0					
BCn	60-80	34.6	37.7					
Cl_1n	80-116	37.5	35.1					
Cl_2n	116-137	38.6	37.2					
Cl_3n	137-158	33.3	38.8					
Cl_4n	158-200	39.5	38.3					

Abbreviations: *WRB-World Reference Base, ST-Soil Taxonomy, SRTS,2003-Romanian Soil Taxonomy, OC-Organic Carbon, y1-hydrolytic acidity, CE -Cation Exchange Capacity, B% -Base Saturation, ESP-Exchangeable Sodium Percentage*

Indicators for salt affected soils
OF Profile No. 14 Cefa

HORIZON	**UM**	**Ah**	**En**	**Btn_1**	**Btn_2**	**BCn**	**Cl_1n**	**Cl_2n**	**Cl_3n**	**Cl_4n**
HORIZON DEPTH	**cm**	**0-7**	**7-12**	**12-24**	**24-40**	**60-80**	**80-116**	**116-137**	**137-158**	**158-200**
TSC	mg/100g sol	0.074	0.990	0.136	0.491	0.290	0.147	0.110	0.095	0.097
ESP	% of CEC	8.2	18.2	14.6	27.6	39.4	27.5	24.1	17.7	13.9
SAR	-	8.0	17.0	12.5	26.0	46.2	26.0	23.0	15.5	12.0
pH in water	-	6.35	7.65	8.50	9.10	9.45	9.30	9.35	9.10	9.00

* *TSC = Total salt content.*
** *ESP = Exchangeable Na percentage.*
*** *SAR = Sodium adsorption ratio: was estimated from the diagram of SAR-ESP correlation.*

Profile-15: *Salonta region*

Gleyic Solonetz (WRB)

*(**Solonet Gleic**) (SRTS, 2003)*

Elevation = 100 m

Topography: **Flat**
Landform: **Riverine plain**
Land use: **Pasture**
Vegetation: *Puccinellia distans, Artemisia maritima, Statice gmelini*

Annual precipitation = 589,2 mm
Aridity index = 1.3 -1.38
Temperature regime: **Mesic**
Soil moisture regime: **Ustic**
Parent material: **Riverine deposits**
Depth of the ground water table: **100-200 cm**

Profile Description

An **0-16**	medium loam, grayish brown (10YR 5/2) when moist, light brownish gray (10YR 6/2) when dry, fine granular structure, firm when moist, hard when dry, plastic, sticky, slightly compact, when dry, strong effervescence, clear boundary.
Btn_1 16-46	medium loamy clay, dark brown (10YR 3/3) when moist, dark yellowish brown (10YR 4/3) when dry, columnar structure, firm when moist, hard when dry, plastic, sticky, slightly when moist, strong effervescence, clear boundary.
Btn_2 46-97	medium loamy clay, dark yellowish brown (10YR 4/4) when moist, yellowish brown (10YR 5/4) when dry, medium angular blocky, firm when moist, hard when dry, plastic, sticky, moderate compact, strong effervescence, smooth boundary.
Cln 97-160	sandy clay, dark yellowish brown (10YR 4/4) when moist, yellowish brown (10YR 5/6) when dry, medium subangular blocky structure, firm when moist, hard when dry, plastic, sticky when moist, strong effervescence, smooth boundary.

Diagnostic horizons: Natric horizon, Gleyic horizon

Analytical data

Genetic layer	Depth	pH (H_2O)	OC	$CaCO_3$	y1	CEC	B	Σ Salt	ESP
	(cm)		(%)	(%)		cmol(+) kg^{-1}	%	(%)	(%)
An	**0-16**	8.65	1.30	0.3	-	16.0	100	0.075	16.0
Btn_1	16-46	9.80	0.62	2.0	-	12.9	100	0.167	12.9
Btn_2	46-97	10.05		1.1	-	23.0	100	0.193	23.0
Cln	97-160	9.95		6.1	-	24.2	100	0.192	24.2

Genetic layer	Depth	% Sand	% Clay	*Texture*	Bulk Density	Field Capacity (pF 2.3)	Wilting Point (pF 4.2)	Available Water (Δ pF 2.3-pF 4.2)
	(cm)	2-0.02 mm	<0.00 2 mm	FAO	(g cm^{-3})	(v v^{-1} %)	(v v^{-1} %)	(v v^{-1} %)
An	**0-16**	43.1	26.8					
Btn_1	16-46	48.1	31.8					
Btn_2	46-97	47.4	38.3					
Cln	97-160	52.2	34.4					

Abbreviations: *WRB-World Reference Base, ST-Soil Taxonomy, SRTS,2003-Romanian Soil Taxonomy, OC-Organic Carbon, y1-hydrolytic acidity, CE -Cation Exchange Capacity, B% -Base Saturation, ESP-Exchangeable Sodium Percentage*

Indicators for salt affected soils
OF Profile No. 15 SALONTA

HORIZON **HORIZON DEPTH**	**UM** **cm**	**An** **0-16**	**Btn_1** **16-46**	**Btn_2** **46-97**	**Cln** **97-160**
TSC	mg/100g sol	0,075	0,167	0,193	0.192
ESP	% of CEC	16.0	12.9	23.0	24.2
SAR	-	13.5	11.0	21.0	22.0
pH in water	-	8.65	9.80	10.05	9.95

* *TSC = Total salt content.*
** *ESP = Exchangeable Na percentage.*
*** *SAR = Sodium adsorption ratio: was estimated from the diagram of SAR-ESP correlation.*

Profile-16: *Salonta region*

Gleyic Solonetz Abruptic (WRB)

*(**Solonet Gleic**) (SRTS, 2003)*

Elevation = 100 m

Topography: **Flat**
Landform: **Riverine plain**
Land use: **Pasture**
Vegetation: *Puccinellia distans, Festuca pseudovina, Poa bulbosa*

Annual precipitation = 589,2 mm
Aridity index = 1.3 -1.38
Temperature regime: **Mesic**
Soil moisture regime: **Ustic**
Parent material: **Riverine deposits**
Depth of the ground water table: **150-200 cm**

Profile Description

A **0-9**	silty loam, grayish brown (10YR 5/2) when moist, light brownish gray (10YR 6/2) when dry, small granular structure, firm when moist, plastic, sticky, slightly compact, when dry, clear boundary.
E 9-18	silty loam, dark grayish brown (10YR 4/2) when moist, grayish brown (10YR 5/2) when dry, granular, silty, firm when moist, hard when dry, plastic, sticky, moderate compact, when dry, clear boundary.
Btn 18-39	medium loamy clay, dark brown (10YR 4/3) when moist, brown (10YR 5/3) when dry, columnar structure, firm when moist, hard when dry, plastic, sticky, very compact, slightly when moist, strong effervescence, clear boundary.
BCln 39-80	medium loamy clay, dark yellowish brown (10YR 4/4) when moist, yellowish brown (10YR 5/4) when dry, medium angular blocky structure, firm when moist, hard when dry, plastic, sticky, very compact, strong effervescence, smooth boundary.
Cln 80-110	medium loamy clay, dark yellowish brown (10YR 4/4) when moist, yellowish brown (10YR 5/6) when dry, wet, medium angular blocky, firm when moist, hard when dry, plastic, sticky, moderate compact, strong effervescence, smooth boundary.

Diagnostic horizons: Natric horizon, Gleyic horizon

Analytical data

Genetic layer	Depth	pH (H_2O)	OC	$CaCO_3$	y1	CEC	B	Σ Salt	ESP
	(cm)		(%)	(%)		cmol(+) kg^{-1}	%	(%)	(%)
A	**0-9**	6.15	1.72	0	-				
E	**9-18**	6.95	1.22	0	-			0.052	
Btn	18-39	9.60		0.7	-	39.0	100	0.152	27.4
BCln	39-80	10.00		7.0	-	36.0	100	0.203	25.0
Cln	80-110	9.90		11.9	-	36.0	100	0.152	28.9

Genetic layer	Depth	% Sand	% Clay	Texture	Bulk Density	Field Capacity (pF 2.3)	Wilting Point (pF 4.2)	Available Water (Δ pF 2.3-pF 4.2)
	(cm)	2-0.02 mm	<0.002 mm	FAO	(g cm^{-3})	(v v^{-1} %)	(v v^{-1} %)	(v v^{-1} %)
A	**0-9**	43.1	26.8					
E	**9-18**	35.0	28.0					
Btn	18-39	35.5	45.2					
BCln	39-80	34.0	44.4					
Cln	80-110	40.9	38.6					

Abbreviations: *WRB-World Reference Base, ST-Soil Taxonomy, SRTS,2003-Romanian Soil Taxonomy, OC-Organic Carbon, y1-hydrolytic acidity, CE -Cation Exchange Capacity, B% -Base Saturation, ESP-Exchangeable Sodium Percentage*

Indicators for salt affected soils
OF Profile No. 16 SALONTA

HORIZON HORIZON DEPTH	UM cm	A 0-9	E 9-18	Btn 18-39	BCln 39-80	Cln 80-110
TSC	mg/100g sol		0.052	0.152	0.203	0.152
ESP	% of CEC			27.4	25.0	28.9
SAR	-			26.0	24.0	28.0
pH in water	-	6.15	6.95	9.60	10.00	9.90

** TSC = Total salt content.*
*** ESP = Exchangeable Na percentage.*
**** SAR = Sodium adsorption ratio: was estimated from the diagram of SAR-ESP correlation.*

Profile-17: *Salonta region*

Gleyic Solonetz (WRB)

*(**Solonet Gleic**) (SRTS, 2003)*

Elevation = 100 m

Topography: **Flat**
Landform: **Riverine plain**
Land use: **Pasture**
Vegetation: *Puccinellia distans, Poa pratensis, Statice gmelini*

Annual precipitation = 589,2 mm
Aridity index = 1.3 -1.38
Temperature regime: **Mesic**
Soil moisture regime: **Ustic**
Parent material: **Riverine deposits**
Depth of the ground water table: **150-200 cm**

Profile Description

A **0-10**	silty clay, grayish brown (10YR 5/2) when moist, light grayish brown (10YR 6/2) when dry, small granular structure, very firm when moist, very hard when dry, very plastic, very sticky, moderate compact, when dry, clear boundary.
Btn 10-28	silty clay, brown (10YR 5/3) when moist, pale brown (10YR 6/3) when dry, columnar structure, very firm when moist, very hard when dry, very plastic, very sticky, very compact, when dry, weak effervescence, clear boundary.
Cnz 28-50	medium clay, dark yellowish brown (10YR 4/4) when moist, yellowish brown (10YR 5/4) when dry, medium subangular blocky structure, very firm when moist, very hard when dry, very plastic, very sticky, very compact, slightly when moist, weak effervescence, smooth boundary.
Clnz 50-76	medium clay, dark brown-brown (10YR 4/3) when moist, brown (10YR 5/3) when dry, silty clay, medium subangular blocky structure, very firm when moist, very hard when dry, very plastic, very sticky, very compact when moist, weak effervescence.

Diagnostic horizons: Natric horizon, Gleyic horizon

Analytical data

Genetic layer	Depth	pH (H_2O)	OC	$CaCO_3$	y1	CEC	B	Σ Salt	*ESP*
	(cm)		(%)	(%)		cmol(+) kg^{-1}	%	(%)	(%)
A	**0-10**	7.45	1.89	0	-			0.068	
Btn	10-28	8.55	1.45	0.2	-	15.9	100	0.124	15.9
Cnz	28-50	8.80		0.8	-	11.2	100	0.317	11.2
Clnz	50-76	9.00		3.4	-	17.5	100	0.310	17.5

Genetic layer	Depth	% Sand	% Clay	Texture	Bulk Density	Field Capacity (pF 2.3)	Wilting Point (pF 4.2)	Available Water (Δ pF 2.3-pF 4.2)
	(cm)	2-0.02 mm	<0.002 mm	FAO	(g cm^{-3})	(v v^{-1} %)	(v v^{-1} %)	(v v^{-1} %)
A	**0-10**	27.9	37.2					
Btn	10-28	38.2	45.0					
Cnz	28-50	24.5	43.6					
Clnz	50-76	37.1	43.0					

Abbreviations: *WRB-World Reference Base, ST-Soil Taxonomy, SRTS,2003-Romanian Soil Taxonomy, OC-Organic Carbon, y1-hydrolytic acidity, CE -Cation Exchange Capacity, B% -Base Saturation, ESP-Exchangeable Sodium Percentage*

Indicators for salt affected soils
OF Profile No. 17 SALONTA

HORIZON HORIZON DEPTH	UM cm	A 0-10	Btn 10-28	Cnz 28-50	Clnz 50-76
TSC	mg/100g sol	0,068	0,124	0,317	0.310
ESP	% of CEC		15.9	11.2	17.5
SAR	-		13.5	9.5	15.2
pH in water	-	7.45	8.55	8.80	9.00

* *TSC = Total salt content.*
*** ESP = Exchangeable Na percentage.*
**** SAR = Sodium adsorption ratio: was estimated from the diagram of SAR-ESP correlation.*

Profile-18: *Salonta region*

Vertic Solonetz (WRB)

*(**Solonet Pelic**) (SRTS, 2003)*

Elevation = 100 m

Topography: **Flat**
Landform: **Riverine plain**
Land use: **Pasture**
Vegetation: *Puccinellia distans, Festuca pseudovina, Artemisia maritima*

Annual precipitation = 589,2 mm
Aridity index = 1.3 -1.38
Temperature regime: **Mesic**
Soil moisture regime: **Ustic**
Parent material: **Riverine deposits**
Depth of the ground water table: **150 – 200 cm**

Profile Description

E 0-9	medium loam, grayish brown (10YR 5/2) when moist, light brownish gray (10YR 6/2) when dry, small granular structure, firm when moist, hard when dry, plastic, sticky, slightly compact when dry, clear boundary.
Btn 9-28	medium loamy clay, dark grayish brown (10YR 4/2) when moist, grayish brown (10YR 5/2) when dry, coarse columnar structure, very firm when moist, very hard when dry, plastic, sticky, moderate compact, when dry, weak effervescence, clear boundary.
BCn 28-64	loamy clay, dark brown (10YR 3/3) when moist, dark brown - brown (10YR 4/3) when dry, coarse columnar structure, very firm when moist, very hard when dry, very plastic, very sticky, moderate compact, strong effervescence, smooth boundary.
CBn 64-87	loamy clay silty, dark yellowish brown (10YR 4/4) when moist, yellowish brown (10YR 5/4) when dry, subangular blocky structure, firm when moist, hard when dry, plastic, sticky, moderate compact when moist, strong effervescence, smooth boundary.
Cln 87-130	silty clay loam, dark yellowish brown (10YR 4/4) when moist, yellowish brown (10YR 5/6) when dry, wet, structureless, firm when moist, hard when dry, plastic, sticky, moderate compact, strong effervescence.

Diagnostic horizons: Natric horizon, Vertic horizon

Analytical data

Genetic layer	Depth	pH (H_2O)	OC	$CaCO_3$	y1	CEC	B	Σ Salt	*ESP*
	(cm)		(%)	(%)		cmol(+) kg^{-1}	%	(%)	(%)
E	0-9	6.35	3.6	0	-		-	0.082	
Btn	9-28	7.45	1,6	0	-		-	0.070	
BCn	28-64	9.25	n.a	0.9	-	39.5	-	0.152	29.1
CBn	64-87	9.45	n.a	0.2	-	37.0	-	0.132	33.5
Cln	87-130	9.40		7.9	-	31.0	-	0.140	20.3

Genetic layer	Depth	% Sand	% Clay	Texture	Bulk Density	Field Capacity (pF 2.3)	Wilting Point (pF 4.2)	Available Water (Δ pF 2.3-pF 4.2)
	(cm)	2-0.02 mm	<0.002 mm	FAO	(g cm^{-3})	(v v^{-1} %)	(v v^{-1} %)	(v v^{-1} %)
E	0-9	47.0	23.5					
Btn	9-28	37.1	39.1					
BCn	28-64	31.7	48.6					
CBn	64-87	26.6	46.6					
Cln	87-130	24.4	38.9					

Abbreviations: *WRB-World Reference Base, ST-Soil Taxonomy, SRTS,2003-Romanian Soil Taxonomy, OC-Organic Carbon, y1-hydrolytic acidity, CE -Cation Exchange Capacity, B% -Base Saturation, ESP-Exchangeable Sodium Percentage*

Indicators for salt affected soils
OF Profile No. 18 SALONTA

HORIZON **HORIZON DEPTH**	**UM** **cm**	**E** **0-9**	**Btn** **9-28**	**BCn** **28-64**	**CBn** **64-87**	**Cln** **87-130**
TSC	mg/100g sol	0.0082	0.070	0.152	0.132	0.140
ESP	% of CEC			29.1	33.5	20.3
SAR	-			28.0	36.0	18.0
pH in water	-	6.35	7.45	9.25	9.45	9.40

* *TSC = Total salt content.*
** *ESP = Exchangeable Na percentage.*
*** *SAR = Sodium adsorption ratio: was estimated from the diagram of SAR-ESP correlation.*

Profile-19: *Salonta region*

Vertic Abruptic Solonetz (WRB)

*(**Solonet Gleic**) (SRTS, 2003)*

Elevation = 100 m

Topography: **Flat**
Landform: **Riverine plain**
Land use: **Pasture**
Vegetation: *Poa pratensis, Puccinellia distans, Festuca pseudovina*

Annual precipitation = 589,2 mm
Aridity index = 1.3 -1.38
Temperature regime: **Mesic**
Soil moisture regime: **Ustic**
Parent material: **Riverine deposits**
Depth of the ground water table: **150-200 cm**

Profile Description

A **0-7**	medium loam, grayish brown (10YR 5/2) when moist, light brownish gray (10YR 6/2) when dry, small granular structure, firm when moist, hard when dry, plastic, sticky, slightly compact, when dry, clear boundary.
Btn_1 7-41	loamy clay, dark brown (10YR 3/3) when moist, dark brown-brown (10YR 4/3) when dry, coarse columnar structure, very firm when moist, very hard when dry, very plastic, very sticky, very compact when dry, clear boundary, weak effervescence, gradual wavy boundary.
Btn_2 41-113	loamy clay, dark yellowish brown (10YR 3/4) when moist, dark yellowish brown (10YR 4/4) when dry, poliedric subangular structure, very firm when moist, very hard when dry, very plastic, very sticky, very compact when moist, smooth boundary, weak effervescence, gradual wavy boundary.
Cln 113-150	medium loamy clay, dark yellowish brown (10YR 4/4) when moist, yellowish brown (10YR 5/6) when dry, structureless, firm when moist, hard when dry, plastic, sticky, moderate compact, wet, smooth boundary, strong effervescence.

Diagnostic horizons: Natric horizon, Vertic horizon,

Analytical data

Genetic layer	Depth	pH (H_2O)	OC	$CaCO_3$	y1	CEC	B	Σ Salt	*ESP*
	(cm)		(%)	(%)		cmol(+) kg^{-1}	%	(%)	(%)
A	**0-7**	6.55	3.21	0	-			0.570	
Btn_1	7-41	8.60	1.55	0.1	-	6.4	100	0.113	6.4
Btn_2	41-113	9.10		0.8	-	25.4	100	0.378	25.4
Cln	113-150	9.50		9.4	-	20.9	100	0.157	20.9

Genetic layer	Depth	% Sand	% Clay	Texture	Bulk Density	Field Capacity (pF 2.3)	Wilting Point (pF 4.2)	Available Water (Δ pF 2.3-pF 4.2)
	(cm)	2-0.02 mm	<0.002 mm	FAO	(g cm^{-3})	(v v^{-1} %)	(v v^{-1} %)	(v v^{-1} %)
A	**0-7**	42.5	26.6					
Btn_1	7-41	31.5	47.5					
Btn_2	41-113	26.0	51.8					
Cln	113-150	25.5	45.1					

Abbreviations: *WRB-World Reference Base, ST-Soil Taxonomy, SRTS,2003-Romanian Soil Taxonomy, OC-Organic Carbon, y1-hydrolytic acidity, CE -Cation Exchange Capacity, B% -Base Saturation, ESP-Exchangeable Sodium Percentage*

Indicators for salt affected soils
OF Profile No. 19 SALONTA

HORIZON HORIZON DEPTH	UM cm	A 0-7	Btn_1 7-41	Btn_2 41-113	Cln 113-150
TSC	mg/100g sol	0,570	0,113	0,378	0.157
ESP	% of CEC		6.4	25.4	20.9
SAR	-		7.0	22.0	19.0
pH in water	-	6.55	8.60	9.10	9.50

* *TSC = Total salt content.*
** *ESP = Exchangeable Na percentage.*
*** *SAR = Sodium adsorption ratio: was estimated from the diagram of SAR-ESP correlation.*

Profile-20: *Cefa village*

Gleyic Abruptic Solonetz (WRB)

*(**Solonet Gleic**) (SRTS, 2003)*

Elevation = 100 m

Topography: **Flat**
Landform: **Riverine plain**
Land use: **Pasture**
Vegetation: *Puccinellia distans, Poa pratensis, Festuca pseudovina*

Annual precipitation = 589,2 mm
Aridity index = 1.3 -1.38
Temperature regime: **Mesic**
Soil moisture regime: **Ustic**
Parent material : clay
Depth of the ground water table: **200 cm**

Profile Description

A 0-9	fine sandy loam, grayish brown (10YR 5/2) when moist, light brownish gray (10YR 6/2) when dry, fine granular structure, firm when moist, medium cohesive when dry, slightly plastic, slightly sticky, slightly compact when dry, clear boundary.
E 9-21	fine sandy loam, brown (10YR 5/3) when moist, pale brown (10YR 6/3) when dry, fine granular structure, firm when moist, medium cohesive when dry, slightly plastic, slightly sticky, moderate compact, when dry, clear boundary.
Bt_1n 21-44	medium loamy clay, yellowish brown (10YR 5/4) when moist, light yellowish brown (10YR 6/4) when dry, angular blocky structure, firm when moist, hard when dry, plastic, sticky, moderate compact, slightly when moist, weak effervescence, smooth boundary.
Bt_2n 44-75	medium loamy clay, dark yellowish brown (10YR 4/4) when moist, yellowish brown (10YR 5/4) when dry, medium subangular blocky structure, firm when moist, hard when dry, plastic, sticky, moderate compact, weak effervescence, smooth boundary.
BCn 75-110	medium loamy clay, dark yellowish brown (10YR 4/4) when moist, yellowish brown (10YR 5/6) when dry, subangular blocky structure, firm when moist, hard when dry, plastic, sticky, moderate compact when moist, weak effervescence, smooth boundary.
Cln 110-150	dark yellowish brown (10YR 4/4) when moist, yellowish brown (10YR 5/8) when dry, structureless, $CaCO_3$ concretions.

Diagnostic horizons: Natric horizon, Gleyic horizon

Analytical data

Genetic layer	Depth	pH (H_2O)	OC	$CaCO_3$	y1	CEC	B	Σ Salt	*ESP*
	(cm)		(%)	(%)		cmol(+) kg^{-1}	%	(%)	(%)
A	0-9	6.10	1.45	0	-		-	0.018	
E	9-21	6.75	0.84	0	-		-	0.025	
Bt_1n	21-44	8.75	0.42	2.0	-	30.0	-	0.124	12.3
Bt_2n	44-75	9.60	n.a	3.0	-	30.0	-	0.216	21.0
BCn	75-110	9.70		3.8	-	30.0	-	0.170	16.0

Genetic layer	Depth	% Sand	% Clay	Texture	Bulk Density	Field Capacity (pF 2.3)	Wilting Point (pF 4.2)	Available Water (Δ pF 2.3-pF 4.2)
	(cm)	2-0.02 mm	<0.002 mm	FAO	(g cm^{-3})	(v v^{-1} %)	(v v^{-1} %)	(v v^{-1} %)
A	0-9	54.9	16.1		1.42			
E	9-21	55.4	14.6		1.46			
Bt_1n	21-44	41.8	36.0		1.54			
Bt_2n	44-75	38.6	38.6		1.65			
BCn	75-110	44.3	32.9		1.60			

Abbreviations: *WRB-World Reference Base, ST-Soil Taxonomy, SRTS,2003-Romanian Soil Taxonomy, OC-Organic Carbon, y1-hydrolytic acidity, CE -Cation Exchange Capacity, B% -Base Saturation, ESP-Exchangeable Sodium Percentage*

Indicators for salt affected soils
OF Profile No. 20 SALONTA

HORIZON **HORIZON DEPTH**	**UM** **cm**	**A** **0-9**	**E** **9-21**	**Bt_1n** **21-44**	**Bt_2n** **44-75**	**BCn** **75-110**	**Cln** **110-150**
TSC	mg/100g sol	0.018	0.025	0.124	0.216	0.174	
ESP	% of CEC			12.3	21.0	16.0	
SAR	-			10.5	19.0	13.5	
pH in water	-	6.10	6.75	8.75	9.60	9.70	9.30

* *TSC = Total salt content.*
*** ESP = Exchangeable Na percentage.*
**** SAR = Sodium adsorption ratio: was estimated from the diagram of SAR-ESP correlation.*

Profile-21: *Mădăraş village*

Salic Solonetz (WRB)

*(**Solonet Salinic**) (SRTS,2003)*

Location:'
Elevation = 100 m
Topography: **Flat**
Landform: **Riverine plain**
Land use: **Pasture**
Vegetation: *Puccinelia distans, Festuca pseudovina, Artemisia maritima*

Annual precipitation = 589,2 mm
Aridity index =
Temperature regime: **Mesic**
Soil moisture regime: **Ustic**
Parent material : riverine deposits
Depth of the ground water table: **150 – 200 cm**

Profile Description

A 0-12	medium loam, light brownish gray (10YR 6/2) when moist, light gray (10YR 7/2) when dry, dry, very friable granular structure, firm when moist, powdery when dry, moderate plastic, moderate sticky, moderate compact, sharp wavy boundary.
$Btnz_1$ 12-40	medium loam, dark brown (10YR 3/3) when moist, brown (10YR 5/3) when dry, dry, columnar structure, very firm when moist, very hard when dry, very plastic, very sticky, very compact when dry, rare fine roots, wavy boundary.
$Btnz_2$ 40-72	medium loam, brown (10YR 5/3) when moist, yellowish brown (10YR 5/4) when dry, columnar structure, very firm when moist, very hard when dry, very plastic, very sticky, very compact, smooth boundary.
BCnlz 72-98	medium sandy loam, yellowish brown (10YR 5/4) when moist, light yellowish brown (10YR 6/4) when dry, slight moist, subangular blocky structure, firm when moist, hard when dry, moderate plastic, moderate sticky, moderate compact when moist, smooth boundary.
Cnlz 98-130	medium sandy loam, olive (5Y 4/3) when moist, olive (5Y 5/4) when dry, slight moist, subangular blocky structure, firm when moist, hard when dry, moderate plastic, moderate sticky, moderate compact.

Diagnostic horizons: **Natric horizon, Salic horizon**

Analytical data

Genetic layer	Depth	pH (H_2O)	OC	$CaCO_3$	y1	CEC	B	Σ Salt	*ESP*
	(cm)		(%)	(%)		cmol(+) kg^{-1}	%	(%)	(%)
A	0-12	6.10	1.91	0	-				
$Btnz_1$	12-40	6.75	0.91	0	-	23.50		0.160	13.06
$Btnz_2$	40-72	8.75	0.54	0	-	26.11		0.140	15.70
BCnlz	72-98	9.60		0	-	25.24		0.090	11.50
Cnlz	98-130	9.70		0		26.11		0.110	10.20

Genetic layer	Depth	% Sand	% Clay	*Texture*	Bulk Density	Field Capacity (pF 2.3)	Wilting Point (pF 4.2)	Available Water (Δ pF 2.3-pF 4.2)
	(cm)	2-0.02 mm	<0.002 mm	FAO	(g cm^{-3})	(v v^{-1} %)	(v v^{-1} %)	(v v^{-1} %)
A	0-12	44.7	31.6					
$Btnz_1$	12-40	43.4	31.5					
$Btnz_2$	40-72	42.7	29.4					
BCnlz	72-98	60.6	19.3					
Cnlz	98-130	58.2	19.5					

Abbreviations: *WRB-World Reference Base, ST-Soil Taxonomy, SRTS,2003-Romanian Soil Taxonomy, OC-Organic Carbon, y1-hydrolytic acidity, CE -Cation Exchange Capacity, B% -Base Saturation, ESP-Exchangeable Sodium Percentage*

Indicators for salt affected soils
OF Profile No. 21 Mădăraş

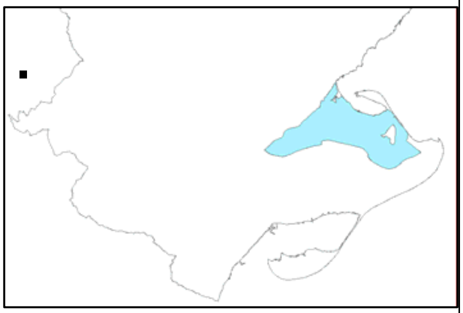
HORIZON **HORIZON DEPTH**	**UM** **cm**	**A**	**$Btnz_1$**	**$Btnz_2$**	**BCnlz**	**Cnlz**
TSC	mg/100g sol	0.000	0.160	0.140	0.090	0.11
ESP	% of CEC		13.06	15.70	11.50	10.20
SAR	-					
pH in water	-	6.10	6.75	8.75	9.60	9.70

* *TSC = Total salt content.*
** *ESP = Exchangeable Na percentage.*
*** *SAR = Sodium adsorption ratio: was estimated from the diagram of SAR-ESP correlation.*

Pilot area: Northern bank of Ebro Delta, Spain

Lead Partner: SARA, Spain (Jaume Boixadera)
RISSAC, Hungary (George Varallyay)
ICPA, Romania (Mihail Dumitru)

Description of the Pilot area

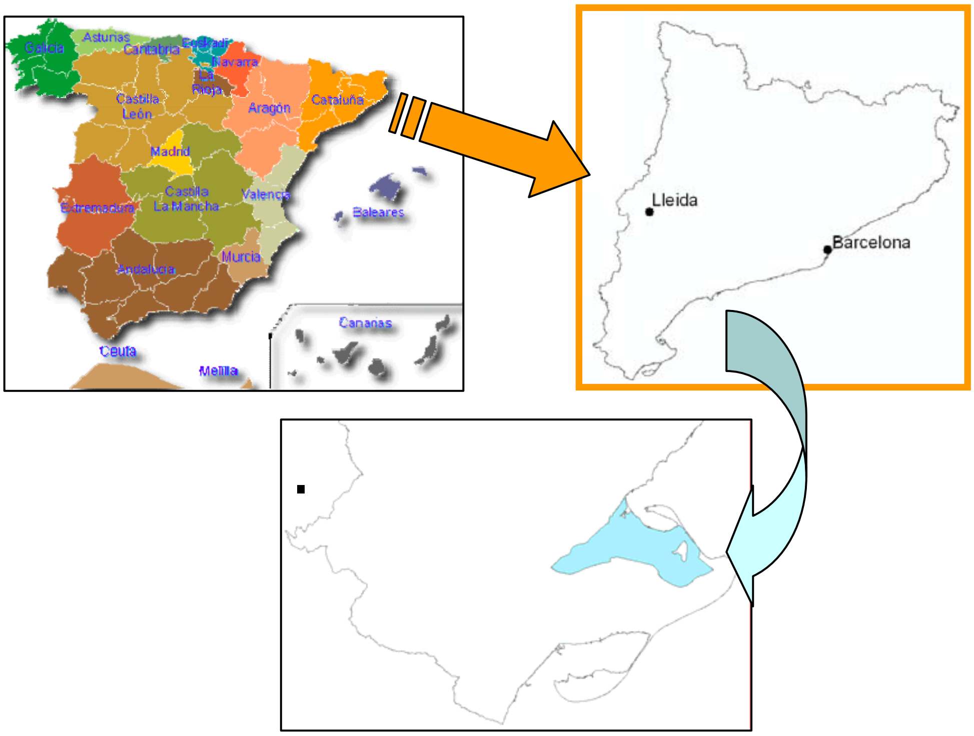
Name of pilot area		Northern bank of Ebro Delta
Names of participating partners	**Lead partner**	**SARA, Spain (Jaume Boixadera)**
	Partner A	RISSAC, Hungary (George Varallyay)
	Partner B	ICPA, Romania (Mihail Dumitru)
Description of the Pilot Area		
Location and description	Member State(s)	Catalonia (Spain)
	Coordinates	X_{min}: 0º 34' 49'' Y_{min}: 40º 33' 16'' X_{max}: 0º 52' 49,2''Y_{max}: 40º 48' 47,83''
	Area of pilot area (km^2) 	102 km^2 into the Mediterranean sea
	Climate	Typical Mediterranean (*Csa* according to the Köppen classification), with mild winters and warm, but not torrid, summers.
	Mean temperature	Average of 25ºC in July - August to 9ºC in January - February. Soil temperature regime: Thermic. Soil moisture regime: Xeric
	Average Annual Precipitation	530 mm
	Outline description of topography	Northern part of Ebro Delta
	Maximum elevation (m)	4,5 m
	Vegetation	In the Ebro delta the dominant vegetation is reed (*Phragmites australis*), where is an important nature protection area.
	Major Land Use	Paddy rice
	Major soils	Fluvisol calcaric, arenosol calcaric, calcisol

Threat and related indicator(s) evaluated in pilot area

Threat	Soil salinisation		
Indicator 1	SL01	Salt profile	Measures: total concentration of salts, electrical conductivity (EC) of a saturated paste or saturation extract.
Indicator 2	SL02	Exchangeable sodium percentage (ESP)	Measures: pH and ESP or SAR
Indicator 3	SL03	Potential salt sources (ground water or irrigation water) and the vulnerability of soils to salinisation/sodification	Measures: ▪ **Water**: total salt content, electrical conductivity (EC), SAR, pH ▪ **Soil**: total salt content or electrical conductivity (ECe) of the saturated paste or saturation extract, pH and SARe or ESPe

Rationale for selection of pilot area

The Ebro Delta is an important aquatic environment in the western Mediterranean. It occupies an area of 32000 ha, from which approximately 24500 ha is cultivated, divided into a northern side (left bank, our pilot area with 102 km^2) and a southern side (right bank).



The land-use system of the Ebro Delta is determined by specific land characteristics and environmental and market factors. Wetland rice cultivation is spread over the major part of the Ebro Delta. Under present conditions one rice crop per year is harvested, yielding, on average, slightly more than 6 tons per hectare of paddy rice (14% moisture)

In this zone we find threats to soil such as salinisation. Soil salinity varies among soil types. Well developed and high soils in elevation, are clearly non-saline. The non developed but well-drained soils are also non-saline. The remaining soil types, other than soils that are high in elevation with respect to the rest of the Delta and are present near the water recharge areas of adjacent uplands, have a high mean and a high intra-variability soil salinity. In this area soil salinity is due to the deltaic cycles of salts accumulation. The salinisation cycles in deltaic zones are complex because the interactions among the sea water, river water and groundwater, saline if it is associated with the sea water and non saline is it is associated with river water.

Soil Types with major extents in this area are Calcaric fluvisol, Calcaric arenosol and Calcisol.

SARA collected salinity data during the period 1994 – 1996 (first sampling) and 2007 (second sampling) under the auspices of different projects. Data was collected with an electromagnetic sensor (EMS) and calibrated with CE measures of the area. This soil data could be linked with other chemical and physical soil properties.

Indicator Evaluation

Indicator SL01. Salt profile

Pilot description

Spatial extent

The extent of the pilot area is 102 km^2 (see diagram on previous page).

Sampling design

Systematic random sampling.

Compilation of soil data and maps for the pilot area

Salinity in this pilot area has been studied 2 times, first in 1996-1997 and second one in 2007. Pilot area has been developed a systematic random sampling. The protocols established in the pilot area are detailed below.

Most plots are used to cultivate paddy rice. Samples have been analyzed in three different laboratories. Samples from 1996-1977 were analyzed in two different laboratories. For the second sampling, undertaken in 2007, all samples were analyzed in one laboratory.

Collection of soil samples in the field and measurement of the conductivity of the soil extract, $EC_{1:5}$ (of the extract in a weight ratio of 1:5) and ECe (of the extract of the saturated paste) in the laboratory is one of the methods available for salinity surveys of irrigated land. ECe is a more reliable indicator for soil salinity than $EC_{1:5}$ because the dilution is lower and the moisture content of the sample is closer to the moisture content in reality. The saturated paste method, however, is more laborious than the EC1:5. (Casanova, D., 1998). It is possible to establish a relationship (linear relationship, single regression…) between ECe and $EC_{1:5}$. The decision whether to use $EC_{1:5}$ data or EC_e and one of the possible relationships, depends on which of these models provide the best adjustment according with data. Our adjustment is detailed below.

Another method available for salinity surveys, and used in our case, is an electromagnetic induction (EM-38) sensor. The EM-sensor has become the first choice for salinity surveys in different parts of the world. Nonetheless, prior to use the SEM, a calibration of the electromagnetic sensor must be done for every field studied or area (McNeil, 1980). In each point sampled two readings were taken; one reading corresponding to the apparent electrical conductivity of the soil (ECa) from 0 – 90 cm ,and it has been measured with the axis of the magnet-coil in the horizontal configuration, and other corresponds to ECa of the soil from 0 to 190 cm depth, it has been measured with the axis of the magnet-coil in the vertical configuration (ECav). A calibration is needed in order to transform the readings of the electromagnetic sensor to ECe values (Enrique, A. *et al.* 2005). Using the ECe values and the readings of the sensor in the same point it is possible to obtain a relationship (linear relationship, single regression…).

Soil map of pilot area was created in 1997-1998 to scale 1:50000. We used some data from the soil map.

Methodology used for calculations / estimations of parameters and indicators, including interpolations.

We calculated the salt profile for every sampled point with the analytical results. To calculate the salt profile it is necessary to know the salt content of every horizon or interval of depth (0-30 cm, 30-60 cm, 60-90 cm and 90-120 cm).

Salt content of the horizon is calculated using: $HSC = \frac{ECe \cdot e}{D}$, where HSC is salt content of the horizon, ECe is electrical conductivity of the extract of saturated paste the in the horizon, e is the thickness of the horizon and D is the total depth of the profile.

Total salt content of the profile is calculated using: $PSC = \sum_{i=1}^{i=n} HSC_i$, where PSC is the salt content of the profile, HSC is the interval of salt content depth.

Definition of baselines

Soil degradation from salt accumulation, sodification, or both, is a threat or a fact in many irrigated lands. Salinisation has often been assessed from changing cropping patterns over time, and often trends in salinisation have not been quantified. (Herrero and Coveta, 2004). Long-term changes in soil salinity can be qualitatively assessed from historic records. Therefore, baselines should be defined different by specific areas depending by the records availability.

Pilot method

Two different protocols were used, one for each sampling. The first sampling was conducted during the winters of 1994 – 1996. The second sampling was conducted during the winter of 2007.

Description of working steps of the first sampling, including

Method development and application

The soil survey was conducted in three steps:

- In the various physiograhic units derived from the geological map, 80 soil pits were dug during the winter of 1994. Full profile descriptions were performed based on the SINEDARES methodology (CBDSA, 1983) and groundwater samples were taken. In addition to the morphological description of the soil horizons (described below), chemical analyses of the sampled horizons were performed. The chemical analyses have been maden by two different laboratories, one laboratory was analyzed all samples of the 1997 and 2007, and other was analyzed only sampled of 1997.

- A grid survey (500x500 m) was performed during the winters of 1995 and 1996. Augerings at each intersection point of the grid (a total of 410 auger-holes). A morphological description of the different horizons and layers was undertaken including: colour, texture, mottling, oxidation/reduction conditions, and a classification of the soil at phases of family level (SSS, 1992).

- Additional closely-spaced augering was incorporated into the sampling scheme (10% of the total data set, approximately 50 observations) to allow geostatistical treatment of the data.

- An EM sensor was used to quantify the EC of the soil. Every auger hole was measured with the EM sensor. Every fifth measurements with EM, one auger was done, and samples were taken at different depths: 0-30 cm, 30-60 cm, 60-90 cm and 90-120 cm.

Statistical and geo-statistical analysis

It has been calculated relationship with ECe and $EC_{1:5}$.

$$ECe = 7.75 \cdot EC_{1:5} - 1.62 \; \left(r^2{}_{adj} = 0.92,\; n = 55\right)$$

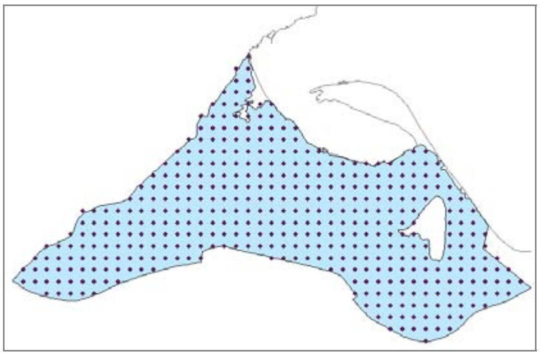
Definition and application of thresholds

The upper threshold is 4 dS m^{-1} of ECe. Soils with ECe ≥ 4 dS m^{-1} are considerate saline soils. In our pilot area soil salinity has a high variability.

Description of working steps of the second sampling, including

Method development and application (i.e. changes to WP4 procedures and protocols)

To create a grid of cells (500 x 500 m) ≈ 50 ha. A consecutive number is assigned to each node in the grid, from left to right and from top to bottom.



Electrical conductivity (EC) is measured to each sample point with the electromagnetic induction (EM) sensor. According to Pérez Coveta (2000), soil salinity is one of soil properties that changes laterally and influences on the reading of the EM sensor. Salinity can vary among near points. Drill samples could be not representative of the soil salinity in the plot. Using an EM sensor, which explores a larger soil volume than a drill and is easy and fast to use, it could obtain a larger representation of the salinity of the plot. It makes five readings in each sample point: the sampled point (C) is in exact coordinates, and other four readings are made at a distance of 2m from C in the direction of cardinal points (N, E, S, W). We recorded the location of sampled points (C) with a GPS device.

It was decided to make a total of 50 to 55 drillings to calibrate the EM sensor. Drillings are distributed proportionally in accordance with extension of superficial textures, previously calculated. To obtain a random representation of points to drill, we assigned each node its superficial texture according to the cartographic units of soil map. Points with the same superficial texture are arranged from lowest to highest number and the number of sample points is calculated.

Example:

Texture: Sandy loam

Nodes with this texture: 23

Number of drills according to superficial texture extension: 3

Interval: 23/3 ≈ 7, then it takes the first drill points which texture is “sandy loam”, and it is drilling. Following drill it will make at the eighth of the points with ArF texture, and so on.

- To drill and to take samples at different depths: 0-30 cm; 30-60 cm; 60-90 cm; 90-120 cm. In the laboratory it is analyzed: EC 1:5 and EC_e.

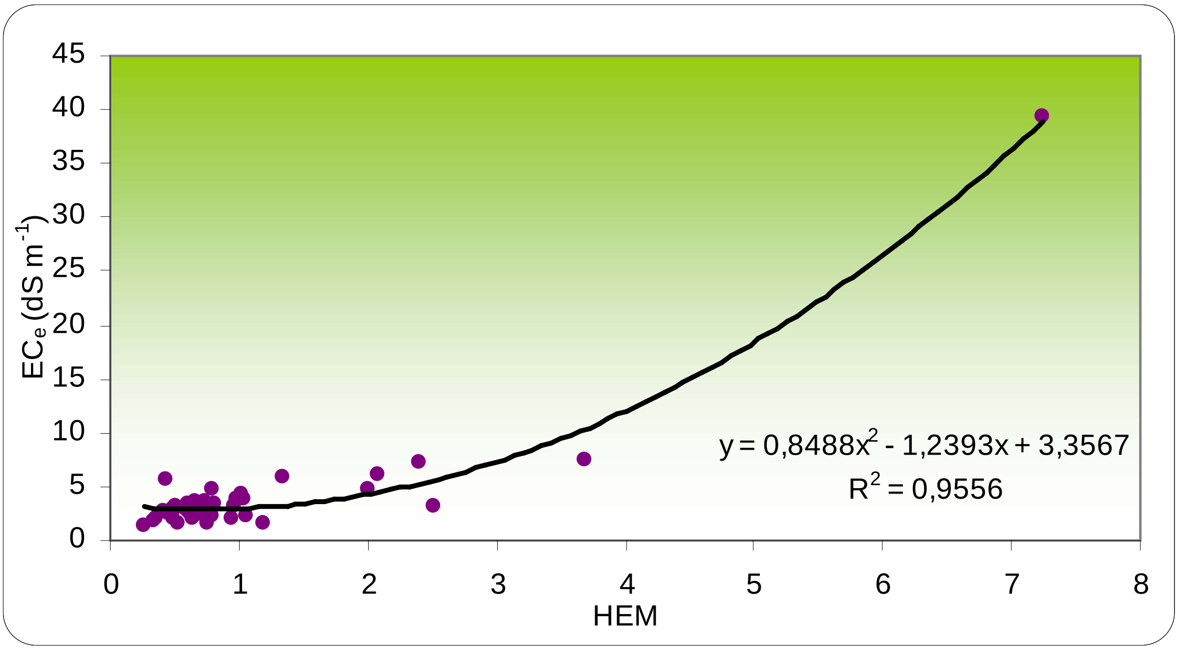
- At the end of field work, samples are sent to the laboratory to be analysed and if there are some samples left, they will be archived in our department.

- EC 1:5 and EC_e measurements are useful to calibrate EM sensor. EC_e data is more precise to calibrate it. To calibrate EM sensor it uses analysis of simple regression (SR) or the equations derived from the EM sensor design (SD) (Geonics). The decision to use EC 1:5 data o EC_e and SR or SD, depends on the model that provides the best adjustment according with data.

Statistical and geo-statistical analysis

It has been calculated the relationship of ECe and HEM (horizontal electromagnetic sensor measure) relationship. HEM is the mean of the five horizontal readings (central point, north point, eastern point, south point and western point) made in each sample point.

$$ECe = 0.8488 \cdot HEM_{1:5}^{2} - 1.2393\ HEM_{1:5} + 3.3567\ (n = 48)$$



Initial statistical analysis undertaken on data collected.

Definition and application of thresholds

The upper threshold is 4 dS m^{-1} of ECe. Soils with ECe ≥ 4 dS m^{-1} are considerate saline soils. In our pilot area soil salinity has a high variability.

Evaluation of pilot results

Feasibility and experience of applying ENVASSO procedures and protocols

It has made the following quantitative determinations to the laboratory: $pH_{1:2,5}$, $EC_{1:5}$, carbonates, then a saturated paste has been prepared and it is measured ECe, content of anions (Cl^-, SO_4^{2-}, NO_3^{2-}, NO^{2-}) and cations (Ca^{2+}, Mg^{2+}, Na^+, K^+). The laboratories apply analysis methodologies that follow the MAPA (Ministerio de agricultura, pesca y alimentación) normative.

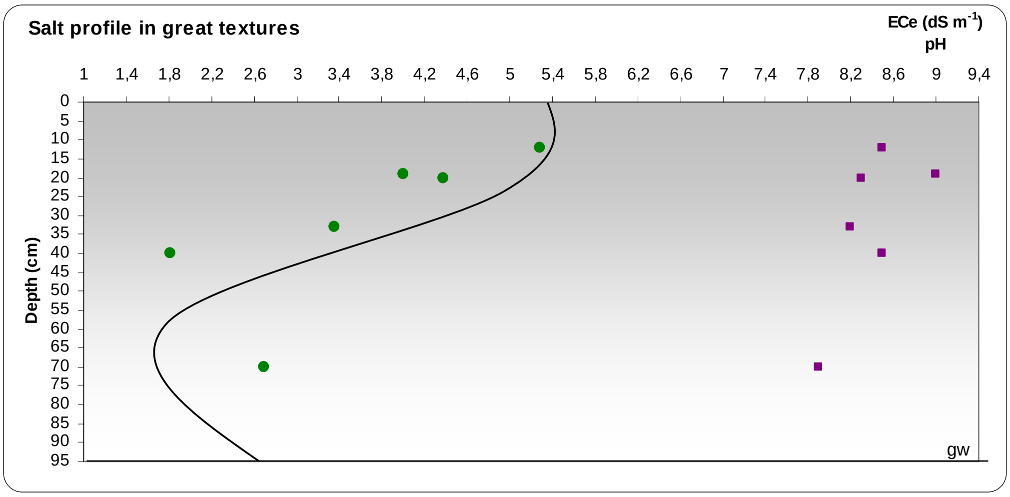
Parameter	Method
$pH_{1:2,5}$	Water solution 1:2,5
$EC_{1:5}$	Soil water extract 1:5
Carbonates	Bernard's calcimeter
ECe	Saturated paste extract
Anions (Cl^-, SO_4^{2-}, NO_3^{2-}, NO^{2-})	Ion chromatography
Cations (Ca^{2+}, Mg^{2+}, Na^+, K^+)	Atomic absorption

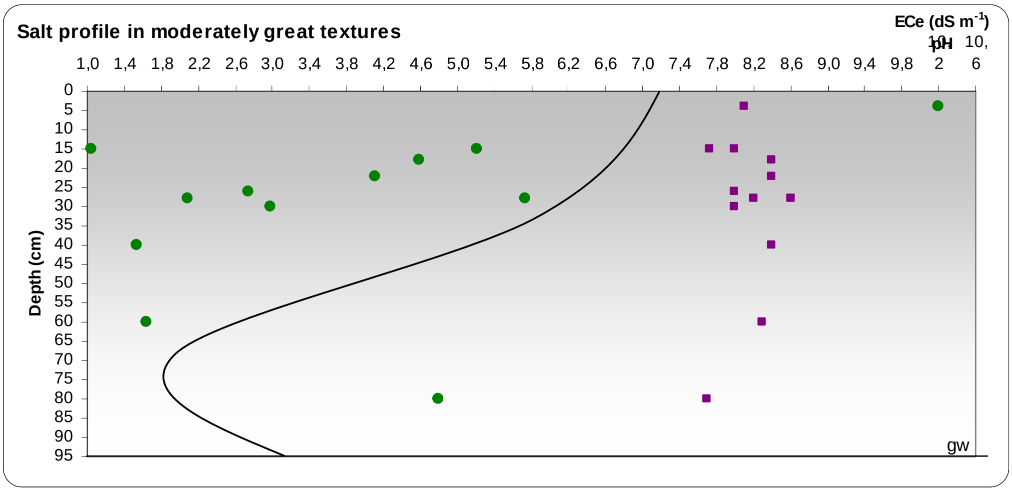
Output performance

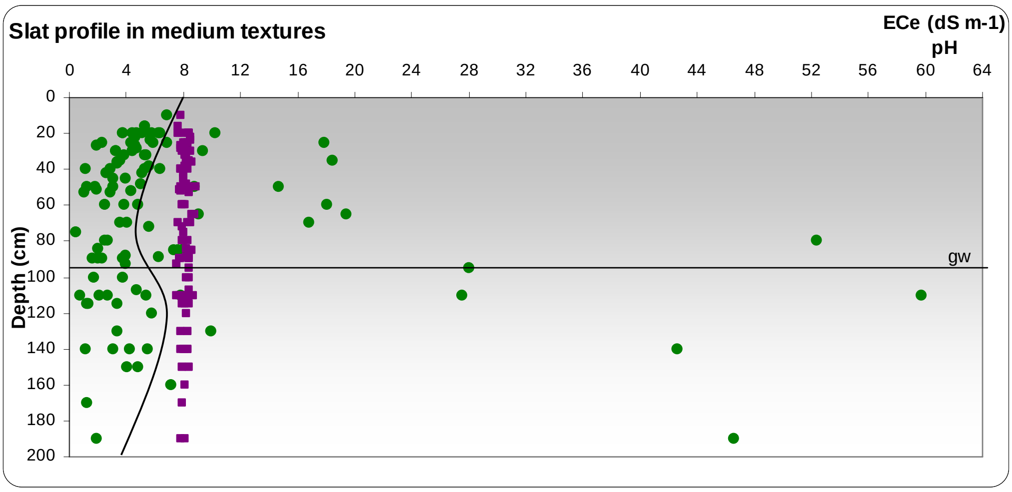
1st sample. Winters of 1994 – 1996.

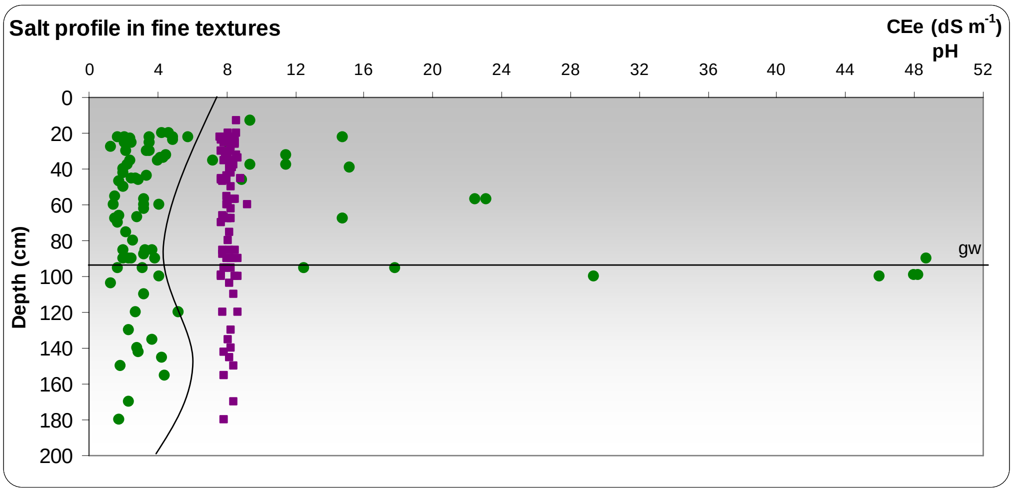
It is possible to know salt profile from ECe or $EC_{1:5}$ records available.

a.1. Salt profile depending on texture class and made from ECe records:

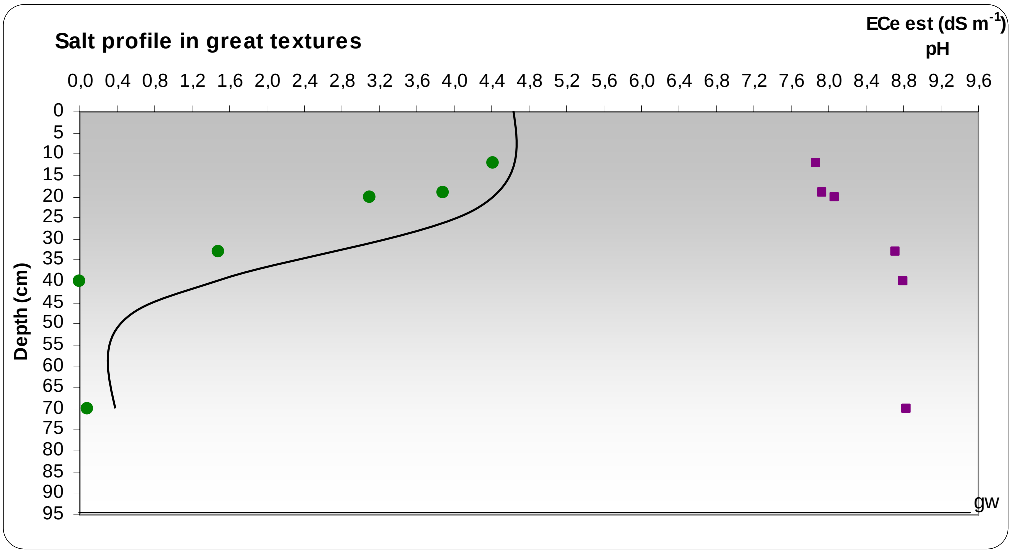


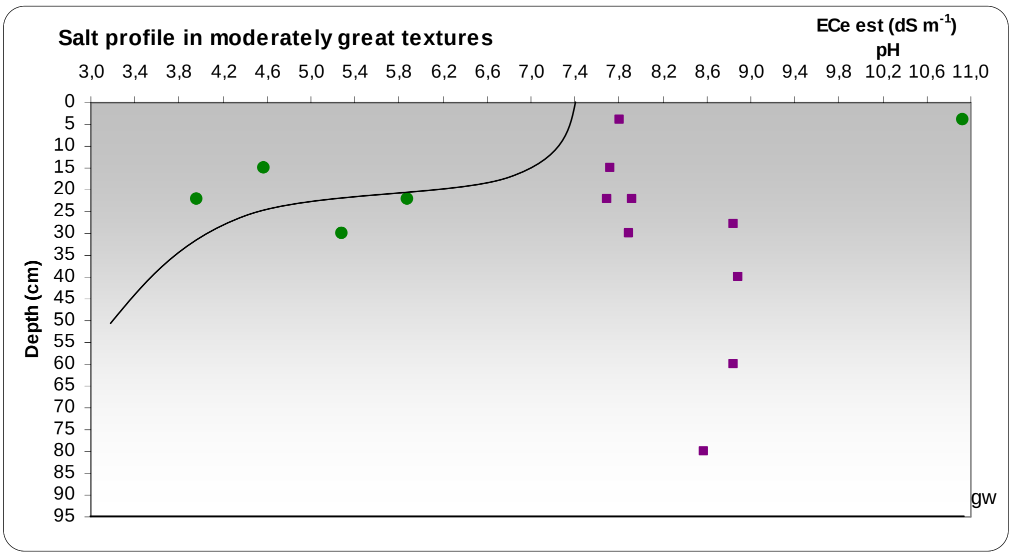


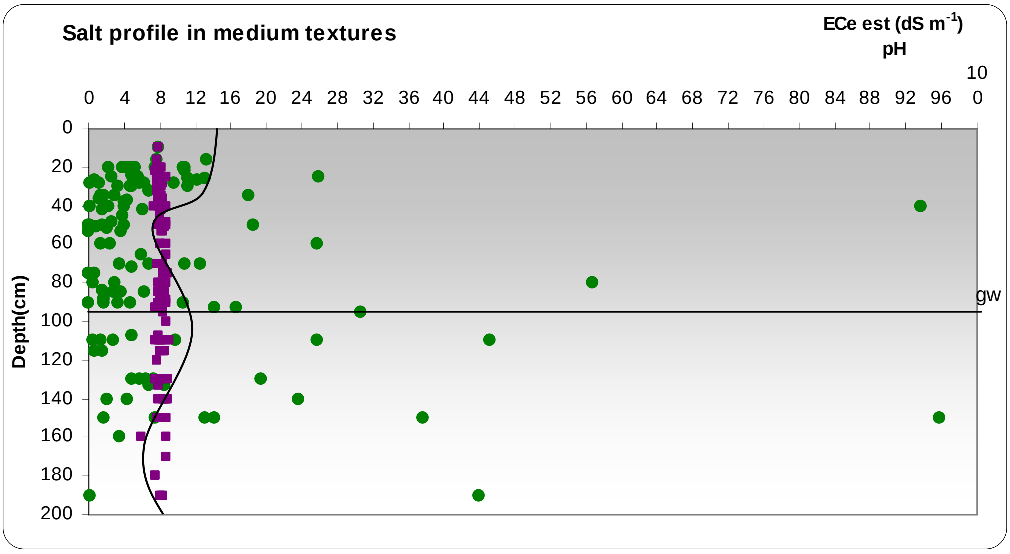


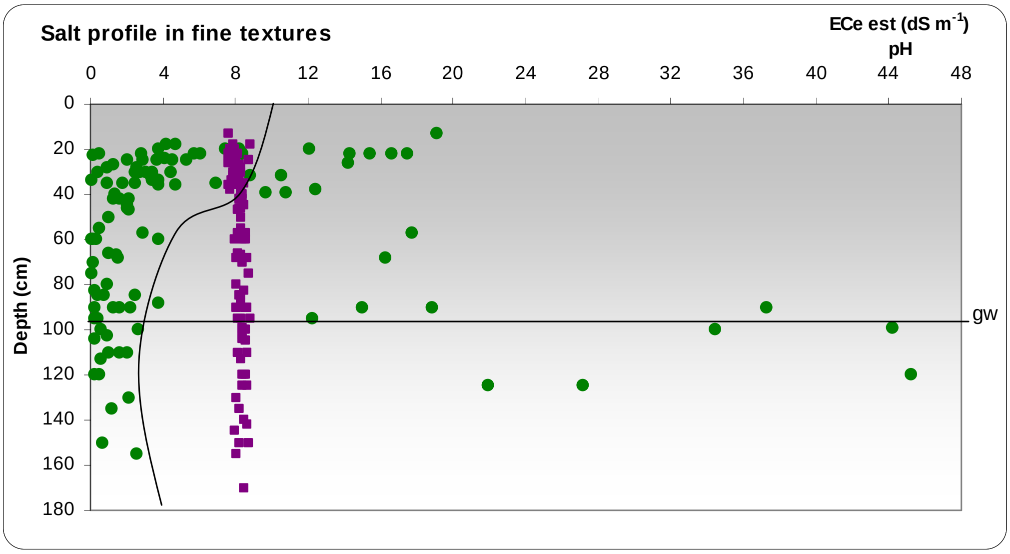


a.2. Salt profile depending on texture class and made from $EC_{1:5}$ records:





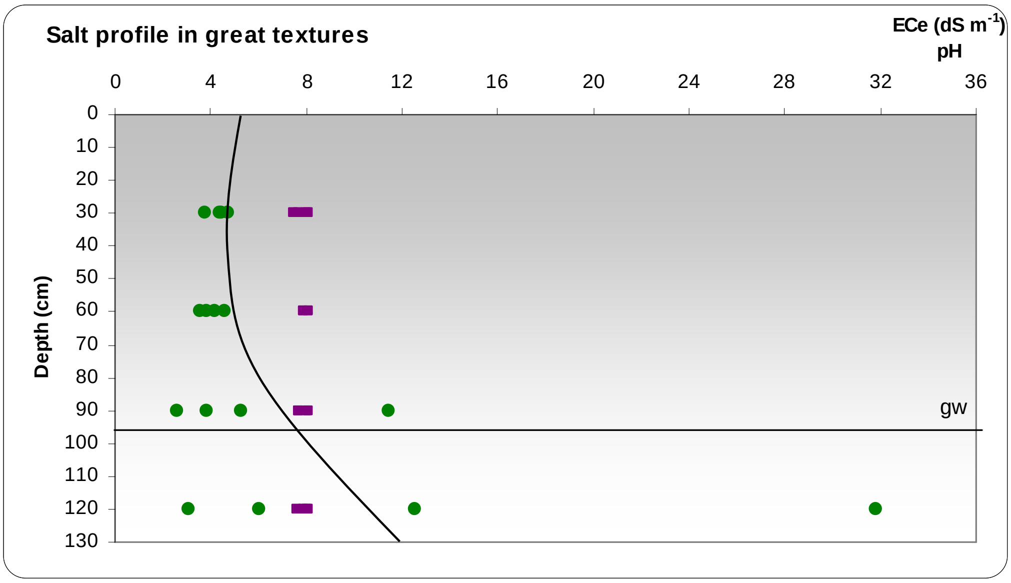

Salt profile in medium textures
ECe est (dS m-1)
pH
10
0 4 8 12 16 20 24 28 32 36 40 44 48 52 56 60 64 68 72 76 80 84 88 92 96 0
Depth(cm)
0 20 40 60 80 100 120 140 160 180 200
gw

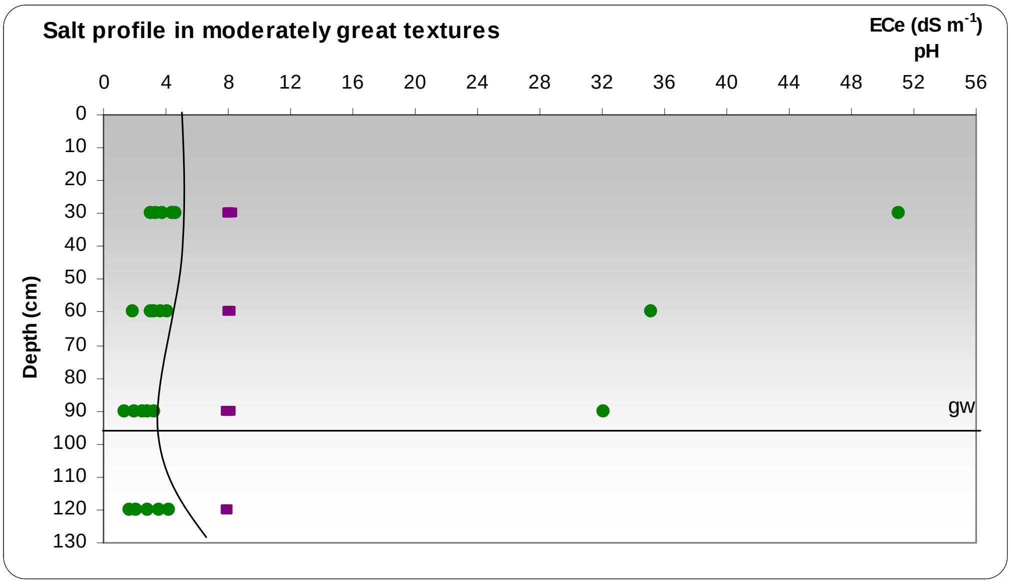

Salt profile in fine textures
ECe est (dS m-1)
pH
0 4 8 12 16 20 24 28 32 36 40 44 48
Depth (cm)
0 20 40 60 80 100 120 140 160 180
gw

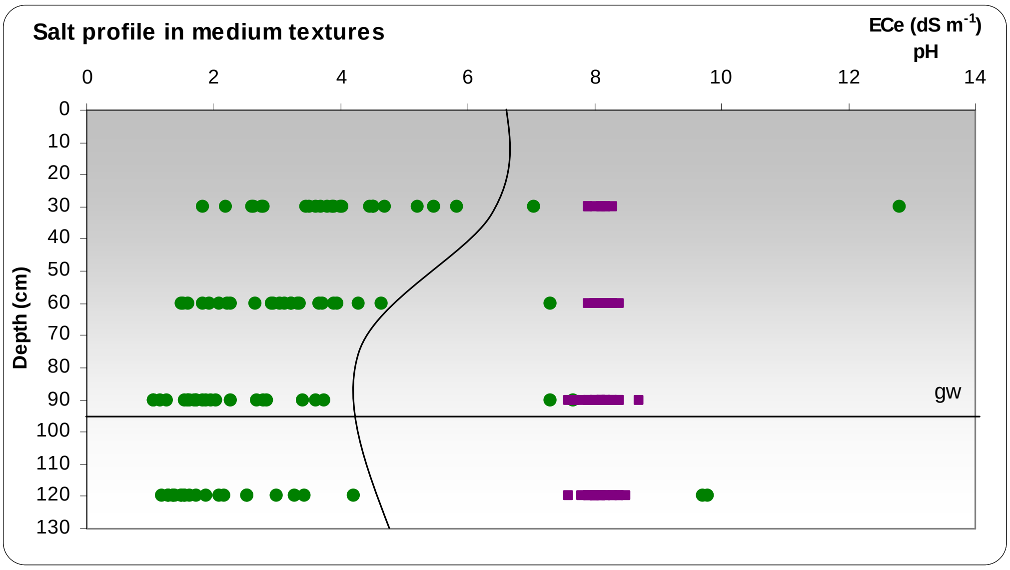
2nd sample. Winter of 2007.

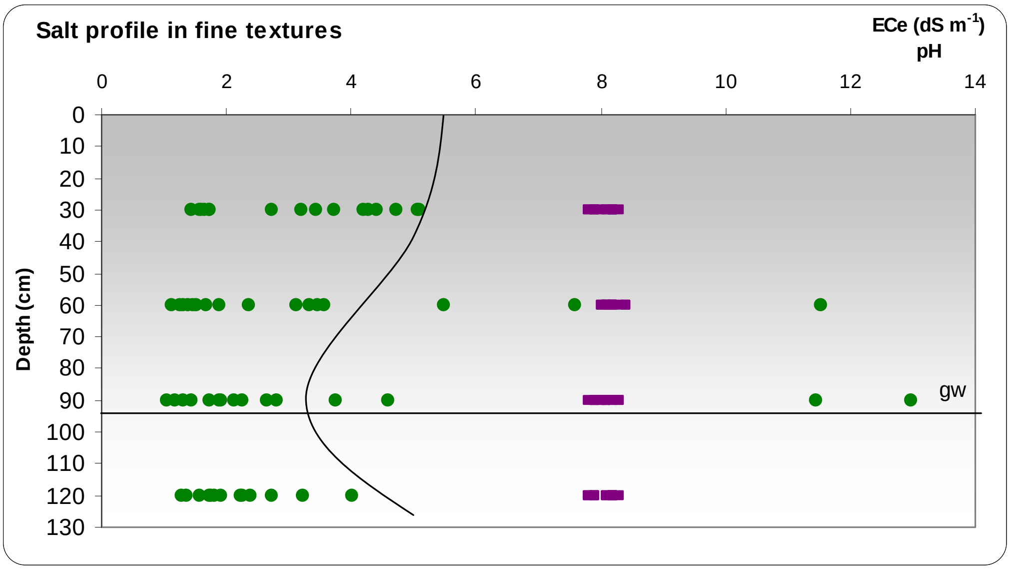
It is possible to know salt profile from ECe or $EC_{1:5}$ records available.

b.1. Salt profile depending on texture class and made from ECe records:

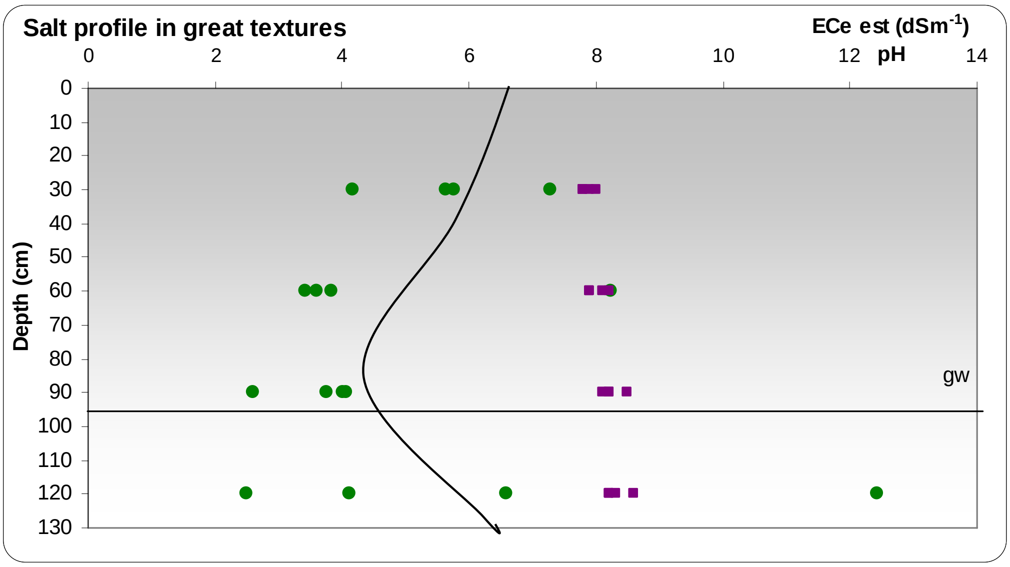


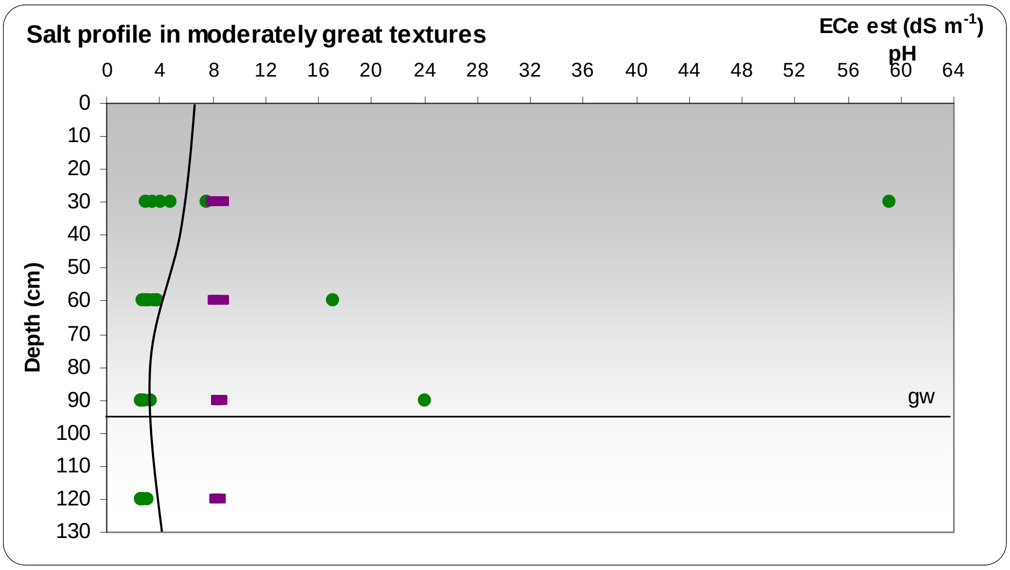


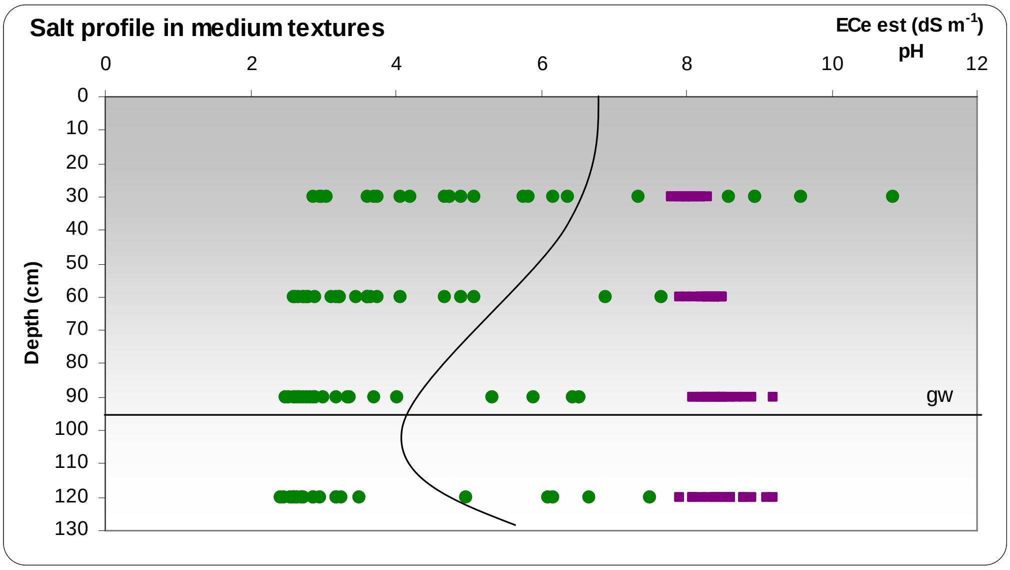

Salt profile in medium textures
ECe (dS m-1)
pH
0
2
4
6
8
10
12
14
0
10
20
30
40
50
60
70
80
90
100
110
120
130
Depth (cm)
gw

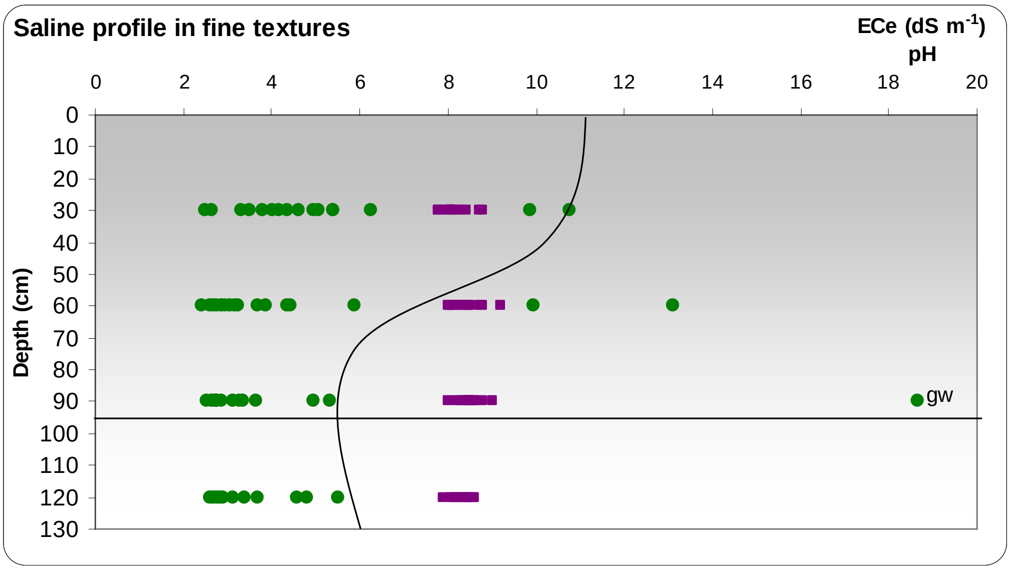

Salt profile in fine textures
ECe (dS m-1)
pH
0
2
4
6
8
10
12
14
0
10
20
30
40
50
60
70
80
90
100
110
120
130
Depth (cm)
gw

b.2. Salt profile depending on texture class and made from $EC_{1:5}$ records:






Salt profile in medium textures
ECe est (dS m-1)
pH
0
2
4
6
8
10
12
Depth (cm)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
gw


Saline profile in fine textures
ECe (dS m-1)
pH
0
2
4
6
8
10
12
14
16
18
20
Depth (cm)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
gw

Tables of each sample period showing the percentage of saline soils and non saline soils.

Data for 1st sample:

dS m^{-1}		0-1,75		1,75-3,5		4-6		6-8		8-10		10-14		14-20		>20		% Non saline	% Saline
	n	**Total**	**%**	**Total**	**%**	**Total**	**%**	**Total**	**%**	**Total**	**%**	**Total**	**%**	**Total**	**%**	**Total**	**%**		
ECe	27	0	0,0	18	66,7	3	11,1	1	3,7	0	0,0	1	3,7	1	3,7	3	11,1	**66,7**	**33,3**
ECe est (EC 1:5)	34	8	23,5	12	35,3	4	11,8	0	0,0	2	5,9	3	8,8	1	2,9	4	11,7	**58,8**	**41,2**
ECe est (EMS)	327	123	37,6	76	23,2	36	11,0	21	6,4	19	5,8	23	7,0	21	6,4	8	2,4	**60,9**	**39,1**

Data for 2nd sample:

dS m^{-1}		0-1,75		1,75-3,5		4-6		6-8		8-10		10-14		14-20		>20		% Non saline	% Saline
	n	**Total**	**%**	**Total**	**%**	**Total**	**%**	**Total**	**%**	**Total**	**%**	**Total**	**%**	**Total**	**%**	**Total**	**%**		
ECe	49	4	8,2	34	69,4	6	12,2	4	8,2	0	0,0	0	0,0	0	0,0	1	2,0	**77,6**	**22,4**
ECe est (EC 1:5)	49	0	0,0	28	57,1	13	26,5	6	12,2	1	2,0		0,0		0,0	1	2,0	**57,1**	**42,9**
ECe est (EMS)	421	0	0,0	348	82,7	24	5,7	14	3,3	5	1,2	14	3,3	9	2,1	7	1,7	**82,7**	**17,3**

Indicator SL02. Exchangeable sodium percentage (ESP)

Pilot description

Spatial extent

The spatial extent of the pilot area is 102 km^2.(see description at beginning of this section)

Sampling design

Systematic random sampling.

Compilation of soil data and maps for the pilot area.

Pilot area has been developed a systematic random sampling. The protocol established in the pilot area is detailed below. Most plots are paddy rice.

Methodology used for calculations / estimations of parameters and indicators, including interpolations.

We calculated SAR for each depth or horizon of the profile. To calculate the SAR profile it is necessary to know the content of cations (Na^+, Ca^{2+} and Mg^{2+}) in every horizon or interval of depth (0-30 cm, 30-60 cm, 60-90 cm and 90-120 cm).

SAR for each horizon or depth through the profile is calculated using the following formula:

$$SAR = \frac{Na^+}{\sqrt{0,5 \cdot \left(Ca^{2+} + Mg^{2+}\right)}}$$

The total SAR for each horison is calculated using: $SAR_h = \frac{SAR \cdot e}{D}$,

where SAR_h is the total SAR of the horizon, SAR is the SAR of the horizon, e is the horizon's thickness and D is the total depth of the profile.

SAR for the whole profile is calculated using: $SAR = \sum_{i=1}^{i=n} SAR_{h\,i}$,

where SAR is the SAR all profile, SAR_h is the SAR in horizon or in interval of depth.

Definition of baselines

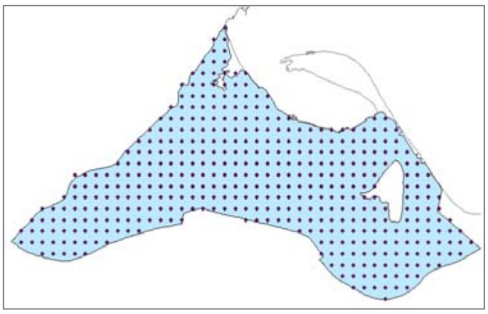
Soil degradation from salt accumulation, sodification, or both, is a threat o a fact in many irrigated lands. Salinisation has often been assessed from changing cropping patterns over time, and often trends in salinisation has not been quantified. (Herrero and Coveta, 2004). Long-term changes in soil salinity can be qualitatively assessed from historic records. Therefore, baselines should be defined different by specific areas depending by the records availability.

Pilot method

Description of working steps of the second sampling, including

Method development and application

- To create a grid cells (500 x 500 m) ≈ 50 ha. A consecutive number is assigned to each node in the grid, from left to right and from top to bottom.
- Electrical conductivity (EC) is measured to each sample point with the electromagnetic induction (EM) sensor. According to Pérez Coveta (2000),



soil salinity is one of soil properties that changes laterally and influences on the reading of the EM sensor. Salinity can vary remarkably among near points in the same plot. Drill sample could be not representative of plot's salinity. Using EM sensor, which explores a larger soil volume than a drill and is easy and fast to use, it could obtain a larger representation of plot's salinity. It makes five readings in each sample point: the first in the exact coordinates of sample point (C), the other four readings are made at 2 m of C in the direction of cardinal points (N, E, S, W).

- To be able to calibrate the measures that it has made with the EM sensor, it is decided to make a total of 50 to 55 drillings. Drillings are distributed proportionally in accordance with extension of superficial textures, previously calculated. To obtain a random representation of the points to drill, we assign to each node its superficial texture according to the cartographic units of sol map. Points with the same superficial texture are arranged from lowest to highest number and it is calculated an interval to decide where we must drill. In the sample points where it is drilled it will analyzed cations and anions.

Example:
Texture: Sandy loam
Nodes with this texture: 23
Number of drills according to superficial texture extension: 3
Interval: 23/3 ≈ 7, then it takes the first drill points which texture is "sandy loam", and it is drilling. Following drill it will make at the eighth of the points with ArF texture, and so on.

- It drills and it takes samples at different depths: 0-30 cm; 30-60 cm; 60-90 cm; 90-120 cm. In the laboratory it is analyzed: pH, anions and cations.

- At the end of field work, samples are sending to the laboratory to be analysed and if there are any samples left will be come back and will be storage in our department.

Evaluation of pilot results

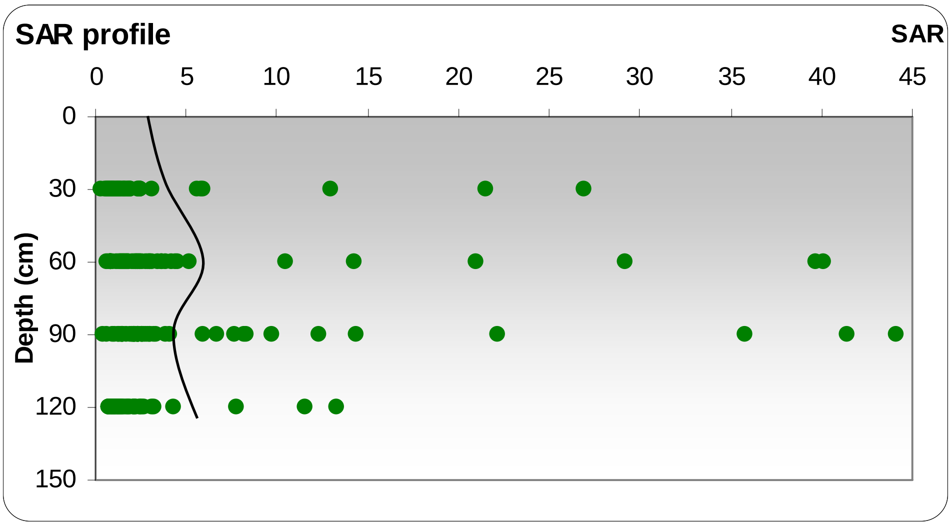
Feasibility and experience of applying ENVASSO procedures and protocols

In the laboratory it has made the following quantitative determinations: $pH_{1:2,5}$, $EC_{1:5}$, carbonates, then a saturated paste has been prepared and it is measured ECe, content of anions (Cl^-, SO_4^{2-}, NO_3^{2-}, NO^{2-}) and cations (Ca^{2+}, Mg^{2+}, Na^+, K^+). The methods used in the laboratories follow the MAPA (Ministerio de agricultura, pesca y alimentación) normative.

Parameter	Method
$pH_{1:2,5}$	Water solution 1:2,5
$EC_{1:5}$	Soil water extract 1:5
Carbonates	Bernard's calcimeter
ECe	Saturated paste extract
Anions (Cl^-, SO_4^{2-}, NO_3^{2-}, NO^{2-})	Ion chromatography
Cations (Ca^{2+}, Mg^{2+}, Na^+, K^+)	Atomic absorption

Output performance

The SAR profile for the records of our pilot area in 2007 are shown in the following graph.

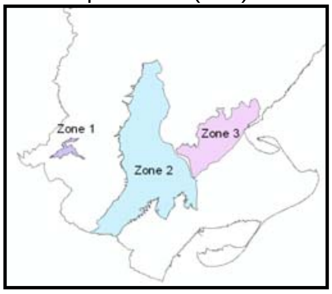


Conclusions and recommendations for revision of the manual of procedures and ENVASSO system.

Pilot area: Terres de l'Ebre, Spain

Lead Partner: SARA, Spain
Jaume Boixadera
Iolanda Simó i Josa

Description of the Pilot Area

Name of pilot area		Terres de l'Ebre
Names of participating partners	**Lead partner**	**Jaume Boixadera, SARA, Spain**
	Partner A	Iolanda Simó, SARA, Spain
Location and description	Member State(s)	SARA, Spain
	Coordinates	Xmin: 0º 15' 15.21'' Ymin : 40º 34' 57.29'' Xmax: 0º 50' 1.82'' Ymax : 40º 55' 48.76''
	Area of pilot area (km^2)  	Has been decided to apply Medalus only in areas where we have enough information. Those 3 zones are: • Zone 1: 8,7 km2 • Zone 2: 316,9 km2 • Zone 3: 107 km2
	Climate	Typical Mediterranean (*Csa* according to the Köppen classification)
	Mean temperature Average Annual Precipitation	• Zone 2 & 3: - Temperature: 16 º C - Precipitation: 413 mm • Zone 1: - Temperature: 14 º C - Precipitation: 800 mm
	Outline description of geomorphologic unit	Flood plain and terraces of Ebro river, glacis of Mora and marls and limestone hills.
	Maximum elevation (m)	1300 m
	Vegetation	- Evergreen shrub
	Major Land Use	- Crop agriculture: Non-irrigated tree crop cultivation, irrigated tree crop cultivation and some paddy rice. - Natural forest and woodland - Nature protection: reserves/park - Areas with human influence
	Major soils	• Zone 1: Phaeozem, Fluvisol, Cambisol. • Zone 2: Fluvisol, Calcisol, Kastanozem, Regosol, Luvisol, Leptosol • Zone 3: Calcisol, Cambisol, Fluvisol, Regosol, Kastanozem, Leptosol.

Threat and related indicator(s) evaluated in pilot area

Threat	Desertification
Indicator 1	DE01 Land area at risk of desertification

Rationale for selection of pilot area

In representative of desertification threat in Southern of Catalonia (Spain), we decided to apply Medalus in 3 different zones which zone 1 is quite different than and zone 2/3 but various types of environmental sensitive areas to desertification occurs. There are availability of relevant existing soil data and monitoring systems for these zones.

Zones 1 and 2 have a high number of hectares of non- irrigated land but it's a possible area will be irrigated in the future and it's susceptible to feel some threats.

SARA has been studying those areas very good and has elaborated curacy information during the elaboration of the soil map of those areas.

Various types of environmentally sensitive areas to desertification occurring in the pilot area of Catalonia were defined after conducting a detailed survey of all the required land parameters and management characteristics mentioned in the proposed methodology. The following maps have been compiled at the scale of 1: 50,000: Soil texture, parent material, drainage conditions surface rock fragment cover, slope gradient, soil depth, degree of soil erosion, rainfall distribution, slope aspect, aridity, vegetation fire risk, soil erosion protection by vegetation, vegetation drought resistance, plant cover, intensity of land use, policy of land protection.

Indicator Evaluation

Indicator DE01: Land area at risk of desertification

Pilot description

Spatial extent

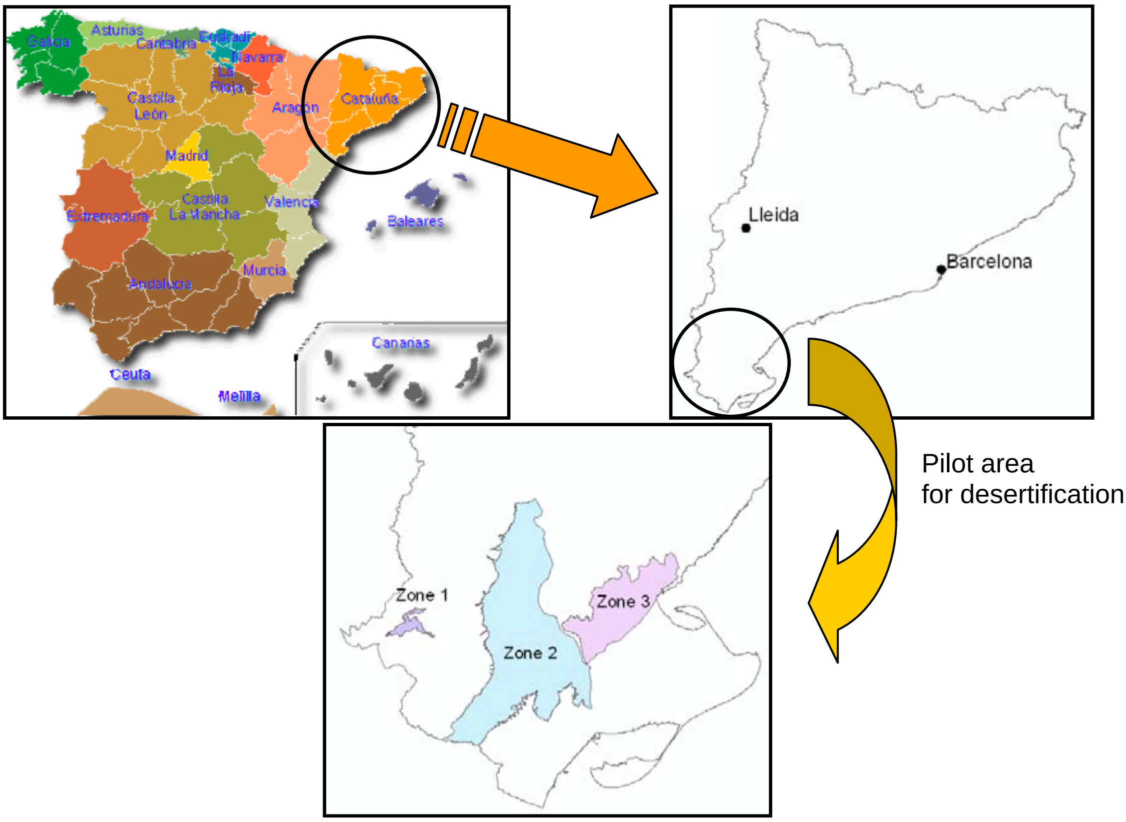


Figure 1. Location of 2 pilot areas.

Data

Detailed description of original data to be used in the pilot.

Testing MEDALUS methodology. The indicator is defined by climatic, soil, vegetation and human-induced criteria. Climatic criteria define the overall degree of aridity, which can be subsequently redefined using the same criteria should the climate change significantly. The soil and vegetation criteria are a measure of the capacity of the land to withstand aridity and human-induced criteria control the management of the land that can mitigate or exacerbate the effects of desertification.

Pilot methodology

Compilation of soil data and maps for the pilot area.

- Prepare data to compute Soil Quality Indices (SQI)
- Prepare data to compute Climatic Quality Indices (CQI)
- Prepare data to compute Vegetation Quality Indices (VQI)
- Prepare data to compute Management Quality Indices (MQI)

Method development and application

- To prepare data to compute Soil Quality Indices (SQI) is necessary to determine soil properties that they will be soil parameters. We used existing soil data from our detailed soil maps (1:25.000) to develop soil parameters, and this scale is high spatial resolution that WP4 proposes.
- To prepare data to compute Climatic Quality Indices (CQI) we used temperature and precipitation data from the climatic atlas of Catalonia. This data is publicly available. We worked with DEM (30 x 30 m).
- To define parameters to compute Vegetation Quality Indices (VQI) has been used the land use map from 1997. Land use is classified in 22 classes. This data is publicly available in raster format (30 x 30 m).
- To prepare parameters to Management Quality Indices (MQI) has been hard work. We could not find very detailed information but could prepare it.

Methodology used for calculations / estimations of parameters and indicators, including interpolations.

MEDALUS methodology such as WP4 for mapping environmental sensitive areas (ESAs) to desertification was used. ARCGIS 9.1 software was used to develop all methodology working in raster format.

Evaluation of pilot results

Feasibility and experience of applying ENVASSO procedures and protocols.

We had some problems to compile all data necessary to develop the Medalus methodology and prepare all parameters has been need. We used regional data because has been easier to compile than national data.

Results of indices determined for according to soil properties, climatic parameters, vegetation characteristics and management.

Results:

Figure 2 shows the resulting soil quality layer; as we can see, the majority of the pilot area (55% of the land) has a moderate quality of soils. A lower part has high quality (39%) and only a very little part can be assigned to the worst quality (6%).

Most of soils with moderate quality are soils well drained, with good texture and very gentle pendent, but soil with low quality are shallow or very shallow soils, with slope 18-35% only Zone 1 has a very steep. The moderate quality is soil with quite good characteristics.

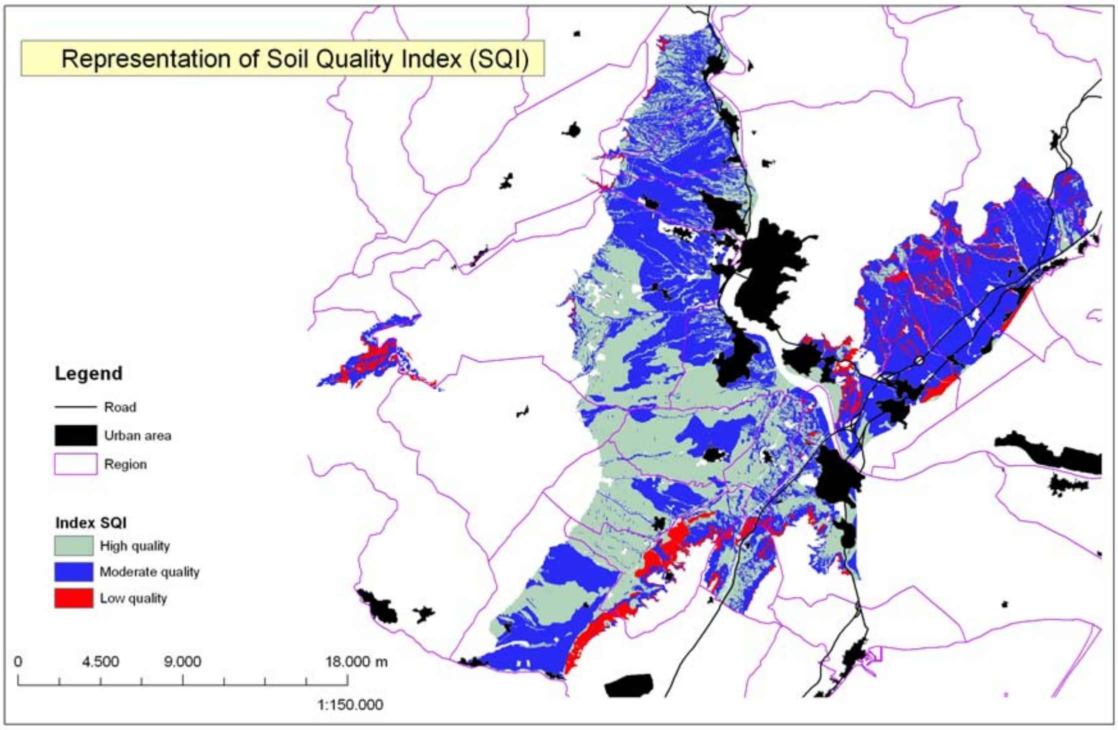


Figure 2. Soil quality map of the pilot area related to desertification risk.

Figure 3 shows that all pilot area is characterised by high (26,34%) and moderate climate quality (73,66%). Rainfall is about 800 mm per year in the high levels and more or less 400 mm near the coast. In addition, the average annual temperature is strictly related to elevation, ranging from 16 ºC near the coast and 12 ºC in the highest parts. Taking into consideration the general aridity index of the climate (fig:4), all pilot area has an index smaller than 125; 29,8% of the pilot area is characterised as a moist with an aridity index less than 50. The rest of the pilot area is characterised as dry with an aridity index ranging from 50-125. As for slope aspect, south-facing slopes are widely diffused creating favourable climatic condition for land degradation and desertification. On the whole, the pilot area can be characterised as having a cool mediterranean climate with a strong gradient from the coastline to the high levels (1300m).

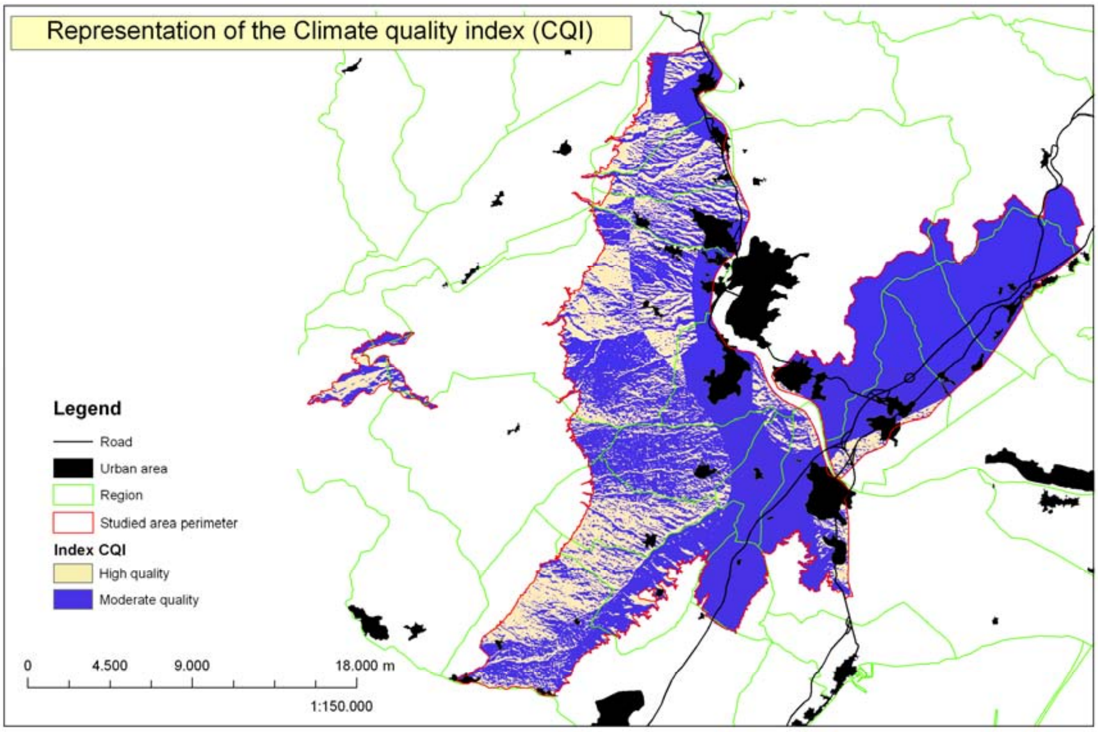


Figure 3. Climate quality map of the pilot area related to desertification risk.

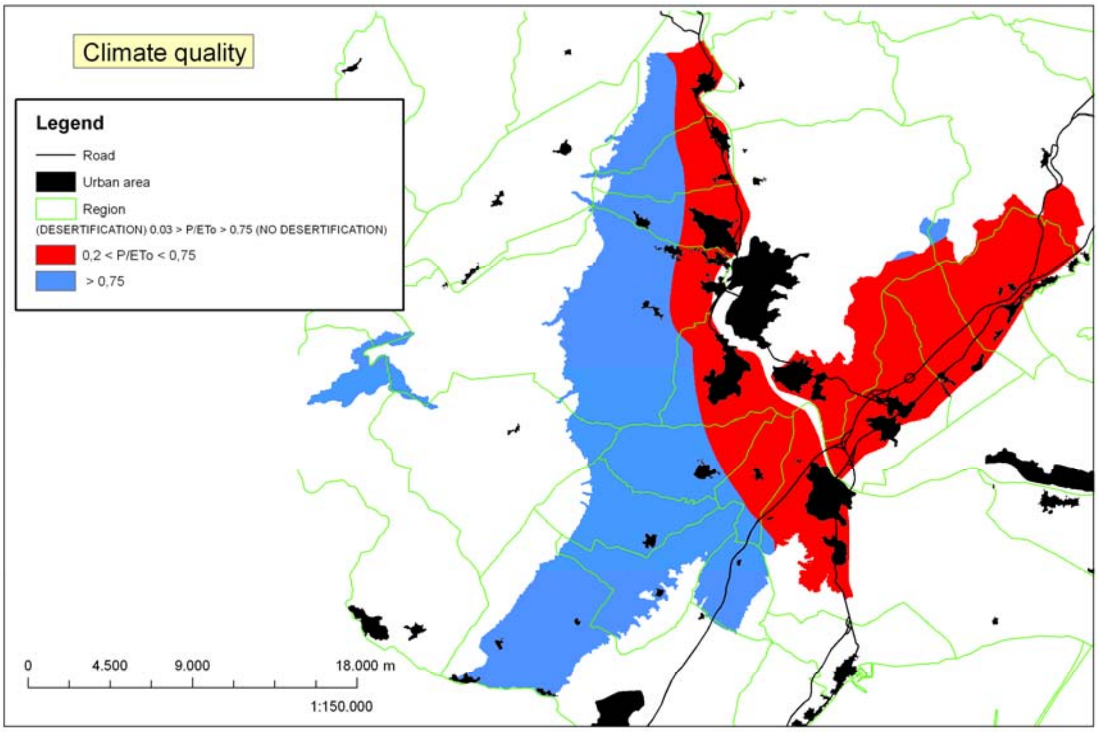


Figure 4. Climate quality map of the pilot area related to desertification risk.

Vegetation cover and vegetation physical structure are important factors concerning erosion. Figure 5 shows, the most part of pilot area is characterised as high quality (91,4%) and the rest is moderate quality. The most important part has moderate or high drought resistance and the same for erosion protection because the main area is covered by natural forest or the well managed olive groves, almond or vineyard. All pilot area has low plant cover, considered vegetation cover less than 40%.

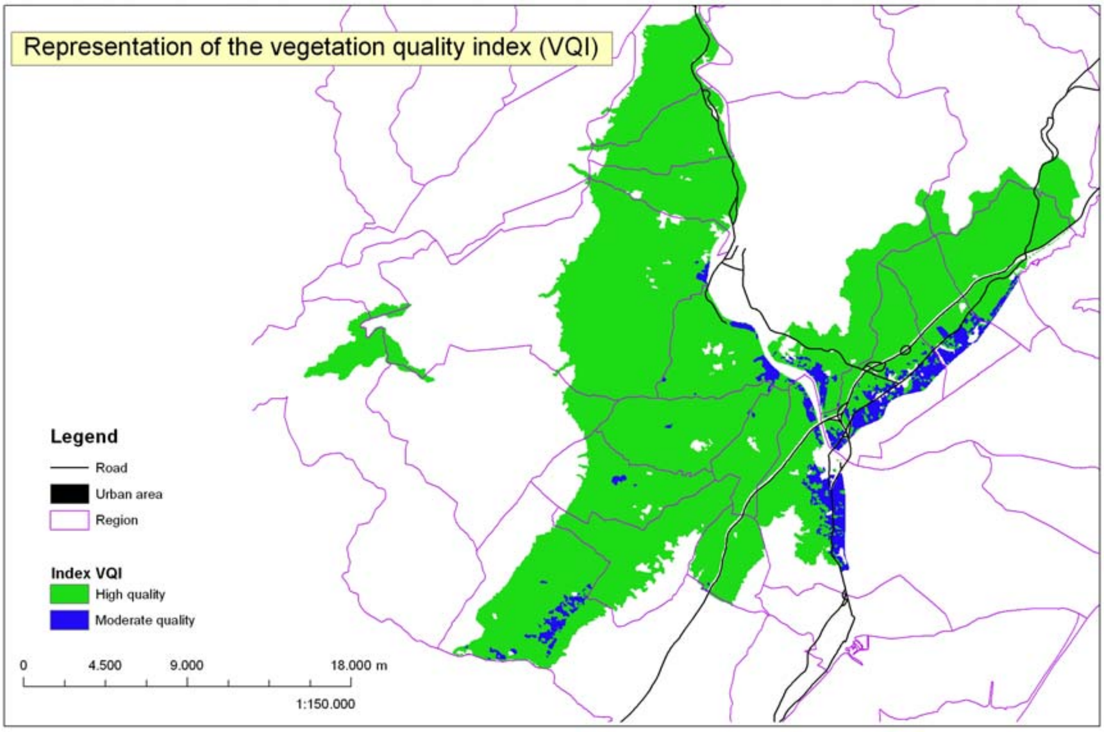


Figure 5. Vegetation quality map of the pilot area related to desertification risk.

Figure 6 shows that the management quality of the land is low (81,8%). This situation is mainly derived by the scare enforcement of the management in the relation to the environmental protection. The second one more important is moderate management with 14% of land that correspond mainly to annual summer/winter crops, vineyard or irrigated trees. Last one, high management (4%) corresponds to environmentally protected lands which are areas under pine or oak forest and they are well managed.

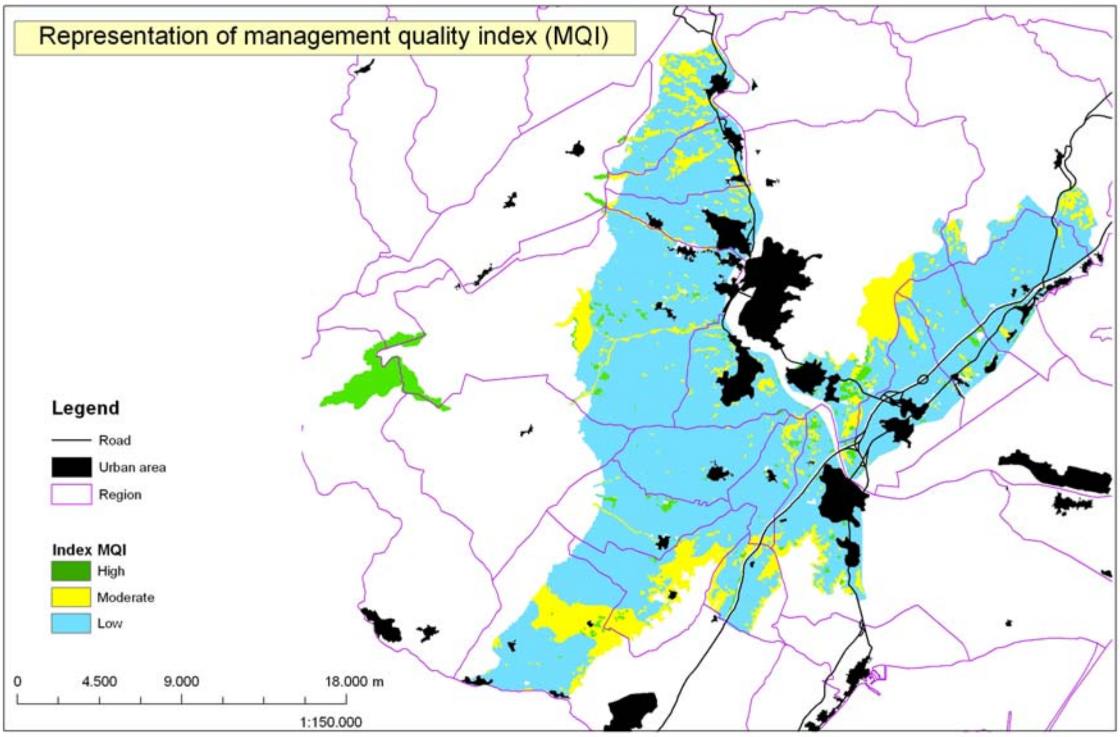


Figure 6. Management quality map of the pilot area related to desertification risk.

Output performance.

Based on the stage of land degradation and the sensitivity to desertification four categories of environmentally sensitive areas (ESAs) were found in all areas, namely fragile, critical, potencial and non-threatened (Figure 7). The most widely extended ESAs areas are critical (84,6%), fragile (10,6%), potential (4,5%) and non-threatened areas (0,1%).

Figure 7 shows that the majority of the pilot areas has critical ESAs (C1,C3) a widely expanded in the whole area. These areas are the most sensitive because are the badly degradated because are very eroded, shallow or/and poorly vegetated. Those areas are high land use intensity and that could constitute a degradation-promoting land use, further deteriorating the existing land resources. Those areas are sensitive to low rainfall and extreme events (hard wind).

The fragile areas (F1, F2, F3) are very sensitive to degradation under any change of climate or land use. The soils of this zone are moderately shallow to moderately deep, well vegetated with fruit trees, annual crops and forest.

The potential areas are mainly localised in the upper part where the main land use is forest. It's quite protected area too. These areas have a favourable climate and soil conditions, good vegetation cover and efficient management are found.

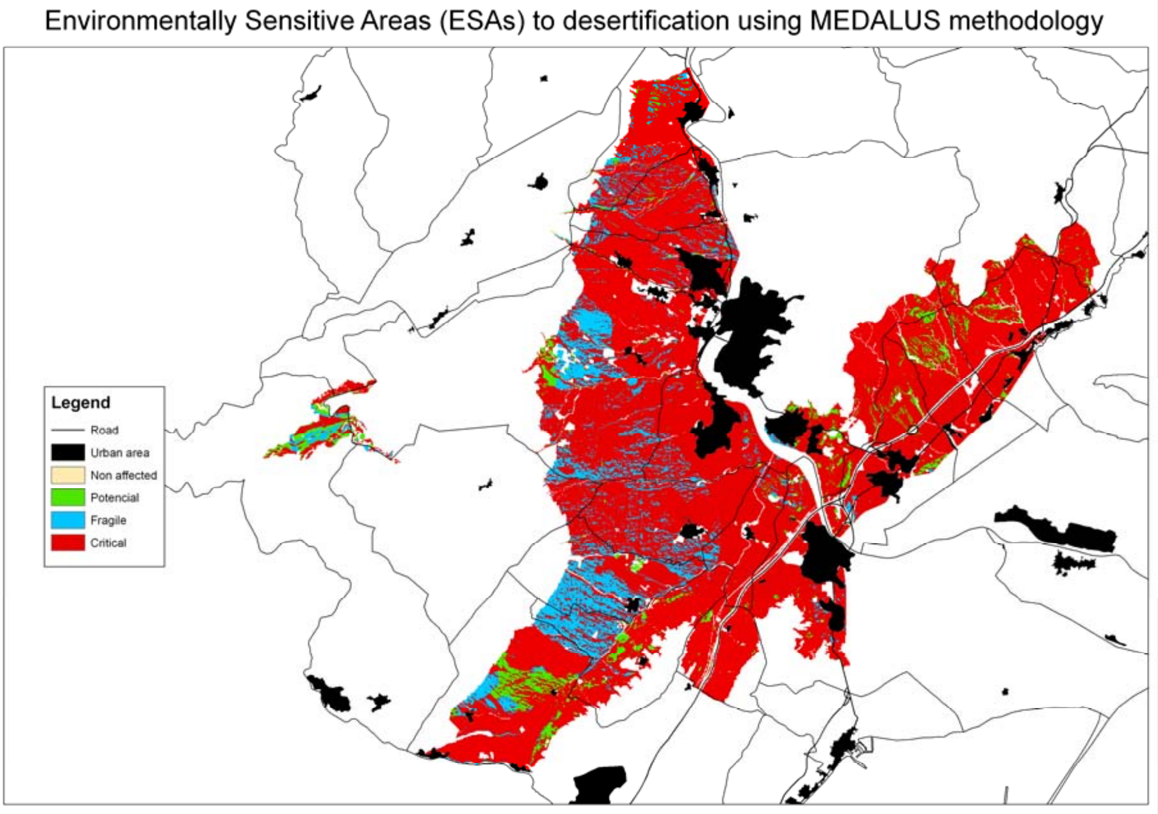


Figure 7. Map of Environmentally Sensitive Areas to desertification to the pilot area.

Identified strengths and weaknesses of:

- the estimation of indicator values
- the interpretation of indicator values

The environmentally sensitive areas map is more restrictive and stronger than the climate quality map because in the first one we consider all the parameters not only one. However, because it is simpler to calculate climate quality, this could be considered as an alternative when not all data needed to apply Medalus methodology is available.

Conclusions and recommendations

In my opinion, to apply medalus methodology is needed some data which is unavailable for some countries or regions. That model need to calculate a lot of parameters, e.g. has been so difficult to find good information to calculate land use intensity.

Pilot Area: Vale do Gaio watershed, Portugal

Lead Partner: INIAP
Maria C. Gonçalves
José C. Martins
Tiago Ramos

C. Kosmas (AUA)

Description of Vale do Gaio watershed, Portugal

Name of pilot area		**Vale do Gaio watershed, Portugal**
Names of participating partners	**Lead partner**	**Maria C. Gonçalves**
	Partner A	Maria C. Gonçalves
	Partner B	José C. Martins
	Partner C	Tiago Ramos
	Partner D	C. Kosmas
Location and description	Member State(s)	Portugal
	Coordinates	38º 22' 22.11'' N 8º 02'' 59.15'' W
	Area of pilot area (km^2)	513
	Climate	Csa (Köppen), $C_2B'_2s_2a'$ (Thornthwaite)
	Mean temperature (FAO 2006*)	16,2 ºC (1979-2006)
	Average Annual Precipitation (FAO 2006	584.4 mm (1979-2006)
	Outline description of topography	Gentle undulating relief
	Elevation (m)	39 to 418
	Vegetation (FAO 2006)	Cork trees, holm oaks, olive trees, wheat, maize, sunflower
	Major Land Use (FAO 2006)	Oak tree Mediterranean woodland, Agricultural crops, Pasture
	Major soils (WRB 2006 RGs**)	Cambisols, Luvisols

Threat and related indicator(s) evaluated in pilot area

Threat	**Land desertification**
Indicator 1	DE01 - Land area at risk of desertification

Rationale for selection of pilot area

The main threats of land degradation for Vale do Gaio are: (1) soil erosion, and (2) desertification. Vale do Gaio is a small watershed, part of the Sado's river catchment area, located in the Alentejo region of southern Portugal where Mediterranean conditions prevail with high temperatures during summer and most of the rainfall concentrated during autumn and winter months. Cambisols, Luvisols and Regosols are the dominant soil units here and throughout the Alentejo region, having generally low organic matter content, infiltration rates and water retention capacity. The major land uses are rainfed agricultural systems and Oak tree Mediterranean woodland, also known as 'Montado', with its multiple land use that combines the *Quercus* trees (*Quercus suber* and *Quercus rotundifolia*), cereal cropping underneath and cattle breeding. Some irrigation areas can also be found. With soil tillage practices coinciding with the start of rainfall period, soil erosion can occur due to surface water runoff and tillage which constitutes a major concern in land degradation in this pilot area. Soil erosion associated to shallow soils, hot and dry climatic condition and scarce vegetation lead Vale do Gaio region to be sensible to land desertification. Desertification is in fact a major concern, felt not only all over the Alentejo region but also in Algarve. Vale do Gaio watershed can be selected as representative for the Alentejo region, where both threats are felt but with less impact than in more marginal rural areas like Mértola's region and Algarve's mountains.

Indicator Evaluation

Indicator: DE01 - Land area at risk of desertification

Pilot description

Spatial extent

Vale do Gaio watershed has been chosen as pilot area for indicator DE01 evaluation. The pilot area is located in southern Portugal, covering an area of 51300 ha (Figure 1). The area is relatively smooth having a gentle undulating relief with a slope gradient very gentle to flat (<6%) in 96.1% of its area. The dominant parent material is granite. The major Reference Soil Groups (WRB, 2006) are mainly Cambisols and Luvisols but Regosols, Fluvisols, Vertisols and Leptosols can also be found in the area. Soil depth ranges from shallow (15-30 cm depth covering 13% of the area) to deep (>75 cm depth covering 36% of the area), being the major percentage covered by moderate depth soils (48%). Soil surface layers are generally coarse textured (79%). Water holding capacity ranges from low (< 50 mm in 10% of the area) to high (>150 mm in 14% of the area) but generally soils in the pilot area present values for water retention between 50-100 mm (39%) and 100-150 mm (37%). Rainfed agricultural land covers 48% of the area and is mainly located in the center and north-eastern part of the watershed, while in the western and south-eastern part, Oak tree Mediterranean woodland are dominant covering 34% of the pilot area. Based in the meteorological Vale do Gaio station, for the period 1979-2006, the average annual rainfall is 584 mm and the average air temperature is 16.2 ºC.

Figure 1 – Location of pilot area Vale do Gaio watershed in Portugal

Data

Sampling design

The soil data used to assess soil erosion and land desertification were based on Portuguese soil survey digital maps (1:25000). These maps only describe the soil mapping units and soil phases related to stoniness, drainage, and depth (shallow or deep). Soil analytical data corresponding to representative soil profiles were obtained from Portuguese soil survey reports and from Soil Science Department (INIAP-EAN) internal database 'PROPSOLO'.

Data description and standards

Soil data, such as, textural classes of the surface layer, water holding capacity, soil depth and drainage conditions, were extrapolated from representative soil profiles of the

Portuguese Soil Survey Service and from Soil Science Department of INIAP-EAN. The soil textural classes used are according to the International Society of Soil Science (Atterberg limits) and were grouped into the following: very coarse (S, LS); coarse (SL); medium (L, SiL, Si); moderately fine (SCL, CL, SiCL); and fine (SC, C, SiC). The Soil classification used is the Portuguese Classification established by the Portuguese Soil Survey Service (soil families). The parent material was defined according to the geological map of the area (scale 1:50000) supplied by the Portuguese Geological Service. The main parent material mapped in the pilot area is mainly granite with some minor areas of schists, sandstones and unconsolidated materials. Slope gradient was determined using the Digital Elevation Model (grid format 250 x 250 meters). Vegetation data were based on the Corine Land Cover 2001 and the dominant species are Corks, Holm Oaks, Olive trees and annual cereals. Climatic data was obtained from Vale do Gaio meteorological station. The following data was used: daily and monthly rainfall (1979-2006); monthly mean temperature (1979-2006); monthly Reference Potential Evapotranspiration Penman-Monteith (2001-2006).

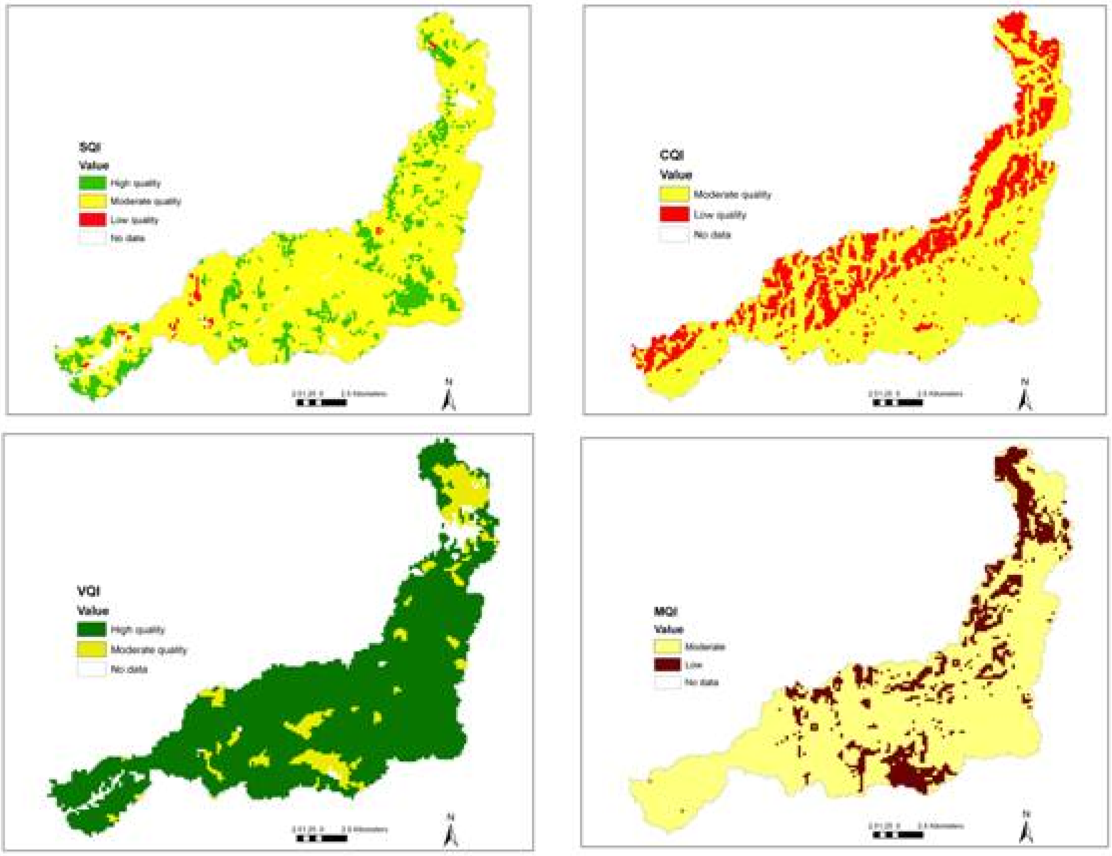


Figure 2 – Intermediate maps used to calculate MEDALUS III (SQI – soil quality index; CQI – climate quality index; VQI – vegetation quality index; and MQI – management quality index)

Soil Quality Index (SQI) has shown that most part of the soils in the area (82.4%) have a moderate quality, while only 16.7% can be considered as having a high quality (Figure 2). With an annual rainfall of 584 mm and a Bagnouls-Gaussen aridity index of 132, the climate in the region can be considered as moderate (74.1%) if the slope has north exposure and as low quality (25.9%) in the south-facing slopes. The existing vegetation is characterized as high quality, covering 88.8% of the area. Plants like Cork and Oak trees are resistant to drought and fire due to its medium to low distribution in the landscape and the Oak tree Mediterranean woodland system they are involved in confer some erosion protection to the soil. In the remaining area, vegetation is characterized as having a moderate quality (11.2%). Concerning the Management Quality Index, since not much information is available in Portugal for this region, the areas having a slope gradient >2% and a more intensive land use were characterized as low protected (18.6%). The remaining area was considered as having a moderate protection.

Critical environmentally sensitive areas (ESAs) to desertification are mainly located in the areas with the south-facing slopes and in the south and north-eastern areas of the watershed (Figure 4) previously defined as having higher land use intensity. Potential and non-affected areas are located where soil was considered as having a higher quality, specially south of the Vale do Gaio water reservoir and in the south-eastern part of the watershed. In these areas climate, vegetation and management moderate or high quality indexes helped reducing the risk of land degradation. Fragile ESAs (F1, F2, and F3) are widely expanded all over the remaining area, being the lower class F1 more dominant in the western and south-eastern part of the watershed where Oak tree Mediterranean woodland prevail and the worse fragile class distributed in the center and north-eastern part of the pilot area. These fragile areas are very sensitive to changes in land use, climate and vegetation cover. Any changes, like the land use increasing, fires resulting in the loss of vegetation cover, long drought seasons, and increase of soil erosion, are likely to enhance land desertification and move the areas characterized as fragile to critical.

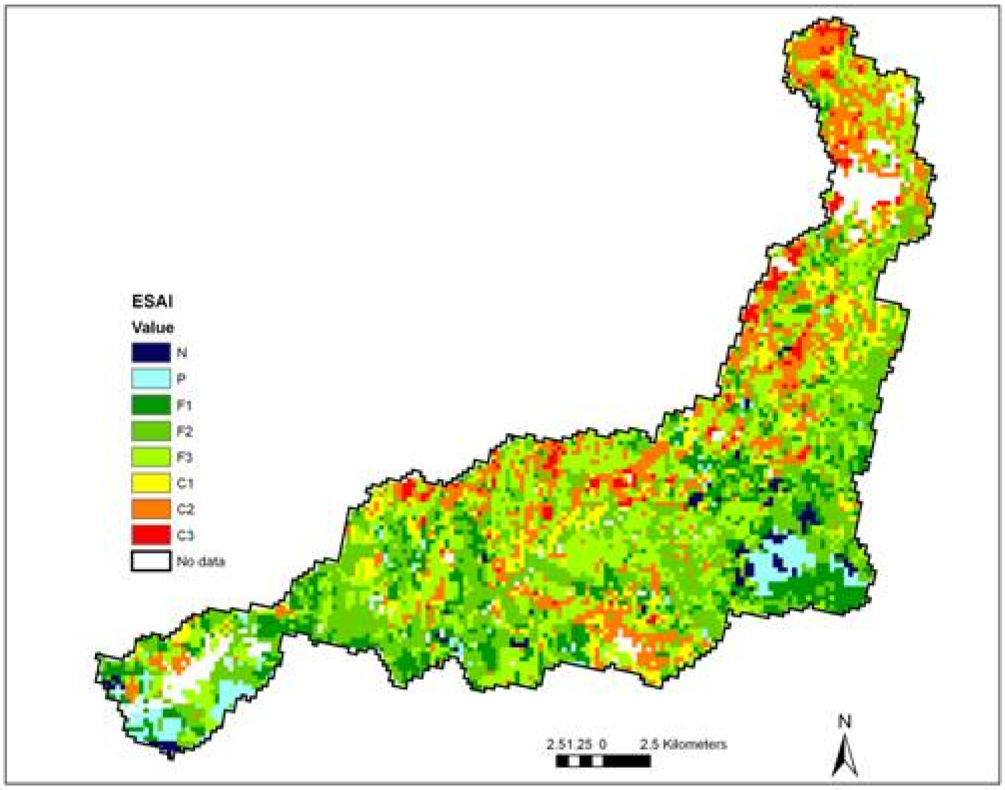


Figure 4 – Map of environmentally sensitive areas to desertification in the Vale do Gaio watershed, Portugal

Evaluation of pilot results

Feasibility and experience of applying ENVASSO procedures and protocols

Land desertification assessment using the MEDALUS III methodology is very easy. Simple soil, vegetation, climate and land management characteristics are used to prepare 15 raster layers including the indices for each parameter and each grid. The environmental sensitive areas to desertification are then determined with the ArcGIS tool. The main difficulty experienced is not so much the methodology but the lack of some data in Portugal regarding soils and policy enforcement.

Output performance

Land desertification assessed by the MEDALUS III cannot be tested for Portugal. There is no soil monitoring system in Portugal with the exception of one erosion experimental centre located in Vale Formoso, near Mértola. Nevertheless, the results for the land at risk of desertification is available accordingly in most part of the area. New research projects must be implemented in order to validate the obtained results with the experimental data in the pilot areas.

Identified strengths and weaknesses

a. the estimation of indicator values

The results obtained for land desertification require validation. At present there is no available data to perform such task, and the final outcome is difficult to analyze without field data and observation. From a visual inspection of the pilot area seems the results obtained are reliable. As expected, 94% of the area is at risk (fragile or critical) of land degradation, presenting the desertification as a problem to the region.

b. the interpretation of indicator values

Land desertification indicator values are also easily interpreted but the sub-classes involved (eg, F1, F2, F3) can be a little subjective.

Conclusions and recommendations

The current ENVASSO system gives a good contribution to organize the existing information, identifying the best methodologies for assessing soil threats using indicators, to be used all over Europe, allowing comparison between different countries. If the information is already organized in databases, it will be easy to apply such methodologies. In our case, the lack of data is a reality, making more difficult to apply some of the methodologies.

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Pilot area: Samoggia River catchment Emilia-Romagna Region, Italy

Lead Partner: Emilia-Romagna Region
F. Malucelli
F. Staffilani
D. Bartolini
M. Pizziolo
M. Guermandi
N. Filippi

R. Jones (CU)

Description of the Pilot Area

Name of pilot area		Samoggia River catchment, Bologna, Italy
Names of participating partners	**Lead partner**	**F. Malucelli**
	Partner A	F. Staffilani
	Partner B	D. Bartolini
	Partner C	M. Pizziolo
	Partner D	M. Guermandi
	Partner E	N. Filippi
	Partner F	R. Jones
Location and description	Member State(s)	Italy
	Coordinates	(Lambert coord.) 165837W -397227N (WGS84 coord.) 44°23'N 11°04'E
	Area of pilot area (km^2)	315
	Climate	Subcontinental temperate
	Mean Annual Temperature	10 – 12.5 °C
	Average Annual Precipitation	650-800 mm in the plain; 1700 mm at 80-900 m
	Outline description of topography	Catchment of the Samoggia River. Hilly area with slopes from gentle to steep and badlands.
	Elevation (m)	317 on average 45 (min) 895 (max)
	Major Land Use	Forest, non-irrigated and irrigated cultivation, grassland, vineyard and fruit trees
	Major soils	Regosols, Cambisols, Calcisols

Threat and related indicator(s) evaluated in pilot area

Threat	Landslides
Indicator 1	Landslides (LS01)
Indicator 2	
Indicator 3	

Rationale for selection of the pilot area

A geomorphological map at the scale 1:25,000 of the mountainous area of the Emilia-Romagna region was available. Within the region, the Samoggia River catchment pilot area was selected because it is highly representative of the typical recurrent pattern in the central and northern Apennines according with geology, geomorphology, climate, soil distribution and human pressure.

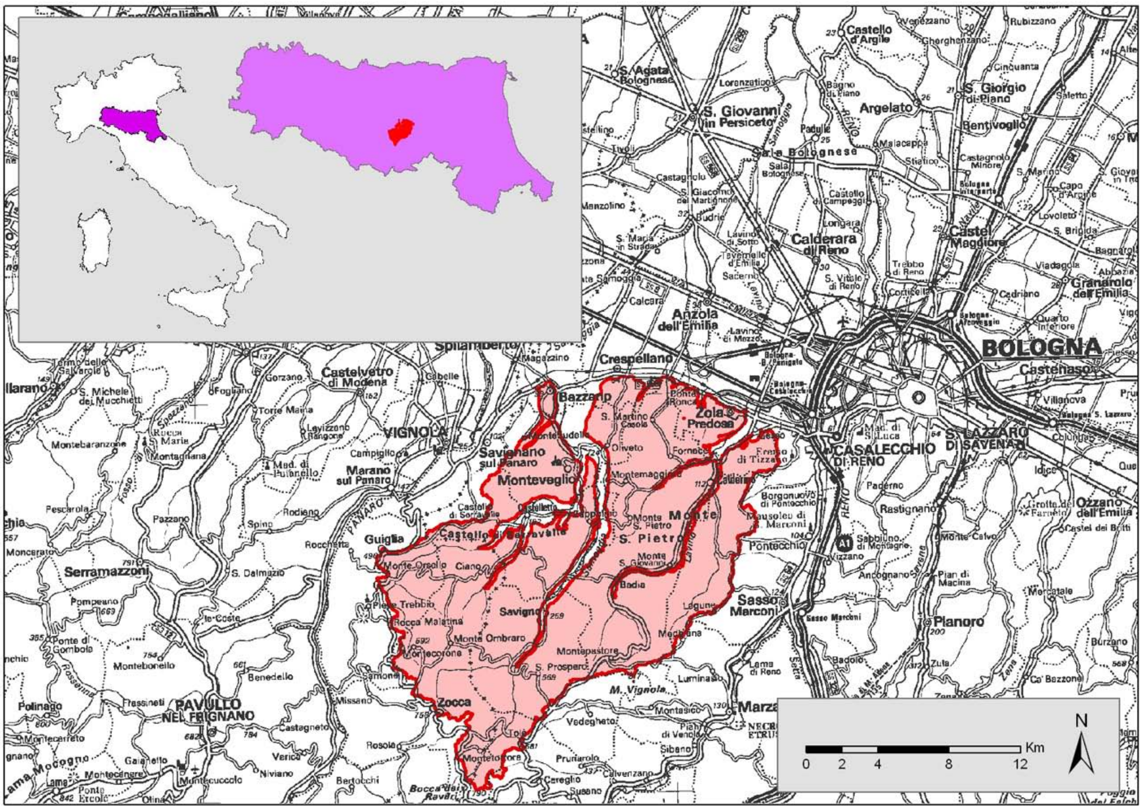


Figure 1. Location of the Samoggia river catchment Pilot area

Indicator Evaluation

Indicator: LS01 Occurrence of landslide activity

Description of the pilot area

Spatial extent

The Samoggia River catchment pilot area is located in Emilia-Romagna region (Italy) in the Tuscan-Emilian Apennines along the Apennine Range.
The Samoggia River catchment is in the western extremity of the inter-regional Reno river basin. The catchment comprises a plain area, downstream to Bazzano town, and a hilly and mountainous area in which the pilot area is located (Figures 1 and 2).

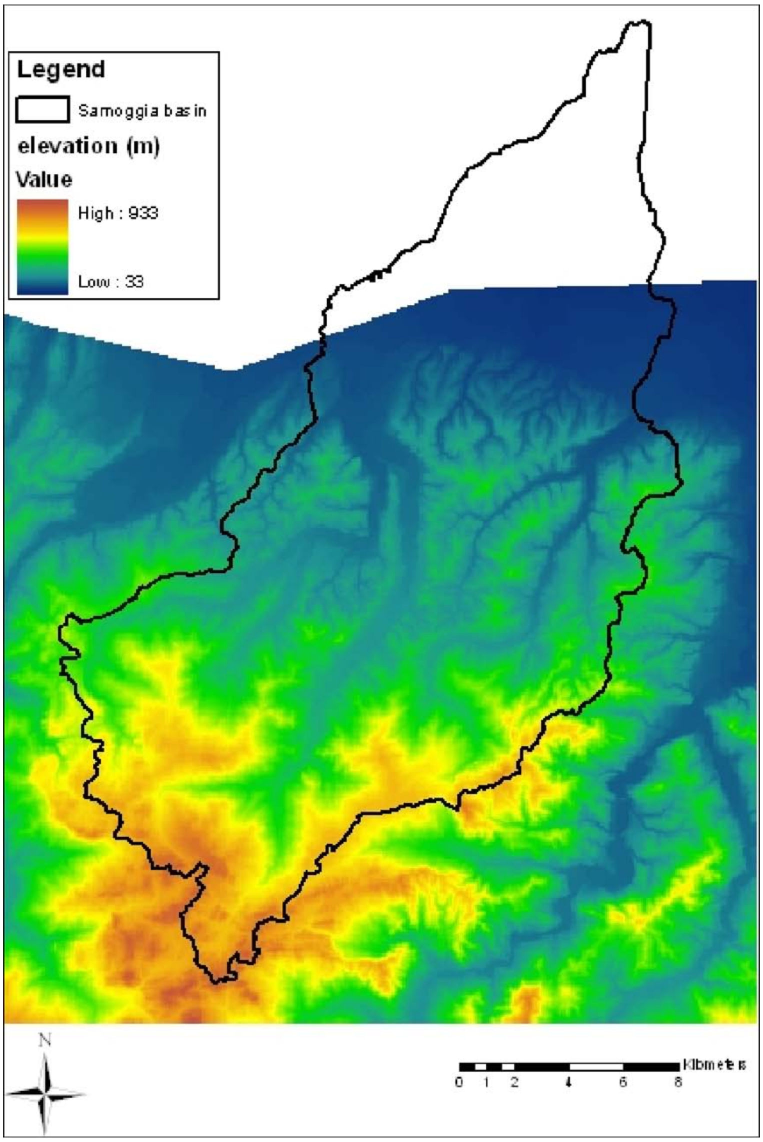


Figure 2. Elevation range of the pilot area (including the plane)

Lithology

The Samoggia pilot area includes a sector of the Apennine chain characterized by an intense tectonic deformation and a restructuring of the original geological formation. These pressures, combined with the poor geomechanical properties of the rocks, have conditioned, and continue to condition the geomorphological dynamics of these territories.

In the pilot area, the stratigraphic sequence is complex. In the central-southern part of the catchment, Cretaceous–Eocene clay outcrop, extensively, the dominant rocks, strongly deformed, belonging to Ligurian Domain. These deep marine sediments are overlaid, in more or less discontinuous areas, by the Eocene- Miocene “Epiliguran Units”, comprising clays and marls alternating to sandstones and, rarely, gypsum, deposited in marine “piggy back” basins. The Pliocene sediments are typical of the hilly sector of the catchment and the morphology of these units, comprising regular marine clayey marls, are typically the “calanchi” morphology (similar to badlands). Continental and marine Quaternary deposits, mainly coastal sandstones alluvial and gravels, occur on the Apennine margin.

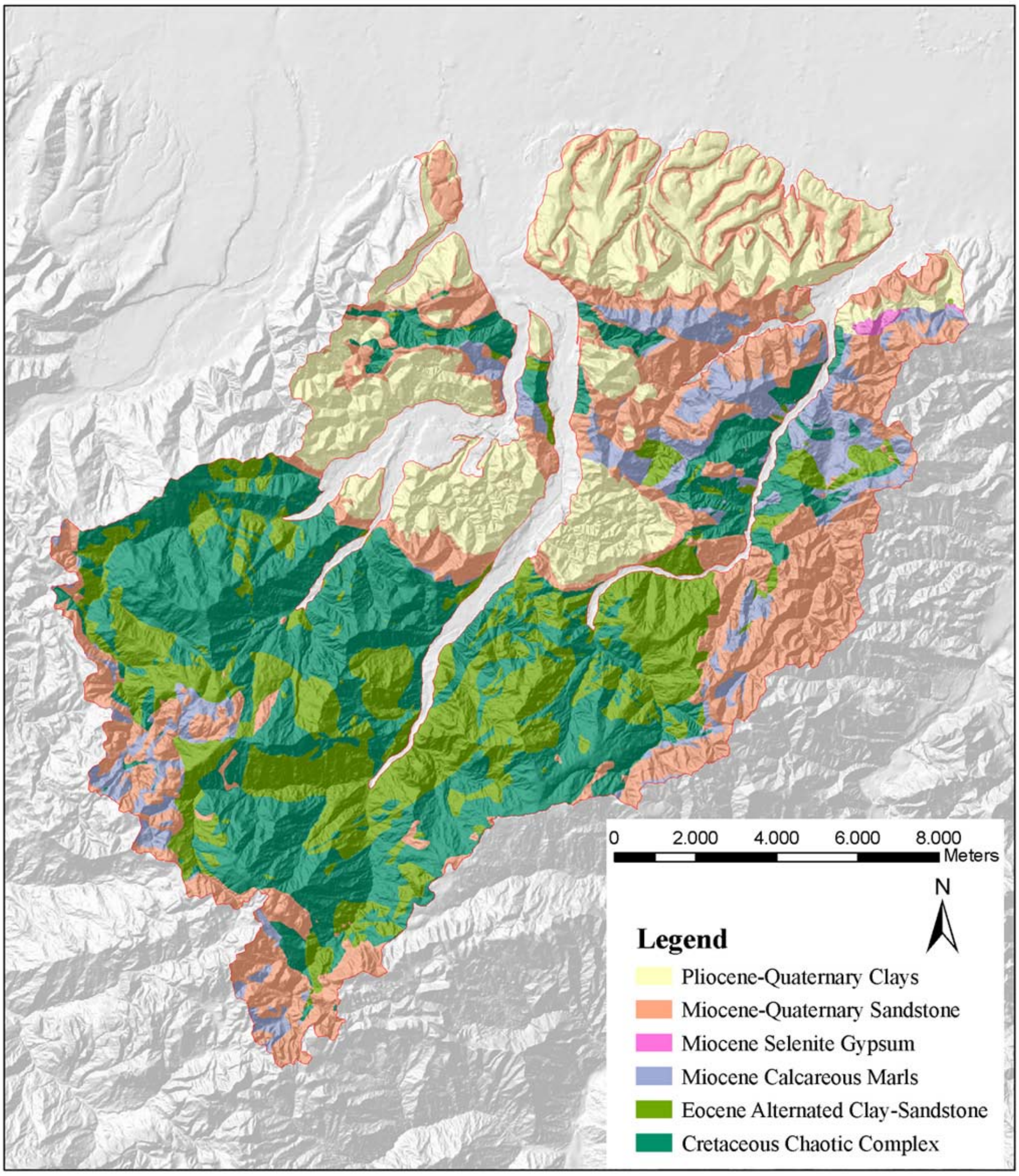


Figure 3. Lithology of the pilot area

Climate

The average annual temperature range is 10-12.5°C in the low Apennine and 8-11°C in the medium Apennine zone. Precipitation gradually reduces from 1600-1800 mm annually on the ridges, at about 800-900 m, to 1000-1200 mm at 500-600 m, and 650-800 mm per annum on the plain.

In the pilot area, the thermic regime (Köppen, 1936) gradually changes from sub-continental temperate in the margin and low Apennine to cool temperate in the medium and high Apennine. According with Thornthwaite e Mather, (1957), this area has a "B" type "Wet" climate.

Windiness normally increases with the elevation. The NE-SW winds are dominant, usually interrupted by orthogonal flow in proximity of main valley.

Land Use and Land Cover

The forests cover about the 37% of the pilot area. They are both on competent lithologies, which are mainly located in very steep slopes, and on clayey or torbiditite rocks, which typically are on slopes bordering the "unstable" areas.
The dominant agricultural uses are arable land and fruit tree plantation (44%), which are widespread over the whole catchment and more abundant along the Apennine fringe. Pastures and shrubs occupy 11% of the catchment, with bare soils in the badlands (*calanchi*) (3%). The urban areas occupy about 4 % of the entire area.

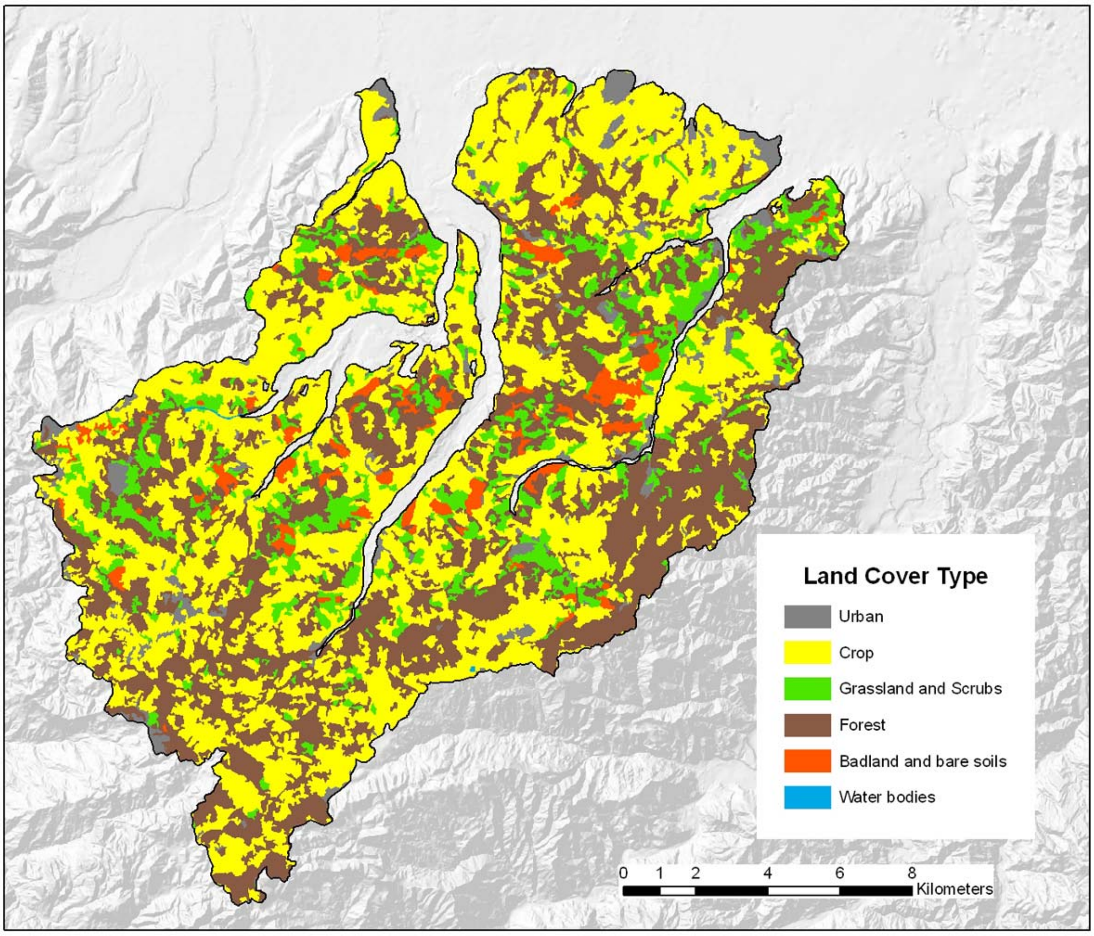
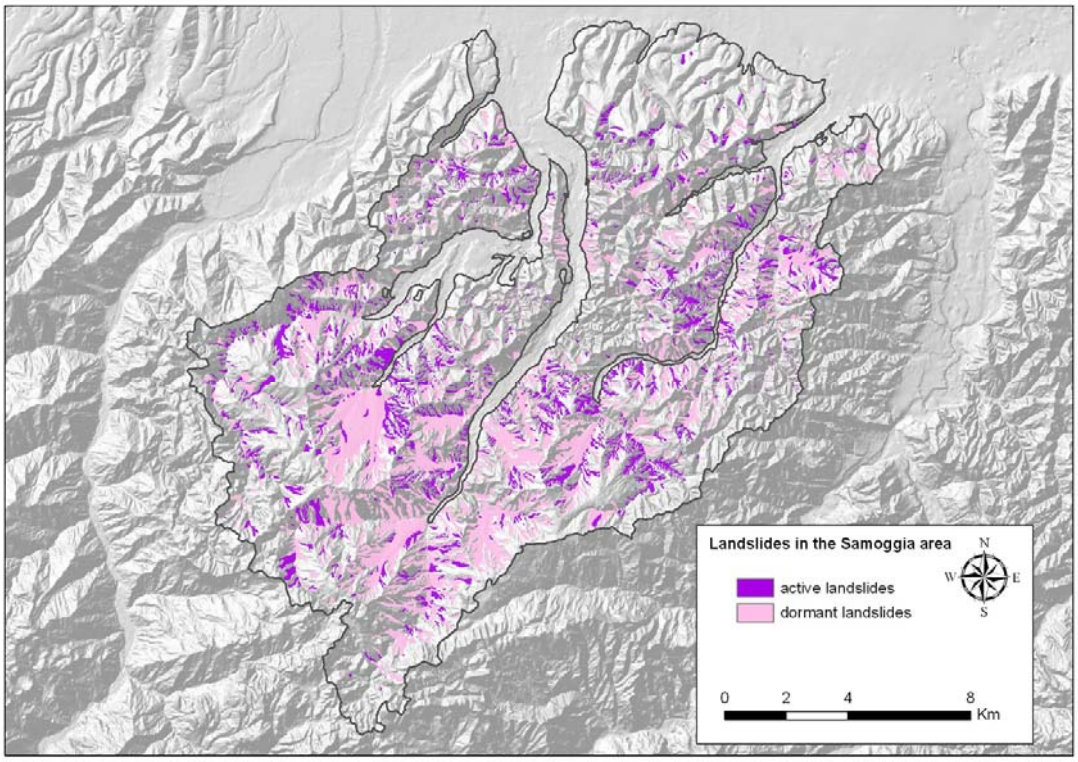


Figure 4. Land Cover

Soils

Three main groups of soils are found in the pilot area.

The uppermost hill soils are formed in chaotic clayey and silty lithotypes. They are moderately steep, deep or very deep, calcareous and moderately alkaline. Texture classes range from medium to fine. Soils that are exposed to intensive erosion processes have a weakly developed profile (Calcaric Regosols, WRB, (1998)). In many tracts of land, soils have well developed profiles, because of accumulation of calcium carbonate in the subsoil and evidence of pronounced changes in volume with changes in moisture content, such as deep wide cracks (Vertic Cambisols, according to WRB, (1998)). In very small remnants of fluvial sediments on the top of the hills, the soils have strongly developed profiles, with significant alteration of primary minerals and removal of carbonate to greater than one meter depth (Vertic Cambisols, WRB, (1998)).



The midslope soils are formed in mainly silty lithotypes. They are shallow, on moderately steep slopes, with a fine texture and good oxygen availability, calcareous and moderately alkaline. In few scattered tracts of land these soils are moderately deep, with a medium texture. They have a weakly developed profile, because of intensive erosion processes (Calcaric Regosols, WRB, (1998)).

The soils downhill are formed on moderately steep slopes, mainly in Pliocene clay, with interbedded sandy layers. They are of medium texture with good oxygen availability, calcareous and moderately alkaline. They range from shallow to very deep. They generally have a very weakly developed profile (Calcaric Regosols, WRB, (1998)). In very small remnants on hill tops, soils with strongly developed profiles occur (Haplic Calcisols, WRB, (1998)).

Pilot area Methodology

In the Emilia-Romagna region, over 70,000 landslide bodies cover one fifth of the hilly and mountainous territory. They are mapped in the Landslide Inventory Map (*"Carta Inventario del Dissesto"*).This analytical map was issued in 1996, at the scale of 1:25,000.

Data derive mainly from field surveying and have been collected by the regional "Geological, Seismic and Soil Survey", in collaboration with Universities and the National Research Council, for the preparation of the geological map of the Emilia-Romagna Apennines. Aerial photographic interpretation was used both to complete and to check the field data.

In the Inventory Map, landslide bodies, slope debris accumulations and terraced alluvial deposits are delineated. Among landslides, active and dormant ones are distinguished. According to Varnes' classification, rock falls and rock block slides are evidenced with respect to flows and slump earth flows (undifferentiated).

The landslides inventory map has been digitized and information is available for GIS management. It provides basic information for land-use planning and subsequent thematic mapping.

Figure 5. Landslides in the Samoggia area

Among the three candidate indicators for landslides that were defined by ENVASSO Work package 1, only the first indicator, LS01 Occurrence of landslide activity, was applied in the pilot area. For the purpose of this work the different kinds of landslides where grouped, according with their activity status - active, dormant, relict and stabilised. Because of the geomorphological survey scale "Relict" and "dormant" were grouped in the "dormant" category. In the pilot area, only active, relict and dormant landslides are found.

The elaboration was made in three different steps:

- **Step 1:** Translation of the coordinate system from the UTM32 to LAMBERT AZIMUTH EQUAL AREA
- **Step 2:** Processing of the data according to INSPIRE Eurogrid, with resolution of 100 m and 1km
- **Step 3**: Statistical description of the 100 m x 100 m cells contained in each 1 km cell

To test the ENVASSO threat indicators, it is necessary to use raster processing. The pilot area (PA) Landslide Distribution Map at the scale 1:25,000, made in vector format, was rastrerised on 100 m x 100 m grid. To assign the values to the grid, the criterion used was the prevalence inside the cell (i.e. [landslide or no landslide] >50%). If the cell was identified as landsliding, the dominant kind of landslide was chosen as final attribute characterising the cell.

The 1 km grid elaboration is the statistical description of the 100 m x 100 m cells contained in each 1 km cell and classified as described above; in this case 4 classes of landslide occurrences were chosen "< 5%", "5 - 25%", "25 - 50%", > 50%".

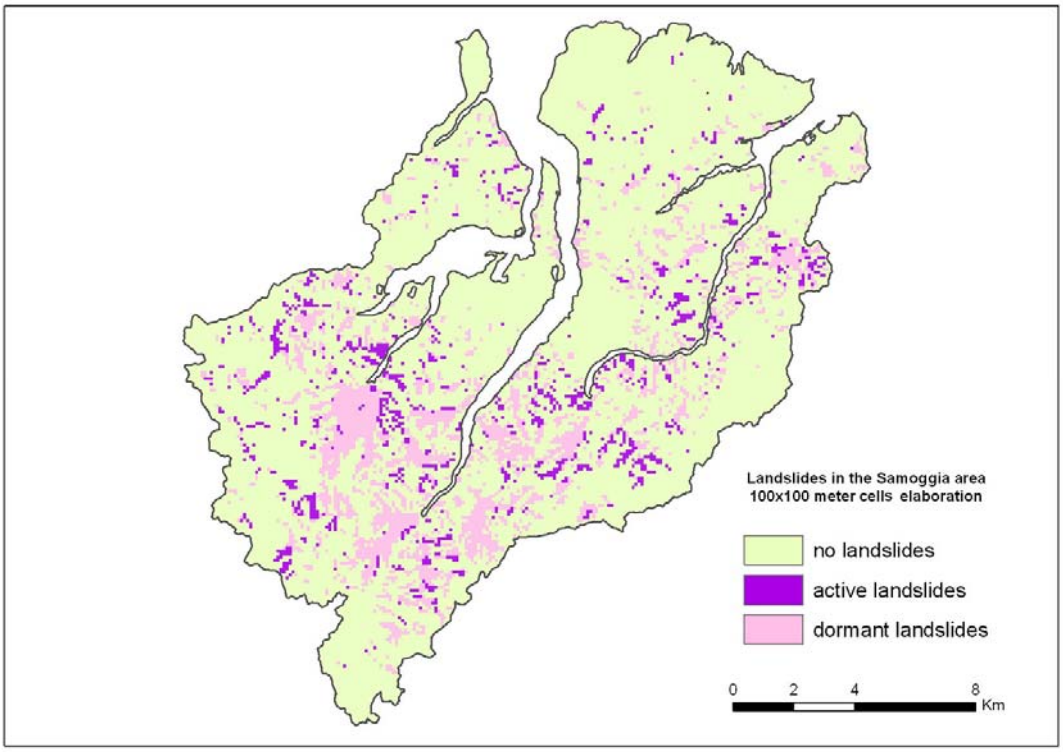


Figure 6. Raster map of the landslides in the Samoggia area; grid resolution 100m

Evaluation of pilot area results

The assessment gave an accurate picture of the landslides threat in the Italian PA, highlighting the areas with the major problems and discriminating the status of activity of the landslides.

The rasterization process from a vector map introduced some “loss of information” directly linked to the size of the cells. Well-detailed landslide distribution map enables delineation of very small or “thin-strongly elongate shaped” landslides. The rasterization process introduces an underestimation of these type of landslide, and consequently of the overall landslide coverage. Considering the total area covered by landslides in the vector map, and the corresponding value in the raster map, the underestimation of the landslides is equivalent to about 3.8% of the total area.
The results of the detailed elaboration (1:25,000 scale) concerning the landslides indicator LS01, can be described quite well using an output with a medium detailed scale (1:100,000 or 1:250,000). For more detailed maps, the elaboration “grid over polygons” can be satisfactory if the dimension of the grids is small.

The 100m cells elaboration, according to Table 1, shows that close to 20% of the area is affected by landslides and a quarter of these are classified as active.

Table 1. Distribution of the landslides in the Samoggia area at 100m resolution

Landslides in the Samoggia Area 100mx100m cell elaboration		
Active Landslides	5.0%	(1276/25415 ha)
Dormant Landslides	13.8%	(3501/25415 ha)
No Landslides	81.2%	(20638/25415 ha)
Total Area	100.0%	(25415 ha)

Changing from 100m to the 1km grid resulted in changing proportions, because the border effect of the coarser resolution the area of interest from the grid change from 245 km^2 to 326 km^2. The content of each 1km cell was the statistical summary of the 100m that comprised the cell. The occurrence of four classes of landslides are shown in Tables 2, 3 and 4. The limits of the classes, > 50%, 50 - 25%, 25-5% and < 5%. were made by ‘expert judgment’.

Table 2. Total distribution of the landslides in the Samoggia area at 1km resolution

Total Landslides in the Samoggia Area 1kmx1km cell elaboration		
>50%	5.2%	(17/326 km^2)
25-50%	20.9%	(68/326 km^2)
5-25%	38.6%	(126/326 km^2)
<5%	35.3% (76/326 km^2 with no landslides)	(115/326 km^2)

Figures 7, 8 and 9 show the distribution of the landslides and their density. The pattern at the finer raster resolution is quantified and described in intensity. It is interesting to note that a minimum threshold of the 5% of landslides indicates an ‘almost stable’ area that is likely to have some hectares completely covered with landslides. If from the statistical point of view less than 5% seems a negligible percentage, in an area with a strong anthropogenic impact it can be an indicator of some criticality. Only half of the area in the lowest class has no landslides (23.3% of the total area, 76/326km^2). But it should be remembered that during the rasterization process landslides covering < 0.5-1 hectares or long and narrow in shape have been excluded from the analysis.

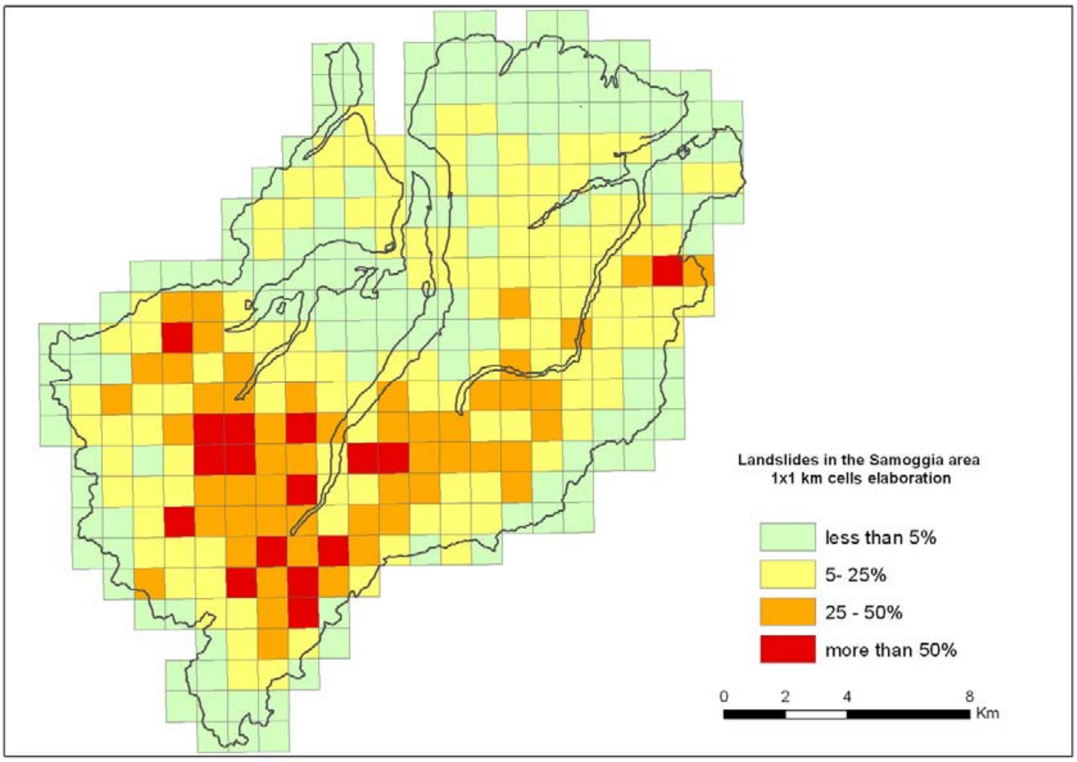


Figure 7. Raster map of the landslides in the Samoggia area; grid resolution 1km
Table 3. Distribution of the active landslides in the Samoggia area at 1km resolution

Active Landslides in the Samoggia Area 1kmx1km cell elaboration		
>50%	0.0%	(0/326 km^2)
25-50%	1.5%	(5/326 km^2)
5-25%	30.7%	(100/326 km^2)
<5%	67.8% (140/326 km^2 with no active landslides)	(221/326 km^2)

Conclusions and recommendations

Among the three landslide indicators proposed by ENVASSO, only LS01 'Occurrence of landslide activity' was applied. Nevertheless the assessment gave a good picture of landslides as a threat in the Italian PA of Samoggia, highlighting the areas with the major problems and discriminating between the different types of landsliding activity. A crucial point has been the processing of the data according to resolution of 100 m. The description of the 1 km cells has been effective because it was based on the analysis of the 100 m x 100 m cells. The loss of information resulting from the direct rasterization at the 1 km grid is shown in Figure 10.

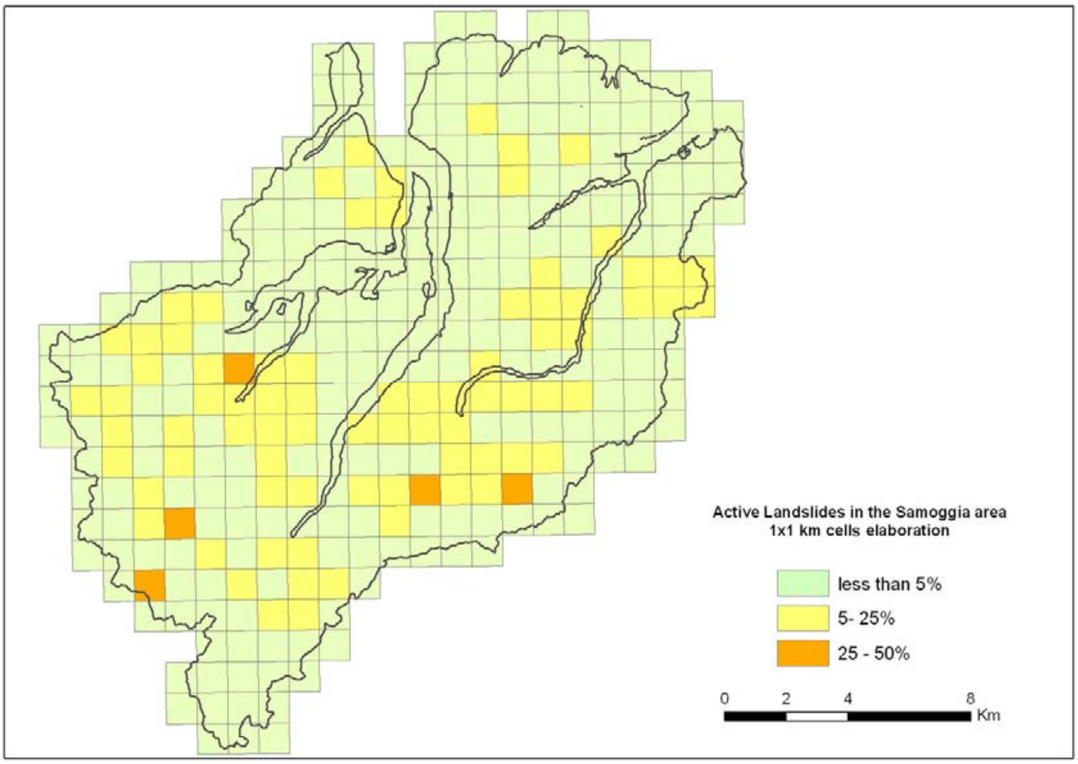


Figure 8. Raster map of the active landslides in the Samoggia area; grid resolution 1km

Table 4. Distribution of the dormant landslides in the Samoggia area according with the 1km grid

Dormant Landslides in the Samoggia Area 1kmx1km cell elaboration		
>50%	3.1%	(10/326 km^2)
25-50%	12.9%	(42/326 km^2)
5-25%	37.1%	(121/326 km^2)
<5%	46.9% (91/326 km^2 with no dormant landslides)	(153/326 km^2)

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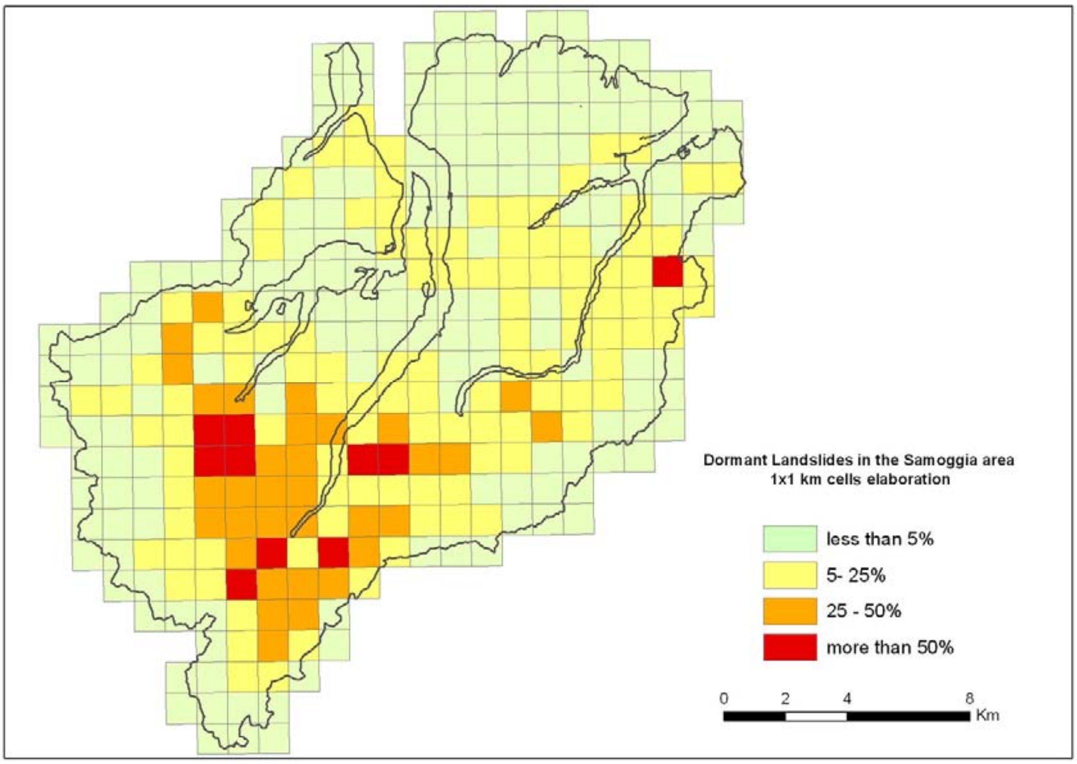

Figure 9. Raster map of the dormant landslides in the Samoggia area; grid resolution 1km

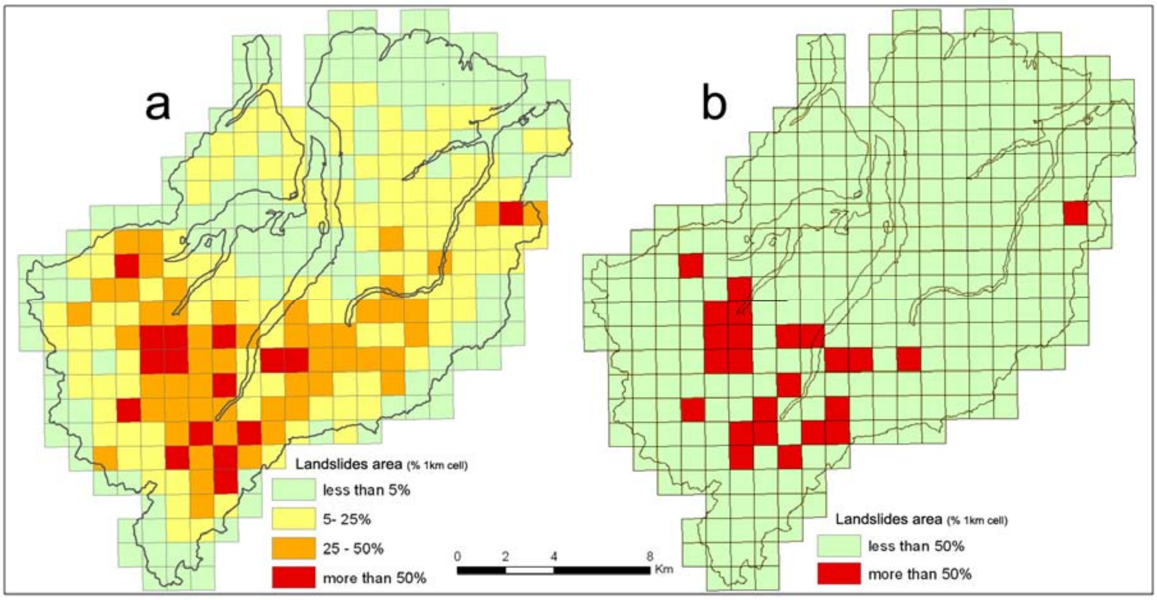

Figure 10. Comparison of the distribution of landslides on a 1km grid resulting from (a) the 100m and (b) processing the 1km grids.

Partner Number	Partner Name	Country
1	Cranfield University (CU)	United Kingdom
2	Bundesanstalt für Geowissenschaften und Rohstoffe (BGR)	Germany
3	Umweltbundesamt (UBA-A)	Austria
4	Institut National de la Recherche Agronomique (INRA)	France
5	Szent István University (SIU)	Hungary
7	Österreichische Agentur für Gesundheit und Ernährungssicherheit (AGES)	Austria
8	Bundesforschungs- und Ausbildungszentrum für Wald, Naturgefahren und Landschaft (BFW)	Austria
9	Bundesamt für Wasserwirtschaft (BAW)	Austria
11	Universiteit Gent (UGENT)	Belgium
12	Nikola Poushkarov Insitute of Soil Science (ISSNP)	Bulgaria
13	Česká Zemědělská Univerzita (CUA)	Czech Republic
14	Københavns Universitet (IGUC)	Denmark
15	Danmarks Miljøundersøgelser (NERI)	Denmark
16	Põllumajandusuuringute Keskus (ARC)	Estonia
17	Maa-ja Elintarviketalouden Tutkimus Keskus (MTT)	Finland
18	Agence de L'environnement et de la Maitrise de L'Energie (ADEME)	France
19	Agricultural University of Athens (AUA)	Greece
20	Magyar Tudomanyos Akademia Talajtani es Agrokemiai Kutato (RISSAC)	Hungary
21	Central Services for Plant Protection (CSSPSC)	Hungary
22	Miskolci Egyetem (UNIMIS)	Hungary
23	Lietuvos Zemes Ukio Universitetas (LZUU)	Lithuania
24	Latvijas Lauksaimniecibas Universitate (LLU)	Latvia
25	Ministry for Rural Affairs and the Environment (MRAE)	Malta
26	Alterra B V (ALTERRA)	Netherlands
27	Rijksinstituut Voor Volksgezondheid en Milieu (RIVM)	Netherlands
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Abstract
The ENVASSO Project (Contract 022713) was funded under the European Commission 6th Framework Programme of Research, 2006-8, with the objective of defining and documenting a soil monitoring system appropriate for soil protection at continental level. The ENVASSO Consortium, comprising 37 partners drawn from 25 EU Member States, reviewed almost 300 soil indicators, identified existing soil inventories and monitoring programmes in the Member States, and drafted procedures and protocols appropriate for inclusion in a European soil monitoring network of sites that are geo-referenced and at which a qualified sampling process is or could be conducted. This volume (IVb), a companion to the summary results (Volume IVa) of testing 22 indicator procedures in 28 Pilot Areas in the Member Sates, describes each pilot area study in detail. These Pilot Area study reports adhere to a standard reporting template to aid comparison and evaluation. They represent a wide range of soil-landscapes from the north to the south of Europe, some of which are transnational, and also represent the most comprehensive investigation of indicator performance at European level.

The other ENVASSO volumes are listed below.
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