"CLASSICAL" AND "MODERN" IN THE REPRESENTATION AND HYDROGRAPHIC ANALYSIS

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Abstract. *The present study has the main purpose representing and analyzing watershed established both by classical methods and modern methods, "automated", to highlight quantitative and qualitative differentiations reflected in the results. The case study presented in this paper is Bega river basin. The results obtained by the "classical" methods, represented by empirical formulas are compared with results obtained using ArcGIS software, the following parameters were determined: the perimeter, area, length, average altitude and average slope of the hydrographic basin. Analysis Bega river basin using GIS technique is based on Digital Elevation Model, which is obtained by extracting the altimetric information from topographic map. Without underestimating the value and importance of the classical methods used in hydrographic analysis, modern methods, namely the use of GIS, offers a number of advantages, the most important being: accuracy in representation and analysis, generating high-quality maps, the possibility to reuse the cartographic materials obtained in each stage and for other types of analysis, significantly reducing execution time and effort by the analyst. The results obtained by applying both types of methods do not show significant differences, which means that GIS methods, easier to apply, can partially or totally replace traditional methods on condition that Digital Elevation Model that underlies this type of analysis to be executed correctly and be in proper spatial resolution.*

Key words: *calculation, method, hydrographic, compared*

INTRODUCTION

Hydrographic basin (catchment), area that feeds the river (PIŞOTA, I, ZAHARIA LILIANA, 2003), can be defined, represented and analyzed by established methods, "classic", but also using "modern" means and methods, based on computer and specific software, which offers opportunities for superior analysis and representation.

Using Geographic Information Systems (GIS), compared to "classical" methods, offers numerous amenities in terms of representation and watershed study and allows the generation of cartographic materials which can then be used in other types of environmental analysis.

MATERIALS AND METHODS

The main purpose of this study is to analyze the capabilities and results obtained by "classical", empirical metods used in watershed delineation and representation (H.B.), compared with the results obtained by "modern" means and techniques. It also highlights the possibilities for calculation of specific watershed parameters by computerized methods.

The case study presented in this paper is the Bega river basin.

From category of "modern" means is used ArcGIS 10.0 software, which is achieved the delimitation, representation and analysis of river basins (HERBEI M, 2013), based on Digital Elevation Model (DEM).

It also presents "classical" methods commonly used in delimitation and empirical formulas underlying the determination of parameters such as area, slope, elevation, etc.

The results of applying the two categories of methods will be presented comparatively, highlighting advantages and disadvantages of each.

RESULTS AND DISCUSSION

Watershed demarcation is done on the boundary line known as the *turn water* or *water dividing line*. This line passes through the points (quotas) for the highest elevation between two adjacent basins (on interfluves), perpendicularly intersecting contour and down to the spill region where close. In the "classical" version, watershed delimitation (perimeter) is performed on topographic maps with relief represented by contour lines (Figure 1. left).

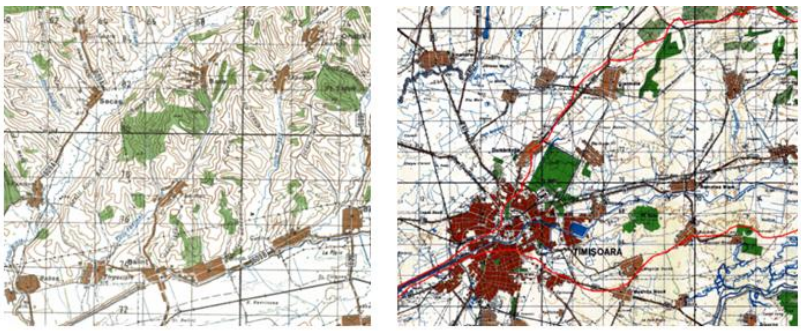

Figure 1 Topographical map of Balinț area (left); Bega river basin delimitation (right)

Correctness and accuracy of the result obtained (Figure 1 right) depend on the quality of topographic maps (contour lines should be well represented) and the level of knowledge and experience of the analyst (contours can be misinterpreted, with repercussions on delimitation).

Scientific progress is reflected in the methods and means of representation and analysis of hydrological and hydrographic being created, through GIS, specialized applications in this regard. Thus, one of these systems, ArcGIS software contains applications range *"Hydrology"*, demarcation applications and representing watershed from DEM.

To delineate H. B. Bega using ArcGIS, was used DEM of the western part of Romania (Figure 2) obtained by extracting altimetric information from topographic map,

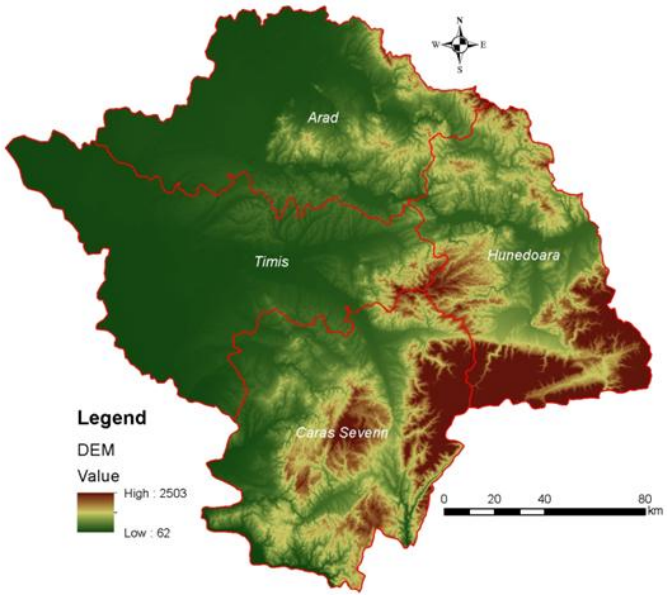

Figure 2 Digital Elevation Model for western Romania (m)

DEM that was adjusted to fill the gaps that are as errors (*Fill command*).

In general, for delimiting "automated" watershed using ArcGIS software, so delimitation H.B. Bega for this study, the following steps (HERBEI M, 2013):

1. Setting the direction of flow *(Flow Direction command)* - at this stage is highlighted "spatial distribution" of water (figure 3).

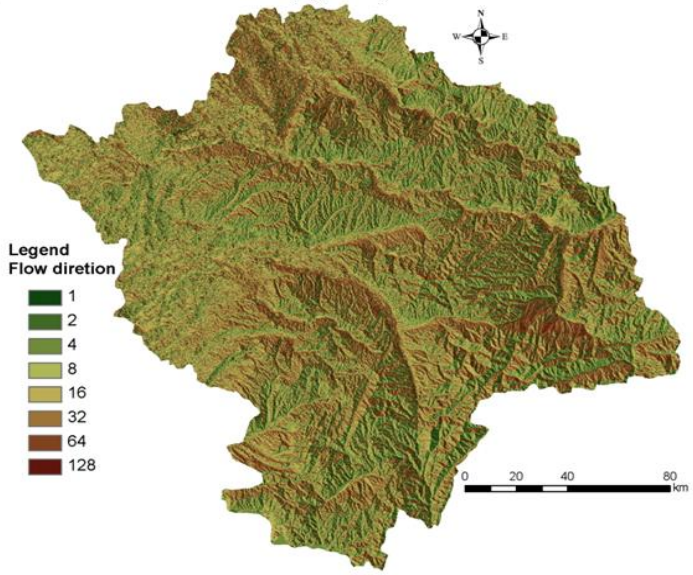

Figure 3 Flow Direction

2. Calculation of possible accumulations *(Flow Accumulation)* - after this operation is possible to establish accumulations, so sketching the hydrographic network (Figure 4. a).

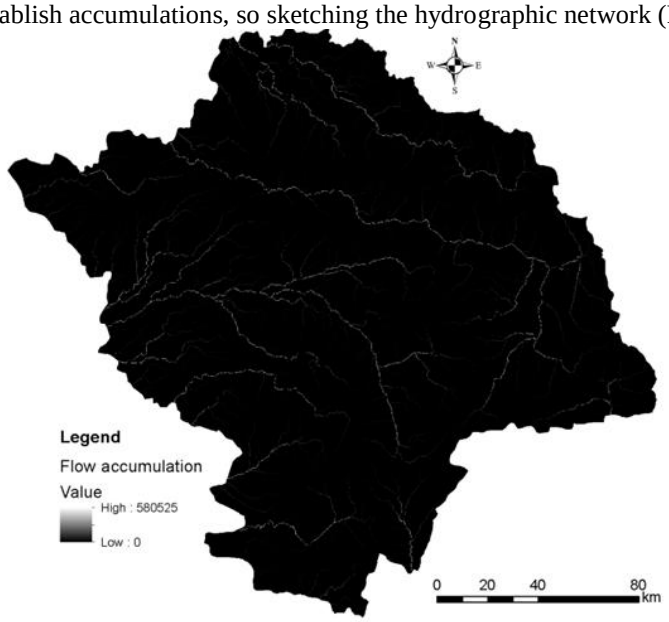

Figure 4.a The calculation of the possible accumulation

To resize the range of values of the raster accumulation (extremely high), is applied to a logarithmic function *(Map Algebra - Raster Calculator)* image is clearly improved and the range of values decreased significantly from 580525 (Figure 4.a) to 5,76382 (Figure 4.b).

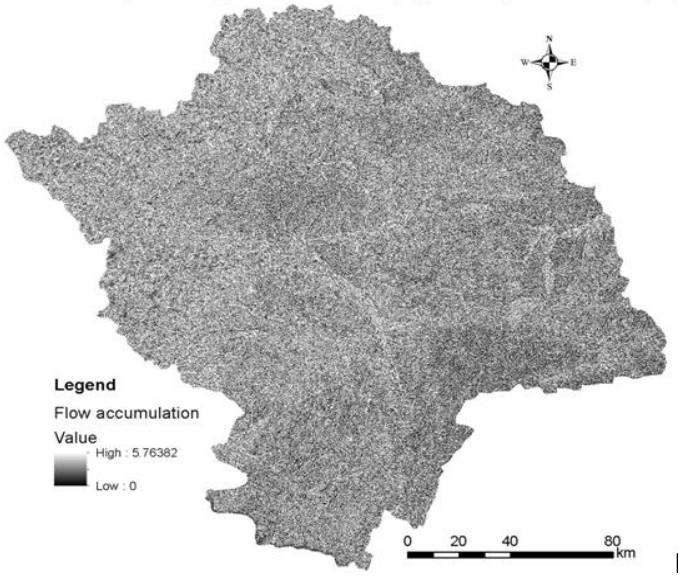

Figure 4.b Resizing raster accumulation

3. Elimination of errors is the stage in which some cells are removed, those which are not represented significant accumulation. Raster whit accumulation calculation (Figure 4.b) is processed by applying a conditional functions *(Map Algebra - Raster Calculator)* to remove values in the range 0-2, considered insignificant accumulation (Figure 5).

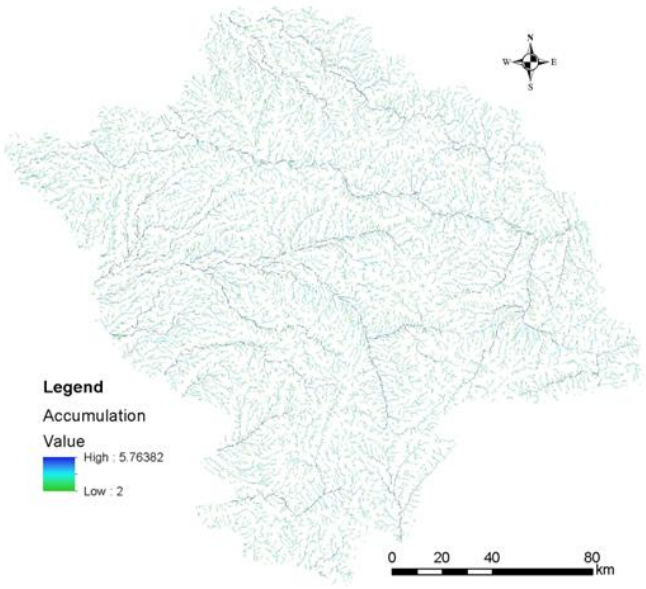

Figure 5 Map accumulation

4. Creating and adjusting points accumulation - the accumulation points are set along the hydrographic network (Figure 6.left), then these points are adjusted *(Snap Pour Point)* to ensure that they correspond to cells with high accumulation (Figure 6.right).

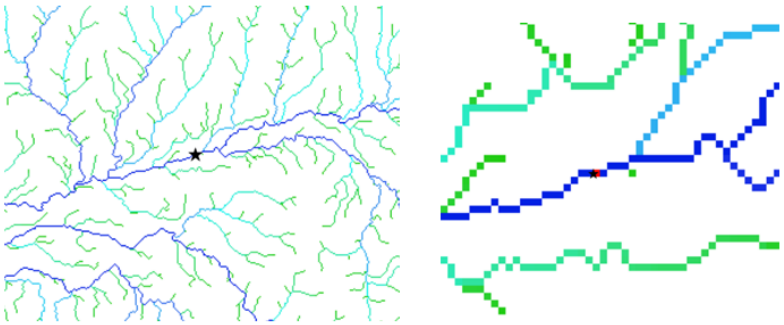

Figure 6 Location (left) and adjustments (right) accumulation points

5. Watershed delineation is based on data/images obtained in the previous steps, namely the direction of flow and accumulation points adjusted (Figure 7).

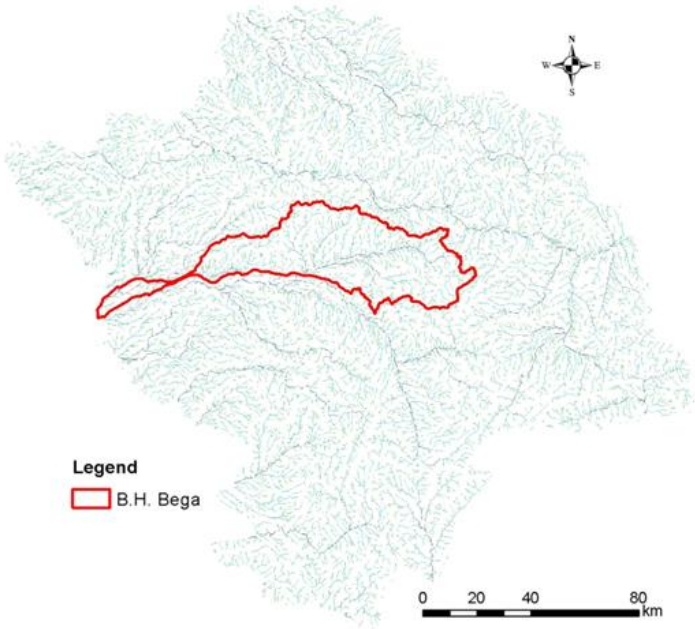

Figure 7 H.B. Bega delimitation

Compared to the „classical" methods, watershed delineation by „automated" methods, in this case GIS technique, has several advantages, the most important being:

- superior precision regarding delimitation, but only if Digital Eevation Model have appropriate resolution and executed correctly
- the possibility of generating higher quality cartographic material
- possibility of using the map, including the other kinds of measurements and analyzes, not only for this study, etc.

The following will be described some of the most important parameters used in the analysis of river basins, both in terms of ways of determining classical and modern, it is possible in this way comparisons of quantitative and qualitative.

Classically, determining catchment area can be achieved by several methods, namely geometrical figures, of squares, by planimeter (PIȘOTA I, ZAHARIA LILIANA, 2003) and determining the spatial distribution of secondary basins and areas interbazinale involves the establishment of purge river basin (Figure 8).

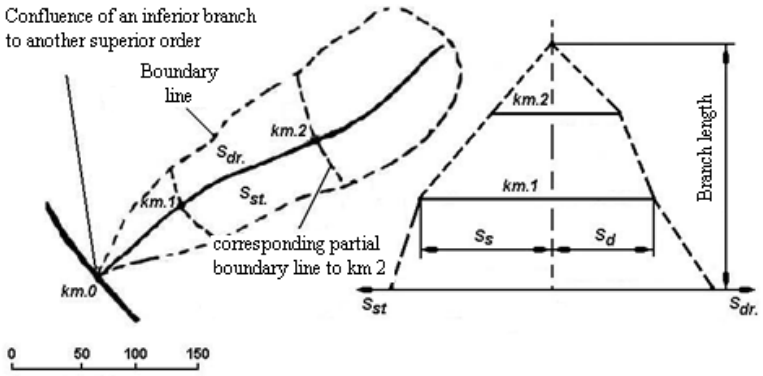

Figure 8 The graph of growth of the basin, depending on the length of principal river – purge river basin (processing after ONU N, ONCIA SILVICA 2003)

The classical method is difficult to apply, as some assume operations that require time and effort on the part of the analyst, obtaining average values, so more measurements, etc. In contrast, the 'automated' method enables high precision measurement of the area in a very short time and with minimum effort from the operator, as follows: raster delineation river basin (Figure 7) is converted to a polygon *(Raster to Polygon command)* in which, through the operation *Calculated Geometry (Area)* area is determined, expressed in km^2 or ha (Figure 9).

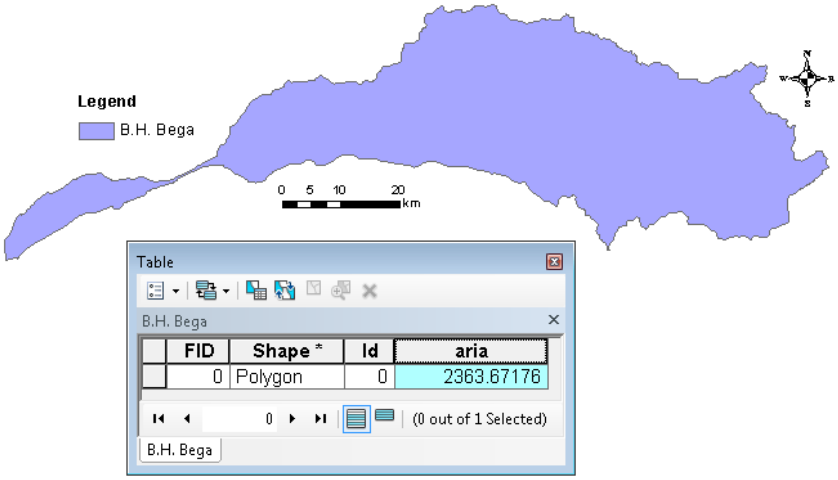

Figure 9 Determination of H.B. Bega surface (km^2) in ArcGIS

Measured with ArcGIS, H.B. Bega surface is 2363 km^2, value confirmed by data taken from the literature [5].

The length of the river basin (km), obtained by measuring the distance from the upstream end to the mouth, on the midline, can also be measured automatically in ArcGIS using *Mesure command.*

The average width of the basin is determined by the relation (ZĂVOIANU I, 2006):

$$B = \frac{S_b}{L_m}$$

where: B - the average width of the basin (km); S_b – surface (km^2); L_m - length of the basin (km).

As with river basin length, by automatic measurement, one can determine its width, based, on empirical formulas and other parameters such as **asymmetry index** and **form index** (ONU N, ONCIA SILVICA, 2003).

The average altitude of the river basin (H_{med}, in m), by classical methods can be determined based on the relation (ZĂVOIANU I, 2006):

$$H_{med} = \frac{\sum f_i h_i}{S_b}$$

where: f_i - partial surfaces of the main contours (km^2); h_i - arithmetic average altitudes contours that define the surface f_i (km)

In other words, the average altitude can be determined on situation plans containing relief represented by contour lines, using equation (ONU N, ONCIA SILVICA, 2003):

$$H_{med} = \frac{1}{S_{bh}} \sum s_i (H_i + H_{i+1})$$

where: s_i - partial surfaces between two contours; H_i, H_{i+1} - altitude contours bounding partial surfaces.

Whatever the relations of calculation used, conventional methods for determining the average altitude are difficult to implement, requires measurements, time, effort and experience of the analyst. In contrast, modern methods offer the possibility of determining the average altitude automatically, information is obtained with the completion of the DEM for H.B.

From the DEM previously created for the western part of Romania (Figure 1) was extracted area corresponding H.B. Bega using the *Extract by Mask command*, resulting DEM of H.B. Bega (Figure 10). Being a raster representation, ArcGIS software "presents" implicit average altitude of the area represented.

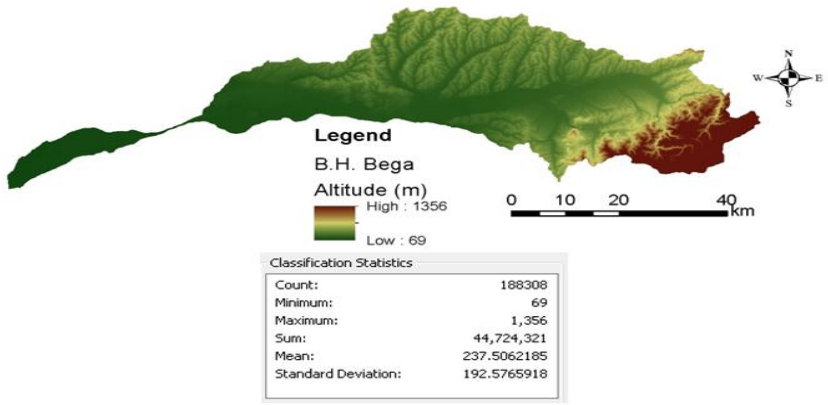

Figure 10 H.B. Bega - Digital Elevation Model and values of altitude (m)

With ArcGIS, to H.B. Bega was determined an average altitude of 237,5 m (Figure 10) and data from the literature specifies the value of 236 m [6], so the differences are insignificant.

The average slope of the river basin (m/km, ‰ or %) by the classical method is determined by the relation (PIŞOTA I, ZAHARIA LILIANA, 2003):

$$H_{med} = \frac{\sum \frac{l_i + l_{i+1}}{2} \Delta h_i}{F}$$

where: l_i - contour lengths (km); Δh - the level differences between contour lines considered (km).

It can also be used formula (ONU N, ONCIA SILVICA, 2003):

$$I_{med} = \frac{\Delta H \times \sum I}{S_{bh}}$$

where: ΔH - contour increments; Σ_l - total length of the contour.

In much easier way, average slope can be calculated using ArcGIS software as follows: on DEM's previously obtained (Figure 10) is calculated slope map *(Slope command)* and similarly displaying the maximum, minimum and average slope (Figure 11).

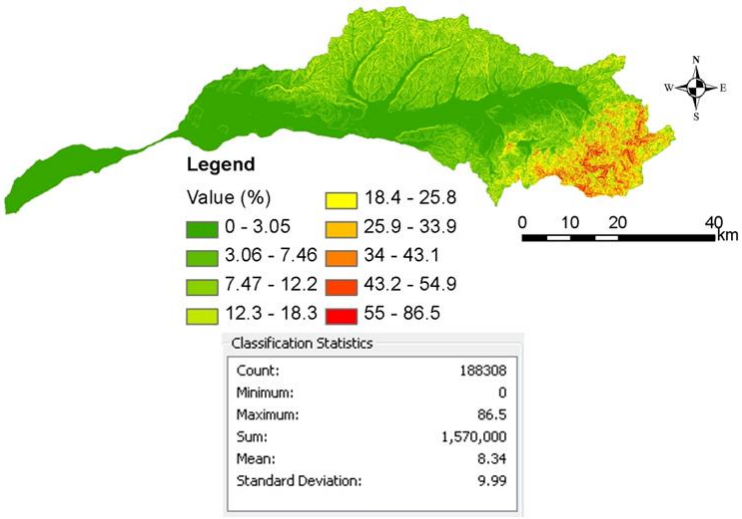

Figure 11 H.B. Bega – Slope map (%)

In the case presented in this study, namely H.B. Bega, slope values were determined as a percentage and to be transformed into m/km is multiplied by 10, thus, average slope is set to 83.4 m/km or 8.34%, confirmed by the data from the literature [5].

CONCLUSIONS

Scientific and technical progress in recent decades is remarkable on the possibilities of investigation and analysis of hydrology, by "automating" the methods and means used.

Without underestimating the value and importance of classical, consecrated method used in watershed analysis, modern methods, in case specific GIS techniques, offers a number of advantages, the most important being: accuracy in representation and analysis, generating high quality maps, can re-use maps obtained in each stage and for other types of analysis, the

possibility of performing overlay analysis type (multilayer), significantly reducing execution time and effort by the analyst, etc.

The results obtained by applying the two types of methods (conventional and automated) do not show significant differences, which means that GIS methods, much easier to apply, can partially or totally replace traditional methods. The main condition is that the Digital Elevation Model, underlying this type of analysis, to be performed correctly and be appropriate spatial resolution.

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