SPATIAL DISTRIBUTION OF THE AVERAGE RUNOFF IN THE IZA AND VIȘEU WATERSHEDS

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ABSTRACT – Spatial distribution of the average runoff in the Iza and Vișeu watersheds. The average runoff represents the main parameter with which one can best evaluate an area's water resources and it is also an important characteristic in al river runoff research. In this paper we choose a GIS methodology for assessing the spatial evolution of the average runoff, using validity curves we identifies three validity areas in which the runoff changes differently with altitude. The tree curves were charted using the average runoff values of 16 hydrometric stations from the area, eight in the Vișeu and eight in the Iza river catchment. Identifying the appropriate areas of the obtained correlations curves (between specific average runoff and catchments mean altitude) allowed the assessment of potential runoff at catchment level and on altitudinal intervals. By integrating the curves functions in to GIS we created an average runoff map for the area; from which one can easily extract runoff data using GIS spatial analyst functions. The study shows that from the three areas the highest runoff corresponds with the third zone but because it's small area the water volume is also minor. It is also shown that with the use of the created runoff map we can compute relatively quickly correct runoff values for areas without hydrologic control.

Keywords: runoff, Maramureș, GIS, spatial analyst.

1. INTRODUCTION

The average runoff analysis is the most practical way of assessing water resources in a particular area. Its spatial distribution is particularly useful in evaluating and sizing water management works. In its quantitative characterization we use several base elements such as average discharge (Q, m^3/s), runoff volume (V, m^3), runoff height (Y, mm) or specific average runoff (q, $l/s.km^2$) (Sorocovschi, 1986) (Table 1).

The study area includes much of the Maramureș basin and also the corresponding mountainous area of the Vișeu and Iza rivers watershed. In the present study we used data from 16 hydrometric stations, eight within each analyzed basin, covering a period of almost 40 years (1968-2006).

Analysis of the average runoff in the study area was performed using MS Excel by mathematical analysis of the primary raw monthly data, while for the spatial analysis we used the ESRI group GIS programs. In the spatial analysis we

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used digital vector (watersheds, hydrometric stations) and raster (digital elevation model, runoff) databases.

In order to generalize spatially the average annual runoff we established a relationship between the average specific discharge values of the hydrometric stations and the mean catchment altitude controlled by them (Table. 1).

Table 1. ***Multiannual runoff characteristics (1968-2006)***

No.	River	Hydrometric station	River catchment		Discharge	Specific runoff	Volume	Runoff high
			Area (km^2)	Altitude (m)	Q m^3/s	q $l/s\ km^2$	V mil. m^3	Y mm
1	Viseu	Poiana Borsa	134	1284	3.932	29.3	124.0	925.4
2	Viseu	Moisei	284	1212	7.130	25.1	224.9	791.8
5	Tasla	Baia Borsa	63.4	1307	1.893	29.9	59.7	941.7
6	Vaser	Viseu de Sus	410	1097	8.494	20.7	267.9	653.3
3	Viseu	Leordina	937	1054	19.833	21.2	625.5	667.5
7	Ruscova	Luhei	185	1177	6.007	32.5	189.4	1024.0
9	Iza	Sacel	66.7	926	1.526	22.9	48.1	721.5
4	Viseu	Bistra	1545	1020	36.953	23.9	1165.4	754.3
8	Ruscova	Ruscova	434	1079	13.243	30.5	417.6	962.3
12	Boicu	Dragomiresti	91.8	928	2.019	22.0	63.7	693.6
13	Botiza	Sieu	97.8	797	1.746	17.9	55.1	563.0
10	Iza	Stramtura	560	740	7.420	13.3	234.0	417.9
11	Iza	Vadu Izei	1126	714	17.624	15.7	555.8	493.6
14	Mara	Mara	155	901	4.563	29.4	143.9	928.4
15	Mara	Vadu izei	410	749	8.622	21.0	271.9	663.2
16	Cosau	Feresti	114	744	2.267	19.9	71.5	627.2

2. STUDY AREA

The analyzed area overlaps the Maramureș basin and the neighboring mountain area, which includes the north-eastern slope of the volcanic Oas – Țibleş Mountains, the northern flank of the Rodna Mountains and southwestern flank of Maramureș Mountains (Fig. 1). The geographical position of the basin and also the river system layout favors a matter and energy flow conveyed by the surface and groundwater from the adjacent mountain area, so from the mountain edge appears a relief characterized by glacis and piedmont deposits which encloses a significant water resource in the region (Sorocovschi & Cocut, 2008).

The landscape has a direct influence on the river runoff organization embodied by the slope and landscape fragmentation, specific features that determine the specific runoff speed and an indirect influence through the vertical zoning of climate. The main collector is the Upper Tisza Basin, the Vișeu and Iza tributaries flow in the SE-NW direction. The hydrographic network is dense reaching values of 0.8 and high slopes of the rivers shows a high theoretical hydropower potential (Sorocovschi, 1994).

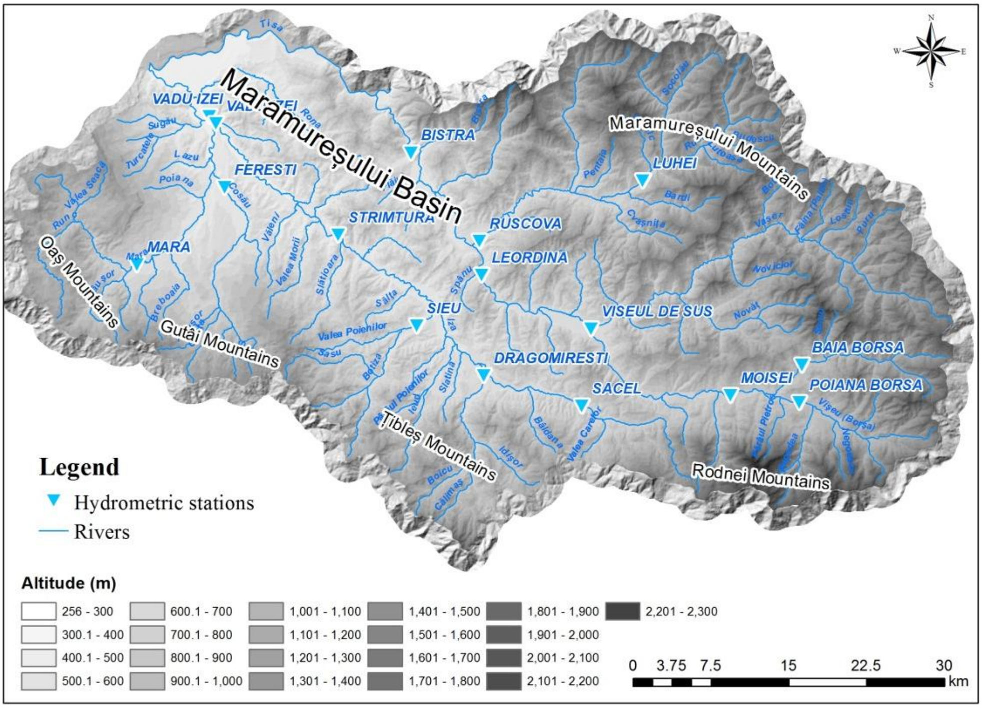

Fig. 1. ***Vișeu and Iza Rivers watersheds***

3. DATA AND METHODS

The analysis of the average runoff was performed based on monthly data from 16 stations in the study area. Average monthly discharge values were converted into annual and then multiannual runoff, values thus obtained was expressed in specific runoff to compare runoff values from different sized catchments.

To analyze spatially the specific runoff thus obtained we choose the validity curves methodology. So we looked for correlations (validity curves) between specific runoff values from hydrometric stations and average altitude of the stations catchment (Fig. 2). To these curves in the study are correspond validity areas in which the average runoff values growth with the altitude is done differently. Validity curves were chosen by the CurveFinder analysis of the CurveExpert program; analysis which choses the best correlation curves also shows the identified function equation.

For the Esri ArcMap 10 spatial analysis we choose the digital elevation model EU-DEM, which is a 3D raster dataset with elevations captured at 1 arc second postings (2.78E-4 degrees) or about every 30 meter.

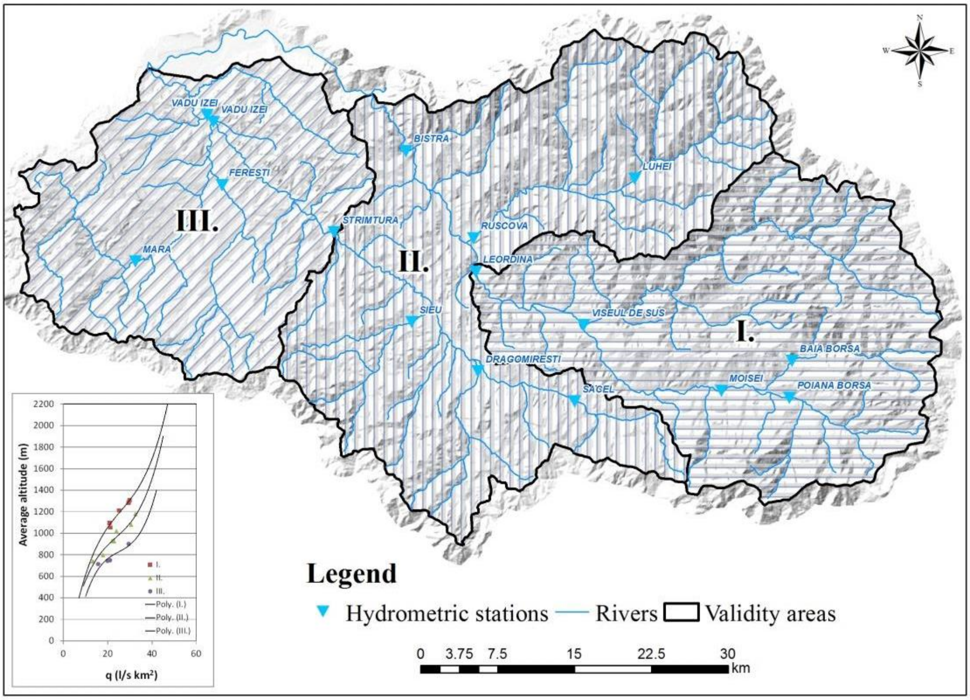

Fig. 2. ***Validity area map and the correspondent correlations between the specific runoff and the average altitude***

From the GIS program group we used the "Spatial analyst" module, where the Raster Calculator function makes possible the integration of mathematic equations into GIS (Bilaşco et al.2009). For the study area average general runoff map we used the Mosaic to New Raster function from the Data Management Tools/Raster toolbox and with its help we managed to merge the three specific runoff raster which were computed separately for every validity curve and the correspondent areas digital elevation model.

4. RESULTS

Analyzing the runoff from the 16 hydrometric stations we found three validity curves corresponding to three validity zones in the study area. The first validity zone, with the lowest runoff values, in the eastern part of the area, represents the upper catchment of the Vişeu River closing at Leordina hydrometric station, it represents 36% of the water volume drained from the whole study area. The second validity zone represents an intermediate zone of the Iza upper basin collecting water from the Botiza and Boicu catchments and also from Ruscovei catchment in Vişeu, it has the largest in area and represents 42% of the entire water volume.

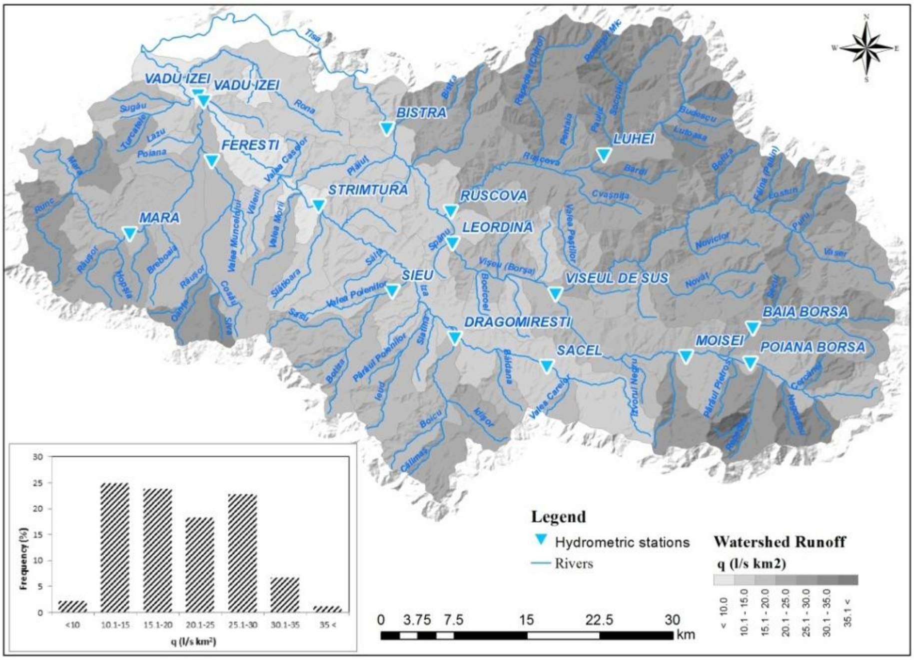

Fig. 3. ***Watersheds and sub-watersheds specific average runoff map and statistics***

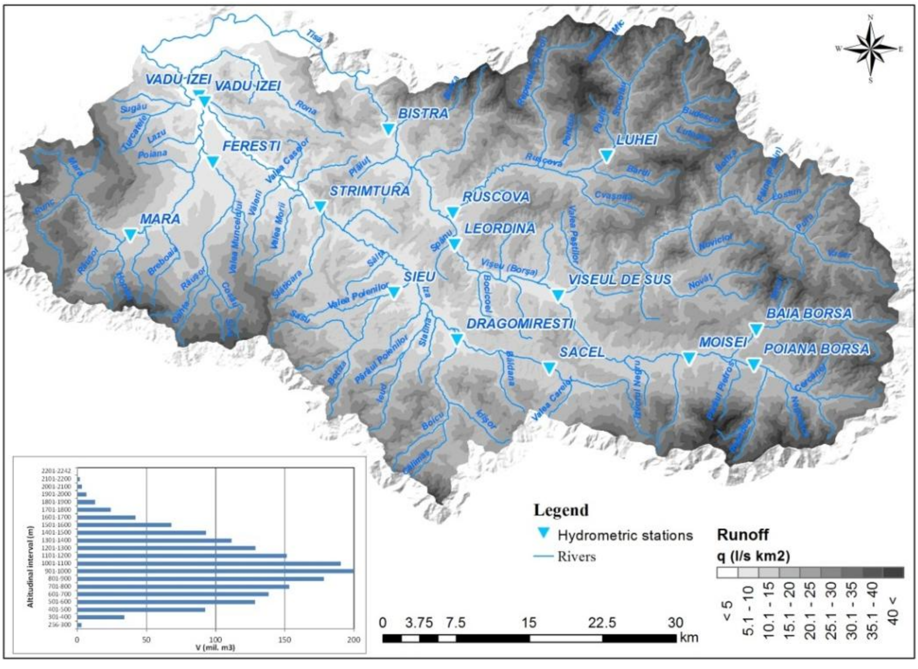

Fig. 4. ***Study area specific average runoff map and water volume (mil. m^3/year) on altitudinal intervals***

The third area with the highest runoff gradients overlaps the lower course of the Iza River, its most representative sub catchment is Mara, with only 22% of the water volume because it has the smallest surface only 25% of the whole area.

The spatial distribution of runoff was monitored at catchment level (Fig. 3) and also at altitudinal intervals (Fig. 4).

Regarding the watersheds runoff we opted for the analysis of all sub-basins larger than 5 km^2, so there were chosen 84 areas and 2 inter-basinal zones on each main collector.

The analysis was performed using the Spatial Analyst Tools/Zonal Statistics function, which trough averaging the specific runoff map (Fig. 4) allows the extraction of runoff data corresponding to each area. Thus of the 86 areas 60% fall below 05 m^3/s and 25% between 0.5-1 m^3/s, we find only 6 catchments with higher discharge values of 2 m^3/s. The highest runoff values are linked to the largest watershed area of course and so the biggest discharge values are recorded in the Ruscova (10.944 m^3/s), Mara (8.533 m^3/s) and Vaser (9.303 m^3/s) basins.

We observe in these values a correlation between the mathematic calculation and the GIS analysis, after analyzing the areas of the different catchments it highlighted the GIS analysis accuracy, the values obtained maintain in the hydrological acceptable error margins. For this we give as example the Vadu Izei station on the Mara River where the multiannual average discharge is calculated at 8.622 m^3/s and the runoff value extracted from the map by GIS methodology is 8.533 m^3/s, so the corresponding error is only 1%.

The runoff analysis on altitudinal ranges (Fig. 4) emphasizes once again the importance of the surface area in the water resource calculation, so although the richest specific runoff are recorded at the highest altitudes, the maximum water volume is found at the 900-1100 altitude interval where there are necessary areas to collect water.

5. CONCLUSIONS

The first aspect which stands out regarding the correlations between the specific runoff measured at the station and the average altitude of the correspondent watersheds is the fact that the 1st area completely overlaps over one major river basin (the Middle and Upper basin of Vișeu River), here the specific runoff is drained from the slopes of the bounding mountains so the average altitudes are high. The analyses of the average measured discharge at the stations that define the 1st area highlight a direct correlation between the specific flow and the catchment average altitude. A special situation can be observed in case of the second validity zone. The area extends over the surface of the two studied basins, the upper basin of the Iza and the lower basin of the Vișeu, including also the interfluvial hills. This is explained by the fact that hydrometric stations associated to the Vișeu River control extended catchments and this diminishes the altitudinal average, while the gauging stations on Iza control small basins with small medium altitudes, so the two data series complement each other. With regard to the 3rd area, in this case the topographic climate conditions prevail in the runoff formation with mainly alimentation from precipitation and in the spring with a significant snow contribution from melting's on the northern slope of the Oaș-Gutâi Mountains. The specific runoff analysis at river catchment level highlights the surface-altitude correlation and also the runoff's alimentation importance; one can also observe the significant differentiation between the Maramureș Basin area, including the interbazinal hills and the Mara-Săpânța Piedmont with average low runoff values and the mountainous area represented mainly by the Maramureș Mountains with calculated average high specific runoff.

So we can conclude that the analysis of the river runoff in the Iza and Viseu catchments highlighted three areas in which runoff values evolve differently. The three identified validity curves present the different runoff variation in accordance with the altitude changes. Integrating these mathematical functions in the GIS analysis facilitates the spatial analysis of the runoff also enables in areas without hydrometric control the calculation of potential water resources.

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