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Stručni članak

Application of GIS Technology in Soil Inventories and Preparing of Special Thematic Maps

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ABSTRACT. The geographic and land information system (GIZIS) of the Zagreb County is an example of the possibility of using a digital model and interpretation in planning and conservation of land resources. The GIZIS database consists of two parts. The first part includes the data referring to polygons – pedological contours, and the second part the data on pedological profiles. The database is organized in a way allowing simple access by the ArcView to all information either by the database search or by putting questions. The data entered into the base represent the basis for elaboration of maps of various scales.

Key words: GIS Technology, special thematic maps, database, soil

1. Introduction

The development and application of GIS technology at the Department of Soil Science of the Agricultural Faculty, University of Zagreb, Croatia has made a considerable progress in the recent years. Thus, by application of GIS technology, the Geographic and Land Information System (GIZIS) of the Zagreb County has been formed. It constitutes the base for the development of agriculture and forestry, planning of sustainable development, environment protection, land conservation and development and physical planning.

The basic data for developing of GIZIS were the data of the Basic Soil Maps, the topographic maps of the Republic of Croatia at the scale of 1:50,000, and the data from other studies made for the purpose of agricultural development in the area. These data, together with the results of processing and analysis by digitizing, generalization and interpolation, were incorporated into the integrated database of GIZIS by using AutoCAD, ArcInfo and ArcView software and the corresponding hardware.

The GIZIS was developed for the purpose of agricultural development of the Zagreb County, and it is the first example of the use of GIS technology in agricul-

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tural development in the Republic of Croatia. The Zagreb County, which also includes the city of Zagreb, is a part of the Central Croatia macro region. Its area is 3.720 sq. km, which is 6.6 percent of the entire territory of Croatia. Large agricultural areas in this part of the country are a natural resources of strategic importance for further economic development. The GIZIS of the Zagreb County is an example of the potential use of the computer model and digital interpretation of data and investigation results. It is designed for development of agriculture and forestry in the area; however, it is also the basis for physical planning, planning of the environment protection policy and, in general, one of the fundamental components for the policy of general economic development. The GIZIS database allows, among other things, soil inventories according to individual criteria, as well as working out of numerous specialized maps. Some examples of possible soil inventories and some specialized maps are presented in this paper.

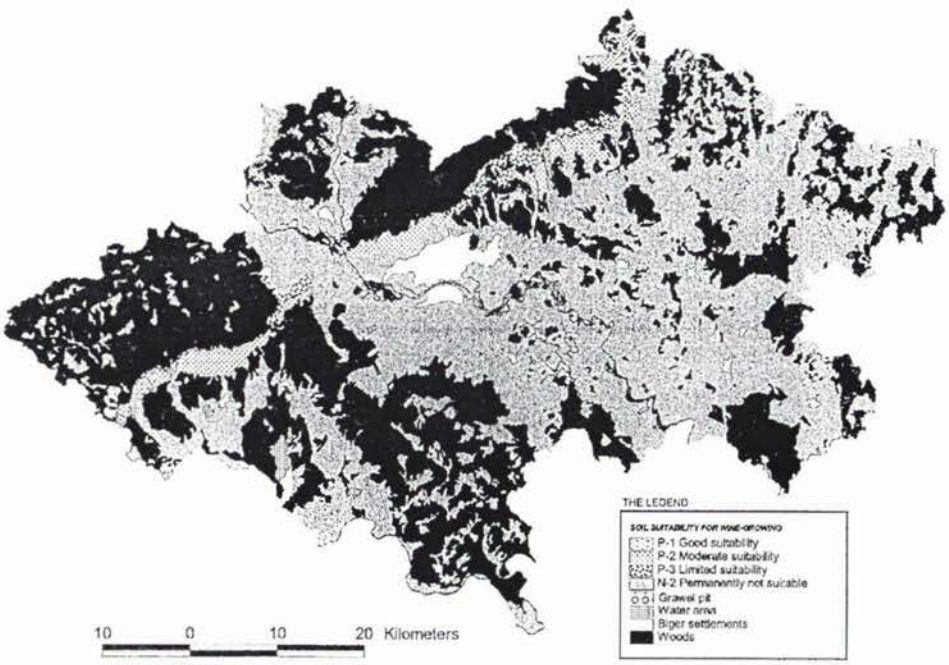

Figure 1. *Soil Suitability Map of Zagreb County*

2. Materials and Methods

This basic source of pedological data for working out of the GIZIS of the Zagreb County was – the Basic Soil Map of the Republic of Croatia at the scale of 1:50.000 in printed or/and manuscript form, with corresponding legends, the regional monography Tla gornje Posavine (Soil of the Upper Sava Basin) (Kovačević et al. 1972), and as well as numerous studies elaborated for the purpose of agricultural develop-

ment of the area. Based on the topographic map at the scale of 1:50.000 forest areas, major settlements, water areas (rivers, lakes and fishponds) and gravel pits have been separated, and they were not the subject of further research. The basic geographic data, including the County borders, the borders of individual communities were supplied by the Client.

The methods are based on the Info technology and are in accordance with the methodology of operation of geographic information systems. The first part of the data for elaboration of GIZIS consisted of the digitalized data of the mapped contours. In this process, the first step was digitalization and separation of forest and water areas, settlements and gravel pits, followed by digitalization of pedological contours, with simultaneous partial generalization, or joining of neighbouring contours into new soil mapping units. Digitalization was carried out manually by digitizer CalComp, model 34360, using the program package AutoCAD. The next step was processing and further generalization of all above mentioned digitized data in accordance with the criteria and standards of elaboration of maps at the scale of 1:50.000 using ArcInfo program package, resulting in strict polygonal structure of all digitized mapped contours. The other part of data for elaboration of the GIZIS of the Zagreb County consists of the data incorporated into the special database of the Zagreb County by the program package Access. The database practically consists of two sub-bases. One sub-base includes the data referring to soil mapping units – pedological contours, and the other data sub-base includes the data in pedological profiles. The data from the two sub-bases processed in Access were then connected with digitized data of mapping units and locations of pedological profiles, processed in ArcInfo into the GIZIS database by ArcView. Thus formed GIZIS database represents, in fact, the geographic and land information system of the Zagreb County.

The GIZIS database consists practically of the database of spatial application and the database of pedological profiles. The spatial application database, consisting of all data on soil mapping units, provides all data according to the following properties: number of the pedological contour or polygon, number of the soil mapping unit, name and composition of systematic units within a mapping unit, area of the mapping unit, circumference of the mapping unit, present use, slope, ecological soil depth, drainability, prevailing way of wetting, major chemical properties of the arable layer (soil reaction /pH/ in MKCl, phosphorus and potassium content, humus content, $CaCO_3$ content and active lime content), type of the agricultural programme with corresponding amelioration measures (liming requirements, fertilization, additional measures, drainage, irrigation and protection from erosion and torrents), order, class and sub-class of soil suitability for farming and for intensive crop farming, vegetable gardening, orchards, vineyards and grassland. From the database of pedological profiles it is possible to obtain or search for the data according to the properties divided in three groups. The first group includes general data for individual soil profiles, as are the number of profiles and systematic units. The second group includes the data on pedophysical soil properties, such as layer depth, mechanical soil composition, soil volume density, density of solid particles, soil capacity for water, soil capacity for air, total porosity, soil permeability, moisture content at 15 bar pressure, limits of soil plasticity (solidity limit, liquidity limit and plasticity index). The third group consists of the data on pedochemical soil properties such as soil re-

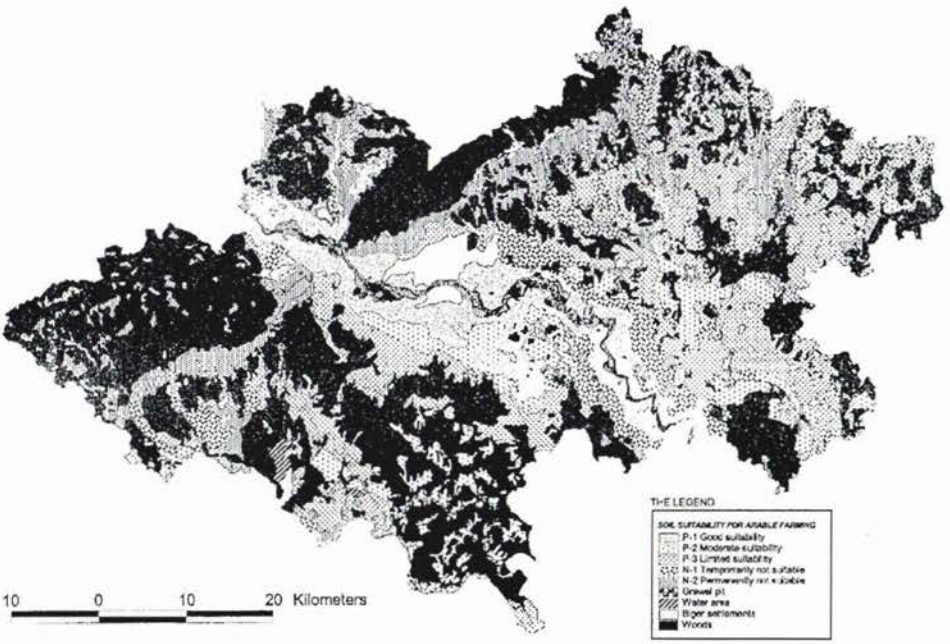

Figure 2. *Soil Suitability Map of Zagreb County*

action (pH) in H_2O and MKCl, $CaCO_3$ content (percent), active lime content (percent), humus content (percent), and nitrogen content (N-percent), physiologically active phosphorus content (mg/100 g of soil), content of physiologically active potassium (mg/100 g of soil), hydrolytic acidity (y_1), and individual parameters of soil adsorption complex.

The integrated GIZIS database offers, using ArcView, comparatively easy and rapid access to the information, either by base searching or by direct questions, and the possibility of further research and working out of specialized maps and inventories of areas according to all specified soil properties. The assessment of soil suitability for intensive multipurpose use in agriculture, the results of which are a part of the GIZIS database, was made on the basis of FAO land evaluation criteria (FAO 1976, Brinkman & Smyth 1972, Vidaček 1979).

3. Results

Based on the new possibilities offered by the digital and GIS technology in soil mapping investigations, the complex land information system of the Zagreb County has been developed. The advantages of such methods of investigation are, first of all, the possibilities of relating, analysis and statistic processing of the data incorporated into GIZIS database, and digital and graphic interpretation of the results. A part of the results obtained in this way are presented in this paper.

The basic data to which the data from the spatial application sub-base were connected, i.e. the data on the properties of the soil mapping units – pedological contours, were obtained from the soil map of the Zagreb County, where 44 mapping units have been sorted out. For each mapping unit, the primary pedological properties were determined, followed by the assessment of soil suitability for multipurpose use, respecting the principle of sustainable management of land resources, in accordance with the principles of FAO classification (FAO 1976). On the basis of the integrated GIZIS database which, as already mentioned, represents the geographic and land information system of the Zagreb County, it was possible, among other things, to work out specialized maps of soil suitability for crop farming, vegetable farming, orchards, vineyards and grassland. The assessment of suitability of the mapping units was made on the basis of the relief, slope, climate conditions, humidity, ecological soil depth, drainability, soil chemical reaction, nutrient supply, humus content, carbonate content, content of physiologically active lime, and on the basis of geographic data collected through description of pedological profiles.

By means of ArcView it was possible to work out 30 special maps. In this paper only two special maps are shown. Fig. 1 shows the map of soil suitability for vineyards, and Fig. 2 shows the map of soil suitability for ploughland crops. The land inventory on the basis of special maps is shown in Table 1. It was determined that out of the total of 205,303 ha of farmland in the Zagreb County there are only 17,772 ha suitable for vineyards, or 8.66 percent of all farmland. Out of the total area of suitable land, the smallest area is that of the 1st class, only 743 ha (0.36 percent), which are also the best quality soils for vineyards. As regards unsuitable soils, it is significant that all of them are permanently unsuitable for vineyards.

The soils suitable for vegetable farming comprise 52,314 ha, which makes 25.48 percent of the total area. Unsuitable soils make 152,989 ha, or 74.52 percent. Most of these soils, or 103,212 ha, which is 50.27 percent of all agricultural land in the Zagreb County, belong to temporarily unsuitable soils for vegetable crops, Table 1. Inventory of specialized map of soil suitability for arable crops show that in the research area there are 138.444 ha, or 67.43 percent of suitable soils for arable crops.

Table 1. *Review of area according to land suitability for multiple use in agriculture*

Suitability classes	Soil suitability for									
	Vineyards		Vegetables		Arable crops		Orchards		Grasslands	
	ha	%	ha	%	ha	%	ha	%	ha	%
S-1 - Good suitability	743	0.36	29.913	14.57	29.913	14.57	1.230	0.60	60.671	29.55
S-2 - Moderate suitability	13.276	6.47	8.600	4.19	30.886	15.04	10.995	5.36	23.641	11.52
S-3 - Limited suitability	3.753	1.83	3.801	6.72	77.645	37.82	93.279	45.43	120.846	58.86
Total suitability	**17.772**	**8.66**	**52.314**	**25.48**	**138.444**	**67.43**	**105.504**	**51.39**	**205.158**	**99.93**
N-1 Temporarily not suitable	-	-	103.212	50.27	30.743	14.98	-	-	145	0.07
N-2 Permanently not suitable	187.531	91.34	49.777	24.25	36.116	17.59	99.799	48.61	-	-
Total not suitable	**187.531**	**91.34**	**152.989**	**74.52**	**66.859**	**32.57**	**99.799**	**48.61**	**145**	**0.07**

There are 66,859 ha of unsuitable soils, out of which 30,743 ha or 14.98 percent temporarily, and 36,116 ha of permanently unsuitable soils for arable crops. There are 105,504 ha of soils suitable for orchards, which is 51.39 percent of the total area. However, it is important to note that only 1,230 ha, or 0.60 percent belong to the first class – good suitability, while the major part of these soils belongs to the third class – limited suitability for orchards. Allmost all soils are suitable for grassland, even 99 percent of all areas.

Graphic interpretation in the form of specialized maps is also possible according to other soil properties and/or results of soil investigations which are available in the GIZIS database. As an example, we presented a graphic interpretation of the results of investigating the soil demand on liming in the programme of soil improvement for crop production, Fig. 3, the special map made it possible to carry out the inventory of soil areas according to the liming requirements. Thus it was determined that out of the total of 205,303 ha of agricultural land there was a need for liming on 119,229 ha (58.1 percent). Out of this, on 5,206 ha (2.5 percent) liming is optional, on 19,627 ha (9.7 percent) comparatively low doses are required, on 90,150 ha (11 percent) mainly high doses are required, while on 3,946 ha (1.9 percent) liming requirements are very high.

The above examples of specialized maps and inventories are only a small part of large possibilities of interpretation of numerous investigation results incorporated in the database of the Geographic and Land Information System of the Zagreb County, and all this would not be possible without the use of GIS technology.

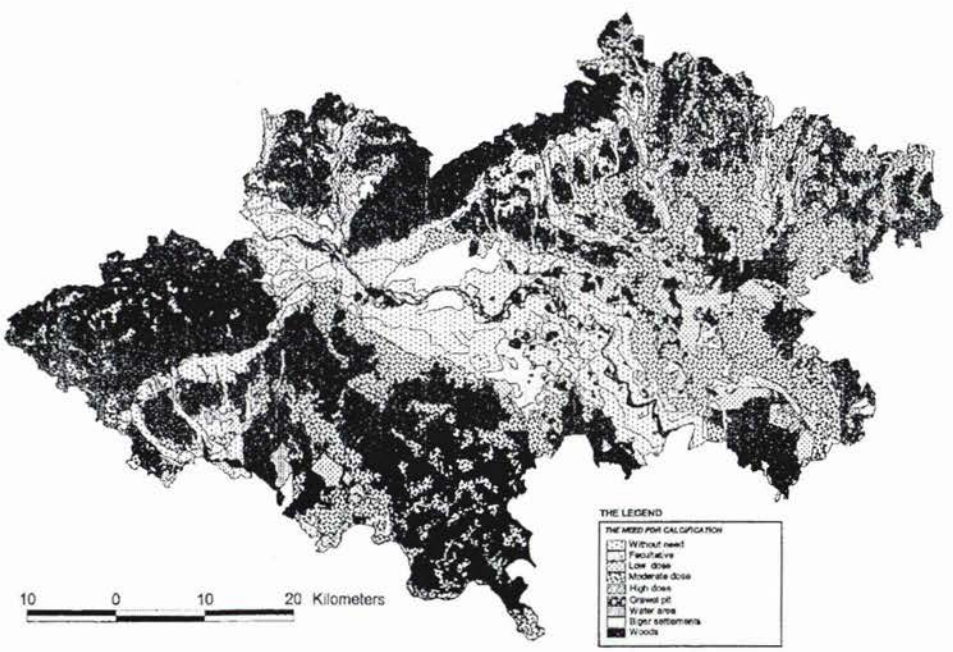

Figure 3. *Soil Suitability Map of Zagreb County*

4. Conclusion

Application of GIS technology led to the elaboration of the Geographic and Land Information System (GIZIS) of the Zagreb County. This method of investigation offers numerous advantages. First of all, it makes possible the digital interpretation of data and results, connecting with GIS databases of other related fields, and complex data processing. The paper shows the examples of possible working out of special maps and, on this basis, area inventories in the scope of planning of crop farming development and land development.

The GIZIS of the Zagreb County has been elaborated primary for the purpose of agricultural development, but it can be equally applied in forest management, physical planning, environmental protection, water management and construction.

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Primjena GIS tehnologije u inventarizaciji tala i izradi tematskih karata

SAŽETAK. Geografski i zemljišni informacijski sustav Županije zagrebačke je primjer mogućnosti upotrebe digitalnog modela i načina prostorne interpretacije u planiranju i zaštiti zemljišnih dobara. GIZIS baza podataka sastoji se iz dva dijela. Prvi dio čine podaci koji se odnose na poligone – pedološke konture, a drugi dio podaci koji se odnose na pedološke profile. Baza je organizirana tako da se na jednostavan i brz način mogu s pomoću ArcViewa dobiti sve potrebne informacije, bilo pretraživanjem baze bilo postavljanjem upita. Podaci uvršteni u bazu su osnova za izradu tematskih karata raznih mjerila.

Ključne riječi: GIS tehnologija, tematske karte, baza podataka, tlo

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