UNIVERSITY OF CRAIOVA Series: Geography
UNIVERSITATEA DIN CRAIOVA Seria: Geografie

Vol. 22 (new series) – 2021
Vol. 22 (serie nouă) – 2021

GIS BASED QUANTITATIVE MORPHOMETRIC ANALYSIS OF THE HYDROGRAPHIC NETWORK: A REGIONAL CASE STUDY (SOUTHWESTERN ROMANIA)

ANALIZA MORFOMETRICĂ CANTITATIVĂ BAZATĂ PE GIS A REȚELEI HIDROGRAFICE: UN STUDIU DE CAZ REGIONAL (SUD-VESTUL ROMÂNIEI)

Cristina Georgiana ZANFIR[1]
10.52846/AUCSG.22.1.03

Abstract: GIS (Geographic information System) techniques, characterized by high accuracy of mapping and measurement, prove to be a competent tool in morphometric analysis. The main goal of the study is to analyze the hydrographic network in linear form (vector) by overlaying databases from different periods (vector layer made in 2003 and layer made in 2017) for a regional case study within Southwestern Romania. The database organized in layers aims to reproduce characteristics of the drainage network: the cartographic maps scale 1: 100.000, Geo-referenced in ArcGIS 10.4); the first version of the hydrographic network used in the first River Basin. The results of this analysis will be concentrated on the length of the river network correlated with the two layers and also on the relief based on a DTM (cell size 5x5 m) within the study area. The relevance of the discussions lies in highlighting the differences appeared over time regarding the hydrographic network spatially using GIS based quantitative morphometric analysis.

Key-words: *GIS, DTM, hydrographic network, geodatabase, Oltenia Plain.*
Cuvinte cheie: *GIS, DTM, rețea hidrografică, bază de date geografice, Câmpia Olteniei.*

1. INTRODUCTION

Understanding the spatial organization of morphological features, their influencing processes, and resultant geomorphic diversity in stream networks are important for efficient river restoration (Thoms et al., 2018). The analysis of the morphometric characteristics of an area leads to highlighting the intensity of the current processes of morphogenesis and their dynamics in space and time (Rai et al., 2018; Răducă et al., 2021). With recent GIS and remote sensing technologies, it is possible to calculate and model new morphological and hydro-morphological characteristics of watersheds (Bezinska & Stoyanov, 2019).

[1] University of Bucharest, Faculty of Geography, Doctoral School "Simion Mehedinți", Nicolae Bălcescu Blvd., No. 1, 010041, Bucharest, Romania. e-mail: cristina.zanfir@drd.unibuc.ro

The quantitative morphometric analysis using GIS derived data is a convenient and effective methodology to study the river basin characteristics (Withanage et al., 2014). The analysis of vector data involves in particular the overlapping of vector layers, being one of the most used capabilities of programs for processing geographic information (Chendeș, 2011). The analysis of the morphometric characteristics of an area leads to highlighting the intensity of the current processes of morphogenesis and their dynamics in space and time.

Oltenia Plain represents the western extremity of the Romanian Plain, which is bordered by the Danube River in the west and south and by the Olt River in the east (Roșu, 1980), covering approximately 8,350 km^2 (17% of the Romanian Plain surface) (Bălteanu et al., 2013) (Fig. 1).

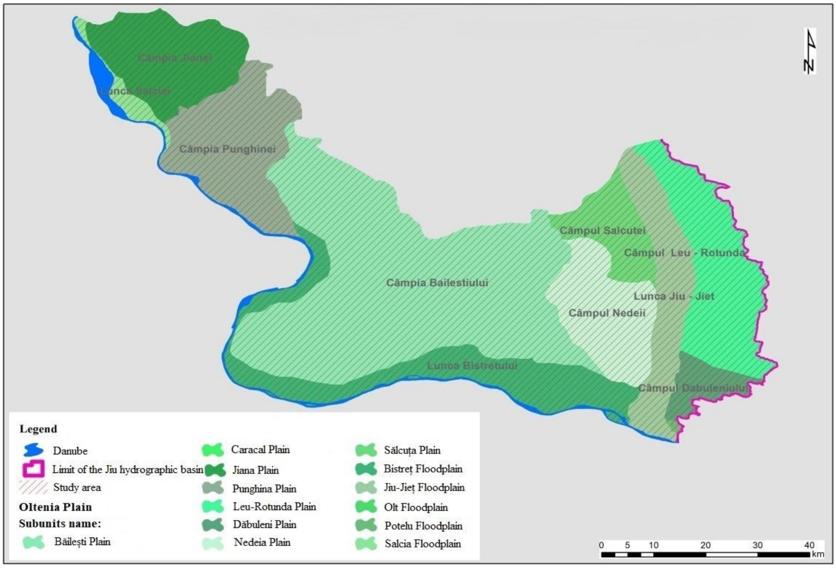


Fig. 1 Relief subunits of the study area

The relief is fragmented by wide valleys that create floodplains, terraces and piedmont plains. An important feature of Oltenia Plain is related to the presence of sand deposits, which can, however, have a major impact on runoff by favouring infiltration (Prăvălie et al., 2016). The rivers that cross Oltenia Plain are generally short (most of them <100 km long) and have a low density (<0.3 km/km^2) (Savin, 2008). While the rivers are supplied mainly by rainfall and snowmelt (up to 65%), groundwater can also contribute, in certain cases, up to 45% to the discharge (Pleniceanu, 1999; Pișota, 2005). Given the autochthonous nature of the rivers and relatively low human interventions, the surface runoff is strongly conditioned by the climatic particularities of the region, drought being the most important climatic factor (Dumitrașcu et al., 2018).

The present study analyses a part of the Oltenia Plain, more precisely the area located between the Danube River and its tributaries, the Blahnita and the Jiu.

The main purpose of the study is to create the hydrographic network in linear form (vector) by overlapping databases from different time periods (2003 and 2017).

2. DATA AND METHODS

In order to analyze the hydrographic network on a certain territory, different parameters can be used, such as: river length, sinuosity coefficient, branching coefficient, and density of the hydrographic network (Pişota & Zaharia 2002).

For rendering the lengtht of the watercourses, a comparative method is used in the representation of the hydrographic network from Oltenia Plain on cartographic maps and satellite images in GIS environment.

The morphometric characteristics of the hydrographic network in the study area are investigated according to the line-type vector data. Initially, 1:100,000 scale cartographic maps made by Aquaproiect, annex to the The Atlas of Water Cadastre of Romania (1992) are transferred in GIS.

The data submitted for analysis are extracted from:

- ➢ the first version of the hydrographic network used in the First Basin Management Plan, 2003 (SHP - vector type - Line);
- ➢ the digitized hydrographic network on hydrogeological sheets 1:100,000 georeferenced in GIS environment;
- ➢ the last version of the hydrographic network related to the new INSPIRE Directive 2007/2/EC;
- ➢ the cartographic map 1:100,000 scale - (georeferenced in ArcGIS 10.4).

The databases are organized in thematic layers in order to reproduce the characteristics of the hydrographic network.

The reason for which the layer of the hydrographic network is analyzed at the level of 2003 is the pre-accession period to the European Union, period in which the first Drafts of the Management Plans at the level of the Hydrographic Basin were carried out in Romania. In 2017, it was made an update of the hydrographic network generated by geospatial techniques according to the European INSPIRE Directive; they were made starting with 2015 and represent the support for the re-publishing of the Water Cadastre made by the National Institute of Hydrology and Water Management.

The application of the presented methodology highlights whether there are or not significant differences in the length and spatial arrangement of the hydrographic network.

3. RESULTS AND DISCUSSIONS

The import in the GIS environment of the area to be analyzed (SHP - Oltenia Plain in the boundary of the Jiu hydrographic area) and the use of the color red for the watercourses from shp-2003 and blue for the shp of 2017 allowed the easy comparison of the two representations of the hydrographic network.

The lengths of each watercourse were generated with the “Calculate Geometry” GIS function. According to the analysis, it resulted that there are 30 watercourses of orders 1, 2, 3, and 4. Subsequently, the watercourses were selected according to their order in compliance with the cadastral order (upstream to downstream). The comparison of the watercourses for the two years considered (2003 and 2017) was made by inserting a column in the table of attributes to observe the differences in length of the two hydrographic networks generated. Significant increases in the length of the hydrographic network, of the order of kilometers, are highlighted on 12 watercourses out of a total of 30 rivers, the others being less than 1 km (Table 1).

Table 1 Hydrographic network – length comparison (2003 and 2017)

No.	Watercourse	Order	Length in 2003 (km)	Length in 2017 (km)	Length dif. (km)
1	Jiu	1	80.199	80.829	-0.63
2	Preajba	3	5.303	5.411	-0.108
3	Prodila	2	2.120	2.470	-0.35
4	Craioviţa	2	1.720	4.930	-3.21
5	Lumaş	2	6.560	5.420	1.143
6	Leul/Ştiubei	2	13.310	15.310	-2.00
7	Valea Bisericii	2	8.580	9.440	-0.86
8	Dîlga	2	6.290	8.750	-2.46
9	Valea Vistieriei	2	10.290	9.210	1.08
10	Gioroc Valea Morilor	2	20.670	15.760	4.912
11	Livadia (Puturoasa)	2	10.890	12.110	-1.219
12	Jiet (Jiul Vechi)	2	51.930	53.370	-1.435
13	Georocel	3	7.494	15.083	-7.589
14	Valea Predeştilor	3	13.351	14.679	-1.328
15	Valea Rea/Valea Rea III	3	4.281	2.844	1.437
16	Desnăţui	2	52.279	42.989	9.29
17	Banaguiu	3	3.369	2.961	0.408
18	Baldal (Jivan)	3	20.631	21.538	-0.907
19	Buzat	3	22.556	22.921	-0.365
20	Portăreşti	4	5.691	4.777	0.914
21	Baboia (Eruga, Baboias)	3	43.592	45.041	-1.449
22	Caraula (Orodel)	4	1.530	1.620	-0.09
23	Cioroiaşi	4	8.625	5.228	3.397
24	Balasan (Cilieni, Motatei)	2	52.887	55.554	-2.667
25	Fântâna Fătului	3	18.210	22.300	-4.088
26	Drincea 1	2	43.698	50.521	-6.823
27	Drincea 2	3	10.469	11.348	-0.879
28	Blahnita (Rogova)	2	40.501	45.642	-5.141
29	Poroiniţa	3	0.513	0.635	-0.122
30	Orevita	3	6.683	6.767	-0.084
Total lenght			**567.026**	**588.691**	-

The greatest increase was registered on the Georocel watercourse (7.58 km), a left tributary of the Jieţ River (Table 2, Fig. 2). There are also situations when the length in 2017 is shorter than the length in 2003 due mainly to the regularization works (which optimized the drainage section) as part of flood protection works; an example in this sense is the Desnățui river (Table 3, Fig. 3).

Table 2 Decrease of the hydrographic network length

No.	Watercourse	Order	Length in 2003 (km)	Length in 2017 (km)	Length dif. (km)
1	Georocel	3	7.494	15.083	-7.589
2	Drincea 1	2	43.698	50.521	-6.823
3	Blahnita (Rogova)	2	40.501	45.642	-5.141
4	Fântâna Fătului	3	18.210	22.300	-4.088
5	Craioviţa	2	1.720	4.930	-3.210
6	Balasan (Cilieni, Motatei)	2	52.887	55.554	-2.667
7	Dîlga	2	6.290	8.750	-2.460
8	Leul/Știubei	2	13.310	15.310	-2.000
9	Baboia (Eruga, Baboias)	3	43.592	45.041	-1.449
10	Jiet (Jiul Vechi)	2	51.930	53.370	-1.435
11	Valea Predeştilor	3	13.351	14.679	-1.328
12	Livadia (Puturoasa)	2	10.890	12.11	-1.219
Total					**-39.41**

Table 3 Increase of the hydrographic network length

No.	Watercourse	Order	Length in 2003 (km)	Length in 2017 (km)	Length dif. (km)
1	Desnățui	2	52.279	42.989	9.290
2	Gioroc (Valea Morilor)	2	20.670	15.760	4.912
3	Cioroiaşi	4	8.625	5.228	3.397
4	Valea Rea/Valea Rea III	3	4.281	2.844	1.437
5	Lumaş	2	6.560	5.420	1.143
6	Valea Vistieriei	2	10.290	9.210	1.080
Total					**21.259**

A special case is represented by the Drincea River, which was analyzed in detail in the perimeter of Punghina settlement, where the phenomenon of anthropogenic intervention in the sense of regularizing the watercourse in order to increase protection against floods (optimization of the drainage section) is highlighted. In 2003 compared to 2017, meanders appear clearly (the cause is the investment works regarding the regularization of this watercourse in the settlement area) (Figs. 4, 5).

Downstream Punghina, the Drincea river presents a meandering course at the level of 2017 because in this sector the anthropogenic impact did not occur (Fig. 5, 6). Although the hydrographic network at the level of 2017 was generated by advanced geospatial techniques, the vector line does not follow the dammed area behind the locality. The maps in SHP (shapefile) format were extracted from the cadastral measurements in DWG (AutoCAD Drawing) format, measurements made achieved by the experts from the Jiu Water Basin Administration.

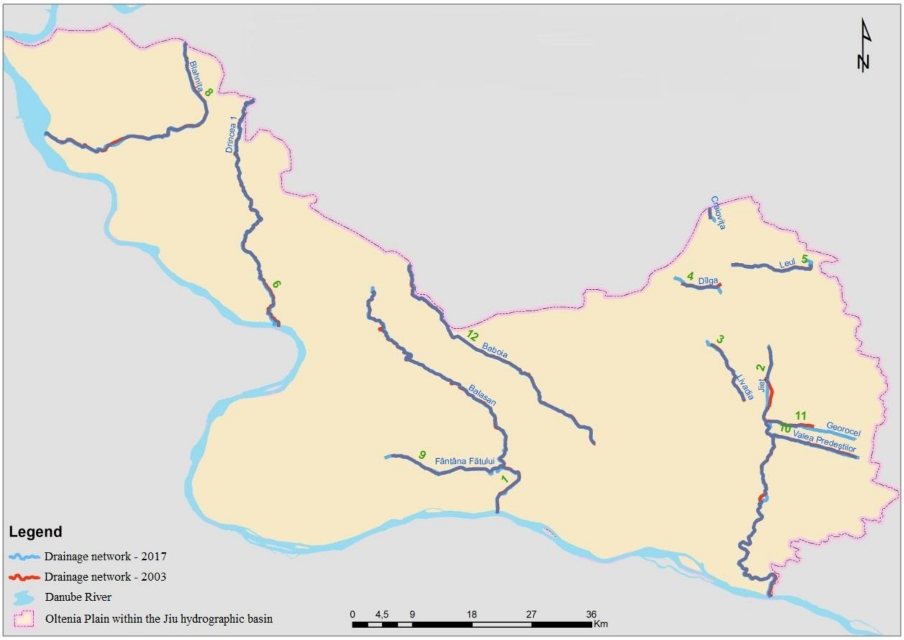


Fig. 2 Watercourses with significant increases in length during the analyzed period

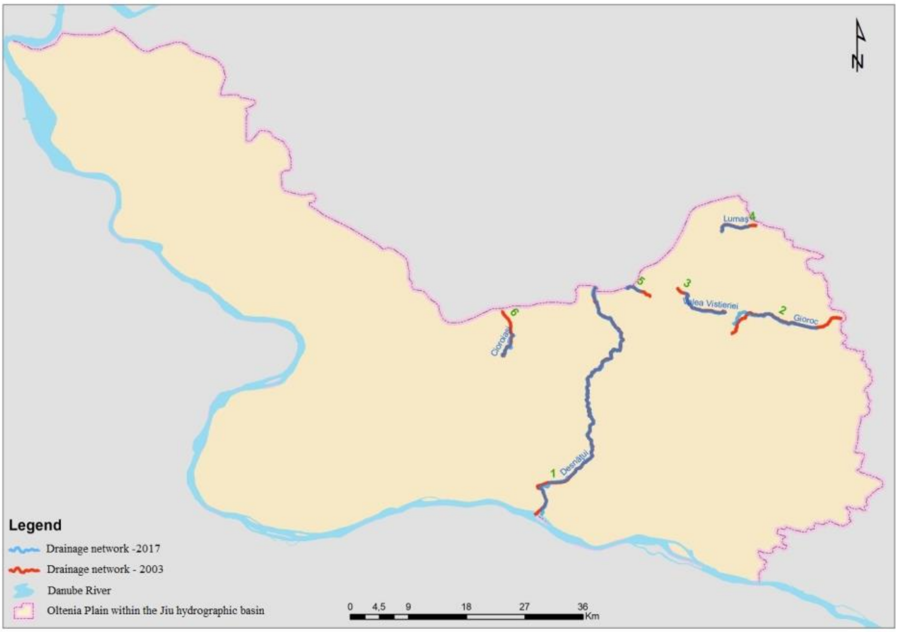
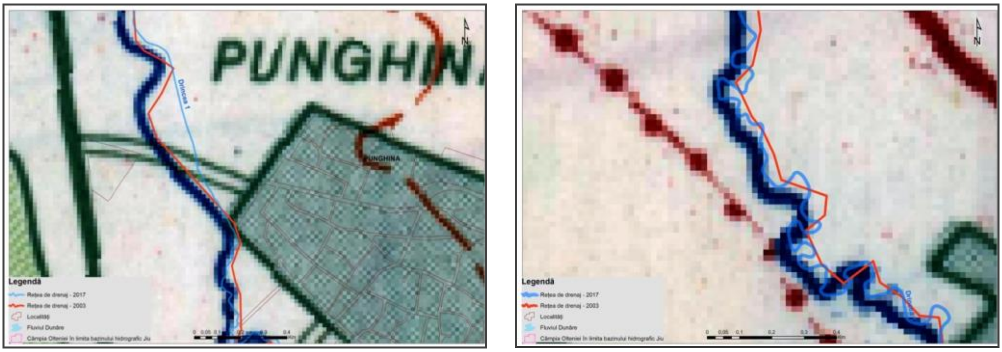


Fig. 3 Watercourses with significant decreases in length during the analyzed period



a **b**

Fig. 4 Drincea River: a. Sector with decreasing watercourse length; b. sector with increasing length of the watercourse

Fig. 5 The dam of the Drincea river - Punghina settlement (April 2017)

Fig. 6 The meandering course of the river Drincea - Cujmir settlement (April 2017)

4. CONCLUSIONS

The present study demonstrates an application of GIS morphometric characterization for understanding and managing the river networks.

Taking into account the results regarding the variations in watercourse lengths (2003 compared to 2017), it is considered that this analysis should be extended on a larger scale, possibly at river basin level, with feasible explanations for significant increases or decreases in these lengths (> + and - 20%).

The spatial organization of watercourses within the study area dictates the human interventions as well as the distribution of water resources (see the cases of the Drincea and the Desnatui rivers).

The results clearly show that the morphology of a watercourse can change substantially when intervening with structural measures (dams, regularization of riverbeds). At regional level, it has been found that these databases need to be constantly updated, thus providing an overview of all the changes in a riverbed. At the same time, this research is very useful to implement different analysis of hydro-morphometric characteristics of rivers basin.

Moreover, detailed comparisons of field-based and GIS approaches for the physical characterization of a hydrographic network is required in future research.

ACKNOWLEDGEMENTS

The author would like to kindly acknowledge the "Romanian Water" National Administration, the Jiu Branch that supplied important information for the GIS analysis. I am also grateful to reviewers for their helpful comments.

REFERENCES

1. Bălteanu, D., Dragotă, C.S., Popovici, A., Dumitraşcu, M., Kucsicsa, G., & Grigorescu, I. (2013). Land use and crop dynamics related to climate change signals during the post-communist period in the south Oltenia. *Romania. Proc. Rom. Acad*, 15, 265-278.
2. Bezinska, G., & Stoyanov, K. (2019). Modelling and hydro-morphometric analysis of sub-watershed. A case study of Mesta river southwestern Bulgaria. *European Journal of Geography*, *10*(2), 77-88.
3. Chendeș, V. (2011). *Resursele de apă din Subcarpații de la curbură. Evaluări geospațiale* (in Romanian). Romanian Academy Publishing House, Bucharest.
4. Dumitrașcu, M., Mocanu, I., Mitrică, B., Dragotă, C., Grigorescu, I., & Dumitrică, C. (2018). The assessment of socio-economic vulnerability to drought in Southern Romania (Oltenia Plain). *International Journal of Disaster Risk Reduction*, 27, 142-154. http://dx.doi.org/10.1016/j.ijdrr.2017.09.049.
5. Pişota, I., & Zaharia, L. (2002). *Hidrologie* (in Romanian). University of Bucharest Publishing House, Bucharest.
6. Pişota, I. (2005). Câmpia Olteniei. Apele (in Romanian). In *Geography of Romania*, Vol. V, Romanian Academy Publishing, Bucharest.
7. Pleniceanu, V. (1999). *Apele din Câmpia Olteniei*. University Publishing House, Craiova.
8. Prăvălie, R., Zaharia, L., Bandoc, G., Petrişor, A. I., & Mitof, I. (2016). Hydroclimatic dynamics in southwestern Romania drylands over the past 50 years. *Journal of Earth System Science*, *125*(6), 1255-1271. DOI 10.1007/s12040-016-0730-x
9. Răducă, C., Boengiu, S., Mititelu-Ionus, O., & Enache, C. (2021). Correlation of the relief conditions, hydrographic network features and human interventions within the Blahnita River Basin (Southwestern Romania). *Carpathian Journal of Earth and Environmental Sciences*, *16*(1), 117-127.
10. Rai, P. K., Chandel, R. S., Mishra, V. N., & Singh, P. (2018). Hydrological inferences through morphometric analysis of lower Kosi river basin of India for water resource management based on remote sensing data. *Applied water science*, 8(15), 1-16. https://doi.org/10.1007/s13201-018-0660-7
11. Roşu, Al. (1980). *Geografia Fizică a României* (in Romanian). Didactic and Pedagogical Publishing House, Bucharest.

12. Savin, C. (2008). *Râurile din Oltenia. Dinamica scurgerii apei* (in Romanian). Sitech Publishing House, Craiova.

13. Thoms, M., Scown, M., & Flotemersch, J. (2018). Characterization of river networks: A GIS approach and its applications. *JAWRA Journal of the American Water Resources Association*, *54*(4), 899-913. doi: 10.1111/1752-1688.12649

14. Withanage, N. S., Dayawansa, N. D. K., & De Silva, R. P. (2014). Morphometric analysis of the Gal Oya River Basin using spatial data derived from GIS. *Trop Agric Res*, *26*(1), 175-188. DOI: http://doi.org/10.4038/tar.v26i1.8082

15. *** (1992). Atlasul Cadastrului apelor din România (in Romanian). Ministry of Environment and Aquaproject S.A., Bucureşti, 683 p.