

BOOK OF PROCEEDINGS



*VII International Scientific Agriculture Symposium
Jahorina, October 06-09, 2016*



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Dusan Kovacevic

Technical editors

Sinisa Berjan
Milan Jugovic
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EROSION PROCESSES IN THE DRAINAGE BASIN OF THE PREDEJANE RIVER (SOUTHEASTERN SERBIA) IN THE PERIOD 1953-2012

Sonja BRAUNOVIĆ*, Mihailo RATKNIĆ, Tatjana RATKNIĆ, Ljubinko RAKONJAC,
Aleksandar LUČIĆ

Institute of Forestry, Kneza Višeslava3, Belgrade, Serbia

*Corresponding author: sonjabraunovic@yahoo.com

Abstract

The first organised torrent control works in Serbia started in Grdelica Gorge in the late 19th century because the area was the locus of the most intensive erosion processes. They required the implementation of various methods and structures for torrent control and soil protection against erosion. The works were carried out in drainage basins (biological and biotechnical works) and in torrent channels (technical works). The effects of the performed works on the state of erosion in the drainage basin of the Predejane River were studied through a comparative analysis of the situation in 1953 and in 2012, with the aim of upgrading the methods of water erosion and torrential flood control. The intensity of erosion processes in 1953 was determined on the basis of available erosion maps, whereas in 2012 it was determined by using satellite images and field research. The values of Z erosion coefficient for all reference periods were calculated after Prof Gavrilović's methodology and then used to conduct a comparative analysis of the obtained data.

Key words: *erosion process intensity, drainage basin, torrent control works, Serbia*

Introduction

A large part of the territory of Serbia is threatened by water erosion of different intensity. It must be stressed that 36% of the territory is affected by extensive, intensive and medium erosion processes. There are more than 12 000 registered torrential streams which cause enormous damage and often endanger human lives. The damage includes removal of soil and sediment accumulation in reservoirs and regulated riverbeds (water management aspect), the loss of soil nutrients and sediment accumulation on arable land (agricultural aspect), damage to roads, industrial facilities, settlements, etc (economy in general) and chemical - mechanical pollution of watercourses and reservoirs (ecological aspect).

In order to improve the methods of controlling water erosion and torrential floods, it is necessary to examine the effects of the works carried out so far and their impact both on the state of erosion in the basin and on the protection against torrential floods.

Materials and Methods

The Predejane River (*Predejanska reka in Serbian*) drainage basin is located in southeastern Serbia, in Grdelica Gorge (*Grdelička klisura in Serbian*). It belongs to the municipality of Leskovac (cadastral municipalities of Predejane and Crveni Breg). The Predejane River is a right tributary of the South Morava River (*Južna Morava in Serbian*), into which it flows near the village of Predejane. It has a relatively long course (8.5 km), with a fan-like basin and very narrow and steep gorge-like river valleys. The drainage area is 19.68 km², with an east-west direction. The field research was conducted in the period from 2011 to 2012 and together with satellite images and thematic (topographic, geological, soil, land use, erosion, etc.) digital maps it formed the basis for assessing the effects of natural factors, land use changes and anthropogenic factors on the state of erosion in the basin. Land use pattern was studied and defined in 2011 (Braunović and Ratknić, 2010). The structure of the area was

determined by using homogeneous plots, within which productive and unproductive areas were identified and digitized. The following productive areas were distinguished: forests, degraded forests, meadows and pastures, degraded meadows and pastures, alpine meadows and pastures, plough land, vineyards, orchards, house yards and gardens. Unproductive areas included: gullies, rocky grounds, gravel, road network, waterways and construction zone of settlements. This classification was then used to define land use and create a thematic map. We studied the state of erosion in 1953 (before the start of erosion control works) and in 2012 (the current state). The intensity and distribution of erosion processes in 2012 were determined on the basis of a 1:50 000 digital map of erosion. The coefficient of erosion (Z) was determined using land survey data, data on bedrock, soil, climate, and distribution of vegetation for each homogeneous plot (Gavrilović, 1972).

Results and Discussion

Orographic and hydrographic characteristics of the basin are presented in Figure 1. Starting from the mouth of the Predejane River, which is at a height of 295 m, the watershed reaches and exceeds 800 m on both sides, and then gradually increases to the highest point of 1284 m, which is also the farthest point from the mouth. The average decrease in the longitudinal profile is 10.36%. The decrease is the biggest in the section upstream of its confluence with the Samarski Creek (*Samarski potok in Serbian*) (14%). The section is 5.3 km long with a height difference of 739 m. The average decrease downstream of the confluence with the Samarski Creek is 6.04% (a 4.4 km long section) and the height difference is 266 m. The longitudinal profile of the upper and partially of the middle part of the course is very steep, which points to the tremendous energy of the topography and results in erosion and accumulation of sediment in the lower course.

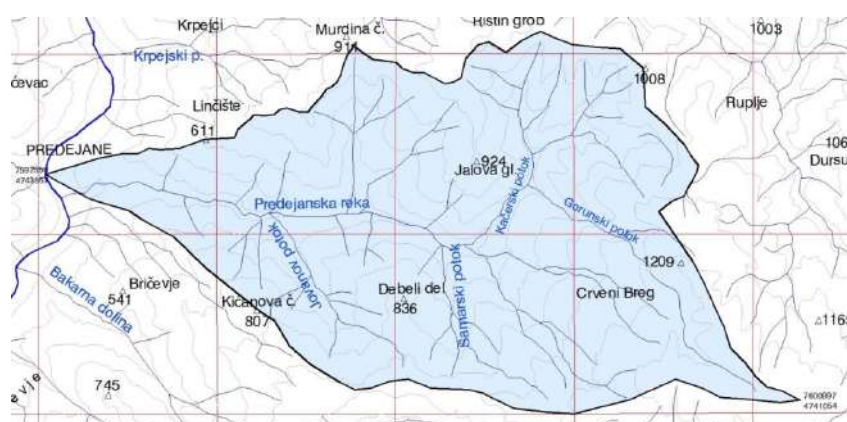


Figure 1. Topographic map of the Predejane River basin (Source: Original)

Table 1. Areas per altitudinal zones in the basin

Area	Altitudinal zones					Total
	below 300 m	300-500 m	500-700 m	700-1000 m	above 1000 m	
km ²	0.3	1.93	4.37	9.38	3.7	19.68
%	1.52	9.81	22.21	47.66	18.80	100.00

Source: Original

The largest part of the basin, or 47.66%, is located in the altitudinal zone from 700 to 1000 meters, while 18.80% of the area is above 1000 meters above sea level. (Table 1).

The bedrock is composed mainly of muscovite schists. Together with large falls and inadequate use of land, it favors the occurrence of erosion processes of different types and intensity. The distribution of bedrock in the basin is shown in Figure 2. Albite-chlorite-

muscovite schists and (dotted) gneisses are found on 86.94% of the total area, while dacites and andesites make 13.6% of the area in the upper part of the basin.

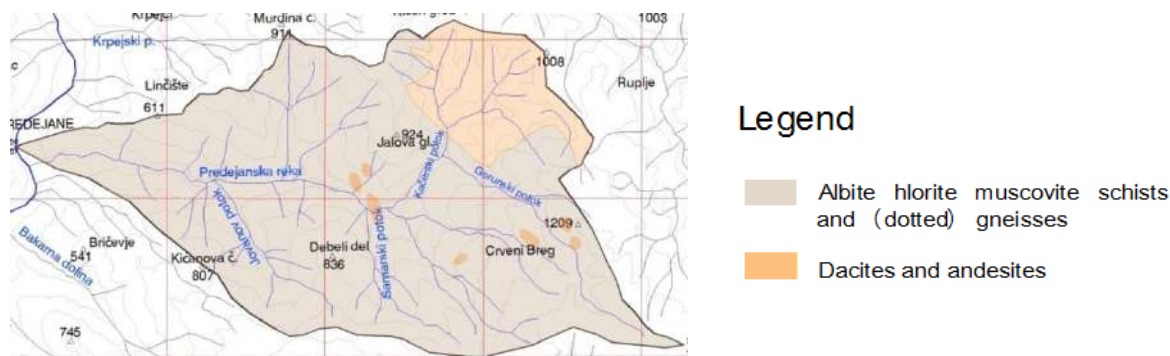


Figure 2. Geological map of the Predejane River basin (Source: Original)

Regarding soil characteristics, it was found that distric cambisol accounts for 19.32 km², or 98.1%, while regosol makes only 2.9% of the total area of the basin (Figure 3). Both types of soil are subject to erosion processes.

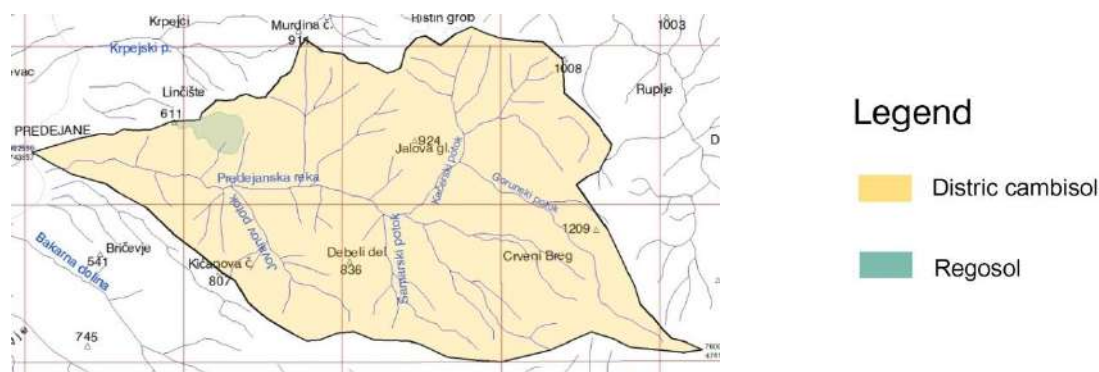


Figure 3. Soil map of the Predejane River basin (Source: Original)

The Predejane River basin is located on the territory of 3 cadastral municipalities. They are characterized by a constant population decline, especially in the CM Crveni breg, located at an altitude of 1083 m (Tables 2 and 3). According to the population projections, Crveni breg will be a depopulated village in 2021 (Penev, 2007). Socio-demographic characteristics of the drainage basin had a significant impact on the development and intensity of erosion processes (Braunović and Ratknić, 2010a).

Table 2. Population statistics by census years

Cadastral municipality	AL masl	Census year							
		1948	1953	1961	1971	1981	1991	2002	2011
Predejane (village)	592	631	528	540	616	508	456	491	401
Predejane	592	469	625	853	857	1217	1434	1222	1086
Crveni breg	1083	400	392	416	287	169	69	30	13
Total		1500	1545	1809	1760	1894	1959	1743	1500

Source: Original

The basin covers 94 homogeneous plots within which the following productive and unproductive areas were distinguished: arable fields, meadows, pastures, settlements, road network, alluvium (gravel). Land use changes were caused by population migration and agricultural land abandonment. There are now arable fields only in the lower part of the basin, but their surface area has been significantly reduced (Table 4; Figure 4). The abandoned arable fields in the upper parts of the basin have had their vegetation cover recovered, so today there are meadows and pastures and in some parts forests (Braunović, 2011).

Table 3. Population density in the drainage basin of the Predejane River

CM	Area (km ²)	Population density							
		1948	1953	1961	1971	1981	1991	2002	2011
Crveni breg	10.46	38.24	37.48	39.77	27.44	16.16	6.60	2.87	1.24
Predejane	9.28	68.00	56.90	58.19	66.38	54.74	49.14	52.91	43.21
Predejane town	0.52	901.92	1201.92	1640.38	1648.08	2340.38	2757.69	2350.00	2088.46

Source: Original



Figure 4. Map of land use in 2012 (Source: Original)

Table 4. Land use in the drainage basin of the Predejane River in 1953 and 2012

LU	1953		2012	
	Area km ²	%	Area km ²	%
Forests	9.15	46.49	10.95	55.64
Plough land	3.78	19.21	0.95	4.83
Meadows and pastures	5.64	28.66	6.50	33.03
Non-productive area	1.11	5.64	1.28	6.50
Total	19.68	100.00	19.68	100.00

Source: Original

Regarding the distribution of erosion processes in 1953, there were processes of excessive (48.77%), intensive (13.38%) and medium (37.84%) erosion in the basin. On the other hand, the erosion processes were intensive (1.63%), medium (6.95%), weak (48.67%) and very weak (33.50%) in 2012 (Braunović, 2013). Based on Z_{mean} in 1953, the basin was generally

affected by intensive erosion processes ($Z_{\text{mean}} -0.93$), but after performing minor erosion control works the basin had the processes of weak erosion ($Z_{\text{mean}} - 0.23$). However, despite the low values of Z_{mean} in 2012, it was observed that the basin still had the erosion processes caused by poor maintenance of technical structures in the riverbed and inappropriate management of the forest plantations which were established in order to mitigate the erosion processes.

The basin was rehabilitated by performing technical and biological works (Table 8). 9 dams were built of stone in cement mortar, and reforestation was done with Austrian pine (bench terraces and pits). The required technical works in the basin have not been completely conducted. Therefore, the Predejane River, regardless of the general state of erosion in the basin, still poses a potential danger. This has been aggravated by the small scale of the reforestation conducted in the basin (only about 5% of the basin area). Furthermore, the applied forest management does not take into account that these are special-purpose forests. This has caused the occurrence of small erosion loci in the area that was considered to be rehabilitated.

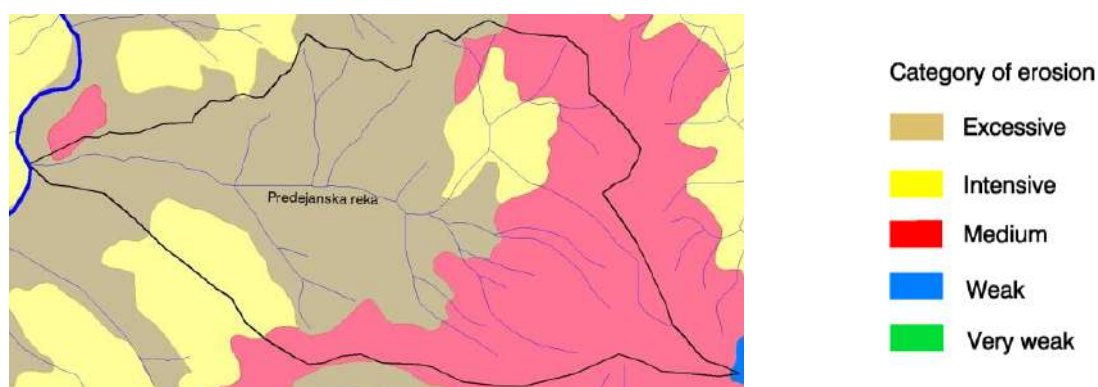


Figure 5. Map of erosion in 1953 (Source: Original)

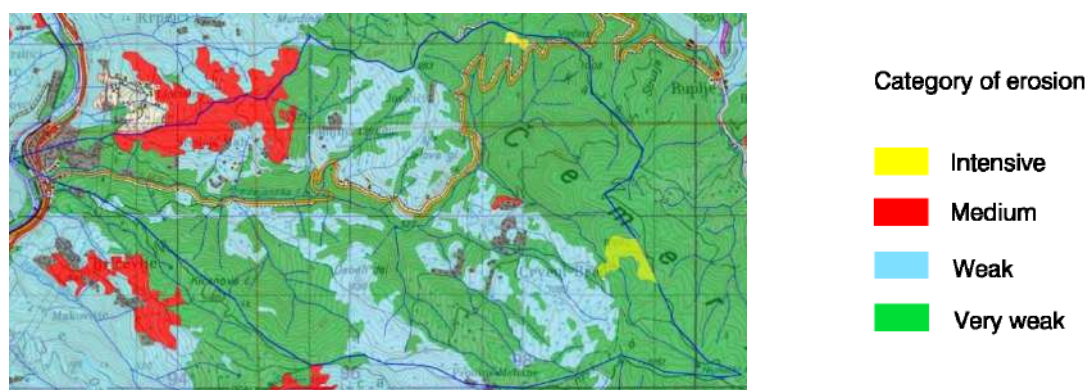


Figure 6. Map of erosion in 2012 (Source: Original)

Table 7. Areas by the intensity of erosion in 1953 and 2012

Erosion category											
I	II	III	IV	V	Z_{mean}	I	II	III	IV	V	Z_{sr}
1956						2012					
9.55	2.62	7.41	0.00	0.00	0.93	0	0.32	1.36	9.53	6.56	0.26

Source: Original

Table 8. Erosion control works conducted in the basin



Number of objects	Excavation (m ³)	Wall m ³)	Reforestation (ha)	Grassing (ha)
9	1940	1390	92,0	63,0

Source: Jelić, B. (1978)

Conclusions

In order to improve the methods of controlling water erosion and torrential floods, this study deals with the effects of conducted erosion control works and their impact on the state of erosion, through a comparative analysis of the situation in the Predejane River drainage basin in 1953 and in 2012.

The natural characteristics of the area are favorable for the development of erosion processes (climate, topography, soil, bedrock, developed hydrographic network).

The intensity of erosion registered in 2012 was primarily the result of the active fight against erosion and the changes in social and demographic factors that caused changes in land use. Positive changes affected the uppermost parts of the basin (the slopes of Kačer, Čemernik and Crveni Breg), areas further away from settlements, where the erosion control works were actually performed.

The land use changes registered in the observation period, along with other factors, contributed to the decrease in the intensity of erosion processes in the Predejane River basin. The Predejane River, regardless of the general state of erosion in the basin registered in 2012, still poses a potential threat. Technical works in the basin have not been completely carried out, the structures are not maintained and the scope of reforestation in the basin is small (only about 5% of the basin). The applied forest management contributes to the recurrence of erosion processes in the areas that have been rehabilitated. This requires continued monitoring of the changes in the erosion processes in the basin, because of the potential risk of torrential floods affecting the lower part of the basin (Predejane village and Predejane town) and the road infrastructure.

Acknowledgement

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