Information Technology of the D-e-Meter Intelligent Land Evaluating System

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Key words: intelligent land evaluation, GIS, agriculture, soil quality, precision farming

SUMMARY

In a market economy a modern land evaluation system is indispensable for establishing the system of subsidisation as well as for working out systems for providing loans in the agricultural sector. Such a land evaluation system is, however, also an essential tool in the arsenal of production and environmental policy, and farmers also need it for rational land use and profitable farming in their everyday work.

In this work we give a possible solution for an internet-based intelligent land evaluating system which is suitable for planning a precision farming and providing data for every participant either in the economic and the agricultural sector.
The main objective of the project is to develop an information system that includes the following:

- displaying soil quality by means of maps using on-line GIS tools,
- plant production modelling on the basis of soil quality and other criteria (e.g. optimal fertilizer use),
- assistance for farmers to fulfil their obligations to provide information on the use of arable land, and providing means for direct communication with the administration agencies of the sector.

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1. INTRODUCTION

In a market economy a modern land evaluation system is indispensable for establishing the system of subsidisation as well as for working out systems for providing loans in the agricultural sector. Such a land evaluation system is, however, also an essential tool in the arsenal of production and environmental policy, and farmers also need it for rational land use and profitable farming in their everyday work.

In contrast to the above, the Hungarian land evaluation system used presently, the so-called gold crown system, is rather an obstacle to the realisation of all the above-mentioned tasks because of its unsuitability. Consequently, it also hinders the development of our agriculture as well as sustainable environmental management. This is the reason of the needs of developing an internet-based intelligent land-evaluating system which is suitable for providing data for every participant either in the economic and the agricultural sector. The article would like to show the main principles of the GIS, used for solving the problem.
The main objective of the D-e-Meter is to develop an information system that includes the following:

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- plant production modelling on the basis of soil quality and other criteria (e.g. optimal fertilizer use),
- assistance for farmers to fulfil their obligations to provide information on the use of arable land, and providing means for direct communication with the administration agencies of the sector.
- In our work we try to find the answers to the questions below:
- What are the main IT tasks?
- The resources of the development laboratory
- Design of the spatial information model, objects in the data model
- Input/output data
- Methodology and process of land-evaluation
- Using the experience of past, what kind of data we need?

After discussing these questions we show a possibility for an efficient on-line GIS-application. Through the development of EU-conform systems of land evaluation and agricultural information networks based on Internet technology, farmers could obtain a tool for choosing the appropriate form of land utilization for their own arable lands being aware of the national land use directives (with the aid of 'plot-level' computerised modelling within the given farming units), would also provide them with a means for direct communication with the competent agencies.

2. MATERIALS AND METHODS

2.1 Methods of Land Evaluation

2.1.1 Building of the Land Use Database

The basis of the land evaluation work is the soil fertility analysis of the databases available from various sources. The conditions have to be created for the uniform handling of the databases in order that statistic analyses will be possible. An integrated database will be made for the integration of available national plant cultivation data, on the one hand, and for organising the information from the sample areas, on the other hand.

2.1.2 Land Evaluation Analyses

Above all, the land evaluation work is based on the computerised statistical processing of available soil and plant cultivation information about the sample area. In the first phase of the statistical analyses the fertility limit values of the soil type and sub-type units of genetic soil classification are to be determined. That can be followed by exploration of the fertility conditions of soil varieties isolated on the lower taxonomic levels. The initial phases of the land evaluation work are followed by the definition of the fertiliser responses of the soils. This is meant to explore the causes of changes in the production potential resulting from fertiliser application of various intensities and to express the extent of such changes. To determine the production value the water regime characteristics of the soils have to be examined as well. In other words, the effect of the water regime and moisture circulation of the soil has to be incorporated in the land evaluation system too. In the course of this work the effects of the elements of the soil water balance (precipitation, evaporation, surface down flow, infiltration, fluctuation of inland water etc.) on the production capacity have to be examined in interaction with the soil characteristics. For the numerical expression the evaluation of the pedological and meteorological factors is also needed. The land evaluation task can be supplemented with the abovementioned criteria, because all the necessary elements are available (the system of categories of the water regime characteristics of the soil, the methodology of large-scale mapping of soil water regime characteristics, the description of water regime and material circulation types of Hungarian soils, collection of geohydrological monitoring information).

2.1.3 Visualisation of the Land evaluation model in Electronic Maps

The creation of GIS databases for the sample areas in the various agro-ecological regions of the country (Hungary) serves several goals. Since the land evaluation model is developed on the basis of archival farming data and the results of experiments it is necessary to calibrate the model also among real conditions of farming. At the same time, sample areas are also needed for the integrated visualisation of the data collection and land evaluation supported by GIS modelling, because the farming data of the sample areas can provide the input data for the data collection module. The results of the land evaluation research and the information technology development can be united in the sample areas. Sample areas can be only areas

where genetic soil mapping has been carried out. For the information system of the sample areas it is necessary to digitalize the 1:10000-scale operating genetic soil maps. This can be followed by the harmonisation of the soil and plot maps also by computer and based on the 1:10000-scale maps. As sample areas we consider 4-5 areas under agricultural cultivation each having an area of about 4-8 thousand hectares.

2.2 Methods of the Information Technology Development

The IT development is based on existing Hungarian and foreign experience. The members of the consortium are all some of Hungary's most dynamic research & development institutions, who follow the present trends, keep pace with new developments often applying new solutions. The IT development is built on a basis that conforms to technologies used in the EU and the most developed countries. Thus, the compatibility of the system has been built can be guaranteed. The database management system, the modelling system, the GIS and the Internet technology has been all constructed according to international standards. This might allow the construction of this type of systems for other countries as well.

2.3 Method of Surveying the Public Opinion

In surveying the public opinion, first of all a thematic compilation was published in the Szabad Föld magazine about the economic, social and environmental factors that require the development of the system. Also in a thematic form Szabad Föld presented the potential users a summary of the characteristics and areas of application of the system. The next step in testing the receptiveness of the society was a four-round quiz game, which is followed by forums all over the country. The content of the quiz was worked out knowing the previously received feedback and the results of the game were processed with regard to the comments and opinions continuously coming in. Another important element of surveying the public opinion is a national conference to which reputable figures of scientific life, representatives of the sectorial administration, experts of the interested service sector (banks, insurance companies) and professionals of farms using the system in practice will be invited. After the evaluation of the public opinion and the feedback from the conference, the experts had been participating in the survey together with the developers of the system and those involved in marketing it determine the possibilities and modes of any necessary modification.

2.4 The Main Characteristics of the IT Developments and their Novelty

In building the system special attention has to be paid to data protection and data security, since the data that is provided has economic value, so efforts to damage or alter the data are also expectable. The logic of the whole system is based on the usual 'inner network – demilitarized zone – open network' structure complemented with the option that if the users who are entitled to realize data are much fewer than the ones using the data, it may be worth dividing the demilitarized zone into two. In this case stricter protection of the resource (constant logging and watching of user transactions, application of special user identification procedures) is only necessary in the case of access to the data modifier server. If the difference between the number of the members of the two groups of users are insignificant,

the two systems can also be located on a common inner network. For the sake of data protection transactions are always initiated by the developer/maintenance system.

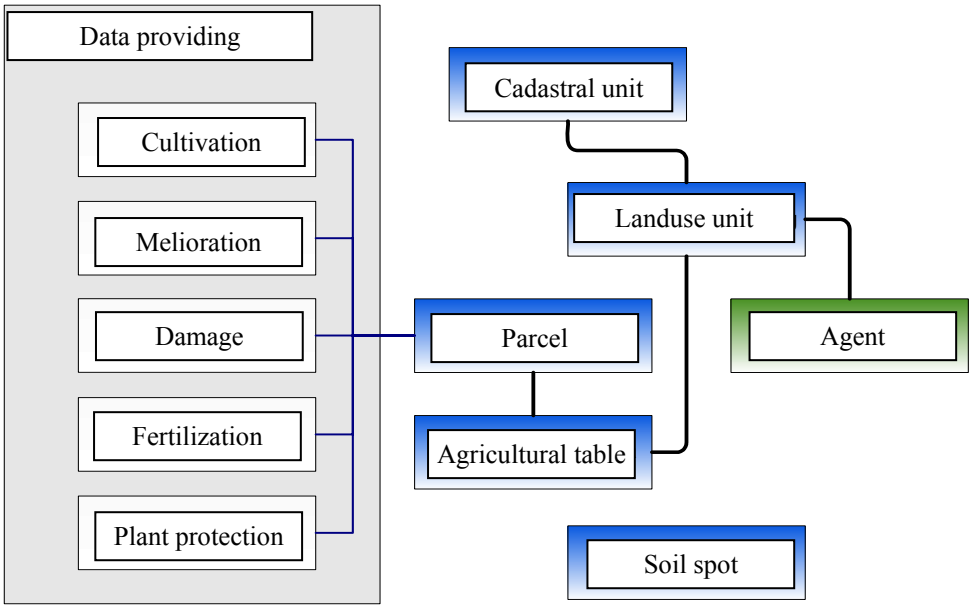
Of course, the condition for accessing the live system is that the authorization of the user has to be checked and found valid by the developer/maintenance system. The configuration of the firewall has to be realized with a "deny all" startup, i.e. the firewall only allows such communication that is indispensable for carrying out the given transaction. For the realization of the developer/maintenance system - provided the development is done in more than one place, or is carried out far from the service system - it will be worth creating a virtual private network (VPN) to connect the individual locations securely over the public Internet.

2.5 Software Background

The GIS development and the data processing were performed by ESRI software (ESRI Educational Lab Kit). The mostly used are ArcGIS Desktop and ArcSDE from this collection. For solving the data management in the system we used the Microsoft SQL Server 2000.

2.6 The Data Model

The database design work is the merit of the effective work of the consortium. It was formed during the developer discussions. The design work followed the relational database designing methodology. It means we got on with the planning from a general aspect to the direction of the more specialized model. In compliance with it, the functionality of the system were expanding continuously.



1. The spatial model

2.7 Spatial Data Relations

We use polygon representation of the farm area. The used polygon objects in the D-e-Meter accordingly to Figure 1:

- Cadastral Unit
- Landuse Unit
- Agricultural table
- Parcel (part of the table, one plant)
- Soil spot

2.7.1 Cadastral Unit

The essential part of the system, it is related to the other objects, carrying security information about the owner of the land unit.

2.7.2 Landuse Unit

This object was initiated by the consortium for managing the farming out. It is made of the cadastral unit with the spatial operation of cut. There is an attribute relate to the object above, the land use polygon inherits the attributes of the cadastral unit. This is the used method for the following objects too.

2.7.3 Agricultural Table

This area is created by a spatial join operation of two or more landuse unit.

2.7.4 Parcel (part of the table, one plant)

This polygon can be built with a spatial cut on the agricultural table.

2.7.5 Soil Spot

This is a unique object, the purpose of using it, to get the soil information of the actual territory. It is related to the other object by a georeference, not with a direct primary key-foreign key pair.

2.8 Operations over the Map

In the designing phase it was an important task to find the appropriate user interface that is suitable for loading the data, and editing the spatial data. It is realized over the map server software using a flash plug-in therefore it works over a number of browser.

- The realized spatial operations:
- Cutting by a line
- Cutting by a multi-line
- Moving of the cutting line
- Join of polygons

2.9 The Land Evaluation Process

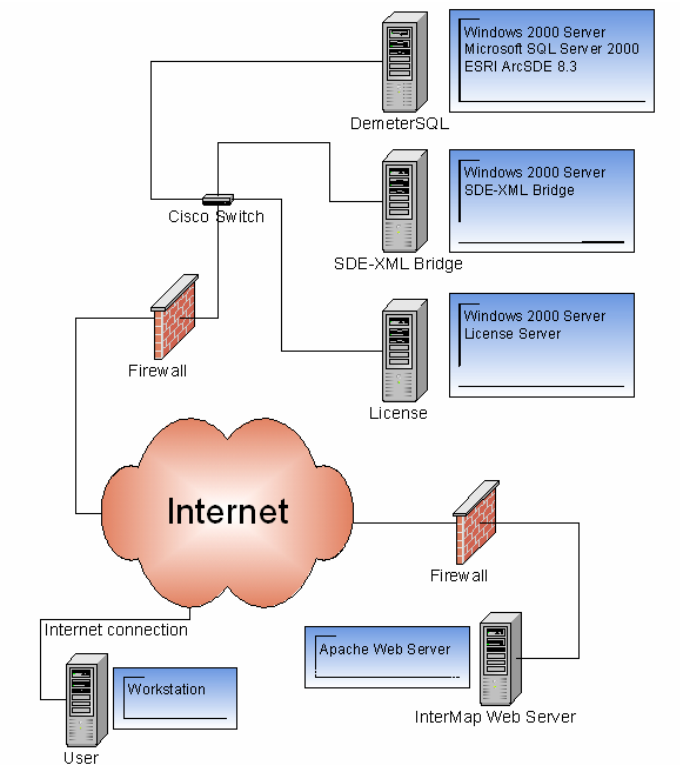
The project developed an evaluation algorithm based on spatial information. This algorithm gets a simple point of the map by its coordinates, and with this information it is able to obtain the related attributes needed for the calculation. There are five calculation modules, what are responsible for calculating:

- Water regime factor
- Soil evaluation factor
- Nutriments factor
- Relief factor
- Previous vegetable

The algorithm calculates the summarized factor of the quality information about the above enumerated objects. This value is a factor what can be used to represent the objective quality of the land.

2.10 The Partitionable System

The development was going in two centre, one for the user interface and one for the data management system, because of a practical reason. The aim of the work was to develop an easy-scalable system, what can operate with smaller, regional data server. It can give more resources and provide a faster service. The database module can be partitioned according to the geographical location. So the network traffic can be reduced and querying the data base can be also faster. It can be realized by operating county or regional servers over the country.



2. The IT structure

3. RESULTS

The system that was to be developed will provide both the service companies involved in the project and farmers using the system with a reliable tool for increasing competitiveness and economic progress. Apart from them, other service providers connected to agriculture (land-bank, insurance companies) and administration agencies can also benefit from the results. We may, therefore, say that positive impacts are to be expected at the levels of private farms, small enterprises, and service providers as well as at state level as a result of the project

3.1 Direct Impacts

The project results will have direct impacts in several fields of agriculture and environmental management. These manifest themselves in the selection of optimal land use, i.e. ecologically and economically favourable modes of cultivation and levels of intensity. The technical development that is necessary for the application of the system can also be regarded as a direct impact (which generates further positive impacts). By using the system the ability of rural farms to attract capital will be increased because the system will allow more precise planning and the production will be more transparent. Direct impacts will also occur at the locations of research and at the companies participating in the development. As a result of the research new scientific results and new technical solutions can be expected, which directly influence the institutions' activities. The financial profit of the firms interested in the marketing of the planned system is also a direct impact resulting from the project.

3.2 Indirect Impacts

From the indirect impacts of the project's output agricultural production, the sectoral administration, environmental management, rural society, the service sector and the institutions participating in the project will all benefit. Modern agri-environmental programs can be based on the environmentally-based expression of soil quality. Thus, the new type of land evaluation can support the establishment of environmentally-based subsidization systems (e.g. the fertilizer application counselling should be adapted to the soil quality). Land evaluation may have in important role in other areas of the sectoral administration as well. In addition to the subsidization systems, the system of granting loans on the basis of land can also be improved by considering production conditions of the given area. (The benefits of this will affect both farms and banks.) The system of production insurances (perhaps a state counter-insurance system) can be developed according to uniform aspects also considering extreme meteorological effects.

4. RESULTS

4.1 General Perspectives

There have been efforts to develop systems for agricultural data collection before now as well. However, these systems processed mostly only the production indicators of farming without clarifying the relationship between the results of agricultural land use (plant product) and the environmental resources. Therefore, we may conclude that no system similar to the envisaged one has ever been created, and if it is finished, it will be a new achievement in the whole world.

4.2 Expected Output Associated with Land Evaluation

A land evaluation system bases on a complex approach of expressing soil quality together with the available tools of information technology (Internet, GIS, database manager software etc.) offer new possibilities that allow the harmonisation of agricultural production and environmental management on a higher level. On the one hand, it is beneficial for the short and long term interests of the people living in a given area, while on the other hand it facilitates the theoretical foundation as well as the practical realisation of sustainable utilisation of areas prone to degradation. From a professional, scientific perspective, previous land evaluation and research in the field of soil fertility were aimed at classification according to genetic soil types. The numerical expression of the role of the factors influencing the fertility of soil types in plant production might also lead to a more precise method for isolating soil varieties. From the perspective of soil conservation the complex approach of determining environmental limit values related to fertility is regarded as a new achievement. This might produce new results primarily in the field of erosion research. Due to Hungary's prospective joining the EU more and more areas will have to be withdrawn from agricultural cultivation and in many places intensive technologies will have to be replaced by extensive cultivation methods. Appropriate subsidisation systems according to directives of sustainable agriculture can only be worked out with ecological foundation. The extent of ecologically

justified fertiliser application can be determined on the grounds of soil nutrient regime research related to expressing the production potential. This can be greatly facilitated by a ecological land evaluation system wich has a flexible structure. The expression of soil water regime characteristics, drought and inland water risks, in relation to production conditions may allow the numerical expression of the environmental factors of production risks. This approach can also influence water management and melioration research, which apart from new scientific achievements may also result in practical benefits. It is important to note that in spite of the fact that the present research project is meant to give a comprehensive solution for land evaluation and in connection with that to the questions of soil nutrient regime and water regime, it is expected that the intended system will need constant maintenance and development due to scientific progress and the changes in practical farming.

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