GEO-INFORMATION FOR SUSTAINABLE MANAGEMENT OF LAND RESOURCES IN CROATIA

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Abstract

Republic of Croatia is Central European and Mediterranean country. Although it’s area is relatively small (56,542 km²), it’s geographic position causes great heterogeneity of topography, geology, soil types, vegetation, climates and land uses. Management of natural resources in such situation is today impossible without geographic information system, modern tools of remote sensing and raster modelling. The aim of this paper is to show the existing geoinformation which can be useful for sustainable management of land resources in Croatia and methodology used. Many specialists from different disciplines started in early 90s to introduce geographical information system in their every day job. In last 8 years several very important products for land management of Croatia such as Geology map, Hydrogeology map, Soil suitability map and Map of grassland vegetation were produced in scale 1:300,000 in digital form. All these products were prepared using old analog maps prepared by terrestrial investigations. The establishment of new topographic digital base maps which are also important as basis for management of land resources, has started in five years ago by using aerial photographs and satellite images. At this moment two big projects dealing with preparation of digital base maps using remote sensing methods are in progress. One of them is establishment of new topographic and cartographic information system (in a scales 1:5,000, 1:25,000), and the other is establishment of CORINE land cover data bases for 2000, 1990 and 1980 (according to common European methodology in a scale 1:100,000). There are also two maps very important in land management on national level, produced on the base of spatial modeling. One of them is a map of soil erosion risk (1:300,000) prepared according to CORINE standards. The second is map of habitats for the whole country in the scale of 1:100,000, that was made using Landsat ETM images and raster modeling with a huge field work. The map was prepared according to the national habitat classification which is strongly interconnected with European habitats classifications.

Key words: Geoinformation, remote sensing, raster modelling, land management, Croatia

1. INTRODUCTION

According to its geographical position, the Republic of Croatia belongs to Central Europe; however, as it extends along the Adriatic coast, it is also a Mediterranean country. It consists of three natural-geographic wholes: continental, mountainous and littoral-Mediterranean Croatia. Despite its relatively small area of 56,542 km², its geographical position influences its marked heterogeneity in topology, vegetation, parent material, soils, land use, climatic conditions, etc. Planning the rational use of land resources requires availability of a large number of good-quality and reliable information, which will allow making timely and adequate decisions (Husnjak et al. 2002). Until some ten years ago, the way to such information was very complex and work- and time consuming. However, the development of GIS technology, remote sensing and raster modelling, notably in the last decade,
enabled implementation of different projects at the national level, the use of which provides the required information in a relatively simple and quick way. In these new conditions, no rational land resources management is possible without development of geoinformation technologies.

The basic aim of this paper is to present the existing geoinformation data at the national level, which can be useful for sustainable management of land resources in Croatia, and the methodology used.

2. SURVEY OF GEOINFORMATION DATA

2.1. Geoinformation data in the form of geographic information systems (GIS)

Many specialists from different disciplines (forestry, agriculture, water management, geology, vegetation science, etc.) started to introduce geographical information systems into their everyday jobs in the early 1990s. In last eight years, several very important products for land management at the national level of Croatia were produced in digital form.

2.1.1. Geological map (1:300 000) and lithological map (1:100 000)

The Geological Institute of Croatia has designed the basic geological map in analog form at a scale of 1:100 000. Maps of almost the whole territory of the Republic of Croatia have been produced for this purpose (five maps still remain to be made). As there was no standardization of lithological members for the entire Croatia, there were finally more than 1500 different members. Oikon – Institute for Applied Ecology has put together all members from the whole state territory in digital form, reducing them to 187 lithostratigraphic members or 80 lithological or 12 ecological members (Oikon 2003). There are still imperfections in that the boundaries of particular members do not fully coincide in some sheets of the 1:100 000 map. Unification and harmonization of the contents are still in progress. Until this is completed, the map can be used only in segments that have been harmonized. Digital geological map of Croatia, scale 1:300 000, produced by the Geological Institute of Croatia for the needs of the Water-management base of Croatia is used for the whole state territory (Biondić et al., 1996). Data about the lithological substratum that can be obtained by searching the lithological map often provide important information for planning the land resources management. Besides, data on the characteristics of particular types of lithological substrata are very interesting for planning the policy of land resources protection as well as for production of different models. These data are also very useful for studies of the vegetation, fauna in forestry, nature protection and biological diversity evaluation.

2.1.2. Hydro geological map (1:300 000)

Hydro geological map with a databank was made using the GIS technology (Biondić et al., 1996). The principal basis for the production of this map was the compilatory Geological map of the Republic of Croatia, scale 1:300 000, in analog form, which was subsequently vectorized and transformed into the Gauss-Krieger projection and then harmonized with the digitalized topographic map, scale 1:100 000, Figure 2.
A component part of this map is the databank that can be searched using the Arc Info or Arc View program packages to retrieve numerous data, among others also data of great importance for land resources management.
The data can also serve for decision making and as input data for different modelling within projects for further needs of land resources management and utilization. Of special value are data like the type of parent rock, its porosity and water permeability, which are directly related to land management.

2.1.3. Soil suitability map (scale 1:300 000)

The soil suitability map was also made using the GIS technology (Bogunović et al., 1996) and it constitutes the most important base to be used within the policy of land resources management at the national level in Croatia. The main source of data for this map was the Basic soil map of the Republic of Croatia, scale 1:50 000, in analog form. Certain sheets of this map have been vectorized along with their generalization and integration into a unique map of 1:300 000 scale. The map was then transformed into the Gauss-Kruger projection and harmonized with the topographic map of 1:100 000 scale. It was then linked to the attribute database and served to design the geographic information system of the soil suitability map of the Republic of Croatia. Searching of the said information system using the Arc View program package can provide, in a relatively simple and quick way, a large amount of land information that has to be considered when planning land management at the national level. Namely, besides data on the soil suitability classes and subclasses (Figure 3), component parts of this information also include ground slope, soil drainage, mode of moistening, ecological depth, soil rockiness and stoniness and parent material, as well as data on the soil major physical and chemical characteristics relating to soil profiles. Listed data constitute important information both for decision making and as input data for various modelling for the needs of land resources management.

*Figure 3: Soil map of Croatia (1:300 000)*
2.1.4. Map of grassland vegetation (1:300 000)

Map of grassland vegetation, scale 1:300 000, was made in digital form as part of the Farmer Support Services Project of the Ministry of Agriculture and Forestry of the Republic of Croatia. Map of the overall grassland vegetation of Croatia was made in the project part Development of pasture and fodder production (IMF 2000). The basis for this map was the Vegetation map of Croatia, scale 1:50 000. That map was designed from 1960 to 1990 and about 130 sheets have been completed so far out of the total 151 sheets covering the territory of Croatia. Many of these maps are still in the manuscript form (only 7 map sections (scale 1:100 000) have been printed, or about 28 sheets of the original map). All grassland vegetation has been interpreted and vectorized. This content served for legend and contents standardization and as ground truth for interpretation of Landsat TM images. A set of 15 Landsat TM images was used for controlled classification that served as the basis for production of the grassland vegetation map of Croatia, comprising the spatial distribution of about 65 grassland types.

Distribution of grassland areas shown on this map constitutes a useful source of information, needed primarily in planning the policy of land resources protection, e.g., soil protection from water erosion, and as input data for modelling connected with land resources management at the national level.

2.2. Geoinformation data provided by remote sensing methods

At this moment two big projects dealing with preparation of digital base maps using remote sensing methods are in progress.

2.2.1. New topographic and cartographic information system

The overall cartography of Croatia is conceived as a topographic and cartographic information system and is based on photogrammetric processing of aero photo images taken during cyclic photographing of the Republic of Croatia (www.dgu.hr). The first such photographing was carried out from 1996 to 2000 while the second cycle started in 2001 (Figure 4). According to plan, the overall area of the state is to be photographed within the 5 years of the cycle, the same area being photographed every 5 years. In the first cycle, the complete area of Croatia was photographed on black-white (panchromatic) images at the scale 1:20 000. In the second cycle, photographing is performed at the same scale but with colour film.

Based on the images from cyclic photographing, principal topographic bases of Croatia are made: topographic map 1:25 000, digital orthophoto of 0.40 m pixel size, corresponding to map scale 1:5000, digital relief model, etc. It is foreseen that the entire system will be completed by the end of 2007 and put into function on the Internet. These topographic bases are indispensable for efficient studies of land resources and will also be an excellent basis for all spatial analyses required in planning, use and protection of these resources.
2.2.2. CORINE land cover data bases

CORINE land cover (Figure 5) data bases for 2000, 1990 and 1980 (according to common European methodology at a scale of 1:100 000) were established in order to make available a complete and systematic land cover inventory of Croatia for the years 2000, 1990 and 1980 to all interested users, mainly from the domain of environmental management and physical planning; to assess and to explain land cover changes between CLC 2000-1990-1980 in order to separate land use changes caused by war (e.g., depopulation of rural areas), and natural land use changes caused by other environmental impacts; to integrate Croatian CLC database with the European land cover database. The project was financed by the LIFE III Program and lasted from 1 Sept. 2002 to 28 Feb. 2005. The beneficiary of the project was the Ministry of Environmental Protection and Physical Planning and it was executed by the companies GISDATA d.o.o. and OIKON – Institute for Applied Ecology. After verification by EEA, the completed databases will be managed by the Environmental Protection Agency. As the bases will be accessible to the public, they will serve as the basis for many investigations and analyses in the sphere of physical planning, nature and natural resources protection, environmental protection, forestry, agriculture and a number of other disciplines.

Figure 4: cyclic photographing of the Republic of Croatia
2.3. Geoinformation data based on spatial modelling

Based on spatial modelling at the national level, two projects of exceptional value for land resources management in the Republic of Croatia were implemented. The first project involving a map produced on the basis of spatial modelling is a map of soil erosion risk (1:300,000) prepared according to the CORINE standards. The second project was a map of habitats for the whole country at the scale of 1:100,000, which was made using Landsat ETM images and raster modelling with a huge amount of field work.

2.3.1. Map of soil erosion risk (1:300,000)

Map of soil erosion risk by water was made using the GIS technology and spatial modelling at a scale of 1:300,000 (Husnjak et al., 2001), and constitutes an important basis for planning the policy of land resources protection at the national level in Croatia. The map was designed using the CORINE method in Gauss-Krüger projection and harmonized with the topographic map of the scale 1:100,000. The CORINE model of assessment of the risk of soil erosion by water involves overlapping of nine thematic maps (maps of soil texture, soil depth, soil rockiness, soil erodibility, precipitation variability, climate aridity, precipitation erosivity, ground slope and vegetation cover), according to which maps of potential and real risk of soil erosion by water were eventually made (Figure 6 i 7). A component of these maps is also the attached GIS database comprising all input data as well as research results. Searching this database can provide extensive information relevant to the assessment of
potential and real risks of soil erosion by water, which can be very useful to the users of this project in designing e.g. the program of land resources protection.

Figure 6: Map of potential risk of soil erosion by water (1:300 000)

Figure 7: Map of actual risk of soil erosion by water (1:300 000)
2.3.2. Map of habitats (1:100,000)

The Ministry of Environmental Protection and Physical Planning of the Republic of Croatia financed the project "Mapping of habitats of the Republic of Croatia" which was implemented by Oikon – Institute for Applied Ecology. The three-year project was completed at the beginning of 2004.

Data sources used for mapping the terrestrial part of Croatian territory were classified and interpreted Landsat ETM+ satellite images, intense field work, ancillary data from various thematic maps (old vegetation maps, forest management maps and lithological maps) and the literature.

Two sets of images were simultaneously used: spring and autumn sets. In the first step, each Landsat ETM+ scene was classified using supervised classification of the basic land cover units. In the second step, each land cover unit (on each scene) was classified into subunits using unsupervised classification supported with the optimization of a number of clusters. Finally, the results of unsupervised classification were interpreted with the support of field data and ancillary data. The whole terrestrial area of the Republic of Croatia was mapped with the minimum mapping unit of 9 ha for polygon contents and 300 m linear contents, which corresponds to the mapping scale of 1:100 000. Due to a relatively small amount of data on the submarine zone, the map of seabed habitats was made at a scale of 1:300 000. A total of ca 120,000 habitats was mapped: about 64000 polygons were classified into more than 120 habitat types, about 50600 linear habitats (watercourses, rocks and mosses, coast, etc.) divided into 20 different categories, and about 5200 point habitats (pits, caves, puddles, scree, etc.) classified into about 120 different habitat types. The map is deposited at the Ministry of Culture, Nature Protection Agency and is accessible to the public for studies in the sphere of nature protection, environmental protection, protection and management of natural resources, physical planning, etc.

Figure 8: Map of habitats (1:100 000)
3. CONCLUSION

Several valuable projects were implemented owing to the development of geoinformation technologies in the last decade in Croatia. The paper presents only part of the geoinformation available for the whole territory of the Republic of Croatia, namely, the information that is of special value as the major source of data required for implementing the policy of land resources management at the national level. Searching the described projects, users can acquire information and data indispensable for decision making. Besides, these data are also valuable as input data in various models designed for land resources management both at the national and continental levels.

4. LITERATURE


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