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Development of an Online Soil Valuation Database

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Abstract: There is a constant need for the rational evaluation of every individual piece of land. To provide continuously upgraded, precise technical and economic assessment, an online digital geographic information system was developed. At the roots of the system are cadastral maps from the land registry and soil maps at the scale of 1:10,000. The basis of the technical land bonitation* is the D-*e*-Meter system, which is used not only for croplands but also for grasslands and forests.

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*As defined by FAO (2003), page 9, "soil bonitation is the comparative assessment of the land quality and productivity with a representative level of agricultural activity. Bonitation involves an analysis of the soil properties, both natural and human-induced, that determine its crop carrying capacity, both its natural productive capacity and that obtained through agricultural activities."

The algorithm for the calculation of the land quality index, which is the core of the D-*e*-Meter system, was developed with a database of 60,000 plots that were monitored during a 5-year period. Based on cultivation field records and a comprehensive system of economic valuation, the indicator "total standard gross margin" was calculated and finally a land value index in euro/ha was provided.

Keywords: Bonitation, GIS, soil valuation

INTRODUCTION

There is an increasing need for improved land valuation all over the world (Burrough 1987; Rossiter 1996). Along with increasing data requirements, there is a range of new technologies, such as computerized spatial data management, remote sensing, and online query techniques, that can be used to improve soil bonitation and land valuation (Lemmens and Kurm 2000).

After one-and-a-half centuries of utilization of the "Gold Crown" land value index (Dömsödi 2006), in spite of new initiatives (Fórizs, Máté, and Stefanovits 1971), there is no functional modern land valuation in Hungary. A new soil bonitation index was developed (Gaál, Máté, and Tóth 2003) by our team to facilitate improved land bonitation and valuation. The basis of the new system is the D-*e*-Meter soil quality index (or bonitation number). The index value is calculated with the help of a complex geographical information system (GIS) of soil and other maps online in realtime.

After the earlier developments, at present the concept of D-*e*-Meter soil quality index is being extended from croplands for other land uses, such as grasslands (Dér et al. 2003) and forests (Bidló et al. 2003).

Earlier we showed the concepts and difficulties of coupling the physical characteristics of lands (Hermann et al. 2006; Tóth et al. 2006a) and the economics of land use (Tóth et al. 2006b, 2006c, 2007).

After this, the next stage is the development of the land valuation system and its realization in the GIS and this publication will focus on these achievements (Szűcs, Farkasné Fekete, and Dobó 2006; Fekete Farkas 2006).

MATERIALS AND METHODS

In the frame of the previous D-e-Meter project, an Internet-based soil quality index was developed, which is based on the processing of three major databases:

1. The statistical interpretation of the Hungarian Soil Fertility Monitoring System (AIIR) soil and yield database compiled between 1985 and 1989 from the agronomic field records kept by the farms. These data were collected from 60,000 fields, covering 4 million hectares yearly (Vass et al. 2003).
   The database contains information on basic data for identification (location, size, slope, exposure, meteorological Gold Crown land value, etc.); soil analytical data [pH, texture, organic matter, nitrogen, phosphorus, potassium concentrations]; and agronomic field records (crops, crop rotations, yields, application of fertilizers, and manure).
2. Statistical processing of data from the long-term field trial network (Magyar et al. 2002). Nine field study sites provided data from long-term field experiments running with the same standard fertilization rates but representing nine different agroecological regions of Hungary (Bircsák and Németh 2002).
3. Data collected in pilot study sites of farms on the effects of cultivation and crop rotation on yields (Gaál, Máté, and Tóth 2003).
   The five steps in the calculation of D-e-Meter points were as follows. Step 1: Base point calculated for a) each genetic soil subtype of the Hungarian national soil classification scheme (Szabolcs 1966) specified for b) crop type, c) water regime of the soil, and d) management intensity level (extensive or intensive) for e) each meteorological region of the grown crop and f) each meteorological type of the year (dry, average, good in terms of the crop yield). Step 2: Different ranges of soil parameters are used to correct the effect (soil texture category, soil organic matter category, soil pH category, soil parent material). Step 3: Different levels of nutrients are used to correct the effect. Step 4: Relief and exposure are used to correct the effect. Step 5: Fore crops are used to correct the effect (Tóth et al. 2006d, 2006e, 2006f).

The study site is a contiguous area of Zala County as shown in Figure 1.

RESULTS AND DISCUSSION

Economic Studies for the Calculation of Land Valuation Algorithm

The land value is closely connected to the D-*e*-Meter soil quality index (Tóth et al. 2006c). A set of correction factors is considered when the land value is calculated as was shown by Tóth et al. (2007). These are 1) the fragmentation of the area, 2) the possibility to irrigate, 3) obstructive objects in the field (elements of infrastructure), 4) accessibility of the area, 5) infrastructure, and 6) distance from waste storage facility. The values of correction factors range between 0.8 and 1.15 and are used as multipliers of the D-*e*-Meter points.

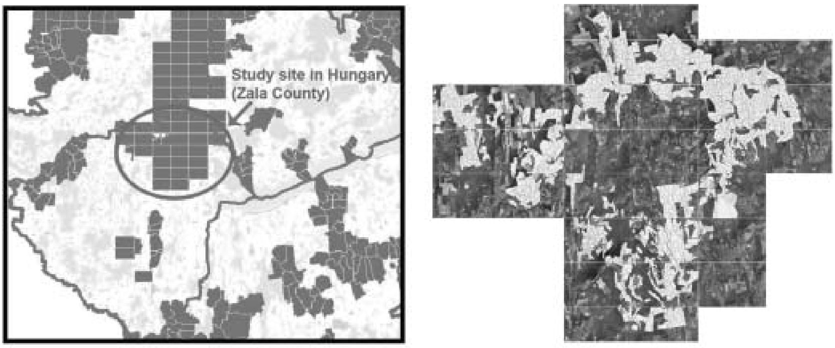

Figure 1. (a) The study site in southwestern Hungary on the right bank of the Zala river before it flows into Lake Balaton. The rectangles indicate the 1:10,000-scale genetic soil maps in the national grid system (Hungarian Datum). (b) The plots selected in the study site are indicated by pale color.

The correction factors are read from digitized soil maps; therefore their interpretation is completely automatic in the GIS.

Sustainable Land Use Planning with the System

Soil texture and slope are two fundamental characteristics of plots. Based on the texture and slope categories calculated by the digital elevation model, important decisions can be made. Those areas that must be excluded from plowing can be automatically delineated. According to the Good Farming Practice as suggested by the European Union Council Regulations, plots with slope gradients exceeding 12 degrees must not be cropped with row crops. The delineation of those areas where the steep gradient of the land causes overconsumption of engine fuel can be carried out automatically in the online system.

In Figure 2a, increasingly dark tones indicate the patches of our Zala study site with increasing clay content, and in Figure 2b the tones indicate the slope degree categories, which are related to fuel consumption. Considering such maps is indispensable because of the evident effect of soil texture on soil cultivation requirements, fuel requirement, and length of growing season as well.

CONCLUSIONS

Based on the D-*e*-Meter soil quality index of agricultural plots, we developed the framework of land value calculation based on an online

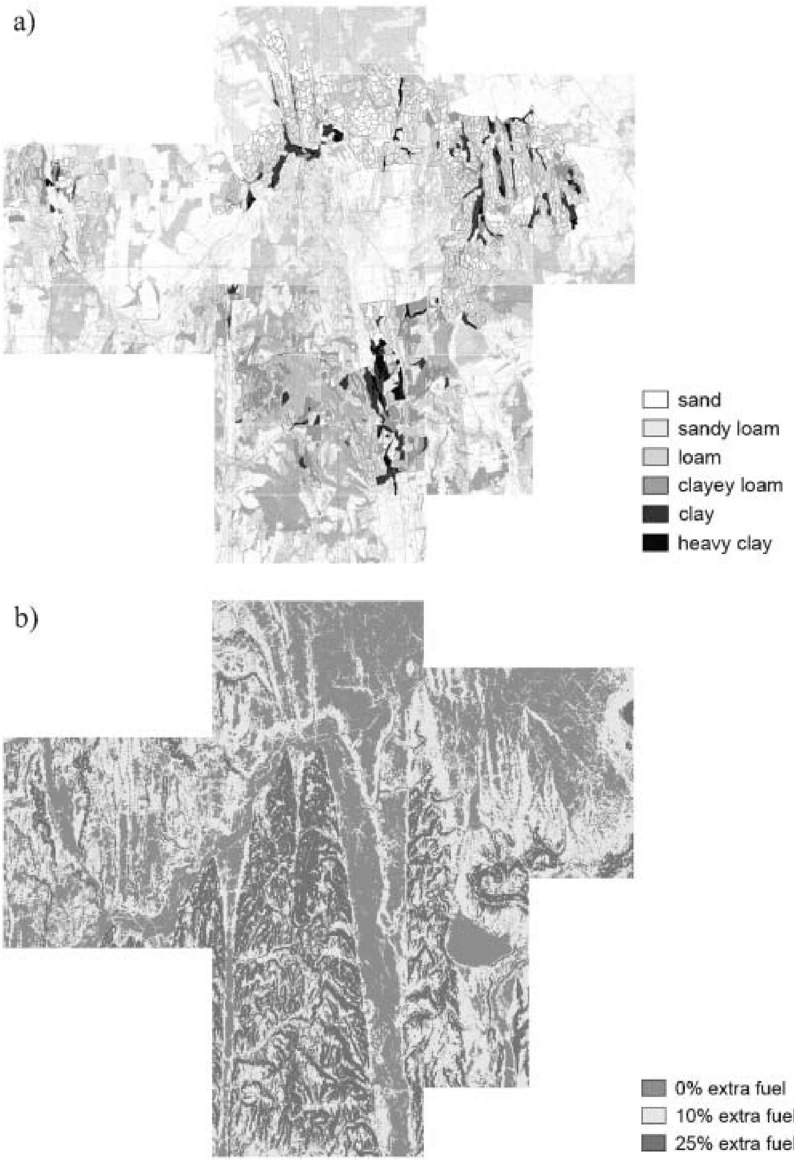

Figure 2. a) Map of soil texture according on the available soil information in study site: lightest tone shows sand, black shows clayey texture. b) Extra fuel consumption on the base of slope in study site [dark grey (>25%) > light grey (>10%) > green] due to slope.

GIS. From the soil D-*e*-Meter soil quality index, the D-*e*-Meter land value can be effectively calculated through the use of digitized databases. There are further opportunities to improve the sustainability of land use by optimizing fuel utilization, crop rotation, and so on inherent to the system.

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