The analysis of morphometric parameters in hydrological modeling using GIS

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Abstract. The analysis of the physical-geographical conditions determines and influences the formation and the regime of the water resources from a hydrographic basin. This paper aims to analyse spatial data based on raster models, more precisely the terrain analysis, later used in hydrological modelling. For the elaboration of the digital model of the terrain, methods of interpolation of certain data are used - the level curves - after which, by running the ArcGIS program will result the structure of the irregular triangulation network (TIN). Next, based on the TIN model, a set of analyses is obtained regarding the morphology of the terrain: the slope map; slope exposure map, etc. The slope is one of the most important factors for controlling surface and intermediate water runoff. The exposure of the slopes depends very much on the direction of the slope of the land. With the help of the analysis of the slope and slope exposure it is possible to: calculate the solar lighting for each location in a region; find all slopes in the southern part of a mountainous region to identify locations where the snowmelt process will start earlier than in other areas, thus avoiding the danger of flooding due to runoff from the slopes and the danger of soil erosion; the value and speed of surface runoff; identify the spread and abundance of flora and fauna, precipitation; identify the productivity classes of the land; find all the north-facing slopes on a mountain as part for the search of the best ski slopes.

1. Introduction

In order to draw up the digital terrain model, it has using of the methods of interpolate certain data - the level curves - after which, by running the ArcGIS program [1], the structure of the irregular triangulation network (TIN) will result. In a geographic information system [2] you can combine and analyze different types of data [3] obtained from a variety of sources such as: topographic measurements [4], scanning and vectorization of maps, aerial photographs, satellite images [5], [6], importing data from other programs or systems [7], [8]. GIS system is a system used to model information, processes and structures, which reflects the real world, including past events, in order to understand, analyze and manage resources [9], [10].
GIS can combine types of maps and display them in realistic, three-dimensional images that present information much more efficiently and to a wider audience than traditional, two-dimensional maps [11]. Traditional maps are abstractions of the real world, a sum of important elements sketched on a sheet of paper by symbols that represent physical objects. Topographic maps show the shape of the terrain using contour lines. GIS graphical presentation techniques make visible the relationships between map elements, increasing the ability to extract and analyze information. Geographic information systems technology can be used in scientific investigations, resource management and development planning [12], [13].

2. Material and method
The field of geographic information systems (GIS) appeared around the '60s, with the advent of computers and the application of computer technology in making simple maps. Early GIS activity included important research conducted by the academic community. Later, the National Center for Geographic Information and Analysis, led by Michael Goodchild, formalized research on key topics in geographic computer science, such as spatial analysis and visualization. These efforts fueled a quantitative revolution in the world of geography and laid the foundations of GIS.

The maps could be encoded and stored on the computer, modified when was necessary and viewed, either by display on the screen or by plotting on paper. From the beginning of this computer mapping, maps contained nothing more than points, straight lines (vectors) and text.

The definition of these graphical elements included a location expressed by a pair (or in the case of a two-pair vector) of coordinates. Starting from these elements, a more complex graphic could be built. Thus, the irregular lines of rivers or shores could be approximated by a succession of small vector elements. With the discovery of the advantages of this simple application, the researchers also realized that many geographical problems required the collection and analysis of a significant amount of information that was not cartographic.

GIS is a technical and organizational set of people, equipment (hardware), programs (software), algorithms and procedures (methods) that provide processing, management, manipulation, analysis, modeling and visualization of spatial data in order to solve complex planning problems and territory management.

Spatial analysis is the process of modeling, examining and interpreting model results. Spatial analysis is the process of extracting or creating new information about a set of geographical entities.

Spatial analysis - includes specific methods to study the connections between entities, from a topological, geometric or geographical point of view. Using the characteristic GIS methods, it is possible to relate the spatial data with information about a certain feature on the map, but only after a good documentation of the problem has been made. GIS modern systems have many powerful spatial analysis tools, two of which are widely used and are very important:

Neighborhood analysis - BUFFER. To answer questions such as: What is the total number of customers to within a 10 km radius around a store? How many houses are less than 200 m from the gas pipeline? GIS systems use a process called buffering to determine the neighborhood relationship between entities.

Overlay analysis. Geographic data is organized into layers. The integration of data that are on different layers and is done through a process called overlay. Behind this operation, which it is a simple
operation from a visual point of view, namely the overlapping of layers, there are algebraic, logical, technological operations, etc. Through this overlap or spatial unification, data on plants, soil, vegetation or properties it can be queried.

3. The study area
The Semenic Mountains represent the most important mountainous group of the Banat Mountains, the situation on the surface of eight administrative-territorial units from Caraș-Severin County, namely: Resita, Văliug, Teregova, Prigor, Bozovici, Anina, Goruia and Carașova. They are part of the site of community importance ROSCI0226 Semenic-Cheile Carașului, with an area of 37,458.7 ha.

For starters, it was created a georeferenced topographic map (figure 1) in the ArcMap program to visualize the extent of the Semenic Mountains, that includes all the elements of a GIS map such as: cartographic elements; graphic elements; elements regarding the projection system, scale and legend.

![Georeferenced topographic map of the Semenic Mountains](image)

**Figure 1.** Georeferenced topographic map of the Semenic Mountains

4. Results and discussion
For realize the study of characterization of the Semenic Mountains, it was necessary to create a georeferenced topographic map and generated in the Global Mapper program (figure 2).

To create the TIN structures (figure 3), it was necessary to use the contours in the desired area. Based on these level curves, which were vectorized, the digital model of elevation of the area was created. TIN structures are the basis of all three-dimensional lifts, and without a well-made TIN structure, the 3D model loses its accuracy and precision.
By means of the 3D model it was able to perform a series of raster spatial analysis such as: slope analysis in degrees, slope analysis in percentage and slope exposure. All these spatial analyses are useful in the morphological research of the terrain.

The slope (figure 5) is a primary topographic parameter and measures the change in the z value between cells. In elevation models (figure 4), the slope measures the steepness or flatness of the terrain expressed in degrees or percentages. The grades simply indicate the slope angle; the percentage is the increase divided by rolling, multiplied by 100. An angle of 45 degrees is equal to a slope of 100 percent, because the ascent and rolling are equal.

![Figure 2. The georeferenced topographic map](image1)

![Figure 3. TIN structure of the area study](image2)

![Figure 4. DEM of Semenic Mountains](image3)

![Figure 5. The slope map is represented in degrees](image4)

With the TIN structure created previously, it was realised a raster image from it, after which we designed the slope map from the respective raster. I generated this map (figure 6) using the Spatial Analyst Tools - Surface - Slope command from the ArcToolBox menu. The distribution of slope values are represented in figure 8 and figure 9. In the same way we made the map of Slope exposure (figure 7).
Figure 6. The slope map represents the percentages

Figure 7. Slope exposure map

Figure 8. Slope distribution in degrees

Figure 9. Slope distribution in percentages

Slope exposure - ASPECT - This tool identifies the direction of descent of the maximum speed of change of value from each cell to its neighbours. It can be said to be the direction of the slope. The values of each cell in the output raster indicate the direction of the compass facing the surface in that location. It is measured clockwise from 0 (north) to 360 (again north), following a complete circle. Flat areas that do not have a downward direction have a value of -1.

The value of each cell from a data set indicates the direction in which the slope is inclined. In relation to the cardinal points, the map of the exposure of the slopes aims to highlight the orientation of the slopes to highlight the degree of sunshine or shading. The exhibition is a parameter determined in turn by geomorphological processes, for its monitoring of solar radiation, temperature and precipitation.

According to the image from figure 10, it was calculated as a percentage the exposure of the slopes on the studied area:
Figure 10. Elevation of the slope exposure

Following analysis of the map with the exposure of the slopes shows the following percentage distribution (Table 1):

| Percentage | Exhibition |
|------------|------------|
| 4.76       | NORD       |
| 9.975      | NORD EST   |
| 13.811     | EST        |
| 10.643     | SUD EST    |
| 7.514      | SUD        |
| 10.548     | SUD WEST   |
| 20.050     | WEST       |
| 17.543     | NORD WEST  |
| 5.441      | NORD       |

5. Conclusions
This paper includes the essential results obtained from studies on cartographic data collection methods and technologies and on methods for digitizing topographic maps.

It was found that of the many advantages of using a GIS, one important one would be that 3D maps can be easily made and also interpreted using various spatial analysis tools and complex queries. Due to this feature of spatial analysis, software dedicated to a GIS differs from other software, such as CAD.

Through this spatial analysis have been evaluated, examined, and interpreted the results of the digital terrain model. These spatial analyses have been made based on specific algorithms using operations appropriate to these categories of data.
In this paper has performed spatial analysis based on raster models, more precisely the analysis of the terrain. For the elaboration of the digital terrain model, it was applied data interpolation methods (level curve), which resulted in the structure of the irregular triangulation network (TIN).

Based on the TIN model, was obtained a set of analyzes regarding the terrain morphology, namely: the slope map; slope exposure map.

The exposure of the slopes depends very much on the discretion of the slope of the land. With the help of the analysis of the exposure of the slopes and slopes, to can:

- calculate sunlight for each location in a region.
- find all the sides of the south of a mountainous region to identify the locations where the snowmelt process will start earlier than in other areas, thus avoiding the danger of flooding due to runoff from the slopes and the danger of soil erosion.
- value and speed of surface runoff.
- identify the spread and abundance of flora and fauna, precipitation.
- identifies the productivity classes of the land.
- find all the north-facing slopes on a mountain as part of the search for the best ski slopes.

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