

The Process of Making, Organizing and Using Thematic Layers in GIS

D. I. Radović, I. S. Fetahović, E. Ć. Dolićanin

Abstract: As Geographic Information System (GIS), as part of the Geoinformation Sciences, deals with a complete system of creating, handling, storing, manipulating, using analysis and presenting information related to the Earth's surface it is in the direct function of solving fundamental problems / issues arising from that process. The organization of data is according to the system of thematic data layers. The research conducted includes the formation of GIS for different types of research for the Tara Mountain area, Serbia. During these researches, various thematic data layers were created. The types of data used in the creation of these layers are: vector, attribute with organized database, raster data and digital models. The processed contents present abiotic, biotic and anthropogenic elements of the real environment. The paper presents specific indicators created in the process of GIS development. Qualitative, quantitative and visual representation of the real environment was achieved. The results of multicriteria thematic and topological analyzes are also presented. System decisioning support is achieved.

Keywords: GIS, thematic data layers, data types, thematic and topological analyzes, visualization

1 Introduction

Geographic information systems (GIS) is a computer-based system to input, store, manipulate, analyze and output spatially referenced data. There is a huge range application of GIS which are generally set out to fulfil: mapping, measurement, monitoring, modelling and management.

GIS, remote sensing, dynamic-simulation modelling and geostatistics, are utilized in a variety of scientific and professional endeavours, ranging from forestry, landscape mapping and watershed ecology, climatology, demography, government, utility companies (power, gas, water, and telephone), business purposes, archaeology, pollution detection, geology. In social investigations, GIS is used to help analyze spatially varying attributes of the population such as income, crime, health or the quality of housing [11], [12]. These applications may include cartographic data, photographic data, digital data, or data in spreadsheets [3],

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[12].

Cartographic data are already in map form, and may include such information as the location of rivers, roads, hills, and valleys. Cartographic data may also include survey data and mapping information that can be directly entered into a GIS. Photographic interpretation is a major part of GIS. Photo interpretation involves analyzing aerial photographs and assessing the features that appear. Digital data can also be entered into GIS. An example of this kind of information is computer data collected by satellites that show land use—the location of farms, towns, and forests.

Remote sensing provides another tool that can be integrated into a GIS. Remote sensing includes imagery and other data collected from satellites, balloons, and drones.

GIS can also include attributive data in table or spreadsheet form, such as all type of quantifications related to any type of phenomenon related to Earth's surface.

GIS technology allows all these different types of information, no matter their source or original format, to be overlaid on top of one another on a single map. GIS uses location as the key index variable to relate these seemingly unrelated data [1], [2].

Putting information into GIS is called data capture. Data that are already in digital form, such as most tables and images taken by satellites, can simply be uploaded into GIS. Maps, however, must first be scanned, or converted to digital format.

The two major graphic types of GIS file formats are raster and vector. Raster formats are grids of cells or pixels. Raster formats are useful for storing GIS data that vary, such as elevation or satellite imagery. Vector formats are in form of points, lines and polygons that use points (called nodes) and lines. Vector formats are useful for storing GIS data with firm borders, such as school districts or streets [3], [12].

By relating seemingly unrelated data, GIS can help individuals and organizations better understand spatial patterns and relationships [3].

In this article we will represent GIS project with implemented procedures as a case study.

2 Research Methods

In order to create functional GIS for Mt. Tara NP, the accent was put to selection and creation of thematic data layers for analyzing natural values through consultations with experts from various fields. The relevant studies on the Park were reviewed and field surveys conducted to collect and check all necessary data on the landscape resources [5]. The data, mostly in analog form had to be transformed into digital form and then organized in the meaningful system of thematic data layers. The procedures also included database creation, adopting GIS guidelines in terms of resource data analysis and conclusion drawing.

Input Data

All data were georeferenced in the National projection system. This is a geodetic system based on datum – Hermanskogel with prime meridian in Greenwich and ellipsoid Bessel (major axis – 6 377 397.155 m, semi major axis – 6 356 078.963 m). Projection is defined

as Transverse Mercator (Gauss-Kruger) with the following parameters:

To create thematic data layers, relevant input data from a large number of various types of data sources were used:

- Topographic map: 1:50,000,
- Topographic map: 1:50,000 (in a digital raster form),
- Relief and hydrology map: 1:50,000,
- Geological map: 1:100,000,
- Soil map: 1:50,000,
- Aerial photographs,
- Satellite image: Landsat 7 ETM+ multispectral; Spot 5 multispectral, pan sharpened,
- Vegetation map of Tara NP: 1: 50,000,
- Map of five managing units of Tara NP: 1: 50,000,
- Map of five managing units of Tara NP: (with 751 parcels): 1:10,000,
- Managing units data, consisting of nine properties for each parcel (unit name, parcel and sub-parcel ID number, woodland type, vegetation communities, vegetation ecological affiliation according to the type of soil, percentage of vegetation communities, type and purpose of land use, level of protection - zoning),
- Data on the fauna and flora diversity, and Tourist map of Tara NP 1: 25,000,
- Corine Land Cover 2000 (CLC 2000) 1: 100,000,
- Corine Land Cover Changes (1990 - 2000) 1: 100,000

In order to understand the current status of the study site thematic data layers in our GIS were logically organized in the three sets of data on the National Park:

- Physical data, i.e. topography (elevation, slope, aspect), geology, soil, hydrology, watersheds and climate [2], [3];
- Biological diversity data, (vegetation community, flora and fauna) and distribution of endemic and relict species;
- Managing mechanisms data and identification of current human pressure that may lead to violation of natural habitats [6], [9].

Thematic data layers creation

We applied the procedures used in most GIS projects: scanning, georeferencing, digitizing (manual and semiautomatic), database creation and data integration [7], [11].

The Mt. Tara NP GIS is divided (by type and format) into various data forms: raster data, vector data, digital elevation model and database. Raster data include all maps, aerial photographs and satellite images (cited in data sources) after having been georeferenced. The following entities are represented in vector form:

- Geology (polygon),
- Soil (polygon),
- Hydrology (line / polygon),
- Vegetation communities (polygon),
- CLC 2000 (polygon)
- CLC Changes (1990 - 2000) (polygon)
- Locations of important species of flora and fauna (point),
- Border of Tara NP (polygon),
- Management units (polygon),
- Management units parcels (polygon),
- Settlements (polygon),
- Roads (line),
- Mountain paths (line) and
- Other structures: hotels, belvederes, waterfalls, caves, (point) [8], [9].

3 Results and Discussion

Thematic data layers in our GIS were logically organized in the four sets of data on the National Park:

1. Physical data, i.e. topography (elevation, slope, aspect), geology, soil, hydrology, watersheds and climate;
2. Biological diversity data, (vegetation map, flora and fauna) and distribution of endemic and relict species;

3. Managing mechanisms data that include detailed attributive information related to 751 parcels and sub parcels with nine attributes for each parcel.
4. Quantification of each abiotic, biotic and anthropogenic factor for occurrence and development of forest fire.

Topography/ Geomorphologic characteristics A digital elevation model (DEM) (resolution 20 m pixels) was created. This digital model combined with all other thematic data layers functions as authentic qualitative, quantitative and visual representation of real world. The DEM covered an area of about 1200 km² providing for each pixel: coordinates (in meters), elevation (in meters), aspect (in degrees), and slope (in degrees and percentages) (Fig. 1). (Fig. 3). Relief and hydrology maps were included as input data for DEM development. The Managing procedure included scanning maps and georeferencing, as well as semiautomatic digitizing of isolines. After that, each isoline was given a unique identification (ID) and then converted to points (retaining ID), which were finally interpolated to grid (DEM) by spline method [9].

The GIS analyses of the National Park's topographic characteristics included: elevation zones, relief aspect and slope. The distribution of the Park area is at altitudes ranging from 800 - 1,200m (12,571ha or 65.56%) (Fig. 1), north (2,853ha; 14.9%), northeast (3,604ha; 18.8%) and northwest (2,199ha; 11.5%) aspects cover most of the Park (Fig. 2). The slope between 0- 9.1% covers 4,964.2ha (25.9%), between 9.2- 18.3% covers 5,363.4ha (28%), between 18.4- 27.4% covers 3,895.4ha (20.32%) and slope between 27.5- 36.5% covers 2,768.2ha (14.44%) of the Park area (Fig. 3). It is possible to correlate and analyze the distribution of biotic elements to topography data as well as all other themes [9].

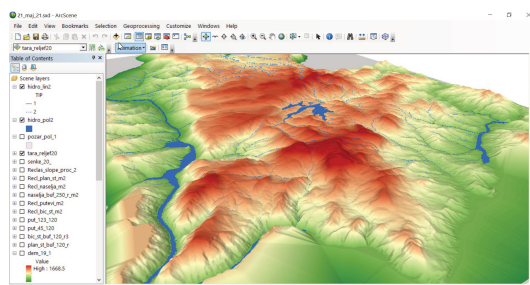


Fig. 1. DEM in 3D scene

Aerial photograph

The material used to process aerial photographs included a series of 19 photos of Tara NP (scale, 1: 30,000; Wild RC-5 camera, year of production 1959). By using photographs that are almost 50 years old, we were able to observe changes in vegetation, some of which were caused by human impact. Processing of these photographs included scanning (resolution 750 dpi grayscale), georeferencing, and their combining with other data (vector and

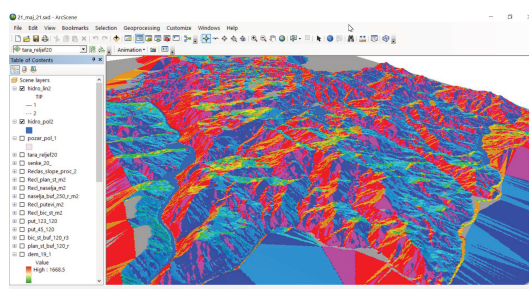


Fig. 2. Aspect in 3D scene

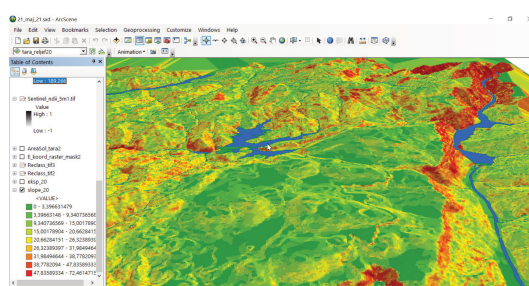


Fig. 3. Slope in 3D scene

DEM) (Fig.4) [9].

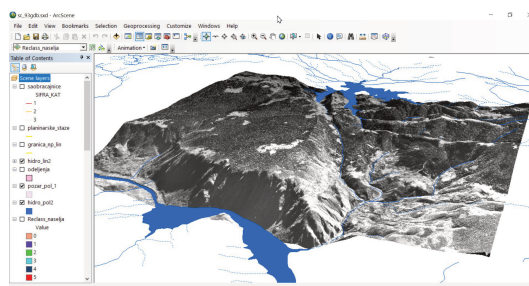


Fig. 4. Aerial photo (1959) georeferenced, combined with DEM and hydrology (actual) (3D)

Settlements. Theme settlements was digitized on the basis of topographic map (in digital raster form). All urban and rural settlements within the National Park are included. The biggest settlement is Bajina Basta, the administrative center of the municipality. There are 654 entities in this layer (Fig. 8).

Roads and transportation. Theme roads was digitized from a topographic map on a scale of 1:50 000 (in a digital raster form) representing all types of roads. Roads were divided into three categories: asphalt, macadam, and dirt roads. All digitalization rules have



Fig. 5. Satellite image combined with DEM and Park border (3D) [6]

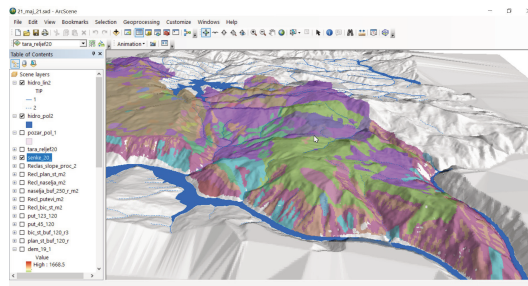


Fig. 6. Vegetation combined with DEM and hydrology (3D) [4], [10]

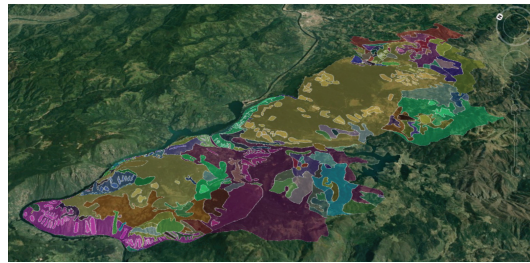


Fig. 7. Vegetation combined with satellite image in 3D [4]

been followed, so that queries enabled getting of precise information about the length of every section and the shortest road distance between any of two points or crossroads in Mt. Tara (Fig. 9) [9].

In this GIS study all 751 parcels of five managing units were digitized. For each parcel, following eight characteristics were put together in the relational database: unit name, parcel and sub-parcel ID number, woodland type, vegetation communities, vegetation ecological affiliation according to the type of soil, percentage of vegetation communities, type and purpose of land use, and level of protection – zoning (Fig. 10). Database consists of eight tables with 2978 rows. Queries about combination of forest species distribution for every parcel in percentages are enabled [9].



Fig. 8. Settlements combined with satellite image in 3D



Fig. 9. Roads combined with satellite image in 3D

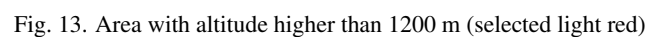
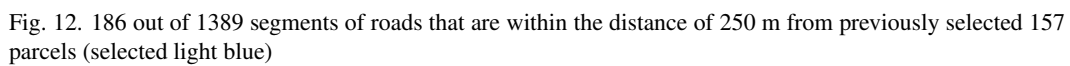
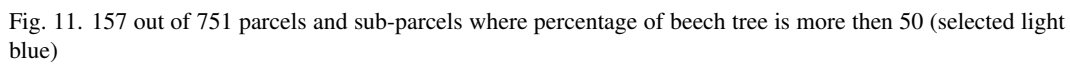


Fig. 10. Five managing units with composed of 751 parcels and sub-parcels combined with satellite image in 3D [6]

Some examples of analytics

It is possible to get information and result of any logical expression. Any type of quantification related to any thematic layer separately and combination of several layers. We can identify any type of cross-factors distribution. In the first query we have selected 157 out of 751 parcels where beech tree is present with above or equal 50 % (Fig. 11). In the second query we have selected 186 out of total 1389 segments of roads that are within the distance of 250 m from previously selected 157 parcels (Fig. 12). In the third query we have selected areas with altitude higher than 1200 m (Fig. 13). In the final query we have selected roads that are within the distance of 250 m from previously selected 157 parcels in altitude higher than 1200 m (Fig. 14). We have shown some possibilities for thematic and topologic multifactorial analysis in real environment. Any hypothesis that is logically established in

And as a final result, system decisioning support for any activities related to research area.



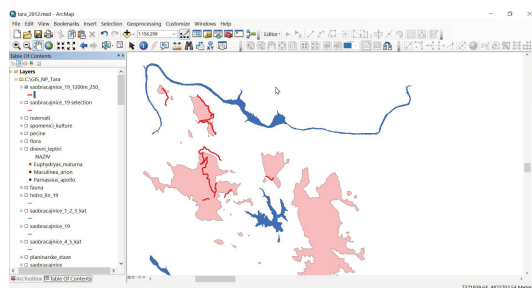


Fig. 14. Roads that are within the distance of 250 m from previously selected 157 parcels in altitude higher than 1200 m (selected red lines)

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