Status and prospect of soil information in south-eastern Europe:

soil databases, projects and applications

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VIII. Overview of soil information and soil protection policies in Hungary

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Summary

Although Hungary has a unique history of soil research, the existing, easily available, on-line databases are not substantially utilised so far. Small scale maps of most types of soil degradations are easily available based on the 1:100,000 scale "AGROTOPO" soil database. There is a complete series of 1:25,000 scale "Kreybig" practical soil maps which are partly digitized and made available in the Kreybig Digital Soil Information System. The most detailed soil surveys at 1:10,000 scale genetic soil mapping were performed for ca. 70% of the agricultural area. Nevertheless, there are very promising applications based on these databases and the availability of a working digital cadastral registry system provides good basis for new approaches. One such application is the D-e-Meter on-line soil valuation system, which is based on the real-time calculation of D-e-Meter soil fertility index in the GIS of 1:10,000 scale genetic soil maps. Besides maps, there are independent soil databases for soil profiles and also exclusively for the plough layer of agricultural fields. There is a working monitoring system, consisting of 1236 points all over Hungary sampled since 1992. Soil protection is institutionally realized by a series of laws and administrative units. A National Soil Protection Strategy has been formulated in order to prevent soil degradation.

VIII.1 Introduction

As a result of former soil surveys, a large amount of soil information has been accumulated for Hungary. The collected data are available in different scales: national, regional, micro-regional, farm and field level and generally, they are related to maps (Várallyay, 2005). This contribution attempts to complement the report of Várallyay (2005) with new information. There is an outstanding record of collecting soil information in Hungary. The historical past is summarized in several publications (Ballenegger and Finály, 1963). As in other countries in the early period of soil mapping, until the First World War there were two tendencies: special mapping of selected, usually small areas and preparation of very small-scale maps, based on scarce observations and continental-scale conceptual models. In Hungary, the first soil (that time called agrogeologic) map was compiled in 1861 (Szabó, 1861) for the area of two counties at the scale of 1:576 000. A major achievement was the first complete soil map of Hungary prepared by Imre Timkó in 1914 (Fig. VIII.1). During the pre-war and after-war periods of 1935-1951, the "Kreybig" practical soil mapping was completed and displayed on maps at 1:25,000 scale. From the 1960's, the 1:10,000 scale mapping of the agricultural land was performed. From 1989 no systematic large-scale soil mapping has been carried out.

In the 1990's, much of the small-scale soil related data were converted into digital format and organized into spatial soil information systems (SSIS), including the AGROTOPO (Várallyay & Molnár, 1989), HunSOTER (Várallyay et al., 1994), MERA (Pásztor et al., 1998) and SOVEUR (Várallyay et al., 2000). Nevertheless more detailed SSIS are anticipated by numerous potential users (land users, planners, policy makers, legislative officers, engineers, scientists etc.) and fields of interests (environmental protection, land evaluation, precision farming etc.). The next step in spatial resolution would be featured by a scale of 1:200,000 up to 1:20,000 (with a nominal spatial resolution of 40-400 m or 0.16-16 ha in territorial units) (Lagacherie & McBratney, 2004), also required by European Soil Protection Strategy (CEC, 2002) and in accordance with the principles of INSPIRE (CEC, 2004; Dusart 2004).

Digitisation and GIS adaptation of the results (1:25,000 scale maps and complementary explanatory booklets) of the practical soil-mapping programme hallmarked by L. Kreybig[6] is under construction (Szabó et al., 2000). The TirSOTER project generated a digital soil database for the territory of Pest County, integrating soil profile data (3195 profiles) and information content of 104 sheets of hand-drawn soil maps based on 1:25,000 scale maps (Pásztor et al., 2001). Beside the elaboration of these soil information systems displayed on 1:25,000 scale maps sheets, there have been numerous initiatives for the GIS-based integration of the large-scale (1:10,000) practical soil map, which seems to be unavoidable from various point of views. For example, Takács et al. (2004) developed a soil information system based on the 1:10,000 scale soil maps for 640 km^2 area in the eastern "Bihar" region of Hungary. These authors also provided an example for creating a multidisciplinary database of a given small area. The "Tedej" soil information system of 15 km^2 comprises topographic sheet, satellite images, aerial photographs, hyper and multispectral images, genetic soil type maps, Digital Elevation Model (DEM), precipitation run-off and similar.

Fig. VIII.1. The first soil map of Hungary at the scale of 1:900,000, prepared in 1914 by Imre Timkó. Categories distinguished in the legend are the following in order 1. chernozems, 2. chernozems on sand, 3. chernozem on alluvium, 4. brown forest soils, 5. terra rossa, 6. grey forest soil on moving sand, 7. grey forest soil, 8. podzol, 9. salt-affected soil, 10. peat, 11. alluvial soil, 12. alpine skeletal soil.

VIII.2 Hungarian Soil Information and Monitoring System (TIM)

The objective of Hungarian Soil Information and Monitoring System (TIM) is the temporal monitoring of soil conditions in order to provide the basis for the legal regulation of the management and protection of soil resources. The soil is sampled yearly and individual parameters are checked with different frequencies ranging from 1 to 6 years (see Várallyay, 2005). The TIM was initiated in 1992, and backed-up in 1994 by Parliament. The activity was developed and is being supervised by a committee of scientist from state institute and practicing soil specialists. The system is based on altogether 1236 points representing the geographical regions of the country as well as different land use types. There are 864 points in agricultural lands, 183 in forests, 189 points such as polluted industrial and urban areas, areas affected by heavy traffic, areas beside military installations and waste storage facilities.

[6] By its completion, in the early 1950s, Hungary was the first country in the World to have such detailed nationwide soil information.

VIII.2.1 Kreybig Digital Soil Information System (KDSIS)

The conversion of soil information originating from the soil maps at 1:25,000 scale to GIS is under construction. There is much more utilizable information originating from this survey, than was processed traditionally and published on the map series and in reports. The surplus information should be exploited by the emerging technologies including the Digital Soil Mapping (DSM) techniques.

The national soil mapping project initiated and led by Kreybig was unique for being a national survey based on field and laboratory soil analyses and at the same time serving practical purposes (Kreybig, 1937). It was carried out between 1935 and 1951 in several stages. When the action was successfully completed, Hungary was the first country in the world to have such detailed soil information for the whole territory. These maps still represent a valuable treasure of soil information. The soil and land use conditions were presented together on the maps. Chemical and physical soil properties of the soil root zone were identified for croplands. Three characteristics were attributed to soil mapping units and displayed on the maps. Further soil properties were determined and measured in soil profiles. The unique feature of the Kreybig method was that one representative and further, non-representative soil profiles occurring within the patch are attached to the soil units of the maps. These profiles jointly provide information on the heterogeneity of the area. The display of non-representative soil profiles indicating within soil unit, unmappable heterogeneity was a unique approach. However, this special feature could not be totally utilized due to the limits of classical cartography. New technologies make the surplus information provided by this methodology exploitable, which can be incorporated into the compilation process of KDSIS.

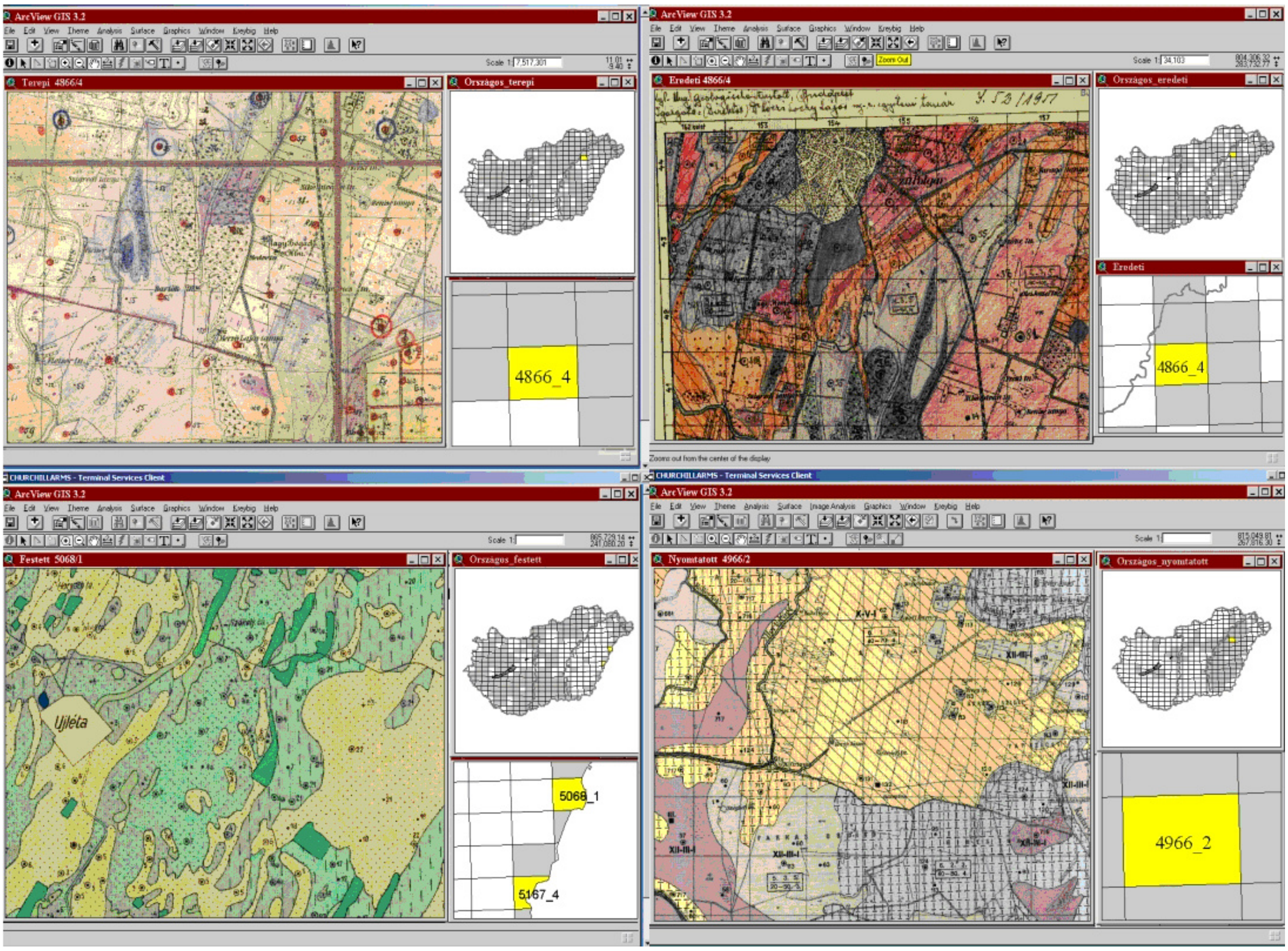

Fig. VIII.2. The steps of compiling map sheets from original field sheets (Upper left) to working map sheet (Upper right) to hand painted (Lower left) and final printed sheets (Lower right). On the right the country-wide availability of the given processing stage is shown.

Integration of the Kreybig Digital Soil Information System within appropriate spatial data infrastructure (SDI) and its updating with efficient field correlation makes an inherent refinement and upgrading of the system possible as well as the estimation, measurement of the reliability of the system (Fig. VIII.2). As a result, the raw information processed using traditional methods, together with complementary spatial, digital, environmental data, could lead to a more accurate and, consequently, more reliable system. The KDSIS provides soil information on different level of accuracy – this kind of multilevel feature can be also preserved and even utilized (Fig. VIII.3).

KDSIS provides various opportunities for increasing the spatial and thematic accuracy of mapped soil properties. Spatial refinement of mapping units is mainly based on DSM tools. Contours of soil bodies can be reshaped using more detailed/recent/accurate/reliable environmental co-variables (DEM-derived terrain features, remotely-sensed images, ancillary data collected with non-invasive soil sensors etc.). New soil units can be delineated by integrating Kreybig profile methodology and SDI. Field verification/correlation completed with appropriate data collection, and the inclusion of newly accessed data into KDSIS can also increase significantly the reliability of KDSIS. This verification should be carried out by the reassessment of the originally mapped areas and the profiles accompanied by new samplings at the revisited sites for assessing current soil status. Fieldwork and sampling are supported by field GIS tools which can be used for spatial refinement of soil mapping units. The appropriate management of KDSIS, on the other hand, makes the elaboration of an efficient survey and sampling design possible. Upgraded KDSIS makes the compilation of up-to-date (polygon-based) soil maps possible. Mapping units of the old and new maps may differ due to several reasons: reshaped contours, new soil units with changed attributes may occur on the new map when compared to the old one. Upgraded soil maps display features of current soil status on a higher confidence level, consequently accuracy and reliability of the upgraded map is significantly higher.

Collection of new sampling data at the same revisited sites makes the comparison of archived and newly-surveyed data possible. Thus, changes in soil properties can be identified. This, in one hand, should be recorded in the database, thus, updating it. On the other hand, trends can be identified in soil characteristics and functions, degradation processes can be realized and/or forecasted. New data can serve as reference to the study of anthropogenic effects. Joint management and application of multi-temporal spatial soil information within an appropriate relational database management system (RDBMS) and GIS environment makes KDSIS also a spatio-temporal soil information system.

The applicability of the Kreybig Digital Soil Information System (KDSIS) has been proven by numerous applications. Molnár et al. (1999) used KDSIS in habitat mapping; Farkas et al. (2005) utilized it for the regional extension of results of their modeling work on impacts of different climate change scenarios on soil water regime. Pásztor et al. (2006) employed it in the quantification and mapping of lowland excess water hazard. Very recently, KDSIS was applied as a base information source within the various task packages (land management planning, water management modeling in the territories of future water reservoirs etc.) of the Action Plan on Flood Prevention and Protection for the Tisza River (Szabó and Pásztor, 2004). The fully loaded KDSIS is suggested to serve as a basis for various further soil related expert systems, as well as for the intermediate level of the soil module of the Hungarian SDI (further detailed – 1:10,000 scale – soil maps should give the basis of the Hungarian SDI).

The complete upgrading of KDSIS cannot be carried out by a single research institute and needs extra-institutional cooperation, but the common concept should be elaborated in advance. Nevertheless, the framework of the KDSIS and its upgrading methodology has been worked out. The elaborated environment and methodology is recommended not only in the case of KDSIS, as it could also be applied for the treatment (compilation, refinement, upgrading etc.) of other large-scale SSISs, processing the information collected during 1:10,000 practical soil mappings. Depending on the raw material, certain specifications in the common framework should be adjusted, which also requires some professional reconciliation and cooperation [http://ilzer.rissac.hu/html_5terseg/].

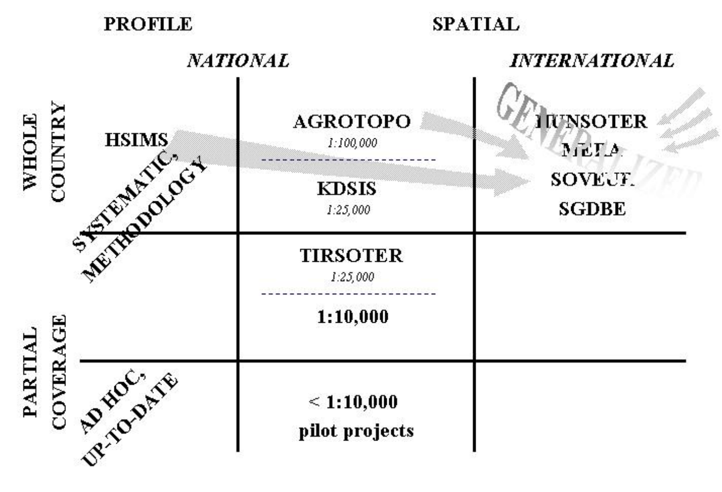

Fig. VIII.3. The relationship of different Hungarian soil information systems

VIII.2.2 Genetic soil maps of 1:10,000 scale

In the early 1960's, a system was elaborated by Hungarian soil scientists, soil surveyors and soil-mapping specialists for large-scale soil survey to satisfy the practical needs of soil information for large farming units (state and co-operative farms), which characterized the Hungarian agriculture between 1950 and 1990. Such maps were prepared for about one-thirds of the area of Hungary (about 35,000 km^2). The system consists of four main parts: (i) genetic soil map, indicating soil taxonomy units and parent material; (ii) thematic soil maps on the most important physical and chemical soil properties; (iii) thematic maps, indicating recommendations for rational land use, cropping pattern, amelioration, tillage practice and fertilization; (iv) explanatory booklets, including a short review on the physiographical conditions; description of soils, recommendations for their rational utilization, field description of soil profiles and results of field observations or measurements and data of laboratory analyses (Sarkadi et al, 1964; Szabolcs, 1966).

Fig. VIII.4. Example sheet of 1:10,000 scale genetic soil map the "Magvető" cooperative farm located in the village Dány. In the lower right corner the first column of the legend (color code) indicates soil subtype ranging from "Calcareous humous sand" (first category of 4/1) to "Slope deposits of forest soils" (last category of 40/2). In the central column soil texture category is listed with line pattern ranging from sand to clay. Under this the depth of soil is shown by increasing number of "+" signs. In the right column of legend the parent material is indicated ranging from sand to loessy silt. Numbers with dots indicate the location of soil profiles described.

These maps were widely and successfully used in Hungary and became an easily applicable scientific basis of intensive, large-scale agricultural production, in spite of the fact that generally these maps were not published in printed form and are available only as manuscripts at the given farming units or at the Plant and Soil Conservation Stations. The large-scale soil-mapping programme was restarted in 1986 within the framework of the National Land Evaluation Programme (AGROINFORM, 1987). The aim of this Programme was to evaluate the agricultural land based on soil information surveyed in a scale of 1:10,000, but was left uncompleted. These huge archives provide appropriate raw material for recent digitally based applications. Spatial soil information systems based on these data could be efficiently used in numerous studies. Szabolcs (1966) described the methodology to be used in the detailed mapping of soils. For example, in the case of salt-affected soils this method at the scale of 1:10,000 can be best illustrated with the set of individual map sheets which might make up a complete soil mapping document.

Soil map:
- soil type and subtype (ca 100 categories for the country)
- parent material (56 categories for the country)

- textural class of plough-layer (9 types categories for the country).

Humus cartograms:

- thickness of humic layer (6 categories for the country)
- organic matter content (5 categories for the country)

Soil reaction and $CaCO_3$ content cartograms:

- pH of plough-layer (7 categories)
- depth of appearance of $CaCO_3$ (6 categories for the country)
- $CaCO_3$ content in the depth of appearance (5 categories for the country)
- hydrolitic acidity of plough-layer (5 categories for the country)
- extent of secondary $CaCO_3$ concentration (4 categories).

Groundwater cartograms:

- average groundwater level (5 categories for the country)
- salt concentration of groundwater (6 categories for the country)
- Na percente of groundwater (8 categories for the country).

Salt-affected properties cartograms:

- depth of appearance of salt-affected layer (6 categories for the country)
- pH in the depth of appearance of salt-affected layer (3 categories for the country)
- total soluble salt content and exNa% in the depth of appearance of salt-affected layer (8 categories for the country)
- depth of most salt-affected layer (6 categories for the country)
- pH in the depth of most salt-affected layer (3 categories for the country)
- total soluble salt content and exNa% in the depth of most salt-affected layer (8 categories for the country)

The complete documentation of field soil maps contains field records of profile descriptions, results of laboratory analyses and evaluations. The smallest polygon distinguished on large-scale maps of 1:10,000 is 1 ha (Fig. VIII.4).

VIII.2.3 1:10,000 scale land valuation system based on D-e-Meter soil fertility index

The Hungarian official land valuation system is the "*Gold Crown*" which was established purely for land taxation in 1875 by the VII Law as the 20% (from 1924 on the 25%) of the net "*cadastral income*". The latter was defined as "*The (financial) value of the long-term average yield which can be received by usual farming practice minus the expenditures from usual farming practice*" (Sipos and Szűcs, 1992). The drawbacks of the old Gold Crown system are the following (from Lóczy, 2002, based on Sipos and Szűcs, 1992 and Góczán, 1980):

- does not reflect the advances of soil science,
- the fertility of the soils during the past 130 years has changed due to soil improvements and management and is not expressed by the values,
- land cultivation and the genetic resources of plants have changed considerably,
- there is no possibility to separate the ecological and economical factors in the Gold Crown value,
- the importance of transport has increased considerable and, therefore, the old economic valuation is not valid,
- there is an intensification of cropping in the agglomeration zones of cities which is not reflected in the old values.

Logically, there is a need to develop a single integrated modern land valuation system (Fórizs et al., 1971). The new system is based on the D-e-Meter soil fertility index (Gaál et al., 2003). The first step of the calculation of the index is a idea of "*soil scoring*" procedure for specific crops based on the long term yield for specific soil subtypes (for example, "No. 202 Non-Carbonatic Meadow Chernozem", or "No. 131 Ramann Brown Forest Soil") and specific combinations of texture × soil reaction × parent material × organic matter and similar categories. The soil scoring index value is modified according to soil water regime, nutrient status, slope conditions and forecrop and results in the D-e-Meter soil fertility index. The determination of this fertility index is carried out in an on-line GIS system (Vass et al., 2003) based on 1:10,000 soil map. Fig. VIII.5 shows an exemplary special cartogram sheet with the polygons having their respective codes.

Three major databases can be used for calculating this index: (A) AIIR soil property database, comprising real management data (yields, soil properties, nutrient data) from plough layer of ca 80,000 cropland field collected during the intensive cropping period of 1985-1989; (B) Data from a comprehensive network of long term field fertilization experiments carried out at nine locations in different agroecological conditions, but with similar fertilization treatments; (C) Data collected at 10 pilot study areas, which contain soil, topography, photogrammetry coverages and time series of management data. At the moment, the D-e-Meter based land valuation system (Tóth et al., 2006a and 2006b) is being extended from cropland to forest (Bidló et al., 2003) and grassland (Dér et al., 2003, Vinczeffy, 1993) as well. Economic evaluation combined with soil fertility assessment makes up the complete land valuation. A specific region inside Zala County was selected as pilot area where the land valuation system is being tested. Current status of the system can be accessed at [http://www.intermap.hu/demeter/].

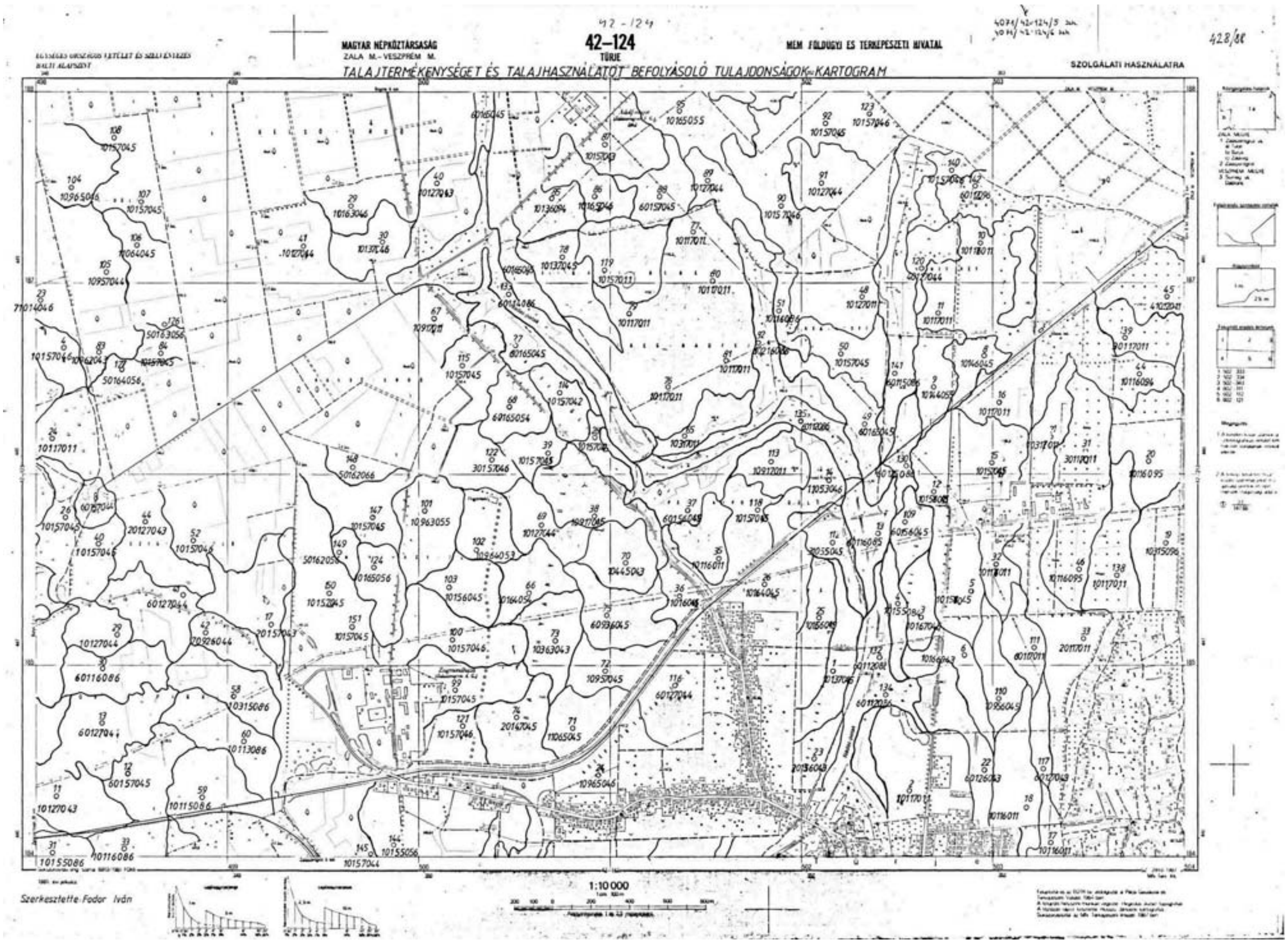

Fig. VIII.5. 1:10,000 scale special cartogram sheet "Soil properties affecting soil fertility and soil use" coded specially for being used for soil bonitation at the village "Türje". Codes inside the soil polygons show categories of the following properties: grades of erosion/deflation (1 digit), depth of lamellae in sandy soils "kovárvány" (2 digits), stoniness (1 digit), soil depth (1 digit), property affecting unfavourably the sois depth (2 digits), thickness of soil problems (1 digit).

VIII.3 Institutional organization of soil information

The highest administrative unit responsible for soil information in Hungary is the Department of Land and Geographical Information at the Ministry of Agriculture and Rural Development (*Földművelésügyi és Vidékfejlesztési Minisztérium Földügyi és Térinformatikai Főosztálya*, FVM FTF). The main tasks of this administrative unit is to look after the national geodesic, cartographical and remotes sensing activity, land registry, soil protection, land valuation, land policy (land property, land use, land consolidation), agrarian information strategy and coordination. It consists of a Department of Land Registry, a Department of Soil Protection and Land Use and a Department of Geodesy, Cartography and Geographical Information Systems

There is an up-to-date cadastral information system in Hungary, which is one of the bases of any soil utilization systems. There is a unified registry, independent from the legal system. It means that all properties, such as houses, flats, plots and agricultural properties are kept in a single registry at 138 Land Registry offices [http://www.takarnet.hu] throughout the country. One advantage of such organisation was the fast reaction to the re-privatisation of cultivated land: it was completely finished in Hungary within five years. The "AGROTOPO" and Kreybig Digital Soil Information System are maintained by the Research Institute for Soil Science and Agricultural Chemisty of the Hungarian Academy of Sciences [http://www.taki.iif.hu].

VIII.3.1 Legislation on soil protection

According to Németh et al. (2005), there are currently nine valid laws, eight government decrees and four ministerial regulations related to the protection of soils. These include Law LV of 1994 on the cultivated soils , Law LIII of 1995 on the general regulations of the protection of environment, Law LIII of 1996 on environment protection, Law LIV of 1996 on forests and the protection of forests, Law XXI of 1996 on regional development, Law XLVIII of 1993 on mining, Law XLIII of 2000 on waste management, Law XXXV of 2000 on plant protection. Among these the single most important for this chapter is the Law LV of 1994 on the cultivated soils. The sections of the Law LV of 1994 on the cultivated soils, for example, are the following:

- Introduction
- Obtaining the property rights
- Use of cultivated soils
- Land consolidation
- Utilization and protection of cultivated soils
- Soil protection, inside which are the following sections found
  - In the Section "Aim of soil protection" it is emphasized that the shrinking of cultivated land acreage should be slowed down. There is a need to safeguard the quality of cropland. Also the law aims the protection against erosion, waterlogging, aridity, salinization, acidification, which protection is expected to be performed by the land user itself.
  - In the Section "Tasks of the state" it is listed that registry, monitoring, legislation, strategy, research as well as creating an administrative authority are the tasks of the state.
  - In the Section "Obligations of the land user" it is listed that such obligations include protection against erosion, acidification, salinization and pollution. Use of certificated amendments is also an obligation of the land user.
  - There is a further Section "Obligations related to land management"
  - In the Section "Land protection authority and its tasks" it is listed that the land protection authority controls soil protection, permits special use of land, provides information on soils as well as imposes fines for illegal actions related to soils.
  - There is a Section "Soil protection fine", in which it is written that the sum of the fine for each hectare can reach between 850 and 18300 times wheat price for kg depending on the illegal action. The fines paid all go to the so called "Soil Protection Fund".
- Closure

VIII.4 Conclusions

In summary, we can conclude that soil monitoring in Hungrary is active, but only to certain limits and with many financial problems. There is plenty of soil information available, but most of the field observations are old (>20 years). It is difficult to access the detailed 1:10,000 soil maps. All 1:100,000 and about half of the 1:25,000 maps are computerized. The most important information source for plot-scale management, the 1:10,000 map series is covering just two thirds of the country. Soil protection is regulated by law. As an overview, the full range of soil information data sources available in Hungary is shown in Table VIII.1.

Table VIII.1. The characteristics of the three most popular Hungarian soil databases. KDSIS is Kreybig Digital Soil Information System. The number of "+" signs indicate estimated availability/easiness of use of databases, 5 is the best.

	Database and scale		
Property	AGROTOPO 1:100,000	KDSIS 1:25,000	Genetic maps 1:10,000
SPATIAL RESOLUTION	+++	++++	+++++
THEMATIC RESOLUTION	+++	+++	+++++
SOIL PROFILE DATA	none	+++	+++++
COUNTRYWIDE COVERAGE	+++++	++++	++
FEASIBILITY OF UPGRADING	none	+++(+)	+++++
DEGREE OF DIGITAL PROCESSING	+++++	+++(+)	+(+)
DATA MANAGEMENT	+++++	+++++	++++(+)

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