Soils

Soil Formation

Soil is the uppermost part of the weathered surface layer of Earth, developed within the interaction zone of the lithosphere, atmosphere, hydrosphere and biosphere under the integrated influence of soil forming factors. Soil is a three-phase, four-dimensional, polydisperse system; a conditionally renewable, multifunctional natural resource with two characteristic features: fertility and resilience. The main soil formation processes are the accumulation of organic matter and structure formation, whilst the main processes taking place inside the soil are the heat, water and organic matter regimes, and the biogeochemical cycles of elements, including both plant nutrients and pollutants.

Soils of Hungary

Hungary is situated in the deepest part of the hydrogeologically closed Carpathian Basin, where the majority of the parent material is of relatively young geological formation; Quaternary loess or Holocene and recent aeolian sands, alluvial or colluvial sediments or re-deposited loess.

The climate includes Atlantic, Continental and Mediterranean elements. The water balance of the Alföld is negative (the deficit being mitigated by surface runoff, seepage or groundwater flow from the more humid mountainous regions).

Drainage conditions are poor; consequently the accumulation processes prevail in soil formation. Human activities (such as deforestation, grazing, water regulation, intensive farming, and urbanisation) have had both significantly effects on the soil formation and soil degradation processes.

Hungarian soil cover is highly heterogeneous. Almost each phase of the following soil sequences can be distinguished:

- chronosequence;
- topo-sequence (catena);
- leaching sequence;
- salinity/alkalinity sequence;
- erosion sequence.

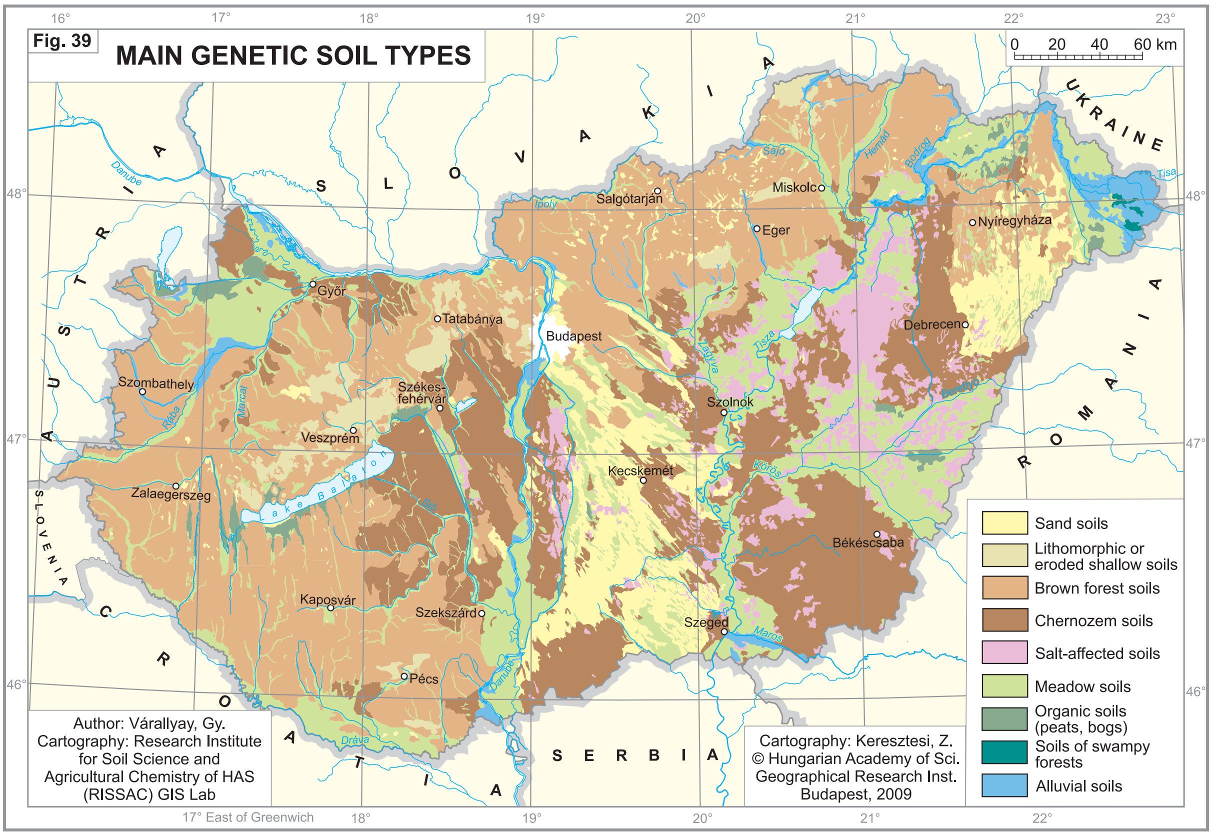
As a generalised summary one can find the following types of soils in the country (*Figure 39*):

- shallow soils eroded to differing degrees, eroded soils on steep hills;
- various brown forest soils in humid hilly regions;
- humous sandy soils and chernozems on sand and loess plateaus of relatively higher elevation with a marked aridity and deep water table;
- various hydromorphic soils, i.e. meadow soils and salt-affected soils at lower altitudes;
- organic soils in areas that are either permanently or periodically waterlogged.

Land Degradation and Soil Fertility

Land, i. e. soil, water and near-surface atmosphere continuum, with its geology, relief and biota represents a key natural resource of Hungary. The most important functions related to soil are that it is:

Fig. 39 MAIN GENETIC SOIL TYPES



– a conditionally renewable natural resource;

– a reactor, transformer and integrator of the combined influences of other natural factors; a host for interaction between the spheres;

– a medium for biomass production and a primary source of food for the biosphere;

– used for the storage of heat, water and plant nutrients;

– a high capacity buffer medium;

– a natural filter and detoxication system;

– a significant gene reservoir; and

– the preserver and carrier of the heritage of natural and human history.

The natural conditions (climate, water, soil and biological resources) of the Carpathian Basin (particularly in the lowlands and plains) are generally favourable for rainfed biomass production (*Figure 40*). However, these conditions show extremely high and irregular (consequently barely predictable) spatial and temporal variability; they are often extreme and sensitive to various natural or human-induced stresses. The generally favourable agro-ecological potential is predominantly limited by three soil factors:

(1) Soil degradation processes;

(2) Extreme moisture regime;

(3) Unfavourable changes in the biogeochemical cycles of elements, in particular those of plant nutrients and environmental pollutants.

In Hungary the most important soil degradation processes are as follows:

– soil erosion by water or wind;

– soil acidification;

– salinisation/alkalisation/sodification;

– physical soil degradation, such as structure destruction, compaction or surface sealing;

– extreme moisture regime: simultaneous hazard of over-moistening, waterlogging and drought-sensitivity;

– biological degradation, such as unfavourable changes in soil biota or decrease in soil organic matter;

– unfavourable changes in the biogeochemical cycles of elements, especially in the regime of plant nutrients; and

– decrease in the buffering capacity of soil, soil pollution, and environmental toxicity. The main regions affected by soil degradation are indicated in *Figure 41*.

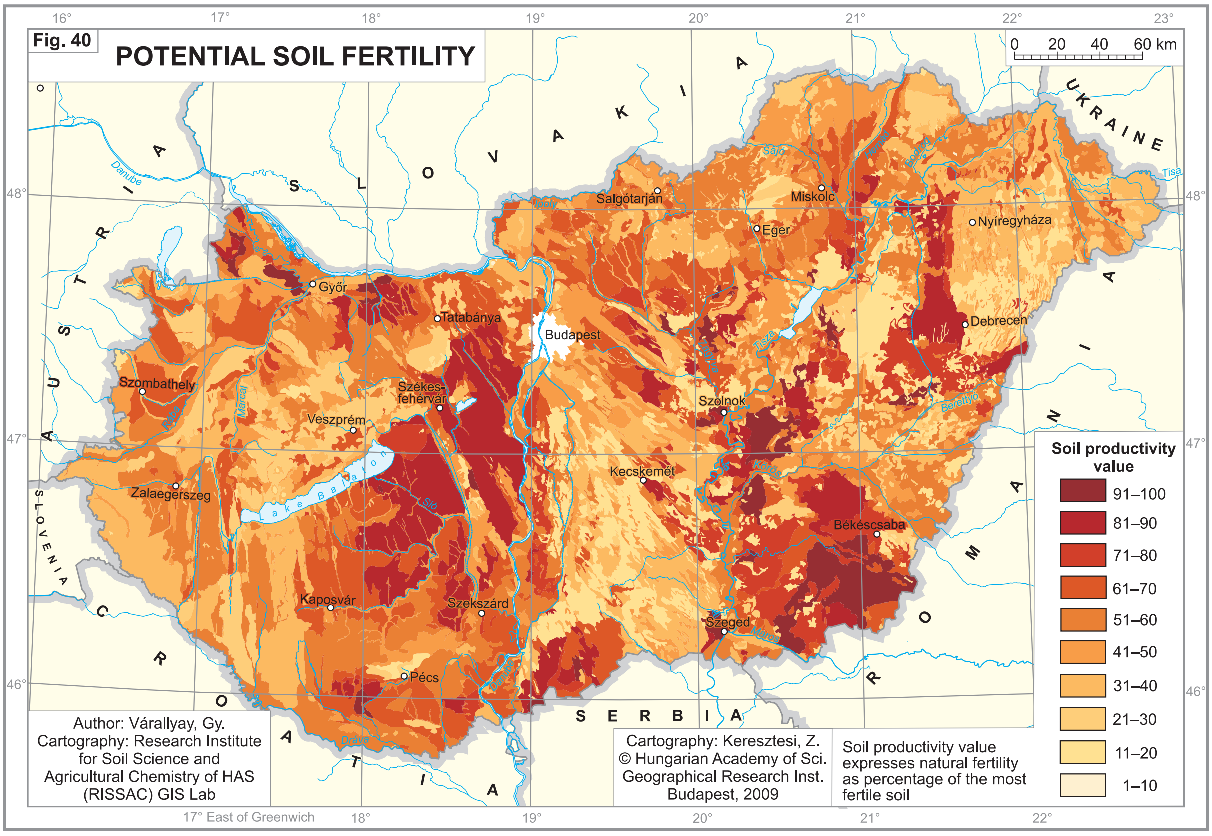


Fig. 40 POTENTIAL SOIL FERTILITY

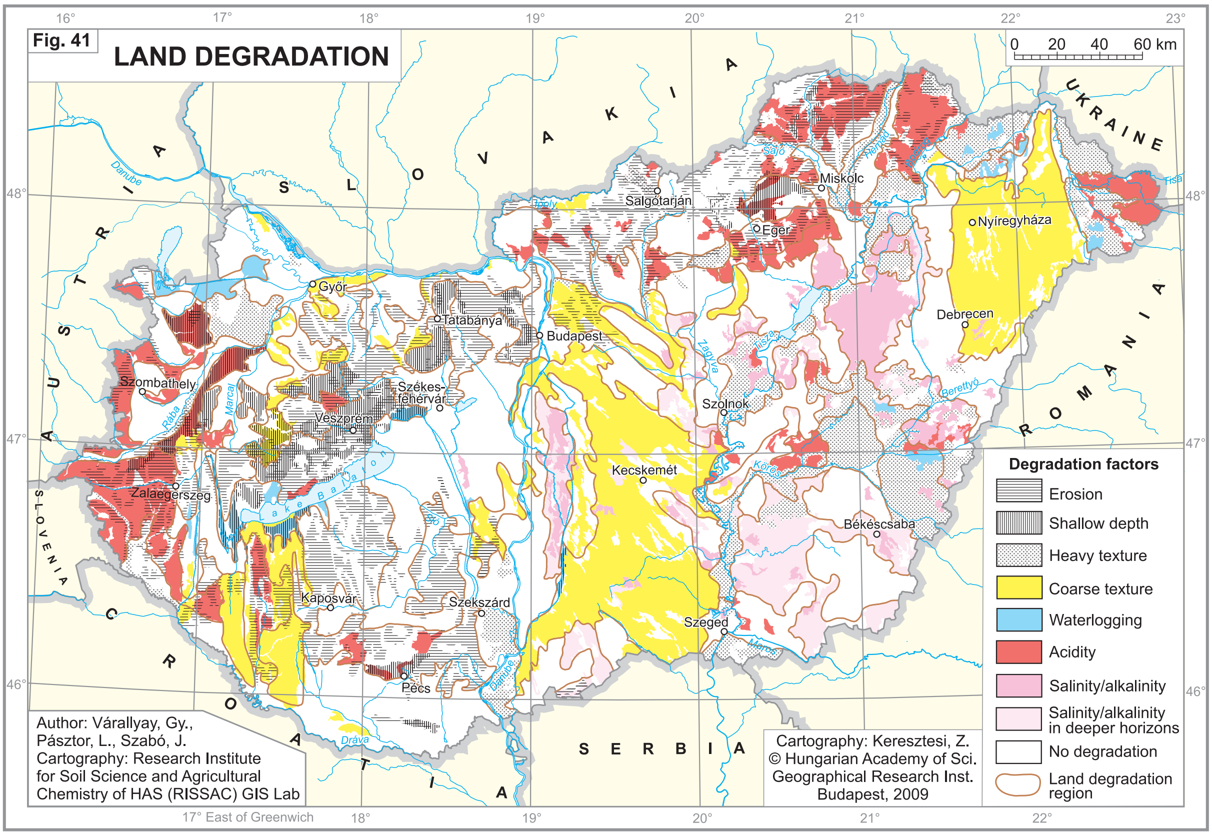


Fig. 41 LAND DEGRADATION

Hydrophysical Properties of Soils

Water resources are limited in Hungary where atmospheric precipitation shows high, irregular and sometimes extreme spatial and temporal distribution. Most surface waters rise from beyond the national borders, whilst a considerable portion of the limited amount of subsurface waters is of poor quality (exhibiting high salinity and/or sodicity).

For the exact identification of the hydrophysical properties and moisture regime of soils a comprehensive system of soil survey and analysis, categorisation, mapping, modelling and prognosis was developed in Hungary, which includes five basic elements:

– general identification of the hydrophysical properties of soils;

– establishment of a category system and mapping of hydrophysical properties and soil moisture constants at a scale of 1:100,000 (*Figure 42*);

– identification of moisture regime types and their mapping at a scale of 1:100,000 (*Figure 43*);

– elaboration of a methodology for large-scale (1:10,000–1:25,000) mapping of hydrophysical characteristics;

– building up models for quantitative monitoring of the soil moisture regime.

Soil is the largest potential natural water reservoir in Hungary. The soil layer down to a depth of 100 cm is capable to store more water than half of the average annual precipitation and about half of this can be termed as the "available" moisture content. In spite of this fact, Hungary is to be characterised by its extreme

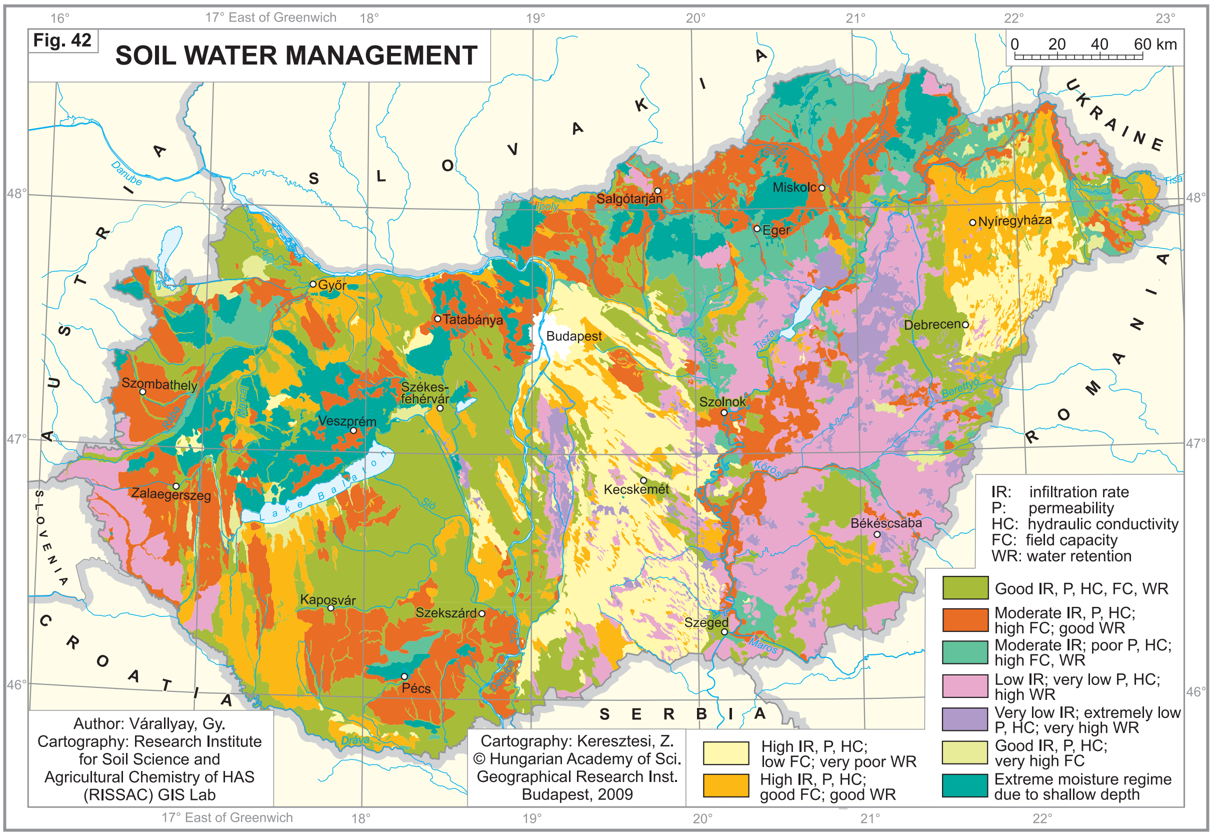


Fig. 42 SOIL WATER MANAGEMENT

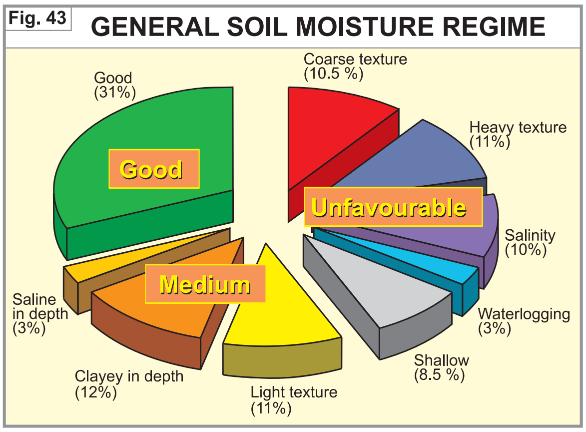


Fig. 43 GENERAL SOIL MOISTURE REGIME

moisture regime. Severe hydrological events occur with a high (and increasing) frequency, intensity, and duration (such as flooding, waterlogging, over-moistening or drought), sometimes within the same year and even in the same location. The cause of this apparent contradiction is that only a small portion of the potential water storage capacity of soils can be used, for the following reasons:

– soil pores are not empty;
– infiltration of water is prevented by frozen topsoil;
– seepage is hindered or reduced by a nearly impermeable layer;
– water retention of soil is poor and a considerable proportion of the infiltrated water is lost to deep filtration.

Traditional and Digital Soil Mapping in Hungary

A large amount of soil information is available in Hungary as a result of long-term observations, various soil surveys, analyses and mapping activities (www.mta-taki.hu). The collected data are accessible in various dimensions: at national, regional, micro-regional scales, at a farm and field level, and generally presented in maps, serving different purposes as to spatial and/or thematic aspects (*Figure 44*).

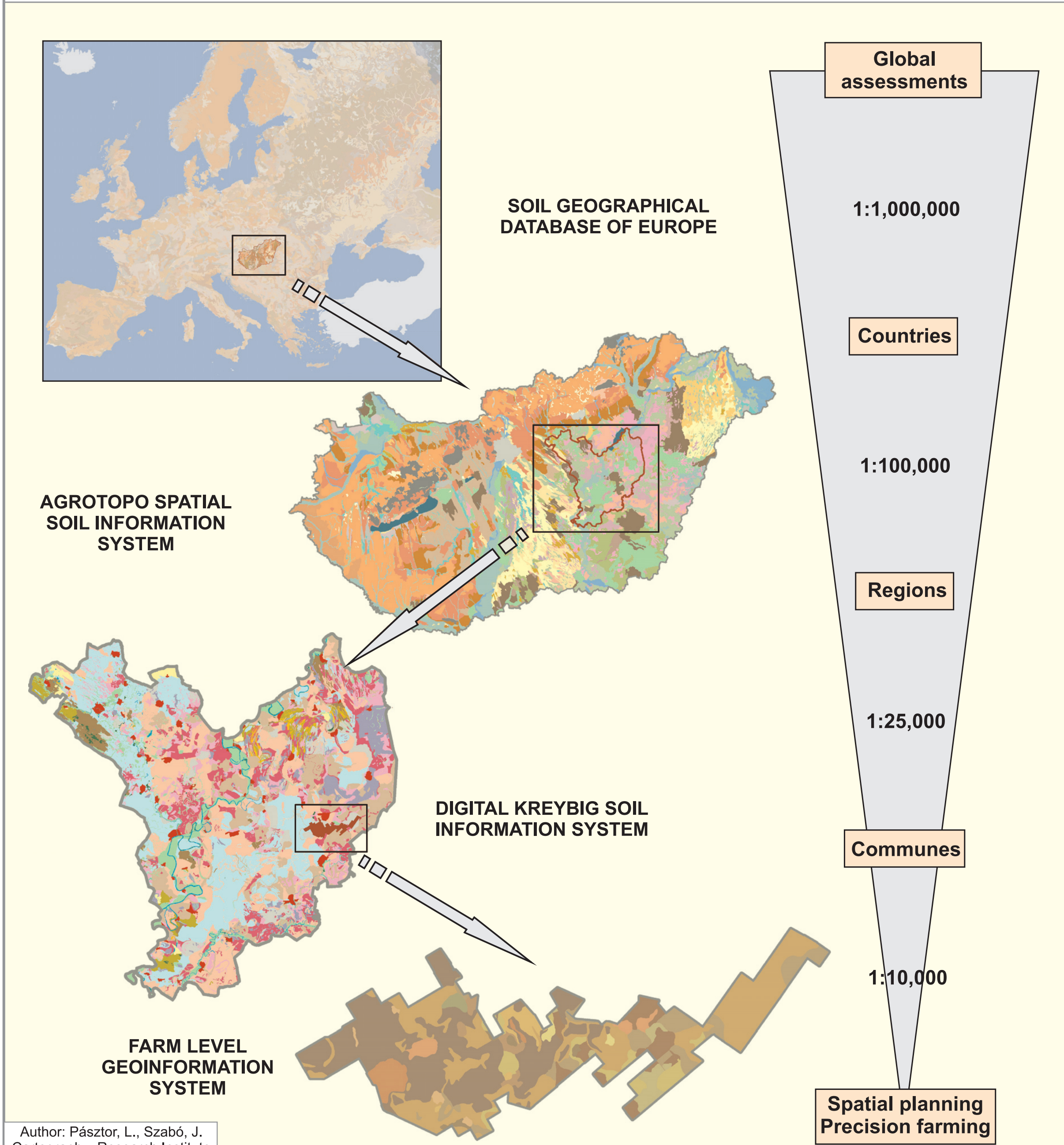
Since the late 1980s, a gradually increasing proportion of soil related data has been digitally processed and organised into various spatial soil information systems. Initially small-scale digital soil maps were compiled. The first national spatial soil information system was known as AGROTOPO, which is virtually the GIS adaptation of the output from the "Assessment of the agro-ecological potential of Hungary" programme, in the form of maps at 1:100,000 scale. AGROTOPO provides a suitable data source on both national and regional levels.

Clearly, various fields of activity (be it environmental protection, land evaluation, precision farming, etc.) need to rely on digital spatial soil information at larger scales. To meet this requirement, GIS processing of the large-scale, practice-oriented soil maps represent a challenging task in Hungary. GIS adaptation and digital reambulation of the 1:25,000 scale, applied soil mapping programme – hallmarked by L. Kreybig – is of prime importance and currently under way to eventually result in the Digital Kreybig Soil Information System which will be available for solving problems on a sub-regional scale.

Digital reambulation and GIS adaptation of the 1:10,000-scale Genetic Soil Mapping and National Land Evaluation Programme are also receiving increased attention. Several pilot projects have been carried out for the compilation of integrated geo-information systems for various agricultural farming units.

Fig. 44

TRADITIONAL AND SPATIAL SOIL INFORMATION SYSTEMS



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Cartography: Research Institute for Soil Science and Agricultural Chemistry of HAS (RISSAC) GIS Lab