Soil and Landsite Databases for the Interpretation and Extension of the Results of Long-term Field Experiments

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Rational land use and soil management are important elements of *sustainable (agricultural) development. Soils* represent a considerable part of the natural resources of Hungary. Their rational utilization, conservation and the maintenance of their multipurpose functionality have particular significance in the Hungarian national economy and in environment protection (VÁRALLYAY, 1995a, b).

Sustainable Development

The term "sustainable development" was not yet mentioned at the first world conference on environmental protection (Stockholm 1972) under the title: UN Conference on Human Environment. However, at the second similar worldwide meeting twenty years later in Rio de Janeiro, this was already the most fashionable and most frequently cited term. The Rio Conference set it as a global objective to realize sustainable development everywhere and in every field, i. e. in every country, whether advanced or developing, and in each branch of the economy, ranging from settlement policy to agriculture and the industry (LÁNG, 1995).

The term sustainable development began to spread in the literature in the early 1980's. Lester R. Brown, President of the Worldwatch Institute, published his book entitled "Building a Sustainable Society" in 1981. In this book, the author emphasized the general task to reach sustainability, including such things as the stability of population, the conservation of natural resources, the utilization of renewable energies and the protection of the natural values. The World Commission on Environment and Development formulated a message in the publication "Our Common Future" in 1987 encouraging the global use and application of the concept of sustainable development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

This formulation reflects essentially a political stand. It concentrates on Man whose primary needs must be satisfied, while those of future generations should also be taken into account. The protection of the environment and resource-saving are not specifically mentioned in this definition. Thus the concept of sustainable development is a message for the world's developing countries, as well as for the low-income strata of society, to give them some hope as to their future. An indirect interpretation of the definition, however, makes it clear that future generations may only share in the worldly goods if natural resources will be saved on a wide scale and if the values of the environment will be preserved (LÁNG, 1995).

It was in the mid-1980's that the elaboration and definition of the criteria of sustainability for the individual sectors of the economy started. FAO adopted the following definition of sustainable agricultural development in 1988: "Sustainable development is the management and conservation of the natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such sustainable development (in agriculture, forestry and fisheries sectors) conserves land, water, plant and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable, and socially acceptable." It is necessary to underline that sustainable agricultural development does not prohibit, in the contrary includes the rational and controlled use of fertilizers and other chemicals, and is far from being equal with "no chemical" agriculture or "bio-farming".

The definition formulated jointly by IUCN, UNEP and WWF tends to emphasize the biological elements: "Sustainable development is improving the quality of human life while living within the carrying capacity of supporting ecosystems."

Following the Rio Conference, the concept of sustainable development has undergone a certain devaluation. It had been used so many times without any substantial content that it was not taken seriously even when its use was professionally or scientifically well-founded and justifiable.

In Hungary an international seminar was held in 1984 (already!) under the title 'Technologies for Sustainable Agriculture" and the papers presented were published in the journal Agrokémia és Talajtan (Tom. 34. pp. 125-210). During the last two decades five national programmes have been initiated and organized by the Hungarian Academy of Sciences and I. Láng:

- The assessment of the agro-ecological potential of Hungary (LÁNG et al., 1983; VÁRALLYAY et al., 1979, 1980a, 1985);
- Possibilities of the multipurpose use of the produced biomass;
- Adaptive agriculture (LÁNG & CSETE, 1992);
- AGRO-21 (Agro-21, 1995; LÁNG et al., 1995);
- AGRO-QUALITY-21 (ongoing programme, started in 1996).

Some months after the Rio Conference an International Symposium was jointly organized in Budapest (28 Sept. - 2 Oct. 1992) by the Hungarian

Academy of Sciences and CAB International on "Soil Resilience and Sustainable Land Use" (GREENLAND & SZABOLCS, 1993; Agrokémia és Talajtan, 1993).

On these bases a group of experts has elaborated the concept of sustainable agriculture best suited to the country's natural endowments. After the discussion of the first draft of this document at six regional meetings four main criteria of sustainable agricultural development in Hungary had crystallized: It should

- be environmentally non-degrading,
- be resource-saving,
- produce healthy food and fodder,
- make the present and future generations of farmers interested in agricultural production.

The new system aims to employ environmentally sound, energy- and material-saving processes, placing special emphasis on quality. This new farming system can only achieve good results with adequate expertise. So research, education, innovation and extension services, including rational field experiments, are to play a prominent role in its realization (LÁNG, 1995).

Data Requirements

The scientifically-based planning and realization of sustainable land use, introduction of site-specific, precision technologies for biomass production, for the maintenance of the favourable and desirable multifunctionality of soils, for soil and water conservation and for nature preservation require

- *adequate information on the soil:* exact, reliable, "detectable" (preferably measurable), accurate and quantitative territorial data on well-defined soil properties with the characterization of their spatial (vertical, horizontal) and temporal variabilities, soil processes and pedotransfer functions and land characteristics;
- *comprehensive knowledge on the existing relationships* among natural factors, soil and land characteristics and the soil biota, native vegetation and cultivated crops (plant responses), including the partial and integral impacts of influencing factors and their mechanisms;
- application of existing (verified and validated or "calibrated") *simulation models for* the *prediction* of the potential consequences of various human actions and for the selection of the most appropriate alternative measures and most efficient technologies for their realization.

Soil Information Requirements Long-term Field Experiments

Long-term field experiments have a distinguished role in the sustainable agriculture concept. Any experiment with plants is a direct *dialogue* between the plants and man. The "experimentalist" formulates questions (meaningful or meaningless questions) to the plants, asking their reaction and response on various influences (treatments and their combinations) and tries to understand and analyse these "answers", make good (real, "truth"-reflecting) *diagnosis* and draw conclusions for the *optimum "therapy"* (treatment, technology). Long-term field experiments are the best means of such a dialogue, representing real (or at least near to real) situations. This is true only in the case of *"representative" experimental sites* (real situation) and rationally planned and implemented experimental design (asking "good questions"). These are the basic criteria of any field experiment and the satisfaction of these criteria is the most difficult task of any "experimentalist". The proper selection of "representative" experimental sites has particular significance in this respect. For this purpose adequate land and soil information are indispensable preconditions. These information are also necessary for the planning, set-up, maintenance and management of long-term field experiments, including all scientific and technical details.

Another field where *adequate* soil and land information are absolutely necessary is the *interpretation of the experimental results* and the determination of their validity (consequently, applicability) and their extension in space and time. If an "experimentalist" presents his/her precisely registered experimental results (even with the desirable statistical evaluation) but his/her conclusions - based on his/her observations - are valid only to the given conditions (for the given soils of the experimental sites, for the applied agrotechnics and for the given year of the experiment) it does not give an applicable answer to the "dialogue questions" and cannot be - satisfactorily - extended to other places and for other years (with other weather, moisture supply, agrotechnics, etc.). The other extreme in interpretation is over-generalization: extension of the validity of the experimental results for a large (and not necessarily similar) area, or for a long (and not necessarily homogeneous) time period. It may lead to false conclusions and dangerous decisions, making the applied "therapy" (treatment, technology) inefficient, unpopular and sometimes even harmful with unfavourable environmental side-effects.

The new, up-to-date *site-specific* production *technologies need* very precise environmental and technical criteria in their proper application. To answer such questions, as:

- to what areas can the registered experimental results be extended?
- to what years (vegetation seasons) can the measured data (and conclusions) be applied? and what are the agrotechnical criteria of their validity?
- to what extent can the measured long-term experimental data be used for the prediction of future trends and the impact of various alternative measures (treatments, technologies) using the basic concept of forecasting methods: "to predict future on the basis of the analysis of the past"

adequate soil and land information are required. Without such information base long-term field experiments lose their unique value, preventing their multidisciplinarity and applicability in the various fields of sustainable land use and soil management.

It is a fact that many long-term field experiments are not (or not fully) usable for such purposes because of simple scientific and/or technical inadequacies, e.g. lack of initial land and soil database; lack of continuous (at least systematic) registration of changes in soil and land characteristics (monitoring); lack of a well-organized soil sample archive; inadequacies in database management; problems and sometimes strict restrictions in the availability of data; etc. A considerable part of these problems can be solved with joint efforts and scientific cooperations; another part of the problems cannot be corrected and give opportunities only for critical conclusions which can be taken into consideration in the planning and establishment of new experimental programs.

The main objective of the present paper is to schematically summarize the available and applicable soil data which can be properly used in the interpretation and extension of the results of long-term field experiments. A more detailed state-of-the-art overview was presented by VÁRALLYAY (1994c).

Data Sources on Natural Factors

In Hungary a large amount of information are available on the various natural factors as a result of long-term observations, survey and mapping activities (The National Atlas of Hungary, 1989). The most important databases and monitoring systems are as follows:

a) Meteorological data. Systematic and regular measurements from 1850. Basic meteorological parameters are registered at 160 observation points; 18 stations are equipped for detailed atmospheric-chemistry measurements and 4 EMEP stations for continuous atmospheric monitoring (MÉSZÁROS et al., 1993).

b) Hydrological data. Regular records on the quantity and quality of *surface waters* (rivers, creeks, canals, lakes, ponds, reservoirs) from the first decade of the century.

Regular measurements on *groundwater conditions* (depth of water table; chemical composition of the groundwater) for 600-1000 groundwater testing wells are available from 1935, including 50 piezometer installations.

c) Geological data. As a result of the 160-year geological survey, the 1:200,000 geological map of Hungary has been prepared as well as a great number of various thematic geological, hydrogeological, geo-chronological maps in larger scales for different regions of the country.

d) Geomorphological data. In addition to the 1:200,000 geomorphological map (geomorphological types, subtypes and varieties) of Hungary a series of regional maps has been prepared, indicating the geomorphology pattern of smaller territories in larger scale using digital relief models in the last years.

Soil Information Sources

A large amount of soil information are available in Hungary as a result of long-term observations, various soil survey, analyses and mapping activities on national (1:500,000), regional (1:100,000), farm (1:10,000-1:25,000) and field level (1:5,000-1:10,000) during the last sixty years. Thematic soil maps are available for the whole country in the scale of 1:25,000 and for 70% of the agricultural area in the scale of 1:10,000.

There are at least three reasons why this rich soil database has been developed (VÁRALLYAY, 1993): the small size of the country (93,000 km²); the great importance of agriculture and soils in the national economy; the historically "soil loving" character of Hungarian people, and particularly Hungarian farmers.

Soil Maps

In Table 1 the most important thematic soil maps in Hungary are summarized, indicating their content, scale, author and date of preparation (Proceedings ..., 1989; VÁRALLYAY, 1989, 1994b,c).

The maps can be divided into three main groups:

(a) *Large-scale maps* (Nos. 1.-4. in Table 1)

(1) "Kreybig practical soil maps (KREYBIG, 1937);

(2) 1:10,000 scale genetic soil maps (SARKADI et al., 1964; SZABOLCS, 1966);

(3) 1:25,000 scale maps on the possibilities and limitations of irrigation (SZABOLCS et al., 1969);

(4) Large scale (1:5,000, 1:10,000) maps for various soil amelioration projects.

Large-scale soil maps (and related databases) will have a "renaissance" in the near future because of the following reasons:

- the new land ownership structure, the rent-a-field system and the developing land market requires more detailed information on land/soil resources than ever in Hungarian history;

- the new soil/land evaluation system (which - hopefully - will be completed, and officially introduced and formulated in legal documents in the near future) also needs detailed soil/land information, convertible to existing or planned EU-standards;

- the site-specific precision agrotechnologies (precise and scientifically-based soil moisture control, water- and nutrient supply, soil and environmental pollution control) necessitates adequately precise data on soil and land characteristics. [The best example in this respect is the new, fully automatized and computerized fertilizer application technology. In the system a large-scale "fertilizer-requirement" map (SARKADI & VÁRALLYAY, 1989; VÁRALLYAY, 1994d) is prepared (on the basis of the forecasted/planned yield, the nutrient requirement and nutrient uptake dynamism of the given crop, the main characteristics and the plant nutrient status of the given soil) and stored in a tractor deck computer; the actual position of the tractor is registered by GPS; and the required quantity of fertilizer is sprayed accordingly, automatically or semi-automatically (controlled by the tractor driver).]

(b) *Medium scale maps* (Nos 5-7 in Table 1).

(1) Soil factors determining the agro-ecological potential (7 characteristics);

(2) Agro-topographical maps (9 characteristics);

(3) Hydrophysical properties of soils (9 main and 17 subcategories);

(4) Status of soil erosion (1:75 000; STEFANOVITS, 1964).

(c) *Small scale maps*

(1) 1:500,000 scale genetic soil map (STEFANOVITS & SZÜCS, 1961) and generalized thematic soil maps (Nos 8-12 in Table 1)

(2) 1:500,000 scale HUNSOTER (HUNgarian SOil and TERrain digital data-base) (PÁSZTOR et al., 1995, 1996; SZABÓ et al., 1996; VÁRALLYAY et al., 1994);

(3) 1:1,000,000 - 1:5,000,000 scale soil maps, prepared for various international programmes, e.g. FAO/UNESCO World Soil Map (1:5 M); FAO Soil Map for Europe (1:1 M); World Map of Salt Affected Soils (1:5 M); GLobal Assessment of SOil Degradation, GLASOD (1:5 M); SOVEUR (SOil Vulnerability against various pollutants in EURope, 1:2.5 M); CTB ("Chemical Time Bomb" - time-delayed effect of various pollutants); Long-term Environmental Risks for Soils, Sediments and Ground-waters in the Danube Catchment Area; etc.

Soil Susceptibility/Vulnerability Maps

In the last years special attention has been paid to the characterization of soils from the viewpoint of their sensitivity/susceptibility/vulnerability to various natural and human-induced stresses (VÁRALLYAY, 1991; VÁRALLYAY et al., 1997).

In Hungary soil susceptibility maps have been prepared for water and wind erosion (1:1 M; STEFANOVITS, 1964; STEFANOVITS & VÁRALLYAY, 1992); acidification (1:500,000, 1:100,000; VÁRALLYAY et al., 1993); salinization/ alkalization (1:500,000; SZABOLCS, DARAB & VÁRALLYAY, 1969); physical degradation, such as structure destruction, compaction and surface sealing (1:500,000; VÁRALLYAY & LESZTÁK, 1990) during the last years and a series of maps on the vulnerability of soils against various pollutants are under preparation in the RISSAC GIS Laboratory by NÉMETH and his team.

Table 1

Thematic soil maps and related databases 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.	VÁRALLYAY, 1985, 1989
2.	Large-scale genetic soil maps	1:10,000	1960-1975	60% of the agricultural land of Hungary, per farming units	m, tm, fd, ld, e	Coll.	SZABOLCS, 1966
3.	Soil conditions and the possibilities of irrigation	1:25,000	1960-1970	present and potential irrigated regions	6 thematic maps fd, ld	Coll.	SZABOLCS et al., 1969
4.	Large-scale maps for amelioration projects	1:5,000-1:10,000	1960-	amelioration projects (occasionally)	m, e	Coll.	
5.	Soil factors determining 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., 1979, 1980a
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 & MOLNÁR, 1989.
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 et al., 1980b

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, 1985
10.	Main types of substance regime	1:500,000	1983	the whole country	m, c	Várallyay, G. Szücs, L. Molnár, E.	VÁRALLYAY, 1985
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., 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.
15.	Soil evaluation	-	1980-1985	soil profiles	fd, ld	Coll.	
		1:10,000 1:25,000	1985-	non-mapped part of agricultural and forest land of Hungary	m, tm, f, ld	Coll.	

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

Soil Monitoring Systems

For the registration of soil changes systematic monitoring systems were established:

(a) *Soil fertility monitoring system (AIIR).*

In the system the most changeable soil characteristics (pH, $CaCO_3$ and organic matter content; saturation percentage (SP); total salt content; total and "mobile" N content; "available" P, K and Ca content; "soluble" Mg, S, Cu, Zn, Mn content) were measured in the topsoil (0-30 cm soil layer or the ploughed horizon; later in the 30-60 cm layer, as well) of about 100,000 agricultural fields covering nearly 5 million hectares [the total agricultural area of the 93 thousand sq. km. Hungary is about 6.5 million hectares], in 3-year cycles. The programme started in 1978 (I.: 1978-1981; II.: 1982-1985; III.: 1986-1989) and stopped before completing the third cycle (BARANYAI, FEKETE & KOVÁCS, 1987).

The data were computer stored per agricultural field (their average size was about 50 hectares at that time), without inner contours of the maximum 12 hectares sampling sites, where mixed samples (composed from 30-30 "sub-samples") were collected in two replicates for laboratory analysis.

In addition to the "soil properties file", separate files contain detailed information on the land-site characteristics (climate, relief, geology), on the agro-technical operations (tillage, sowing, nutrient supply, pest control, etc.) and on crop yields, respectively for the registered fields.

(b) *Microelement survey.*

In this system - in addition to the above-mentioned basic soil parameters - the "total" (interpreted as a potential "pool") and "soluble" (interpreted as mobile and plant available /?/) content of 20 elements were determined in the 0-30, 30-60, 60-90 cm soil layers of 6,000 soil profiles, representing about 5 million hectares of agricultural fields. 1000 "representative" soil samples have been selected for detailed laboratory analysis. 20 elements were determined: Al, B, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, Mg, Mn, Mo, Na, Ni, P, Pb, S, Se, Zn in 5 various extractants (by ICP): 0,1 *N* HNO_3; 0,02 *N* $CaCl_2$; NH_4-lactate-EDTA; $(NH_4)_2SO_4$; LAKERV.

On the basis of analytical data 1:2,000,000 scale thematic maps were prepared for Cd, Co, Cr, Cu, Hg, Mo, Ni, Pb.

The planned cycle was 3 years, but the programme stopped after the first cycle (1987-1988) because of financial limitations.

Soil Information Systems

In the last years all existing soil data were organized into computerized *soil information systems* (VÁRALLYAY, 1993, 1994b):

(1) *Soil and agronomy database for rational* soil management and *plant nutrition* (AIIR). See earlier.

(2) *Soil information system* (HunSIS = TIR) (CSILLAG et al., 1988; KUMMERT et al., 1989). It contains - in addition to the basic topographic information - point information on the characteristics of soil profiles and their different layers and diagnostic horizons; territorial information (1:25 000 scale thematic maps) on the most important soil and land characteristics; and validated models on pedotransfer functions, soil processes and soil - plant - environment relationships.

The system, which was prepared for Pest county (one of the 19 administrative regions of Hungary, covering about 6500 km²) gives a wide spectra of output facilities: integrated data; classification and grouping of soils according to various criteria; interpreted results; practical recommendations for sustainable land use and proper soil management.

(3) *Agrotopographical database* (AGROTOPO) (VÁRALLYAY, 1994b,c; PÁSZTOR et al., 1995). Digitized data of the 1:100,000 scale agrotopographical maps (Table 1, No. 6) organized into GIS.

(4) *Soil information and monitoring system* (TIM) (TIM, 1995; VÁRALLYAY, 1994a, c).

Based on physiographical-soil-ecological units 1237 "representative" observation points were selected (and geo-referenced by GPS): 865 points on agricultural land, 183 points in forests and 189 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.

In the monitoring system some soil parameters are measured every year (the sampling date is Sept 15 - Oct 15), some others every 3 or 6 years, depending on their changeability (ARNOLD et al., 1990).

According to the basic concept, TIM is an independent but integral mosaic (subsystem) of the Environmental Information and Monitoring System (KIM).

The data-base management and the hardware-software configuration of the system

- guarantee the compatibility of TIM with the other subsystems of KIM which are under elaboration now (e .g. for the atmosphere; surface- and subsurface water resources; geological deposits and mineral resources; biological resources and biodiversity; landscape; human resources and socio-economic aspects of the environment; etc.);
- establish potential conversative connections to similar international systems for the joint regional, continental and global actions of sustainable development;

- give opportunities for the development of various environment-related user-friendly expert systems for scientific applications and for public uses.

The establishment and operation of TIM was and is financed directly from the national budget. Consequently, the data of TIM are open for public, with some necessary and rational limitations. Because the primary hard data - in most of the cases - are not directly usable for practical purposes by the public, in the contrary they can be easily misused and mis-interpreted, their public use will be officially regulated. According to the future plans both KIM and TIM will be open (usable/utilizable) for the public through the set of local work-stations adequately equipped with proper (possibly multimedia) expert systems: hardware-software configurations operated by well-trained technical experts.

(5) *SOTER-HUNSOTER* (PÁSZTOR et al., 1995a, b, 1996; SZABÓ et al., 1996; VÁRALLYAY et al., 1994).

The International Society of Soil Science (ISSS) proposed a world-wide project in 1986 for the establishment a World SOils and TERrain Digital Database at a scale of 1:1 million. The main function of the SOTER database is to provide the necessary data for improved mapping, modelling and monitoring of changes of world soil and terrain resources and present a wide range of accurate, timely interpretative analyses for decision- and policy-makers for their development concepts, decision-making, planning and implementation activities.

In 1993 a project proposal was elaborated by (RISSAC, 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)".

Using all available soil information summarized earlier 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). Within the 1210 SOTER units about 2000 terrain components and about 5000 soil components have been distinguished. The database contains point data for about 1300 representative soil profiles and for their horizons.

For the wide spectra of potential practical applications of the HUNSOTER database five examples have been demonstrated by comprehensive case studies (PÁSZTOR et al., 1995, 1996; SZABÓ et al., 1996; VÁRALLYAY et al., 1994):

- land (soil and terrain, "land-site") evaluation;

- evaluation of the vulnerability of land and susceptibility of soils to various soil degradation processes as: water erosion; wind erosion; acidification; salinization/alkalization.

- vulnerability assessment of soils against various pollutants, potentially harmful chemical compounds: NÉMETH and his team, and the GIS Laboratory (SZABÓ & PÁSZTOR) in RISSAC, partly in the frame of the SOVEUR (Soil Vulnerability in EURope) Project, coordinated by ISRIC (International Soil Reference and Information Centre), Wageningen.

Multipurpose Applicability of Soil Information

"*Soil survey* is at a crossroad. Over the last several years pessimistic views have been expressed about its future. Some of the reasons put forward are external to soil survey and strongly influenced by the general economic situation. These "conjunctural" issues include budget restrictions as an effect of the ongoing economic recession, decreasing governmental land use planning, and the near-completion of systematic soil map coverage in some countries. Criticism also concerns internal, structural issues related mainly to the surveyor-user interface. Insufficient visibility, inappropriate presentation and the poor accuracy of soil information, together with high survey costs, are often to blame. The rapid dissemination of new information technologies imposes additional constraints on soil survey organizations". This was the initial "argument-statement" of the International Workshop for the heads of national soil survey organizations under the general title "Soil survey: Perspectives and strategies for the 21st century" (ITC, Enschede, The Netherlands, 23-25 November, 1992) (Proceedings..., 1993). On the basis of the discussions on the four main topics (the technologic paradox in soil survey: new methods and techniques of data capture and handling; multipurpose application of soil information; supply and demand of soil survey information: international policies and stimulation programmes; strategies for the development of soil surveys and dissemination of soil information) it was recognized that "soil survey remains a vital activity for gathering data and generating interpreted information on the use, management and conservation of the soil resource. However, traditional demand sources, at national and international levels, are either drying up or changing their requests to more purpose-specific soil information that can be integrated into large projects for sustainable development or environmental management. Soil survey must undergo a modernization process, supported by the implementation of new soil concepts, the use of advanced survey techniques and information technologies, and the development of innovative and diversified applications."

Similar problems were raised and similar conclusions were drawn - almost simultaneously at the International Symposium on Soil Resilience and Sustainable Land Use (Budapest, Hungary, 28 September - 2 October, 1992), where a - successful - attempt was made to precisely define "soil resilience" and the criteria of "sustainable land use", formulating their "soil information" requirements (GREENLAND & SZABOLCS, 1993; VÁRALLYAY, 1993).

The *multipurpose applicability of soil information* was discussed and summarized during the International Workshop on the Harmonization of Soil Conservation Monitoring Systems (Budapest, 14-17 September, 1993), as follows (International...., 1994):

- assessment of the state of the environment;

- exact description, quantitative characterization, modelling and forecast of the influence of natural factors and human activities on soils (impact assessment, risk assessment);

- contribution to the assessment of long-term global changes;

- providing information on the state of soils (and related terrestrial and aquatic ecosystems), soil degradation processes, soil toxicity;

- providing data for the control of soil processes; for the prevention of soil and land degradation; for the elaboration of strategies for rural development, sustainable agriculture and rational environment protection, and of technologies for rational land use, agrotechnics and amelioration;

- providing data for predictive models and early warning;

- serving as a scientific basis for economically viable and environmentally sound land use policy and legislation measures for soil protection (enforcement, penaltization, stimulation).

The various practical applications can become "wide-spread" and efficient if the information producer/user interface will be improved considerably.

Hungarian soil science, soil survey and soil testing practices always have successfully served agricultural development, the planning and organization of crop production and environment control (VÁRALLYAY, 1989, 1993, 1994c).

The *main fields of* successful *applications* were as follows:

- rational land use;

- optimation of cropping pattern and crop rotation;

- control of limiting factors of soil fertility and soil degradation processes (water and wind erosion; acidification; salinization/alkalization; physical degradation of soil as structure destruction, compaction; biological degradation of soil; etc.);

- planning and implementation of various agrotechnical measures (e.g. tillage operations; irrigation, drainage; etc.) and land improvement practices (e. g. land amelioration, soil reclamation, recultivation of disturbed lands, remediation of polluted sites, etc.);

- control of soil moisture regime;

- control of nutrient regime; rational plant nutrition (organic manure and mineral fertilizer application);

- control of soil and water pollution;

- control of other environmental hazards (e.g. landscape deterioration, etc.), biosphere preservation, including biodiversity, etc.

Particular attention has been paid to the control of plant nutrients' regime of soil (or the biogeochemical cycles of the biosphere) and to the use of soil information in rational plant nutrition (BARANYAI et al., 1987; SARKADI & VÁRALLYAY, 1989).

The quick technical development and new technical tools (analytical development, new possibilities for the continuous registration of the quantity and quality (status) of more and more soil components; GIS; remote-sensing; geo-statistical evaluation of measured data; bio-indication procedures; etc.) give sharply increasing opportunities for a more comprehensive and more efficient application of soil and landsite information for the better interpretation and riskless (or at least risk-reduced) spatial and temporal extension of the registered results of *long-term field experiments*. This multipurpose use will give a "renewed" high value of the existing long-term field experiments (giving scientific arguments for their continuation), but it requires a new - multidisciplinary - conceptual approach in their management and evaluation.

In the future long-term experiments combined with adequate environmental (at least land-site) monitoring will have a sharply increasing significance in sustainable agricultural production (and its risk-reduction) harmonized with successful environment protection, ensuring pleasant life in a clean and nice environment.

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