SOTER (Soil and Terrain Digital Database) 1:500,000 and Its Application in Hungary

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Soils represent a considerable part of the natural resources of Hungary. Consequently, sustainable land use and proper soil management ensuring normal soil functions are particularly important elements of both the natural economy (optimum utilization of natural resources, rational biomass production and agricultural development) and of environment protection (with special regard to soil and water conservation). All soil-related actions require adequate information on soils and its environment (terrain, land site, ecosystem). Soil science (and the related earth and environmental sciences) can provide these information for scientists, policy- and decision-makers on various levels, planners and for land users (VÁRALLYAY, 1989c, 1993, 1994). The main objective of our present work was to given examples on the multipurpose applicability of the SOTER concept and SOTER database in the decision support systems of various soil-related activities.

Introduction

The International Society of Soil Science (ISSS) convened an international workshop on experts (Wageningen, The Netherlands, January, 1986) to discuss the necessity, rationality and possibility of the establishment of a uniform database (ISSS, 1986a) summarizing the results of a "Global Soil Resources Inventory " (SOMBROEK, 1984). Based on the conclusions and recommendations of this workshop a project proposal was prepared for SOTER: a World SOils and TERrain Digital Data Base at a scale of 1:1 million (ISSS, 1986b); and this proposal was officially endorsed during the 13th Congress of ISSS (Hamburg, August, 1986).

The primary aim of the SOTER Project is "...to utilize current and emerging information technology to establish a World Soils and Terrain Database, containing digitized map units and their attribute data. The main function of this database is to provide the necessary data for improved mapping, modelling and monitoring of changes of world soil and terain resources" (ISRIC, 1993) and presenting a wide range of accurate, timely interpretative analyses for decision- and policy-makers for their development concepts, decision-making, planning and implementation activities (BATJES, 1994a, 1994b).

In the general SOTER concept the following criteria have been formulated for the SOTER database:

a) it is structured to provide a comprehensive framework for the storage and retrieval of uniform soil and terrain data that can be used for a wide range of applications at different scales;
b) it will contain sufficient data to allow information extraction at a resolution of 1:1 million, both in the form of maps and tables;
c) it will be compatible with global databases of other environmental resources;
d) it will be amenable to periodic updating and purging of obsolete and/or irrelevant data, and
e) be accessible to a broad array of international, regional and national environmental specialists through the provision of standardized resource maps, interpretative maps and tabular information essential for the development, management and conservation of environmental resources.

The methodology of SOTER was elaborated by ISRIC (Wageningen, The Netherlands) within the frame of a UNEP-funded Project, with the cooperation of an international expert group (ISRIC, 1990a, 1991; ISRIC - UNEP, 1988; SHIELDS & COOTE, 1988). It was discussed, modified and improved several times on the basis of new views, scientific achievements and practical experiences (ISRIC, 1990b). Finally it was published by ISRIC (UNEP-ISSS-ISRIC-FAO) in 1993, as: "Global and National Soils and Terrain Digital Databases (SOTER). Procedures Manual".

For the demonstration of the SOTER concept, the database development and its multipurpose applicability regional SOTER projects ("SOTER windows") were established in various parts of the World, representing different physiography (climate, relief, hydrology and soil cover), economy, land use and environmental problems (BATJES, 1994a,b; OLDEMAN, 1994). A similar regional project proposal ("Computerized Land Development and Environmental Management System") was prepared and submitted for Central Europe (CE-SOTER): Austria, Czech and Slovak Republics, Hungary and Poland in 1990. The RISSAC-coordinated project was not implemented, because of the lack of financial support from international organizations and funding agencies.

Basic Elements of the SOTER Methodology

The two main - simultaneous - task groups of the SOTER system are:

- the delineation of areas with a homogeneous set of terrain and soil characteristics (mapping of SOTER units);
- the development of an attribute database related to the mapping units and based on well-defined differentiating criteria.

In SOTER three hierarchic levels are distinguished:

1. *SOTER unit.* It is an area (mapping unit) that can be identified, characterized and quantified by similar physiography (at the given level of scale-determined accuracy and probability): major land forms, based on the dominant gradient of their slopes and their relief intensity.

These areas can be subdivided according to lithology or parent material. Consequently, in the SOTER context, *terrain* is a particular combination of land form and lithology.

2. *Terrain components.* An area within each terrain, with a particular (pattern of) surface form, slope, mesorelief: and texture of parent material (in areas covered by unconsolidated material).

3. *Soil components.* An area within a terrain or terrain component covered by a particular (pattern of) soil, distinguished according to the appropriate (scale and complexity-determined) level of the used soil classification system.

Only the SOTER units are delineated on the map, because the territorial separation of the distinguished terrain components and soil components is not always possible at the applied SOTER scale, due to the complexity of their occurrence. Consequently, these information are stored in the attribute database only, and no entry is made into the geometric database: their territorial occurrence is not indicated on the map with contoured polygons.

This hierarchy of the SOTER system is shown in Figures 1 and 2 (ISRIC, 1993).

The non-spatial attributes of a SOTER-unit are summarized in Table 1 (ISRIC, 1993).

The detailed SOTER methodology, including the mapping approach and database construction; SOTER differentiating criteria; SOTER database structure; coding of SOTER units; number of terrain and soil components; representative soil profiles; attribute coding; description, characterization and coding of land cover (land use, vegetation) are summarized in the "Global and National Soils and Terrain Digital Databases (SOTER)" Procedures Manual. It contains guidelines for the development (construction) of reference fields (source map; laboratory information) and separate climate file, too.

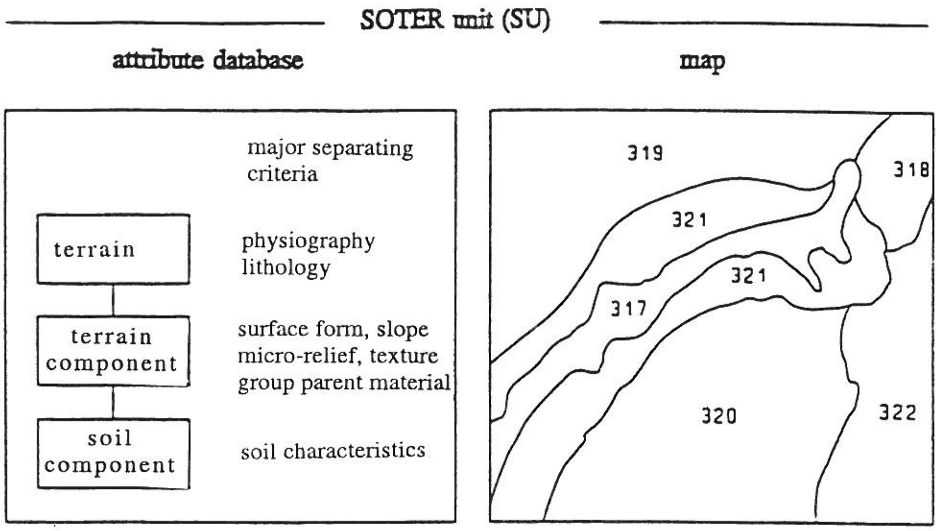

Figure 1
Relations between a SOTER unit and their composing parts and major separating criteria. Possible legend of the map:

317	one terrain type with one terrain component and one soil component
318	one terrain type, consisting of an association of two terrain components each having a particular soil component
319	one terrain type, consisting of an association of two terrain components, the first having one soil component and the second having an association of two soil components
320	one terrain type, consisting of an association of three terrain components, the first having one soil component, the second having an association of three soil components and the third having one soil component
321	one terrain type with one terrain component having an association of two soil components (occurs as two polygons)
322	one terrain type, consisting of an association of two terrain components each with a soil component

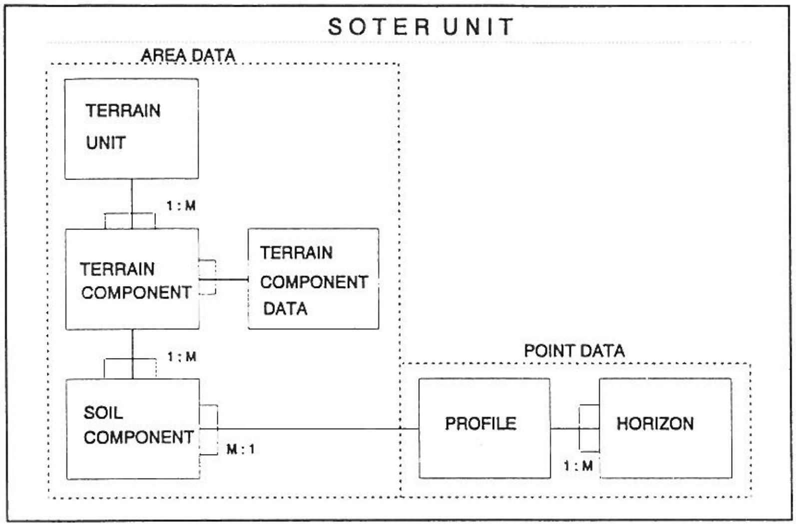

Figure 2
SOTER attribute database structure with area and point data (1:M = one to many, M:1 = many to one relations)

SOTER 1:500,000 Applications in Hungary (HunSOTER)

In 1993 a project proposal was elaborated by the Research Institute for Soil Science and Agricultural Chemistry (RISSAC) of the Hungarian Academy of Sciences, Budapest under the title "Multipurpose applicability of soil and terrain digital database (SOTER) for sustainable land use and soil management (HunSOTER)". The proposal was submitted to and accepted by the United Nations Environment Programme (UNEP) as "Establishment of soils and terrain data-base for sustainable agriculture and environmental protection in Hungary (HunSOTER)" (Project No. FP/6101-93).

Arguments (Why in Hungary?)

The proposal to select Hungary as a "SOTER window" was based on the following arguments, guaranteeing the efficient implementation of the Project within a short time, with high accuracy and low costs:

a) *Highly variable physiographical conditions:* highly variable climate and weather (under the influences of the Atlantic, Mediterranean and Continental effects); highly variable geology and relief (alluvial plains, lowlands, slightly un-

Table 1
Non-spatial attributes of a SOTER unit

TERRAIN

1 SOTER unit_ID
2 year of data collection
3 map_ID
4 minimum elevation
5 maximum elevation
6 slope gradient
7 relief intensity
8 major landform
9 regional slope
10 hypsometry
11 dissection
12 general lithology
13 permanent water surface

TERRAIN COMPONENT

14 SOTER unit_ID
15 terrain component number
16 proportion of SOTER unit
17 terrain component data_ID

TERRAIN COMPONENT DATA

18 terrain component data_ID
19 dominant slope
20 length of slope
21 form of slope
22 local surface form
23 average height
24 coverage
25 surface lithology
26 texture group non-consolidated parent material
27 depth to bedrock
28 surface drainage
29 depth to groundwater
30 frequency of flooding
31 duration of flooding
32 start of flooding

SOIL COMPONENT

33 SOTER unit_ID
34 terrain component number
35 soil component number
36 proportion of SOTER unit
37 profile_ID
38 number of reference profiles
39 position in terrain component
40 surface rockiness
41 surface stoniness
42 types of erosion/deposition
43 area affected
44 degree of erosion
45 sensitivity to capping
46 rootable depth
47 relation with other soil components

PROFILE

48 profile_ID
49 profile database_ID
50 latitude
51 longitude
52 elevation
53 sampling date
54 lab_ID
55 drainage
56 infiltration rate
57 surface organic matter
58 classification FAO
59 classification version
60 national classification
61 Soil Taxonomy
62 phase

HORIZON (* = mandatory)

63 profile_ID*
64 horizon number*
65 diagnostic horizon*
66 diagnostic property*
67 horizon designation
68 lower depth*
69 distinctness of transition
70 moist colour*
71 dry colour
72 grade of structure
73 size of structure elements
74 type of structure*
75 abundance of coarse fragments*
76 size of coarse fragments
77 very coarse sand
78 coarse sand
79 medium sand
80 fine sand
81 very fine sand
82 total sand*
83 silt*
84 clay*
85 particle size class
86 bulk density*
87 moisture content at various tensions
88 hydraulic conductivity
89 infiltration rate
90 pH H_2O*
91 pH KCl
92 electrical conductivity
93 exchangeable Ca^{++}
94 exchangeable Mg^{++}
95 exchangeable Na^{+}
96 exchangeable K^{+}
97 exchangeable Al^{+++}
98 exchangeable acidity
99 CEC soil*
100 total carbonate equivalent
101 gypsum
102 total carbon*
103 total nitrogen
104 P_2O_5
105 phosphate retention
106 Fe dithionite
107 Al dithionite
108 Fe pyrophosphate
109 Al pyrophosphate
110 clay mineralogy

dulating hilly regions, mountains, etc.); great variation in surface and sub-surface hydrology, and natural vegetation).

b) Occurrence of a *large range of soils* in the various phases of their development as well as a *large range of soil deterioration* due to natural factors and/or human activities: water and wind erosion, acidification, salinization-alkalization, structure destruction - compaction, biological degradation, extreme moisture and nutrient regime, soil pollution and toxicity, etc.

c) Various types of farming units (small private farms, cooperatives, state farms, etc.), *land use* and *cropping pattern, agrotechnics* and *amelioration.*

d) *Various* types of *environmental problems* and *hazards* ("hot spots") for the "Chemical Time Bomb" Projects), such as

- highly industrialized areas (air- and water pollution and their consequences);
- large urban agglomerations (Budapest, Miskolc) (drinking water supply - waste and waste-water disposal);
- shallow lakes (Balaton, Velence) with low buffer capacity and highly vulnerable ecosystems);
- frequented tourism centers;
- large rivers (Danube and tributaries) with their environmental consequences (flood hazard, water pollution);
- concentrated, large-scale livestock farms (→ liquid manure problem).

e) *Large amount* of precise and accurate *data* of long-term observations on the environmental factors (climate, geology, geomorphology, surface- and sub-surface hydrology, vegetation), soil conditions, land use and cropping patterns, environmental problems (see later).

f) Traditionally good institutional and personal scientific contacts and long-term experiences in (soil) scientific cooperation. Similar (or easily transferable) field survey methods and analytical procedures; soil and land classification and evaluation systems; mapping concept and methodologies in the whole Central and Eastern European region which make the data comparable and the conclusions and elaborated methods and technologies transferable.

Background

a) During the last decades a considerable amount of *soil and terrain* (land site) *information* has accumulated in Hungary. This was the result of various national, regional and local programmes related to the inventory, mapping, monitoring and evaluation of meteorological, geological, topographical, hydrological, vegetation and soil conditions, land use and environmental problems (National Atlas of Hungary, 1989).

b) A great number of *thematic soil maps* were prepared in various scales, with various contents and accuracies (VÁRALLYAY, 1989c, 1993). The most important maps are summarized in Table 2.

Table 2

Thematic soil maps in Hungary

No.	Map	Scale	Date of preparation	Prepared for	Content	Author(s)	References
1.	Practical soil maps	1:25,000	1935-1955	the whole country per topographical map sheets	m, tm, fd, ld, e	Kreybig and coll.	
2.	Large-scale genetic soil maps	1:10,000	1960-1975	60% of the agri-cultural land of Hungary, per farming units	m, tm, fd, ld, e	Coll.	
3.	Soil conditions and the possibilities of irrigation	1:25,000	1960-1970	present and potential irrigated regions	6 thematic maps fd, ld	Coll.	
4.	Large-scale maps for amelioration projects	1:5,000-1:10,000	1960-	amelioration projects (occasionally)	m, e	Coll.	
5.	Soil factors deter-mining the agro-ecological potential	1:100,000	1978-1980	the whole country per topographical map sheets	m (with an 8-digit code), c	Várallyay, G. Szücs, L. Murányi, A. Rajkai, K. Zilahy, P.	VÁRALLYAY et al., 1985.
6.	Agro-topographical map	1:100,000	1987-1988	the whole country per topographical map sheets	m (with a 10-digit code), c	Várallyay, G. Molnár, S. Szücs, L.	VÁRALLYAY, 1989c.
7.	Hydrophysical properties of soils	1:100,000	1978-1980	the whole country per topographical map sheets	m, c	Várallyay, G. Szücs, L. Rajkai, K. Zilahy, P.	VÁRALLYAY, 1989c.

No.	Map	Scale	Date of preparation	Prepared for	Content	Author(s)	References
8.	Limiting factors of soil fertiltiy	1:500,000	1976	the whole country	m	Szabolcs, I. Várallyay, G.	SZABOLCS & VÁRALLYAY, 1978
9.	Main types of moisture regime	1:500,000	1983	the whole country	m, c	Várallyay, G. Zilahy, P. Murányi, A.	VÁRALLYAY, 1989b.
10.	Main types of substance regime	1:500,000	1983	the whole country	m, c	Várallyay, G. Szücs, L. Molnár, E.	VÁRALLYAY, 1989c.
11.	Soil erosion	1:500,000	1960-1964	the whole country	m, tm, e	Stefanovits, P. Duck, T.	STEFANOVITS, 1964
12.	Salt affected soils	1:500,000	1970-1974	the whole country	m, e	Szabolcs, I. Várallyay, G. Mélyvölgyi, J.	SZABOLCS, 1974.
13.	Susceptibility of soils to acidification	1:100,000 1:500,000	1985-1988	the whole country	m, c	Várallyay, G. Rédly, M. Murányi, A.	VÁRALLYAY et al., 1989, 1993.
14.	Susceptibility of soils to physical degradation	1:500,000	1985-1988	the whole country	m, c	Várallyay, G. Leszták, M.	VÁRALLYAY & LESZTÁK, 1990.

Remarks:

m: soil map; tm: thematic map; fd: field description; ld: laboratory data; e: explanatory booklet; c: computer storage

c) In the last years all existing soil data were organized into a computerized geographic soil information system (HunSIS = TIR) containing

- point data for soil profiles and their main horizons;
- digitized 1:25,000 scale thematic maps on the most important soil properties;
- models on soil - plant - water relationships (KUMMERT et al., 1989).

d) For the registration of soil changes three systematic *monitoring systems* were established (VÁRALLYAY, 1993):

- Soil fertility control system (AIIR): measuring the most changeable soil characteristics in the top soil (ploughed horizon) of 5 million hectares of agricultural fields in 3-year cycles. The programme started in 1978 and stopped before completing the third cycle.
- Microelement survey: Measuring the total and soluble microelement content, including micro-nutrients and (potentially) toxic pollutants, in 3-3 horizons of soils in 6,000 agricultural fields.
- Soil information and monitoring system (TIM). It is a subsystem of the integrated Environmental Information and Monitoring System (KIM). TIM contains 1200 representative observation points: 800 points on agricultural land; 200 points in forests and 200 points in environmentally threatened "hot spots", where all the important soil parameters are measured regularly: in 1-, 3- or 6-year cycles - depending on their changeability.

e) The provided *information were properly used* in Hungary as a scientific basis *for planning and implementation* of rational land use; prevention of soil degradation processes and soil pollution; planning of activities on soil fertility and soil moisture control, as amelioration, agricultural water management, irrigation, drainage, agrotechnics; territorial planning of industry, urban and rural development, infrastructure, etc.).

Hungarian soil science, soil survey and soil testing practices always serve as the basis of the planning and organization of crop production and environment control. Within the new political/economical/social circumstances these tasks represent a new and exciting challenge for Hungarian soil science in the phase of economy restructuring and in the development of a rationally privatized, market-oriented, sustainable agricultural production harmonized with successful environment protection.

Main objectives

The large amount of available information and the long-term experiences in their practical utilization in Hungary give rational opportunity for the development of a comprehensive, scientifically-based computerized land resource development and environmental management system in Hungary using the

SOTER concept and SOTER methodology, proving its multipurpose applicability in the regional and national decision-making process concerning

- the sustainable use of land and water resources for agricultural production and for other purposes;
- the conservation of these resources ensuring their renewal and normal functions;
- the prevention of natural environmental hazards and human-induced side-effects, such as soil or land degradation processes and landscape deterioration.

The HunSOTER database

The system is a well-structured, simple and easily applicable soil and terrain digital database prepared in the scale of 1:500,000 for the whole country (93,000 km²) following the SOTER methodology (ISRIC, 1993).

The database - according to the internationally accepted SOTER Guidelines - contains the necessary information on the distinguished SOTER units, terrain components and soil components (see Table 1).

The 1:500,000 scale map of SOTER units (altogether 1210) was prepared for the whole country, in cooperation with the experts of the Geographical Research Institute (D. LÓCZY) and the Department of Soil Science and Agrochemistry of the Gödöllő University of Agricultural Sciences (E. MICHÉLI). The schematic version of this map is shown in Figure 3. Within the 1210 SOTER units about 2000 terrain components and about 5000 soil components have been distinguished.

The database contains point data for about 1000 representative soil profiles and for their horizons (Table 1). The three main sources of these data are:

- The 1:100,000 scale agro-topographical map of Hungary (VÁRALLYAY, 1989c, 1993)
- GIS database of the Hungarian Soil Information System (HunSIS = TIR) developed in RISSAC for Pest county (one of the 19 administrative regions of Hungary);
- The database of the newly established "National Soil Conservation Information and Monitoring System" (TIM) operated by the Ministry of Agriculture (Division of Agricultural Environment Management). The 1200 representative soil profiles (800 in agricultural lands, 200 under forest, and 200 in environmentally sensitive or particularly threatened "hot spots") were selected by well-trained regional soil experts with long-term soil survey experiences. The laboratory analyses were done by the accredited regional laboratories of the National Laboratory Network for Soil and Plant Analyses. For the SOTER database the data of the first (starting) sampling were used which was carried out between 15 September and 15 October, 1992.

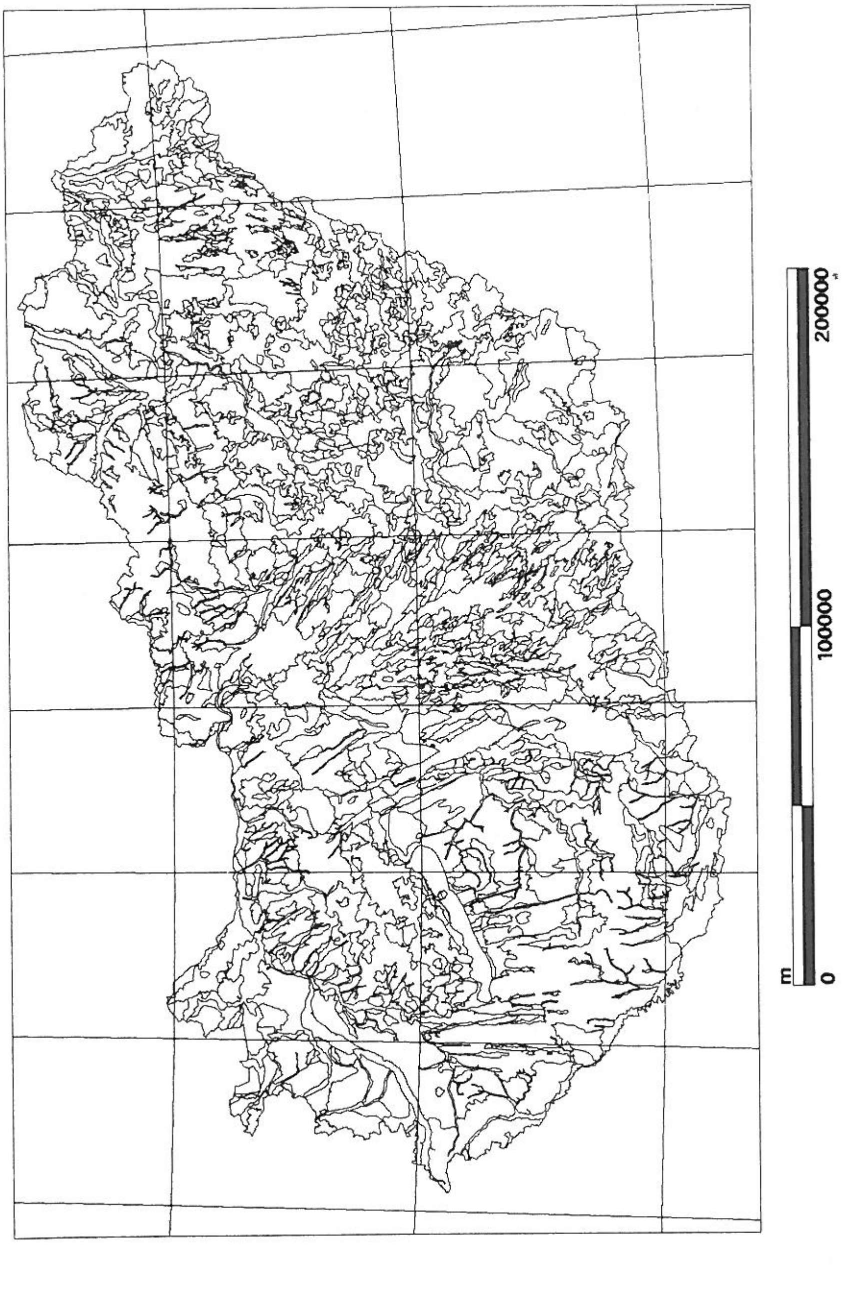

Figure 3
SOTER units in Hungary

The periodical sampling and analysis of these profiles present a unique opportunity for the continuous control and up-dating of the SOTER database (VÁRALLYAY, 1993).

For the purpose of demonstrating the multipurpose applicability of the SOTER database on national level at the 15th Congress of the International Society of Soil Science (Acapulco, Mexico, 10-16 July, 1994) (the present paper) a "window area" was defined from the whole country (see Fig. 3). The territory of this "demo window" is approximately 25,000 km² (about one quarter of the whole country). Within this area 355 SOTER units were indicated in the 1:500,000 scale map, consisting of 470 terrain components and 1089 soil components. For the characterization of their soils 337 representative soil profiles have been selected and their profile and horizon attributes are included in the present database. The filling up of the HunSOTER database (in a similar way) for the whole country is going on and will be completed in 1994.

In Figure 3 the HunSOTER mapping units are presented for the whole country. On the map shown in Figure 4 for the selected "demo-window", the territorial percentage of the dominant soil type within a SOTER unit is indicated, which gives a certain idea about the complexity (heterogeneity) of the mapping units from the viewpoint of soil conditions. More illustrative information can be obtained if we indicate the area-percentage of the first two (or in special cases the first three) "dominant" soil types on various thematic maps, especially in the case of (nearly) similar soil types and their complexes.

Expected Benefits and Multipurpose Applicability of the HunSOTER Database

The HunSOTER Database is:

- compatible with the Global soil and terrain digital database and with Global databases of other environmental factors;
- amenable to updating and purging of obsolete and/or irrelevant data;
- easily applicable for computer storage, digitalization and modelling;
- accessible to a broad array of international, regional and national decision-makers responsible for the development, management and conservation of natural resources;
- transferable to national databases at larger scale (greater detail).

The HunSOTER database with its "windows" represents a scientific basis of the various "Plan of Actions" for sustainable land use and soil management.

a) It offers wide-range opportunities for the spatial quantification and comprehensive analysis-modelling-evaluation of soil properties, pedotransfer functions and soil processes determining:

- soil fertility and soil productivity for various crops;

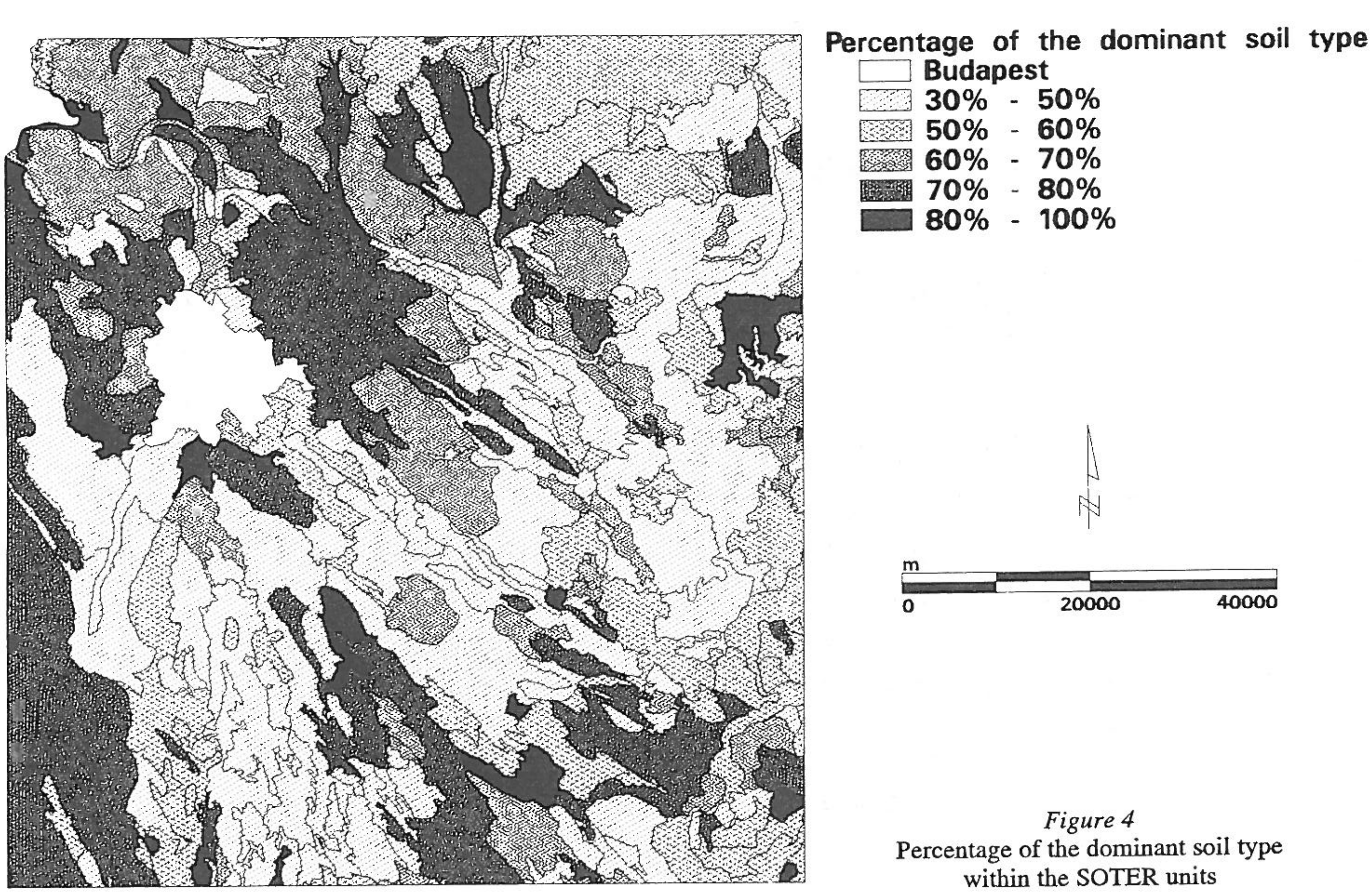

Figure 4
Percentage of the dominant soil type within the SOTER units

- the efficiency of environmental soil functions, such as: storage of heat, water, nutrients and pollutants; buffer-capacity; filter functions; element of biodiversity, etc.
- the vulnerability of terrain and susceptibility of soils to various natural and anthropogeneous impacts, environmental hazards (water- and wind erosion; acidification; salinization-alkalization; soil structure destruction, compaction; biological degradation; unfavourable changes in moisture and nutrient regimes; soil toxicity; pollution of surface and subsurface water resources; landscape deteriorations);
- degradation and decline of forest and grassland ecosystems; and the forecast of potential future changes due to the impacts of natural factors and human activities, assuming various plausible scenarios.

b) The SOTER database (with its above-mentioned functions) can be properly used for the:

- rational use and management of natural resources (surface and subsurface waters, soils; vegetation, biota, etc.;
- protection and conservation of land-, soil-, water- and biological resources;
- evaluation of land productivity; maintenance or increase of soil fertility;
- optimalization, rationalization and regionalization of land use, cropping pattern;
- national planning (concepts, main directives, general guidelines) of activities on soil fertility and soil moisture control, such as amelioration, agricultural water management, irrigation, drainage, agrotechnics;
- transfer and exchange of technologies for sustainable land use and soil management, as well as for ecosystem redevelopment;
- evaluation, modelling, monitoring and forecast of environmental hazards for their prevention or control;
- provision of data for retrospective or predicting models and early warning systems;
- prevention, elimination or moderation of soil degradation processes (water and wind erosion; acidification; salinization-alkalization; soil structure destruction, compaction; biological degradation; unfavourable changes in moisture and nutrient regimes);
- "inventarization" of environmental "hot spots" (environmentally sensitive, valuable, protected ecosystems and their land-sites; highly polluted areas with susceptible soils; etc.);
- evaluation of the buffer capacity of soil; level, form and sources of soil pollution and toxicity (possibilities and criteria of liquid manure, sewage sludge, waste and waste-water disposal, etc.);
- evaluation, mapping and monitoring of critical loads for various ecosystems;
- rational territorial planning of non-agricultural land use (industry, surface mining, infrastructure, urban and rural development, recreation, etc.);

c) HunSOTER can serve as an indispensable soil and terrain digital database for many *international programmes for environment control,* such as:

- "Chemical Time Bombs" (non-linear, time-delayed impact of potentially harmful chemicals);
- "Long-term Environmental Risks for Soils, Sediments and Groundwaters in the Danube Catchment Area";
- "Mapping of Critical Loads and Areas....";
- "Global Change of the Environment" (IGBP Programme);
- "Global Assessment of Human-Induced Soil Degradation - GLASOD" (UNEP-ISRIC); etc.

d) The database can be used for the *transfer* and exchange *of technologies* for sustainable land use and soil management, as well as for *ecosystem re-development.*

e) The general SOTER *concept and methodology* can be *improved* on the basis of HunSOTER experiences.

f) The improved SOTER database development methodology and the experiences of the presented HunSOTER case studies can be directly used or adapted) with minor or some modifications) in many countries of the World with similar natural conditions and socio-economic circumstances. The conclusions drawn and the elaborated modules are (can be) applicable in many developing countries, as well.

g) In the last year(s) radical political and economical changes have been going on in Central and Eastern Europe and the idea of "Common Europe" became a reality. However, this requires economy restructuring on a scientifically-based up-to-date land resource development and environmental management policy. The HunSOTER project will present numerous case studies to illustrate the necessity and practical applicability of a regional (or national) SOTER *database for* such purposes in the transition period of *economy restructuring.*

Case Studies

From this wide spectra of potential practical applications five practical possibilities are demonstrated by case studies.

1. Land (soil and terrain, "land-site") evaluation

In Figure 5 a map is presented for Pest county (one of the nineteen administrative regions of Hungary) indicating soil bonitation value categories for the distinguished HunSOTER units according to the Hungarian land evaluation system (STEFANOVITS, MÁTÉ & FÓRIZS in VÁRALLYAY, 1988). In this system the soil bonitation value (land productivity) "B" (1 expresses the lowest and

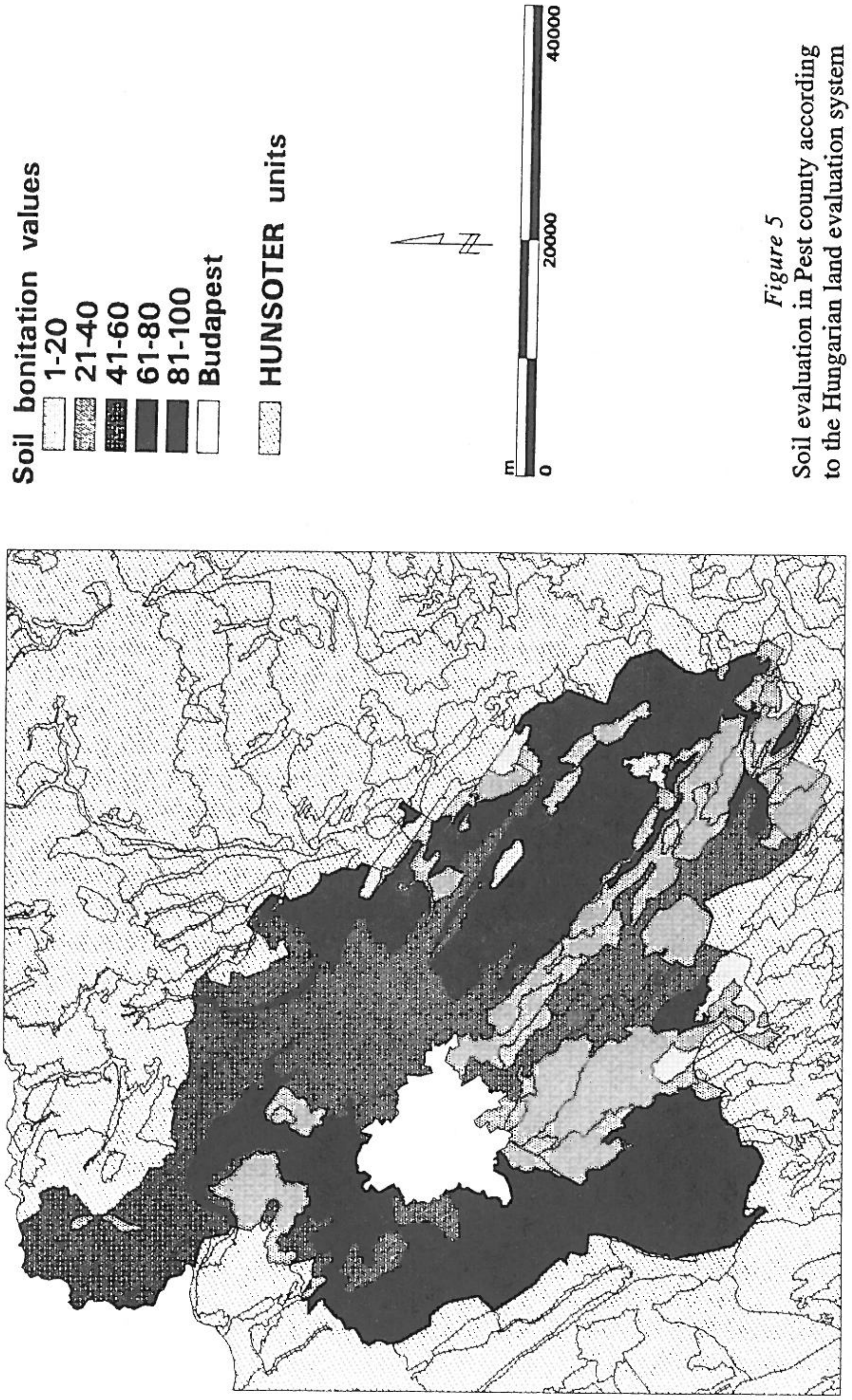

Figure 5
Soil evaluation in Pest county according to the Hungarian land evaluation system

100 the highest soil fertility/land productivity in Hungary) is calculated as follows:

$$B = A - (a + b + c + \dots n) - R$$

where:
B = soil bonitation value;
A = starting point, depending on the soil type, according to the Hungarian soil classification system;
a,b,c,...n = limiting factors of soil fertility evaluated by a special, experimentally validated point system [the following limiting factors are evaluated in the system in a soil-type specific way): extreme soil reaction (too low or too high pH); extreme soil texture (too coarse or too heavy); high carbonate content; low organic matter content; lack of, or shallow humus horizon; salinity-alkalinity; shallow depth (to the solid rock, gravel, hardpan or other cemented layer, etc.); coarse fragments on the surface or within the soil profile; high susceptibilty to water and/or wind erosion; parent material]
R = relief factor (depending on slope gradient and exposure).

Because all the above-mentioned input parameters are stored in the Hun-SOTER database as terrain, terrain component or soil compontent data; or as profile or horizon attributes (for the representative soil profiles) the preparation of such a thematic map is a routine output of the System.

Having - preferably experimentally validated - land-site (especially soil - ecological) requirement criteria of a given crop, or even its selected/breeded varieties, the land suitability map for that crop can be prepared with the application of the SOTER database. Similar approach was successfully tested within the National Programme for the "Assessment of the Agro-ecological Potential of Hungary" (LÁNG et al., 1983). Such an evaluation can be the scientific basis for a better territorial coordination of the agro-ecological conditions of the country and the agro-ecological requirements of cultivated crops (and their varieties or even eco-types): rational land use and cropping pattern, regionalization of biomass production, crop rotation, etc., favourable both for crop production, soil and water conservation and environment protection.

2. Evaluation of the vulnerability of land and susceptibility of soils to various soil degradation proceses (State of the Hungarian Environment, 1991; VÁRALLYAY, 1989a, 1991)

These case studies are illustrated (as potential possibilities) on the four "sub-windows" of the map shown in Figure 6:

a) *Vulnerability of soils to water erosion* (STEFANOVITS, 1964; STEFANOVITS & VÁRALLYAY, 1992).

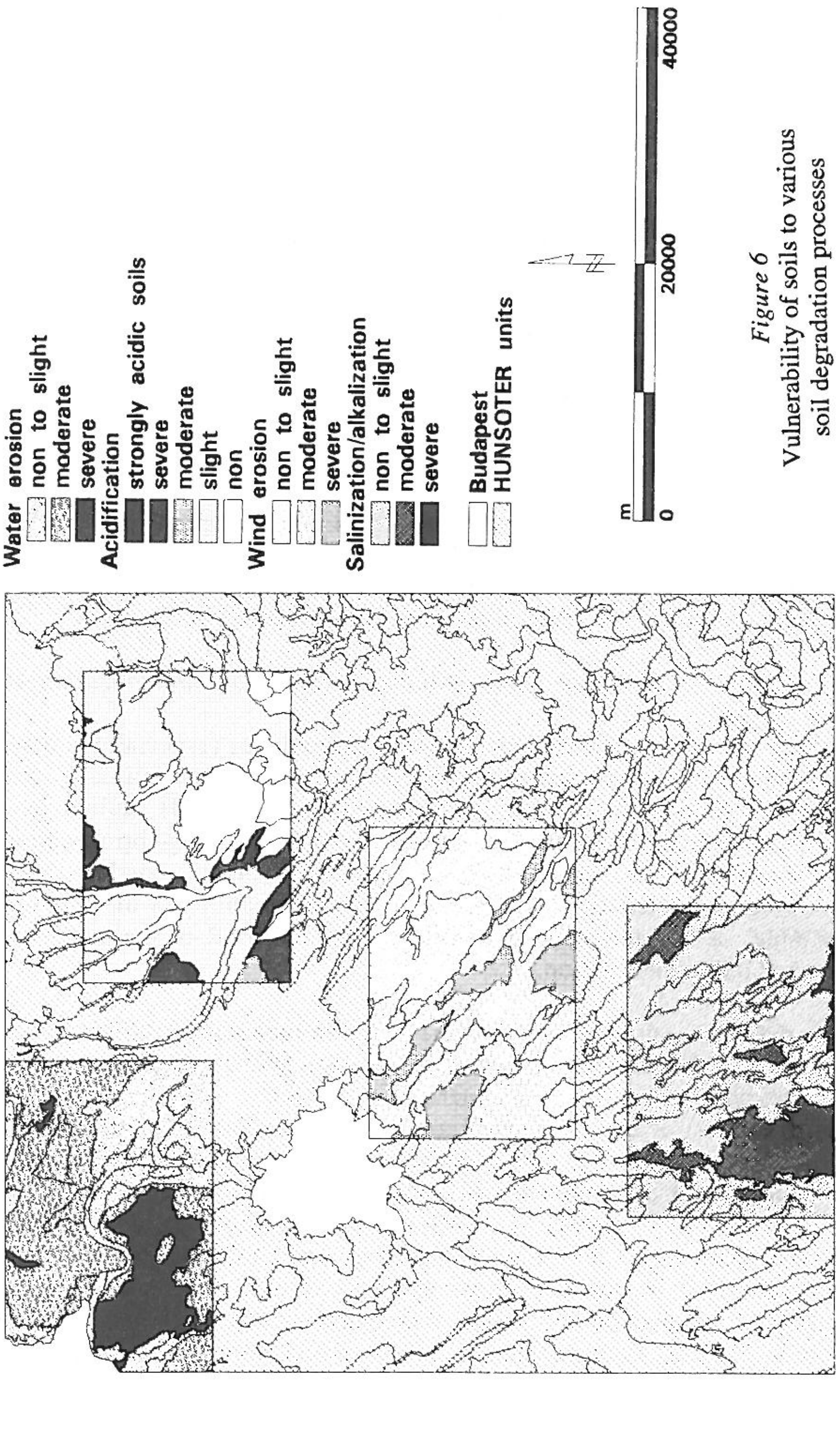

Figure 6
Vulnerability of soils to various soil degradation processes

In this system the following land characteristics are taken into consideration for the water erosion risk assessment (either as causative or influencing factors):
- climate - weather characteristics (rainfall distribution, frequency and intensity of heavy rains);
- relief characteristics (slope gradient and slope morphology);
- erodability of soil (texture, compactness, porosity, state of soil structure; infiltration rate, permeability; depth of the soil and water storage capacity);
- density, type and duration of vegetation (land use, cropping pattern, natural vegetation).

b) *Vulnerability of soils to wind erosion* (STEFANOVITS, 1964; KARÁCSONY, 1994).

In this system the influencing factors are the wind characteristics; stability and morphology of soil surface; soil texture, structure, compactness and organic matter content; and type of vegetation cover.

c) *Susceptibility of soils to acidification* (VÁRALLYAY et al., 1985, 1989).

In this system the distinguished susceptibility categories depend on the parent material, present soil reaction and carbonate status, texture, organic matter content and soil depth (determining the buffer capacity of the soil).

d) *Hazard of secondary (human-induced) salinization/alkalization* (SZABOLCS, 1974).

In this system - in addition to climate characteristics (especially aridity: the ratio between potential evapotranspiration and atmospheric rainfall) and the character of field water balance - soil properties (present pH, salinity profile, salt composition and ESP; texture, structure, rate of swelling-shrinkage phenomena, infiltration rate, saturated and unsaturated hydraulic conductivity) and groundwater characteristics (average and temporal variability of the depth of the water table; salt content, salt composition, pH, and SAR of the groundwater) were taken into consideration.

The definition, dimension and citeria of the various susceptibility/vulnerability classes and the methods of their determination are described in detail in the relevant publications of the above-mentioned authors.

Because most of these required input data can be found in the HunSOTER database (or in the attached climate and hydrology data files; or they can be derived from these data) similar sensitivity analyses can be extended to the whole country (VÁRALLYAY, 1991) and to other soil degradation processes or soil pollution risk assessments, too. E.g. VÁRALLYAY and LESZTÁK (1990) developed a system for the assessment of the susceptibiltiy of soils to physical degradation of soils (soil compaction and structure destruction) and investigations are carried out in RISSAC for the evaluation of the critical loads of various potentially harmful chemical pollutants in soils of Hungary with different "chemical vulnerability" and soil resilience.

The presented HunSOTER case study and our SOTER application experiences can be directly used or adapted (with minor or some modifications) in many countries of the World under similar natural conditions and socio-economic circumstances. The current UNEP Project might be extended in the future to establish a regional SOTER Centre at RISSAC (Budapest, Hungary) for training scientists from Central and Eastern Europe in the SOTER concept and in the compilation, interpretation and utilization of the SOTER database, as well as to coordinate and harmonize SOTER activities in the region.

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