SETOF Soil Erosion and TOrrential Flood Prevention: Curriculum Development at the Universities of Western Balkan Countries

RISK ASSESSMENT OF SOIL EROSION IN THE AREA OF THE SOURCE OF WATER SUPPLY RZAV

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INTRODUCTION

- Soil is a key natural resource in providing basic human needs.

Food and Agriculture Organization of the United Nations

- The Food and Agriculture Organization of the UN (FAO) defines soil as a limited resource, which means that its loss and degradation cannot be compensated during the average human lifespan, given that it takes between 100 and 400 years to form a layer of soil 1 cm thick.

- Soil erosion is the main and most widespread form of land degradation, and as such, represents a serious limitation to the sustainable development of the economy and society.

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Subject of research

- **Land and water resources**
- **Veliki Rzav river watershed** (southwestern part of the Republic of Serbia, 566 km2)

Goal and Importance of the research

- Water of the Veliki Rzav has been determined as the **most important water management object** within the framework of integrated water management use, regulation, and protection of the waters of the Republic of Serbia.
- **Aim of this research** - determine the spatial distribution of the intensity of erosion processes and the production of erosive material, in the territory of the Veliki Rzav river watershed.

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Erosion as a form of soil degradation

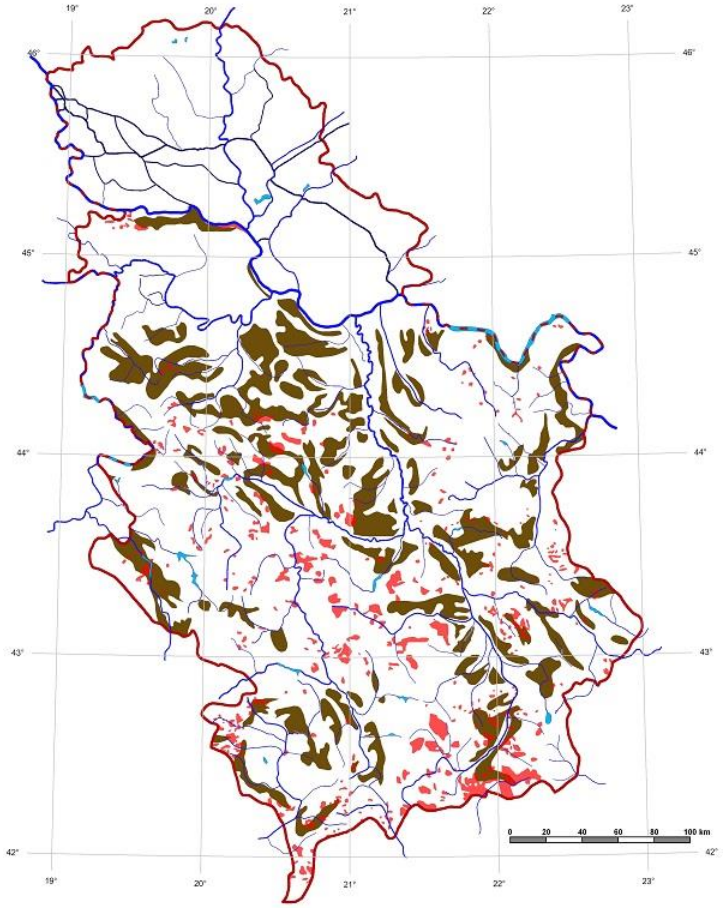

Figure 1. Erosion map of the Republic of Serbia (Lazarević, 1983)

- Erosion processes not only destroy the land fund but also cause major disruptions in the available water supplies necessary for human life and its economy because the provision of a sufficient amount of health-safe water is prescribed in a large number of European and world documents as a basic human right (UN General Assembly, 2010).
  - very slight erosion - 41.19%;
  - slight erosion - 18.16%;
  - medium erosion - 12.67%;
  - heavy erosion - 13.21%;
  - excessive erosion - 1.16%.
- The annual production of erosive material in the Republic of Serbia is about 37.25x106 m3, i.e. 487.85 m3km-2, which is 4.88 times more than normal (geological) erosion (Ristić, Nikić, 2007).

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Material and method

Veliki Rzav River watershed

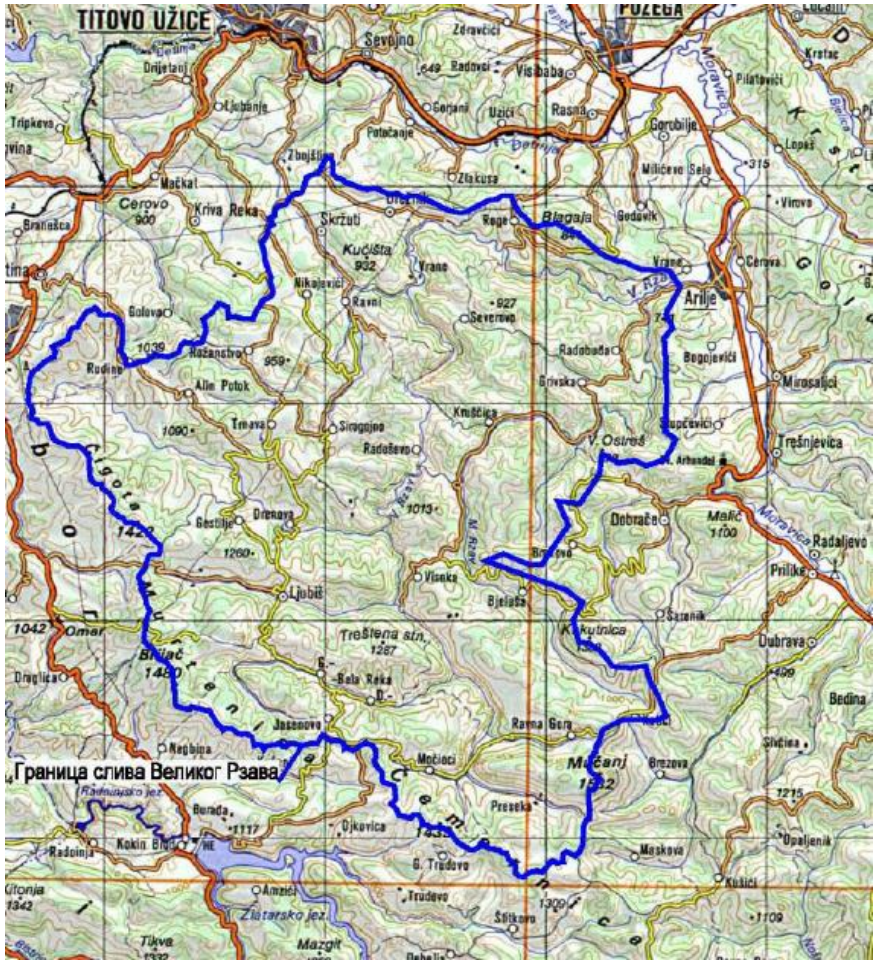

Figure 2. The geographical position of the Veliki Rzav River watershed (Institute for Water Management „Jaroslav Černi“, 2014)

Basic facts:

- Location: southwestern part of the Republic of Serbia.
- Covers area: about 566 km2 up to the "Ševelj" flood barrier, that is, to the water intake for water supply.
- The joining of the Presečka River and the Bukovo Potok creates the Rzav River, and the joining of the Rzav and the Bela River creates the Veliki Rzav.
- Length: including the rivers from which it originates is 66.6 km.

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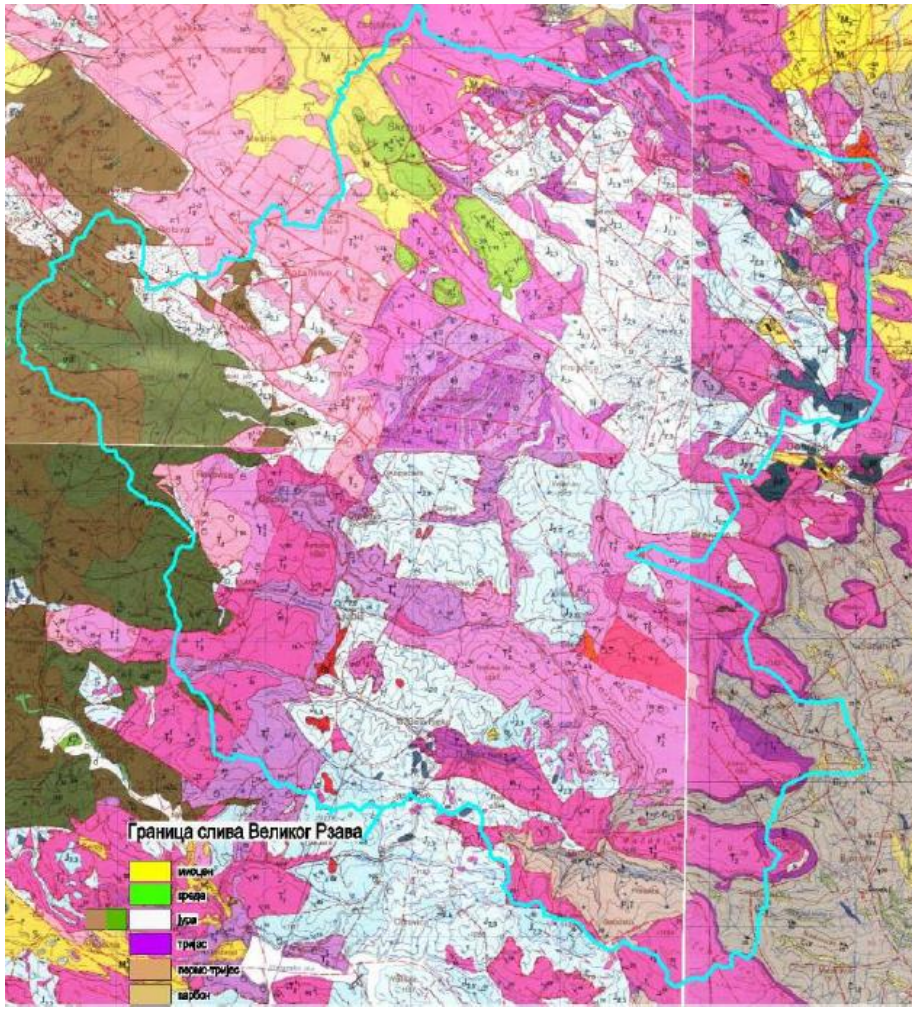

Figure 3. A geological map of the Veliki Rzav River watershed (Institute for Water Management „Jaroslav Černi“, 2014)

- The most common soils are brown ore on limestone and dolomite, and brown skeleton soil on shale.
- Today's natural vegetation in the area of the Rzav basin is represented by two basic vegetation types: forests (35%) and grass communities (42%).

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Erosion Potential Method

According to this method, the total annual production of erosion material is calculated according to the formula (Gavrilović, 1972):

$$W_{god} = \mathrm{T} \cdot H_{god} \cdot \pi \cdot \sqrt{Z^3} \cdot \mathrm{A}$$

W_{god} – annual yields of erosive material $[\mathrm{m}^3 \cdot \mathrm{god}^{-1}]$;

T – temperature coefficient;
H_{god} – average yearly precipitation [mm];
π – Ludolf number (Archimedes' constant) - 3,14;
Z – erosion coefficient;
A – drainage area $[\mathrm{km}^2]$

The total production of erosion material can be expressed as well as the specific value (per square kilometer of the researched area) according to the formula (Gavrilović, 1972):

$$W_{godsp} = \frac{W_{god}}{A}$$

W_{godsp} – specific production of erosion material in the watershed $[\mathrm{m}^3 \cdot \mathrm{km}^{-2} \cdot \mathrm{god}^{-1}]$

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Classification category of erosion by erosion coefficient Z

- Erosion coefficient (Z): $\mathbf{Z = Y \cdot X \cdot a \cdot (\varphi + \sqrt{I_{sr}})}$
- Y – Coefficient of soil resistance to erosion;
- X · a – Land use coefficient;
- φ – Coefficient of the observed erosion process (takes into consideration clearly visible erosion processes);
- I_{sr} – Mean slope of terrain.

Table 1. Classification category of erosion by erosion coefficient Z

Category of erosion	Range of values	Name of category
I	Z > 1,0	Excessive erosion
II	0,71 < Z < 1,0	Heavy erosion
III	0,41 < Z < 0,7	Medium erosion
IV	0,20 < Z < 0,4	Slight erosion
V	Z < 0,19	Very slight erosion

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Results and Discussion

Coefficient of soil resistance to erosion (Y)

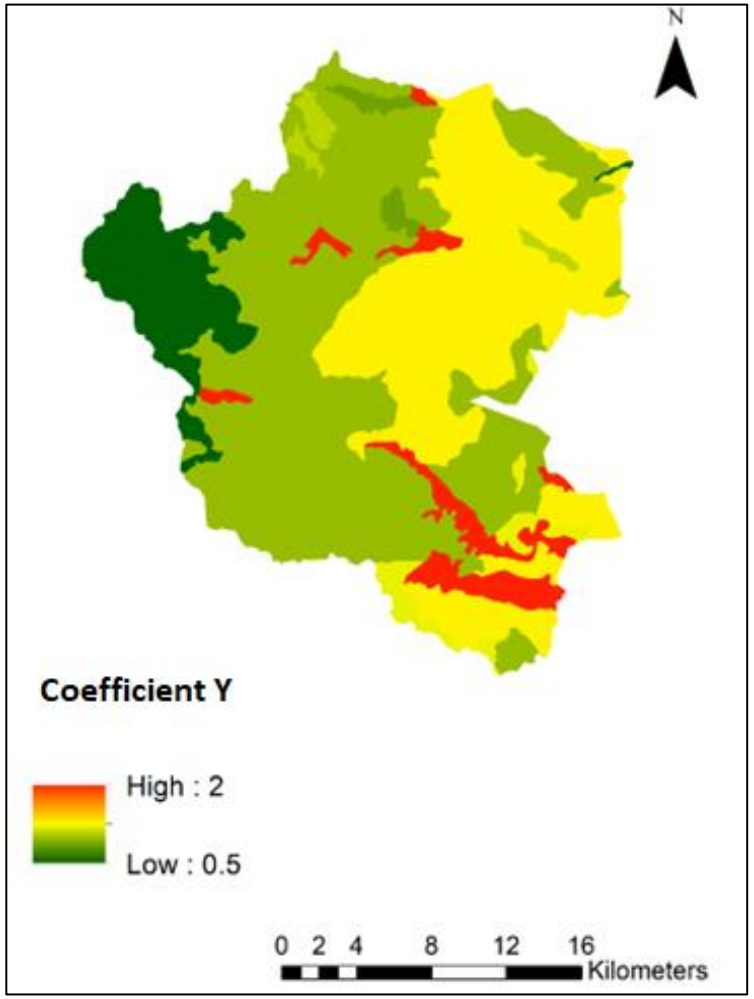

Figure 4. Spatial distribution of soil erosion resistance coefficient (Y)

Table 2. Coefficient Y of the research area

A type of pedology with geology	Coefficient Y
Alluvial loam deposit	0,5
Black on serpentine	0,5
Brown ore on limestone (locally leached)	0,8
Brown ore on limestone	0,9
Parapodzole (pseudoglue)	1
Skeletal on limestone (karst)	1,1
Brown skeletonoid on sandstone	1,1
Brown skeletoid on shales	1,2
Skeleton	2

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Land use coefficient (Xa)

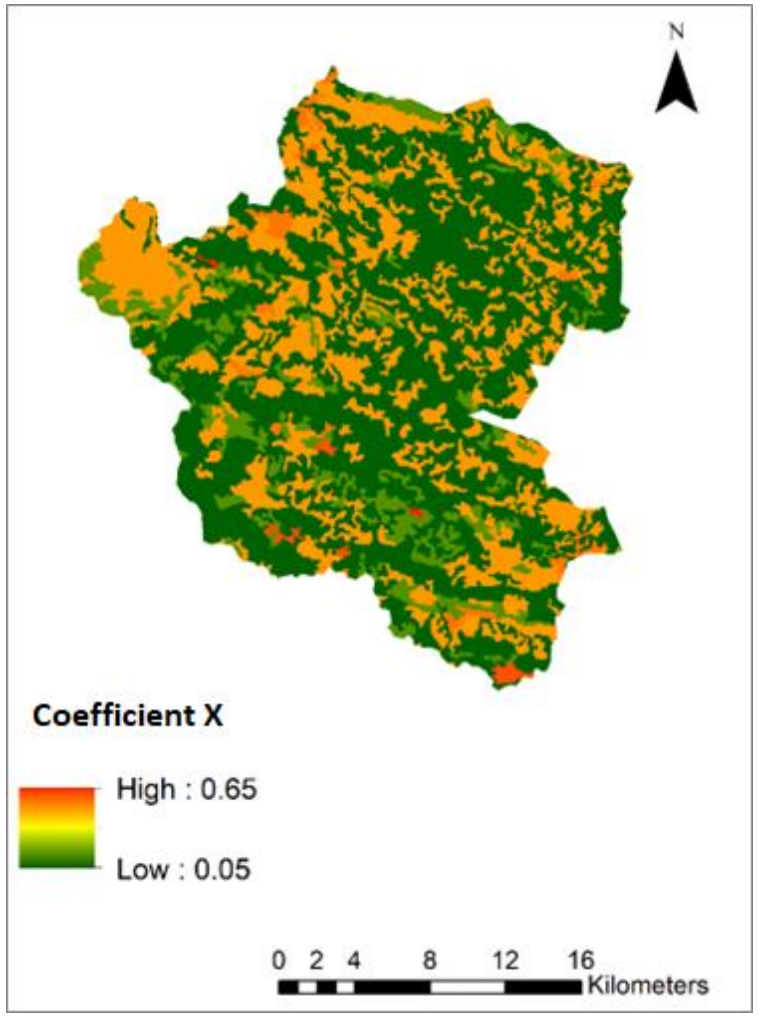

Figure 5. Land use in the Veliki Rzav River watershed (X·a)

- The value of X·a - 0.05 to 0.65
- Average value - 0.42.

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Coefficient of the observed erosion process (φ)

- Based on the analysis of the Elaborate on the zones of sanitary protection of the source of the regional water supply system "Rzav" which was prepared by the Institute for Water Management "Jaroslav Černi", and based on the described erosion processes, the coefficient of the observed erosion process at the level of the entire watershed, which is 0.39, was adopted.

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Digital Elevation Model

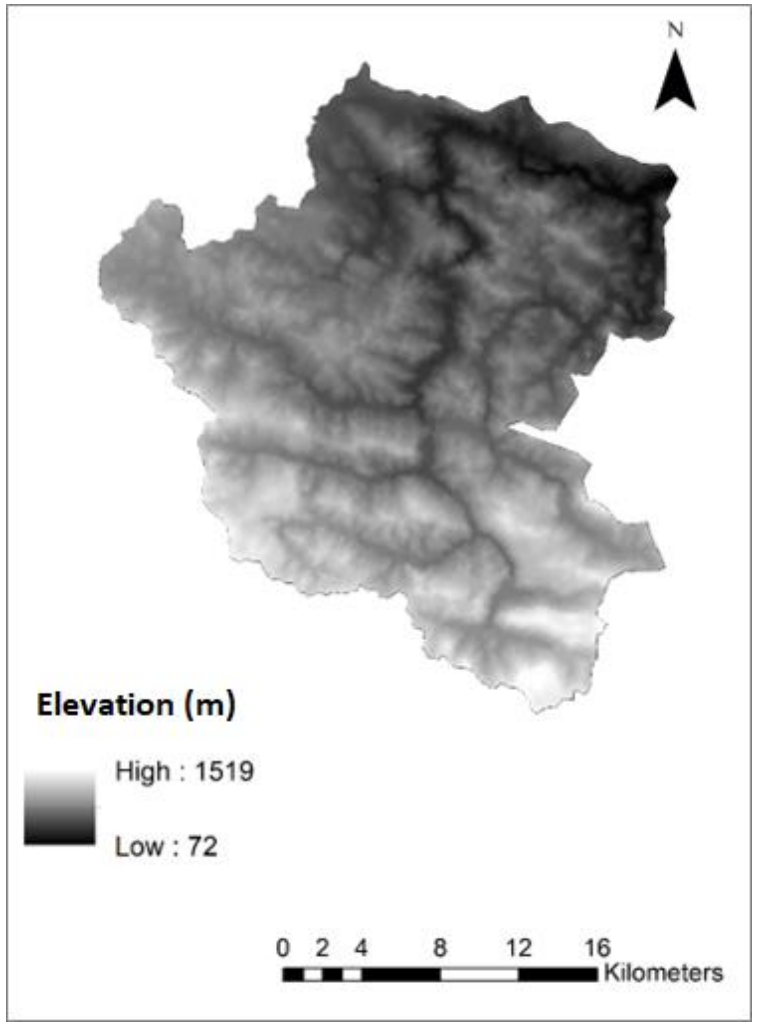

Figure 6. Digital Elevation Model of the Veliki Rzav River watershed

- The lowest point - 72 m.a.s.l. - located in the valleys of the Veliki Rzav river watershed
- The highest point - 1519 m.a.s.l. – located in the southeastern part of the watershed
- The average altitude - 890 m.a.s.l.

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Mean slope of terrain (Isr)

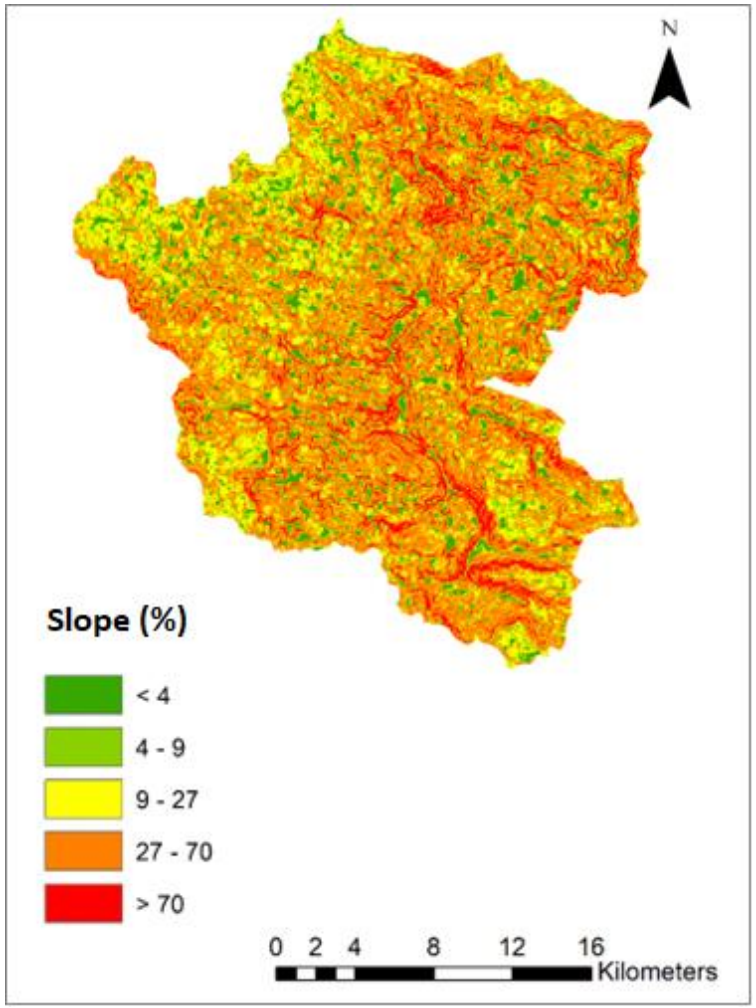

Figure 7. Slope of terrain in the Veliki Rzav River watershed

Table 3. Classification of terrain slopes (according to IGU, 1968)

Category	Slope (%)	Characteristics	Surface	
			Km²	%
I	0 – 4	There are no visible traces of mass movement, surface washing reduced to a minimum	49,9	8,8
II	4 – 9	Movement phenomena are visible, washing, liquefaction, and sliding of the soil are pronounced	42,8	7,6
III	9 – 27	Strong erosion, intensive flushing and mass movements	150,5	26,6
IV	27 – 70	Very strong erosion, increased washing and removal of material	262,5	46,4
V	> 70	The movements of the masses are so pronounced that the accumulation material is retained only in places, predominantly bare rock surfaces	60,2	10,6
Total			566	100

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Erosion Coefficient (Z)

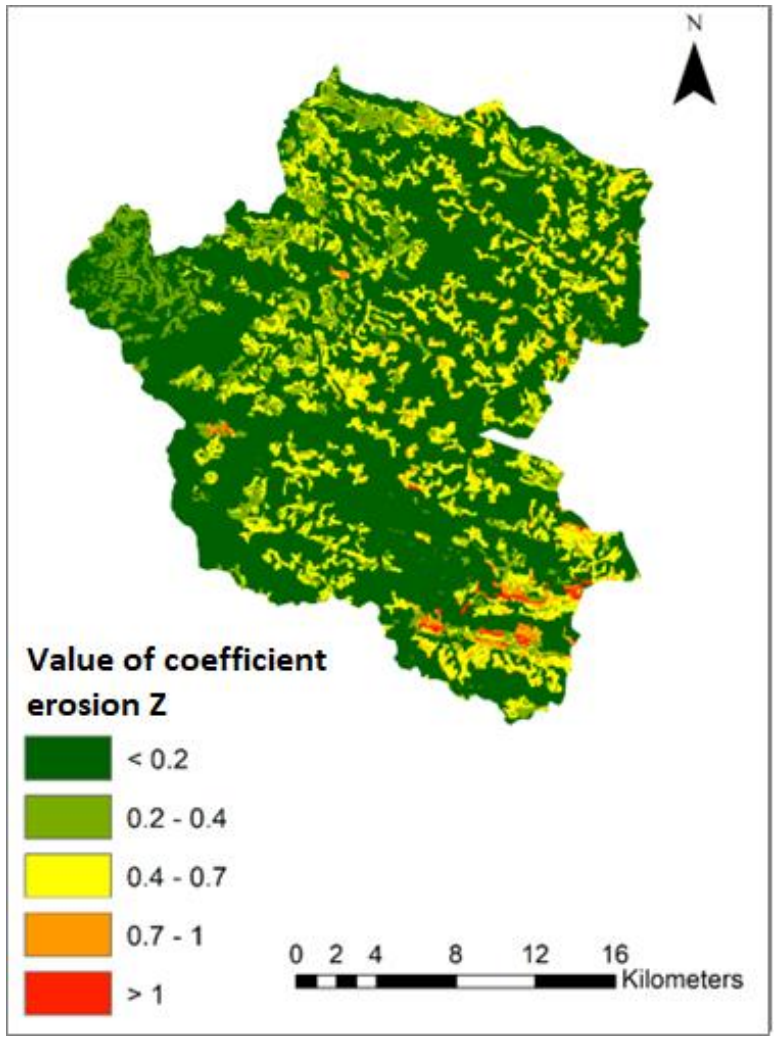

Figure 8. A map of Erosion Intensity in the Veliki Rzav River watershed

Table 4. Representation category erosion of the river basin Veliki Rzav, using EPM

Category	Representation	
	km²	%
Very slight erosion	382,72	67,62
Slight erosion	68,78	12,15
Medium erosion	99,93	17,65
Heavy erosion	11,35	2,01
Excessive erosion	3,22	0,57
Total	566	100

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Temperature coefficient and average annual precipitation

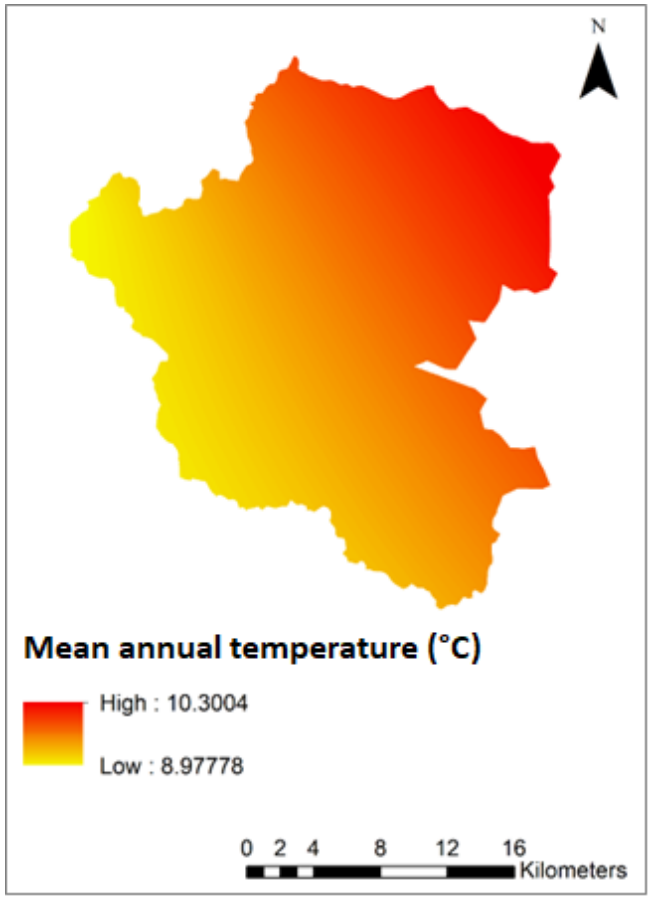

Figure 9. Spatial distribution of mean annual temperature values

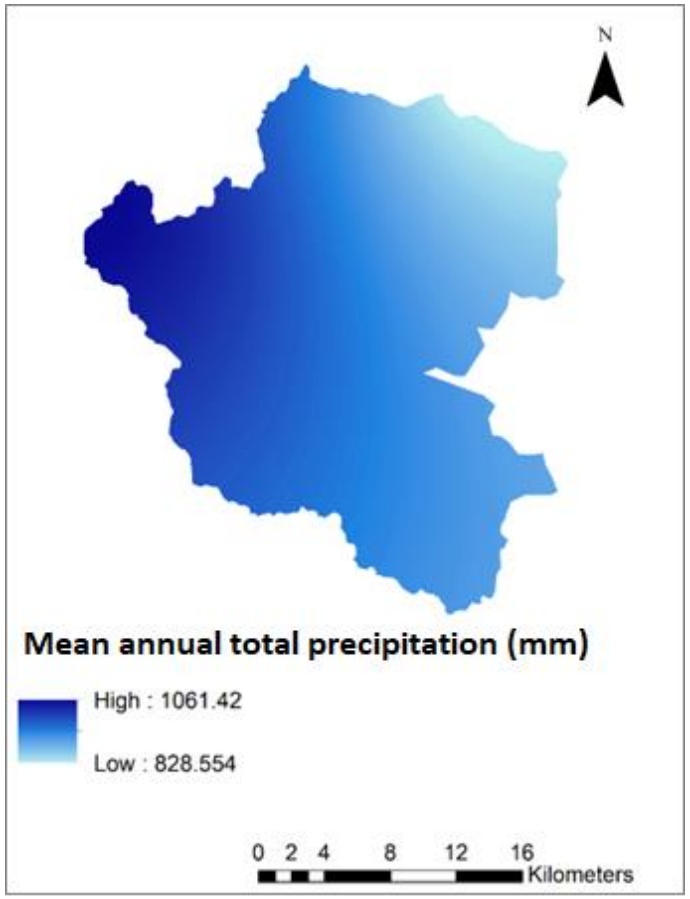

Figure 10. Spatial distribution of mean annual precipitation values

- Empirical Bayesian Kriging - temperature
- Inverse Distance Weighting - precipitation

Table 5. Measuring stations with coordinates

Measuring station	Coordinates		Altitude (m)
	latitude	longitude	
Požega	43° 51’	20° 02’	311
Užice	43° 53’	19° 50’	822
Zlatibor	43° 44’	19° 43’	1029
Sjenica	43° 16’	20° 00’	1038
Kraljevo	43° 43’	20° 42’	219

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Assessment of soil losses according to the Erosion Potential Method

- Total production of erosion material according to the method of the professor Gavrilović is calculated on the basis of previously defined parameters (T, Hgod, Z).

- The total production of erosion material for the researched area is **Wgod=149,298,711 m3.year-1**, while the specific production is **Wgodsp=263.78 m3·km-2·year-1**.

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CONCLUSION

- According to the Water Management Base of the Republic of Serbia, the Veliki Rzav river watershed has a significant role in the supply of drinking water at the macro-regional level, and for this reason, it is necessary to assess the risk of soil erosion in the area of the source of water supply.

- Given that erosion represents one of the most significant vulnerabilities of this watershed, data on the risk assessment play an important role in further research and the selection of measures and works that must be carried out in order to reduce the risk.

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