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ANALYSIS OF MORPHOMETRIC INDICATORS IN COASTAL HYDROGRAPHIC BASIN OF ROMANIA, USING GIS TECHNOLOGIES

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Abstract: *The goal of the paper is to conduct a comprehensive analysis of morphometric indicators within the Coastal Hydrographic Basin of Romania, utilizing Geographic Information System (GIS) technologies. In the current state of the field, morphometric analysis plays a crucial role in understanding hydrological systems and environmental management, particularly in regions with unique characteristics such as Romania's coastal area. The study uses a climatic dataset to gather essential climatic information. GIS tools are then employed to systematically evaluate morphometric parameters, including aridity index, watershed divide, basin area, shape, circularity and elongation ratio, and other relevant factors, providing a detailed and spatially explicit analysis of the basin's morphometric characteristics. The results of this analysis offer valuable insights into the hydrological and environmental conditions of the coastal area. However, it is important to acknowledge the limitations of the study, including potential constraints imposed by available datasets, which may limit the accuracy and depth of analysis. Nonetheless, the implications of the findings are significant for water resource management, environmental conservation, and sustainable development in Romania's coastal region. The study underscores the importance of integrating morphometric analysis into broader environmental management strategies and highlights the need for further research to enhance our understanding of coastal basin dynamics.*

• Introduction

Exploring hydrographic basins is crucial for effective resource stewardship and environmental preservation. In the context of climate change and anthropogenic activities, the Coastal Basin of Romania demands detailed analysis. Situated in proximity to the Black Sea, this basin showcases a variety of landscapes, from sandy beaches to wetlands and agricultural land, making it subject to diverse natural and anthropogenic pressures. Understanding these dynamics is imperative for informed decision-making and sustainable management practices.

Morphometric analysis stands out as a paramount method for comprehensively understanding the intricate relationships within watershed systems (Strahler, 1964). This analytical approach delves into various facets, encompassing linear, areal, and relief parameters, thereby providing invaluable insights into watershed characteristics (Abboud & Nofal, 2017).

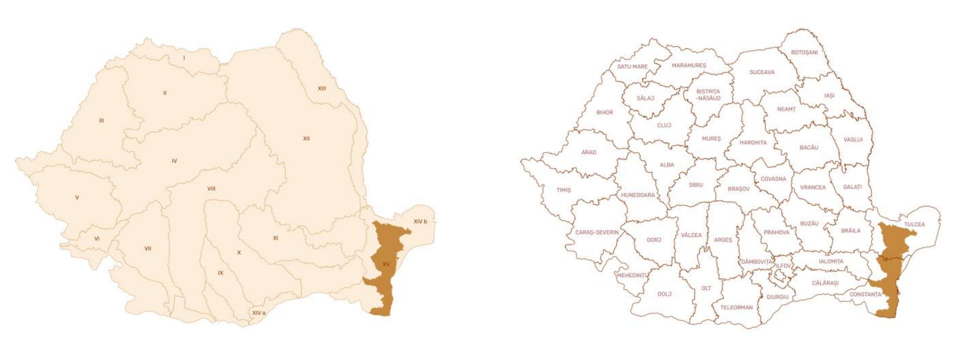


Figure 1. Map of the main hydrographic basins of Romania

Figure 2. Map depicting the Coastal Basin's alignment with the counties of Romania

Table 1

The names (Figure 1) and surfaces of the main hydrographic basins of Romania

Basin	Name	Surface (km²)	Percentage (%)
I	Tisa	4573.71	1.9
II	Someș	17885.65	7.5
III	Crișuri	14933.10	6.3
IV	Mureș	29513.21	12.4
V	Bega-Timiș-Caraș	13135.72	5.5
VI	Nera-Cerna	2769.78	1.2
VII	Jiu	10112.39	4.2
VIII	Olt	24052.01	10.1
IX	Vedea	5412.16	2.3
X	Argeș	12619.31	5.3
XI	Ialomița	10465.29	4.4
XII	Siret	42976.56	18.0
XIII	Prut	11105.95	4.7
XIV a	Dunăre (Danube)	23612.88	9.9
XIV b	Dunăre-Dobrogea	10122.93	4.2
XV	**Litoral (Coastal)**	**5432.01**	**2.3**

• Material and method

The study focuses on a series of morphometric indicators that provide a detailed perspective on the physical and hydrological characteristics of the basin. The selected indicators, such as aridity index, watershed divide, basin area, its shape, and other parameters, are essential for the assessment and sustainable management of natural resources and the environment. The indicators developed in this study, derived from Zăvoianu, I., (2006): Hidrologie, 4th Edition, Bucharest, Editura Fundației România de Mâine, constitute an essential part of our analysis, providing a solid foundation for evaluating and understanding hydrological processes within the specific context of our research.

• Results and discussions

The analyses conducted in this study encompass a range of morphometric parameters, including the aridity index, watershed divide, average slope of the watershed divide, basin area, basin shape and form factor, circularity ratio, elongation ratio, shape ratio, average basin altitude, average basin slope, forest cover coefficient, and lake coefficient. These parameters provide valuable insights into the hydrological and topographical characteristics of the study area, shedding light on key factors influencing watershed dynamics and water resource management practices. Moreover, the utilization of quantitative analysis yields basin parameters in the form of ratios and dimensionless numbers, facilitating effective comparisons across different scales (Krishnamurthy et al., 1996).

1. Aridity index (K)

This index is calculated by considering two key variables: the amount of precipitation (P) and the air temperature (T), to assess the degree of dryness in a region.

The formula used is K = P / (T + 10 °C), where P represents the amount of precipitation (in mm), and T is the average temperature (in degrees Celsius). The calculation can be done monthly or annually, providing flexibility in analyzing climatic conditions over different periods.

➢ Aridity Index (K): 413.58 / (10.61 + 10 °C) = 20.06

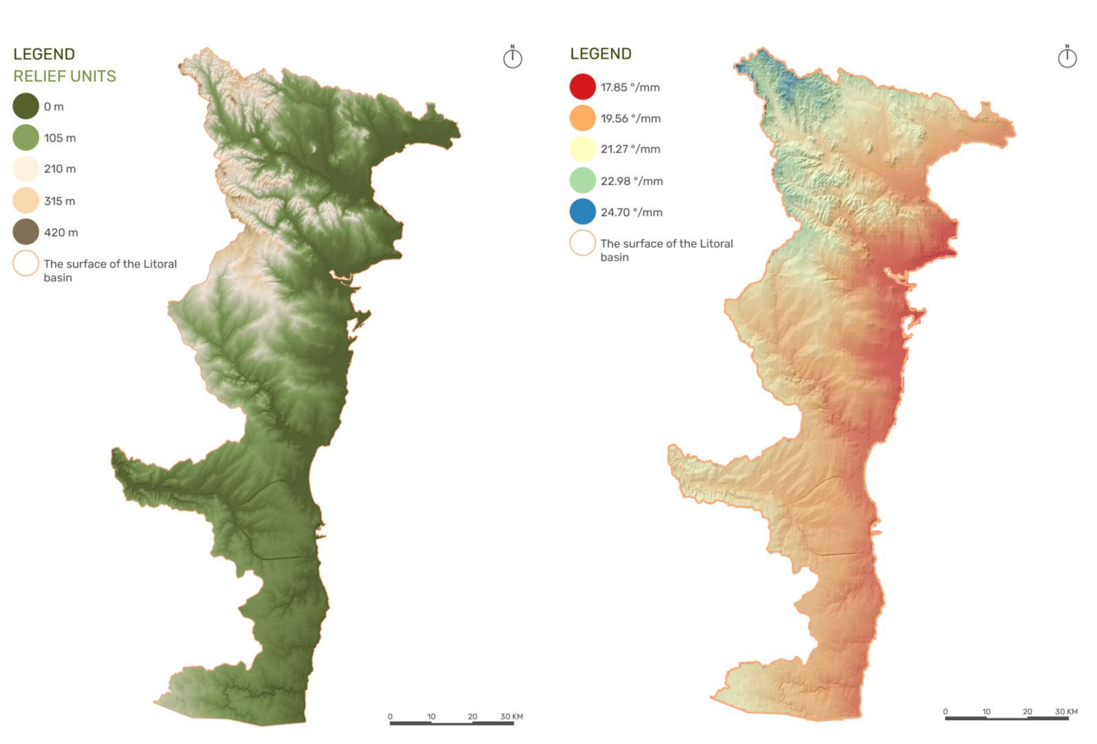


Figure 3. Hypsometric map (values ranging from 0 to 420 m)

Figure 4. Map of the aridity index (values recorded between 17.85 and 24.70 °/mm)

2. Watershed Divide (WD)

- Length of WD = 713,132.46 km
- Average Elevation of WD = 103.45 m
- Average Slope of WD

The average slope is calculated using the formula 2ΔH/P, where ΔH is the difference in altitude, and P is the length of the Watershed Divide.

Average slope = 2(420-0)/713132.46 = 2*420/713132.46 = 0.0000011779

0.00006749° (converted to degrees)

3. Basin Area

For the Coastal Basin, the total area is 5432.01 km².

4. Basin Shape and Form Factor (Ff)

The calculation formula is Ff = Sb/Lb², where Sb is the basin area, and Lb is the length of the side of the square that has an equivalent area to the basin's maximum length.

The maximum length of the basin (L), measured between its extreme points equals 166.82 km / 166820 m.

Lb = 166820 m. Area of the square (with side Lb) = 166820 m x 166820 m => 27,830 km². Sb = 5432.01 km²

Calculation of the Form Factor: Ff = 5432.01 km²/27,830 km². ➢ Ff = 0.195

5. Circularity Ratio (Cr)

It is calculated based on the formula Cr = Sb/Sc, where Sb represents the basin area, while Sc is the area of the circle that has the same perimeter (P) as the basin. The formula for Sc is Sc = P²/4π.

As follows:

The perimeter length of the basin (P) = 713,132.46 km. The area of the circle (Sc) = 713,132.46²/4 π = 508,557,905,506/12.56 = 40,490,279,100.8. The basin area (Sb) = 5432.01 km² Rc = 5432.01 km²/40,490,279,100.8

➢Cr = 1.34

6. Elongation Ratio (Er)

The calculation formula is Er = Db/Lb, where Db is the diameter of the circle with the same area as the basin, and Lb is the maximum length of the basin. The formula for Db is Db = 2√Sb/π

Basin area (Sb) = 5432.01 km². Calculating the radius (r) of the circle, we have r = √5432.01/3.1415 (π) = √1729.11. r = √1729.11 = 41.58 km. Thus, the diameter (Db = 2r) = 83.16 km. Maximum length of the basin (Lb) = 166.82 km

Er = 83.16/166.82. ➢Er = 0.49

7. Shape Ratio (Sr)

It suggests the general shape of a hydrographic basin and it is calculated using the formula Sr = Sb/(P/4)², where Sb is the basin area and P is the basin perimeter.

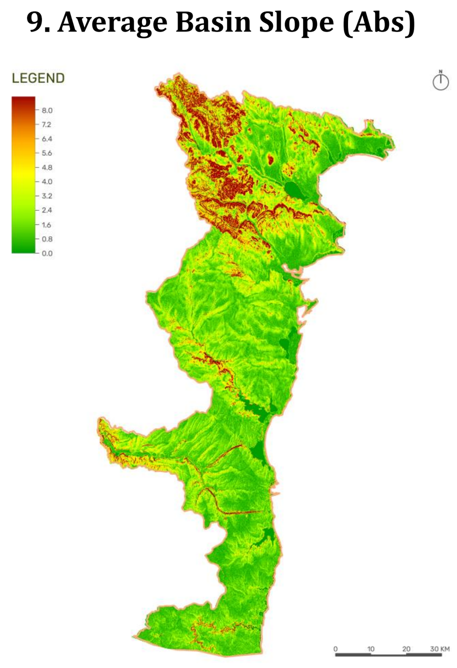
Basin area (Sb) = 5432.01 km². Basin perimeter (P) = 713,132.46 km. (P/4) represents the length of a square side with the same perimeter as the basin: P/4 = 713,132.46 km / 4 = 178,283.115 km. Sr = 5432.01 km²/(178,283.115 km)²

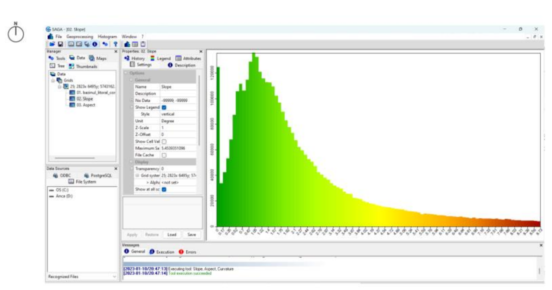
Sr = 5432.01 km²/3178.48. ➢ Sr = 1.70

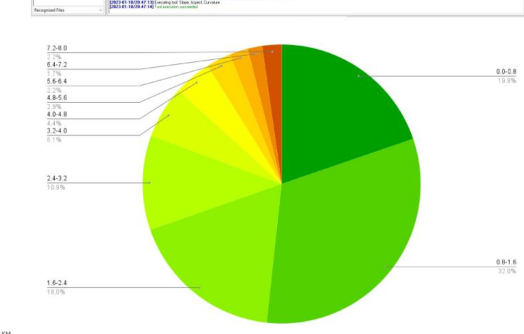
8. Average Basin Altitude (Aba)

It is an important indicator for the physical and ecological characterization of the basin. For our studied basin, the recorded altitudes are: Maximum altitude = 419.84 m. Minimum altitude = -3.74 m. ➢ Aba = 93.65 m

9. Average Basin Slope (Abs)







The average slope represents a measure of the general incline of the terrain within the basin and is expressed in degrees.

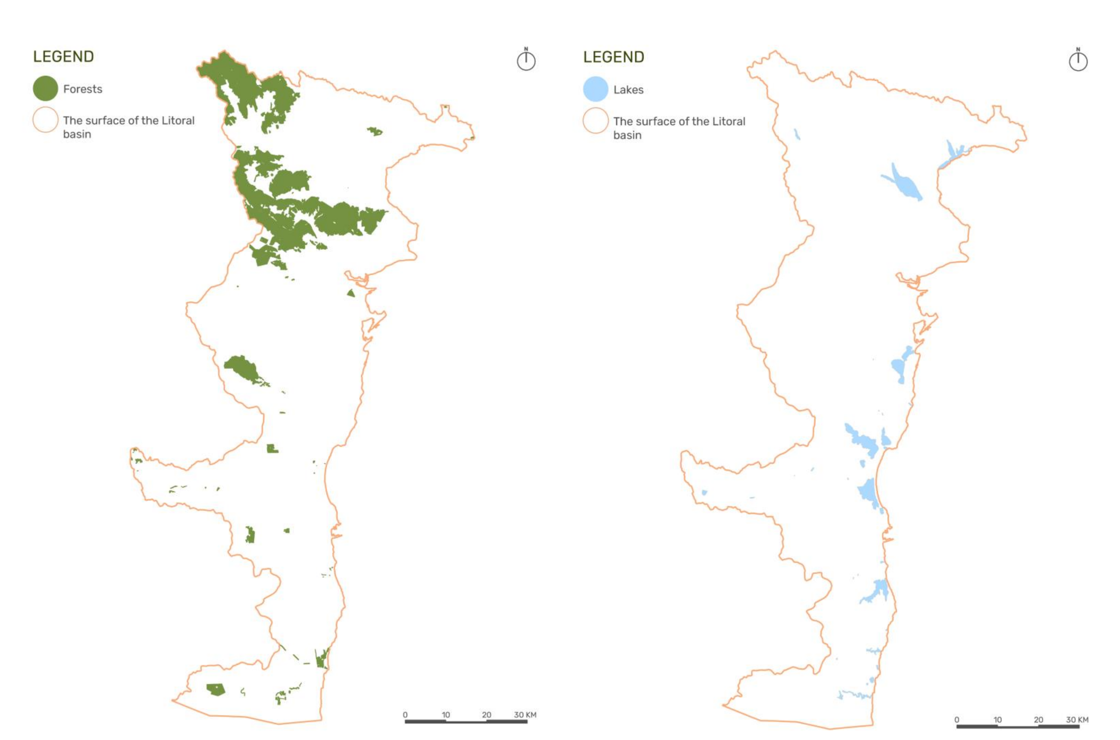
For the coastal basin, it is considered: ➢ Abs = 1.6°

This result indicates a relatively moderate slope of the terrain.

Table 2

Summary table

Nr. crt.	Indicator	Value
1	Aridity Index (K)	20.06
2	Watershed Divide Perimeter (P)	713,132.46
	Average Height of WD	103.45
	Average Slope of WD	0.00006749°
3	Basin Area	5432.01 km²
4	Shape Factor	0.195
5	Circularity Ratio (Rc)	1.34
6	Elongation Ratio (Ra)	0.49
7	Form Ratio (Rf)	1.70
8	Average Basin Altitude (Hmed)	93.65 m
9	Average Basin Slope (Ib)	1.6°
10	Afforestation Coefficient	21.56%
	Lake Coefficient	14.69%



10. Forest Cover Coefficient (Fc) and the Lake Cover Coefficient (Lc)

The Forest Cover Coefficient (Fc) and the Lake Coefficient (Lc) are expressed as percentages and represent the proportion of the basin area occupied by forests and lakes.

The calculation formula is = (Sf/Sb)*100, where Sf represents the forested area (or lake area) of the basin, and Sb is the total area of the basin.

Fc = (1171.43 km²/5432.01 km²)*100

➢ Fc = 21.56%

Lc = (798.07 km²/5432.01 km²)*100

➢ Lc = 14.69%

• Conclusions

The GIS analysis revealed important characteristics of the Coastal Hydrographic Basin, such as variations in altitude, aridity index, and average terrain slope. The results of the analyzed parameters indicate a moderate climate, with a balance between precipitation and temperature, which is crucial for water resource management.

The moderate slopes suggest a low risk of erosion, favorable for agriculture and soil conservation. It is also emphasized the importance of conserving natural habitats and maintaining ecological balance.

The paper underscores the importance of an integrated approach in natural resource management, considering the impact of human activities on the hydrological and ecological balance of the basin. Additionally, multidisciplinary research in water resource management is recommended to understand the interactions between natural and human factors within hydrographic basins.