



**SETOF**

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

# **Presentation of the analysis of soil degradation/soil erosion state and torrential floods in Serbia**

## **Authors:**

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Reference Number: 598403-EPP-1-2018-1-RS-EPPKA2-CBHE-JP

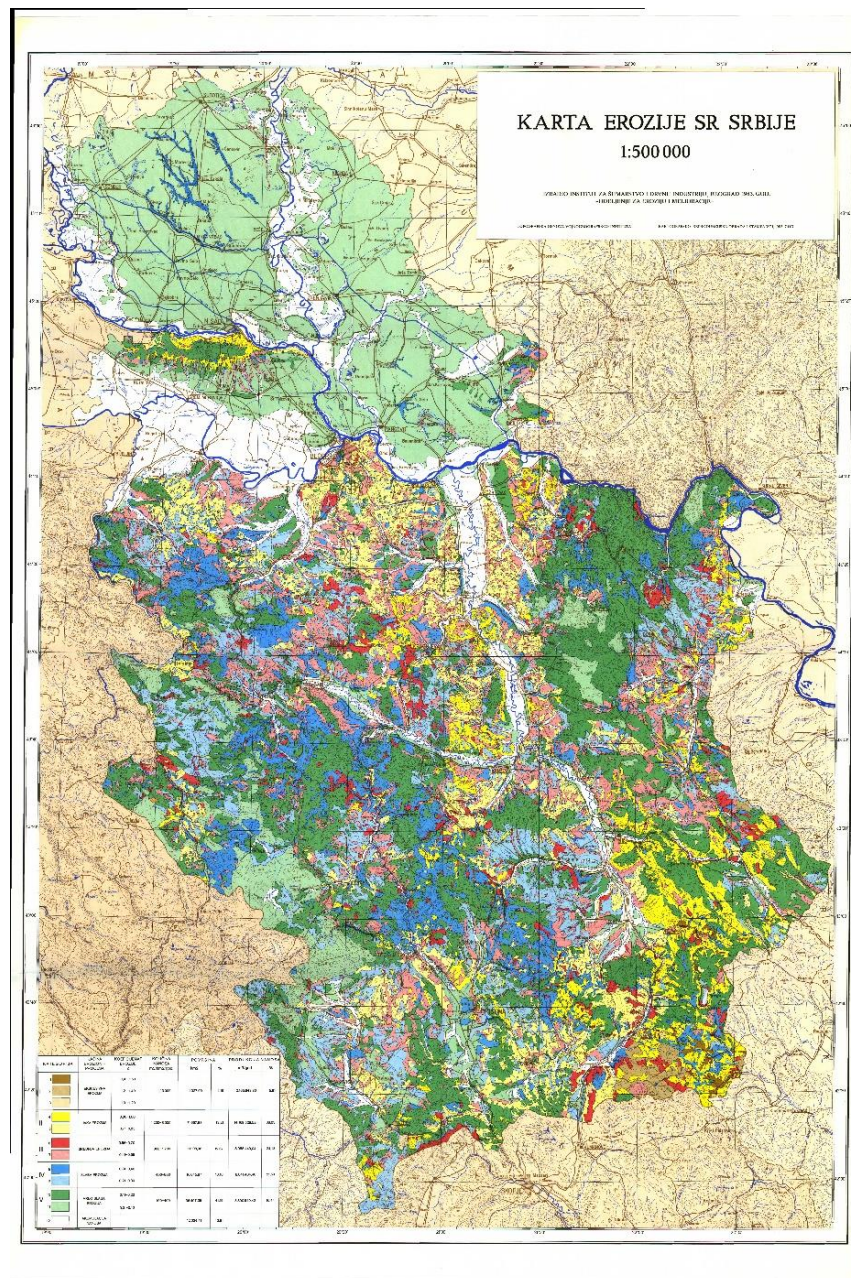
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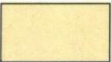

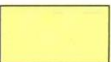



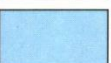

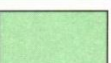

**Soil  
Erosion  
map of  
Serbia**



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CATEGORY	EROSION PROCESSES INTENSITY	COEFICIENT OF EROSION Z	SPECIFIC SEDIMENT YIELD $m^3 \cdot km^{-2} \cdot god^{-1}$	SURFACE AREA		SEDIMENT YIELD	
				km <sup>2</sup>	%	m <sup>3</sup> ·god <sup>-1</sup>	%
I	1 	1,41-1,50	≥ 3.000	1.027,00	1,16	2.165.643,30	5,81
	2 	1,21-1,40					
	3 	1,01-1,20					
II	4 	0,86-1,00	1.200-3.000	11.657,83	13,21	14.169.528,52	38,03
	5 	0,71-0,85					
III	6 	0,56-0,70	800-1.200	11.198,98	12,67	8.988.449,04	24,13
	7 	0,41-0,55					
IV	8 	0,31-0,40	400-800	16.045,87	18,16	8.041.404,46	21,59
	9 	0,21-0,30					
V	10 	0,11-0,20	100-400	36.407,35	41,19	3.890.949,42	10,44
	11 	0,01-0,10					
12		ACCUMULATION OF SEDIMENT		12.024,41	13,61		





Category	Erosion Processes Intensity	Area	
		km <sup>2</sup>	%
I	Excessive Erosion	2,888.0	3.27
II	Intensive Erosion	9,138.0	10.34
III	Medium Erosion	19,386.0	21.94
IV	Weak Erosion	43,914.0	49.78
V	Very weak Erosion	13,035.0	14.75
Total		88,361.0	100



# Krupanj, 2014.



# Krupanj, 2014.



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# Krupanj, 2014.



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# Uncontrolled forest harvesting

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# Consequence of mismanagement: appearance of furrows (Stara Planina, 2004., public forest)



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# Zlatibor mountain (Ljubiš, 2004)



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# Road erosion-the village of Kumane (1999)



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# Bad farming (straight rows, down the slope)



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# Degraded pastures on the slopes of Stara Planina



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# The confluence of a stream into the Danube river



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# Stara planina – July 2007.



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# Stara planina – August 2007.



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# Stara planina – September 2007.



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# September 2007



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## **Ski run Konjarnik 1 before (2007) and after restoration (2014)**



**(2007)**



**(2014)**



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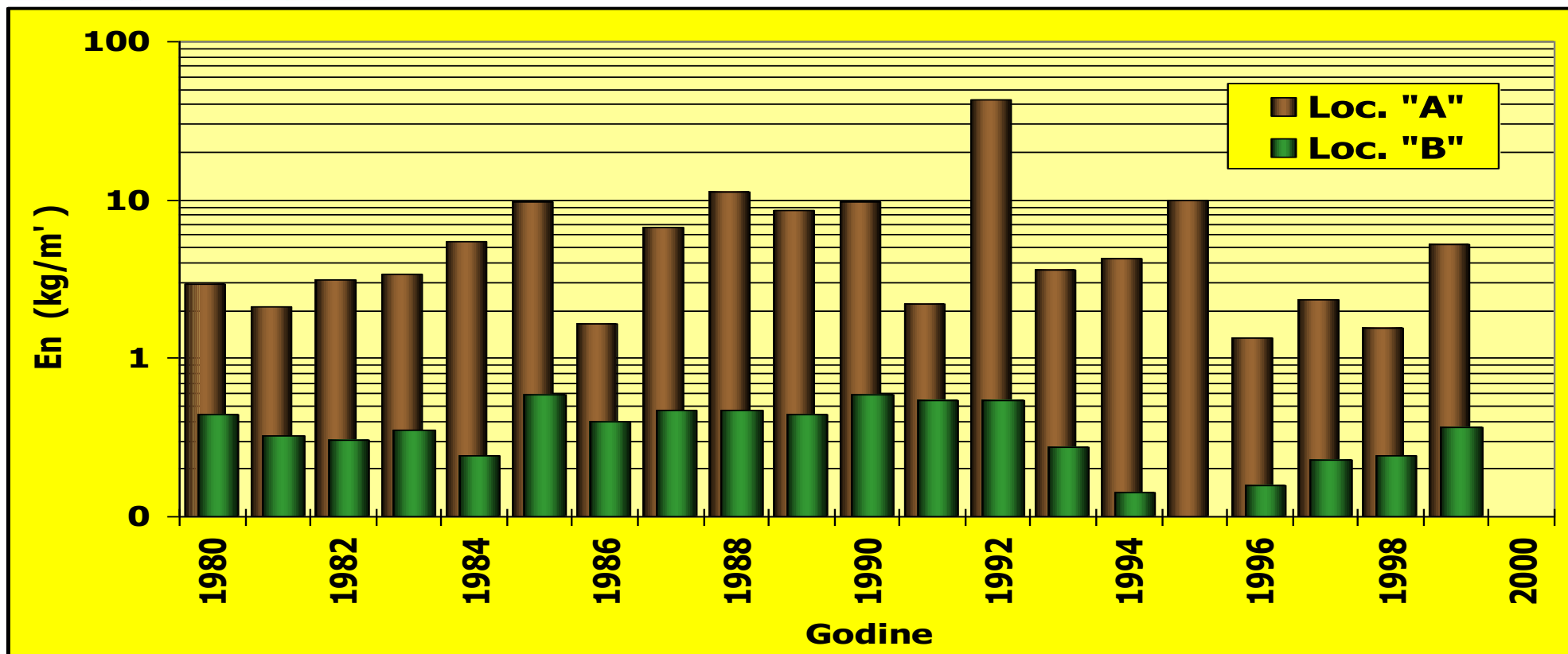


# Effect of forest belts on intensity of wind erosion

(Savić, Letić, 2003)



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<b>En "A" (without pfb)</b>	<b>1.3 – 43.2 (mean: 6.9 kg/m²)</b>
<b>En "B" (with pfb)</b>	<b>0.1 – 0.6 (mean: 0.36 kg/m²)</b>
<b>En "A"/En "B"</b>	<b>4 – 98 (mean: ~ 20 times)</b>



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# Drying (dieback) of *Picea abies*, mountain Golija, Serbia

Photo: prof. dr Branislav Milanović





# Drying of *Picea abies*, mountain Golija, Serbia (67.000 m<sup>3</sup>)

Photo: prof. dr Branislav Milanović



# Clear cutting in private forest (Arilje, Serbia, 2017.)



# Forest fires in Serbia







# Forest fires in Serbia





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# Forest fires in Serbia

**2012-2016:**

316 events, 8075 ha

## Causes:

- thunder, 15;
- man-induced, 158;
- unknown, 143



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**Krupanj, May 2014.**



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**Tekija,  
September  
2014.**



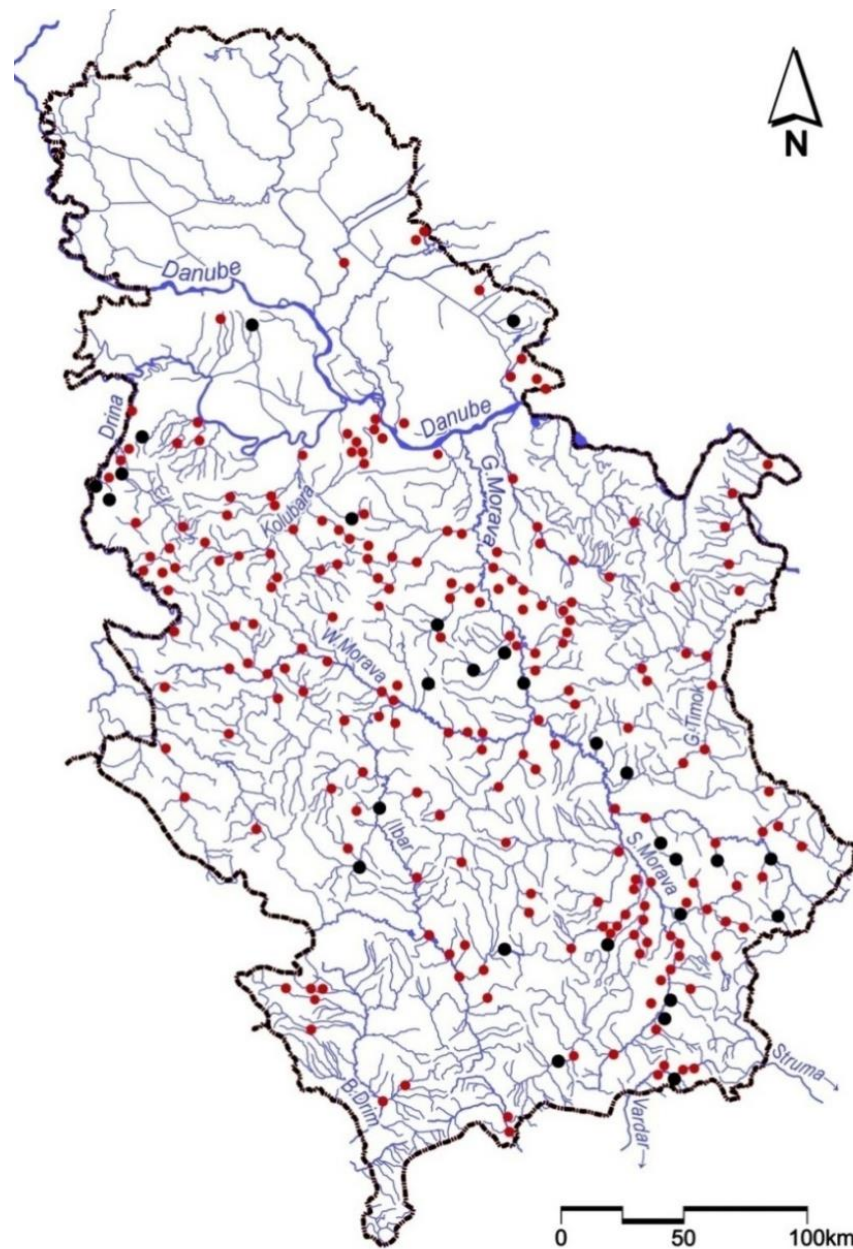
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- - material damage and loss of human lives;
- - material damage

*Torrential floods have caused death of more than 130 people in the last 64 years and material damage estimated at more than 10 billion euros.*



**Spatial disposition of the most destructive torrential floods in Serbia from 1950 to 2018**





# Bad maintaining of regulated streams (Boleč, 2004)



# Damaged check dam (Ibarska Gorge, 2011)

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# Illegal construction (Vladičin Han, 2011)







## Illegal building (Sopot, 2004).



# Loznica (May 2014)

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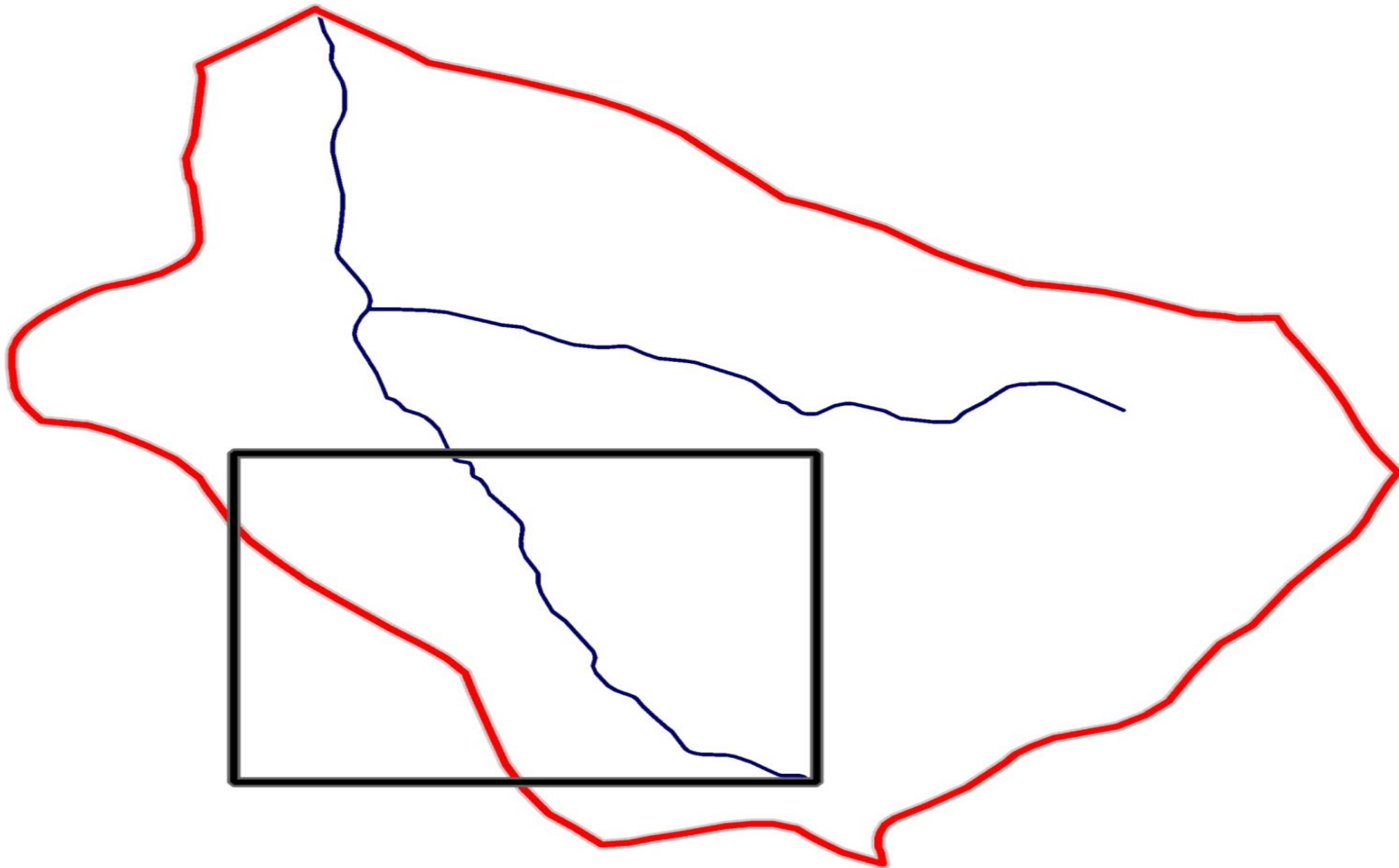


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# Illegal urbanization (Jelezovac stream watershed)



# An aerial photo of a part of Jelezovac watershed (2003)

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# An aerial photo of a part of Jelezovac watershed (2010)

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# Torrential floods-man made or natural hazards?

## Natural conditions (out of man control)

### Climate

-frequent appearance of intensive rain events; coincidence of snow melting and heavy rains...

### Physical characteristics of the watersheds

-shape, slopes, density of drainage system...

### Geology

-Porosity of rocks; filtration velocity...



# Torrential floods-man made or natural hazards?

## Forestry

- clear cuttings on slopes and transport of timber...

## -Agriculture

- straight row farming down the slope; overgrazing on slopes; usage of annual crops...

## Urbanization

- increase of impervious surfaces (residential building; dense network of roads without structures for evacuation of surface water; unsustainable solutions in spatial planning...)



# Check-dam and regulation (1938)

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# Stone masonry check-dam (2002)

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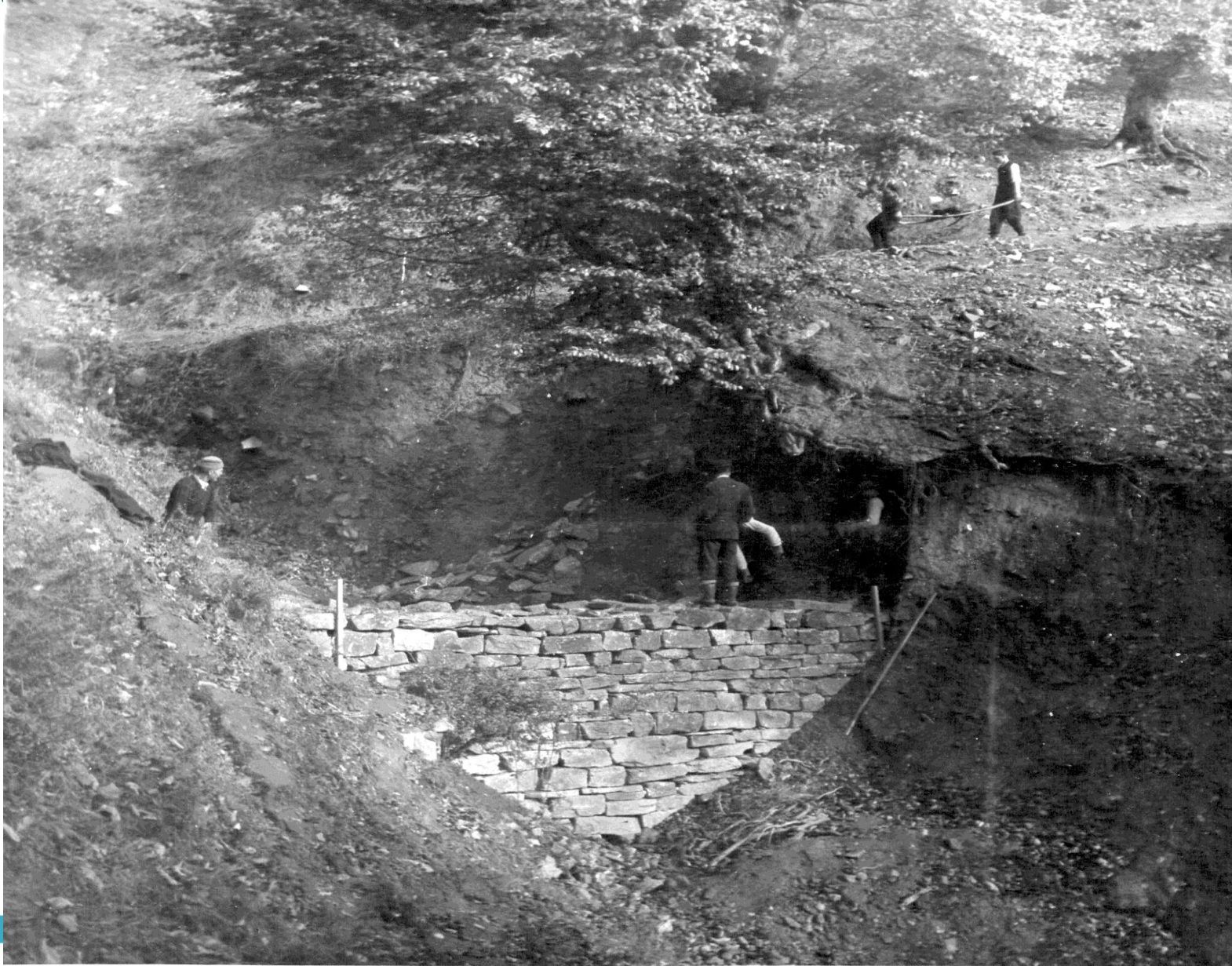


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## Gabion check-dam (2008)



# Construction of the dry laid masonry check-dam (1946)





## Dry laid masonry check-dams



# The system of wattlings in the gully (1949)



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# Contour wattling (1949)



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# The system of dry laid masonry check-dams in the gully (1949)



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# System of wattlings with stone fill (willow stakes and branches) - 2012



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# Double wattling with stone fill (2012)



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# Afforestation with *Robinia pseudoacacia* (1953)



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# Grassed terraces with ditches (1954)

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# Paving of terrace with turf (1954)

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# Newly established grass cover in the orchard on terrace (1955)



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# Contour ditches in combination with fruit trees (1956)



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# Contour ditches with pools (1956)



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# Contour ditches with water in the pools, after heavy rain (1957)



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## Orchards on terraces (1995)



# The Kalimanska river headwater (1953)



# The Kalimanska river headwater (1983)



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# The effects of restoration

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## Changes of hydrological conditions

- Improvement of interception effect and water storage capacity of soil
- Balancing the runoff regime (increased low flow, reduced potential for fast surface runoff forming)



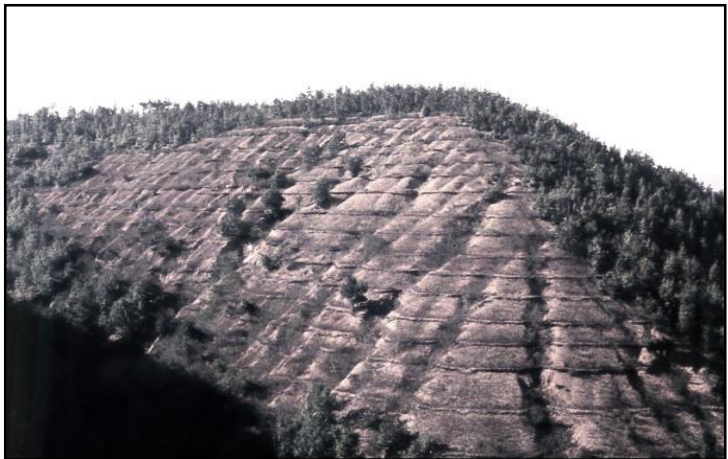
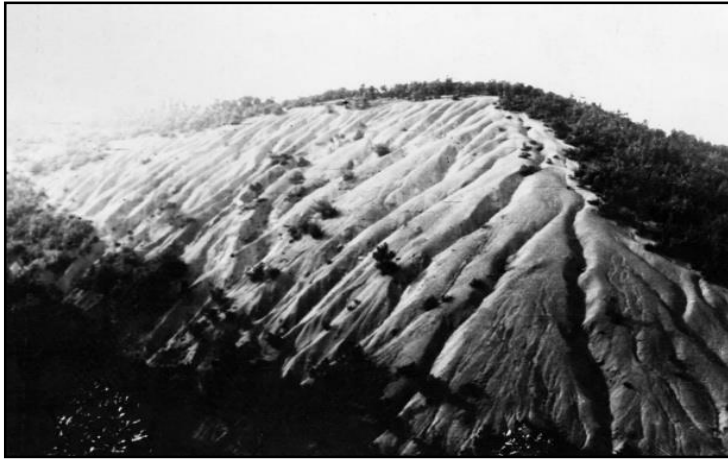
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# Afforestation of bare land (1953-2001)



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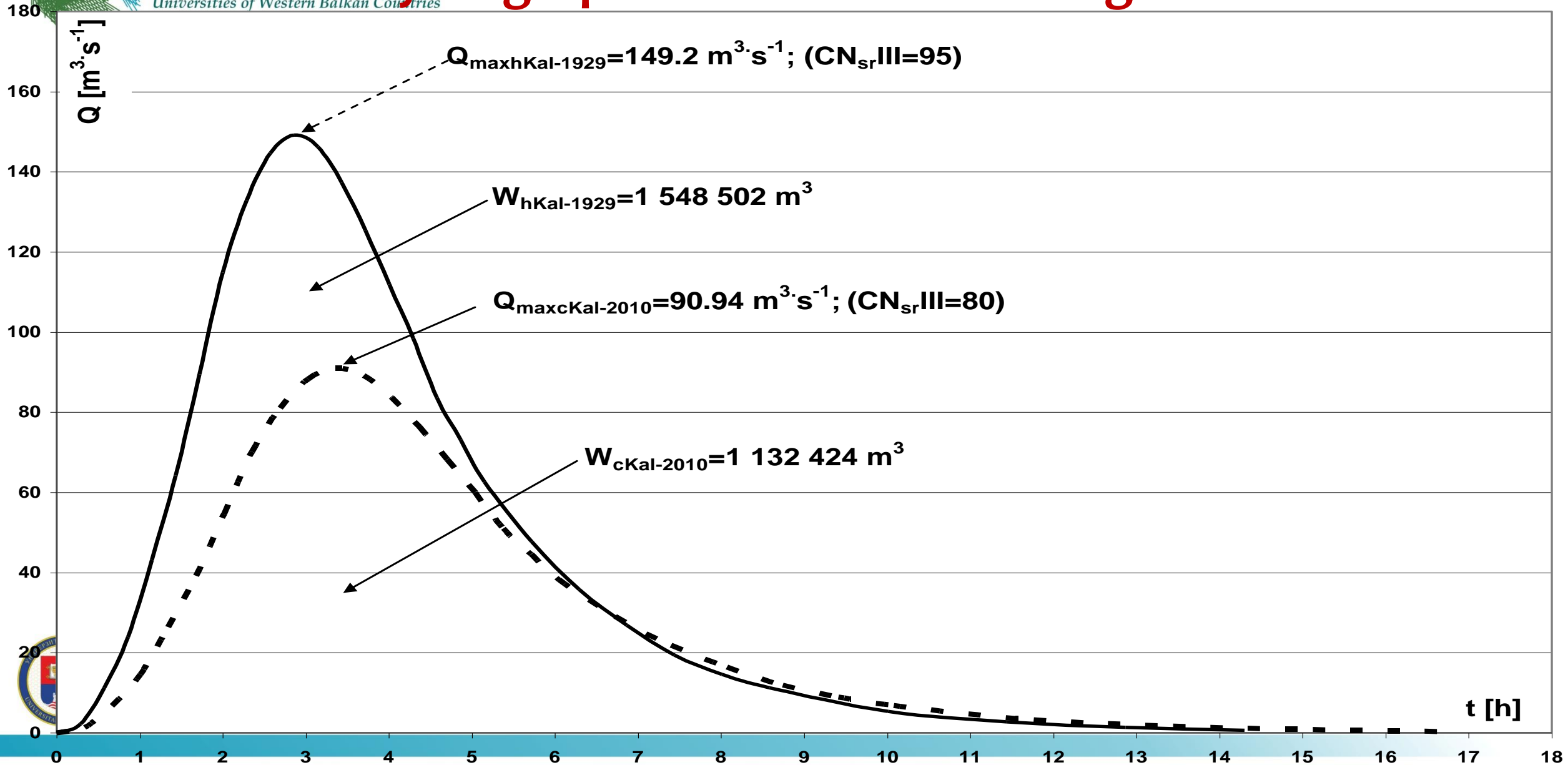


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# Afforestation of bare land (1953-2001)



# Historical (1929) and calculated (2015) hydrographs of maximal discharges



# The effects of restoration



1953



2015

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## Water Resources Management Plan

- **90** mil. euros per year (both river and torrential floods) in next 10 years

**In total: 900 mil. Euros**

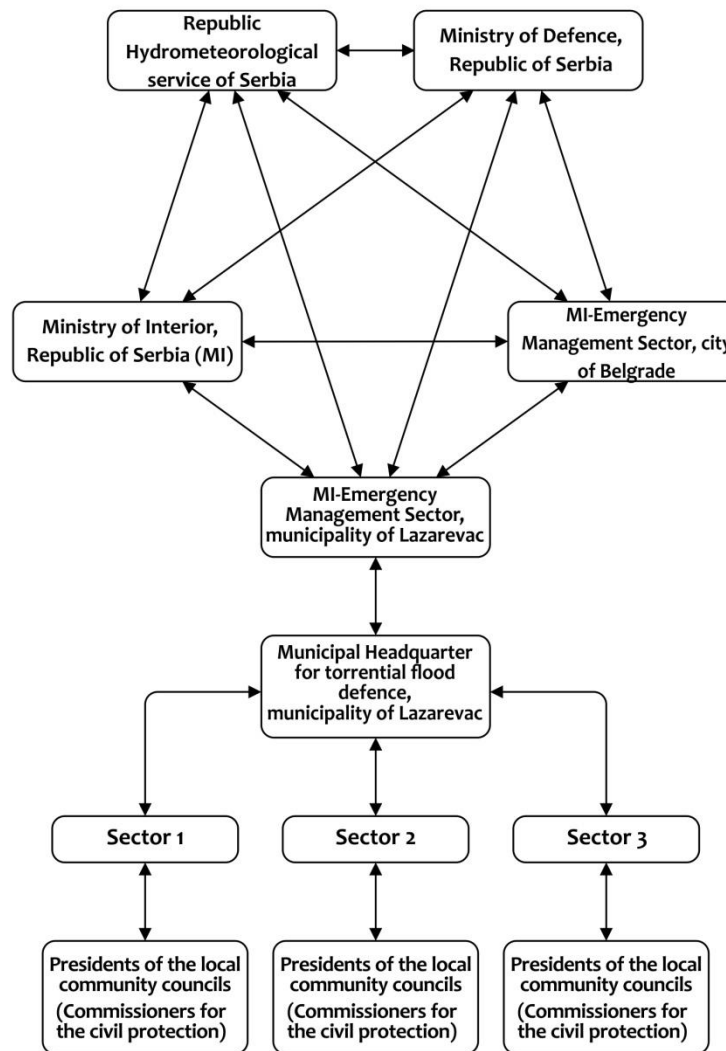
- **30** mil. euros per year for prevention of torrential floods (technical and soil engineering works) in next 10 years

**In total: 300 mil. Euros**



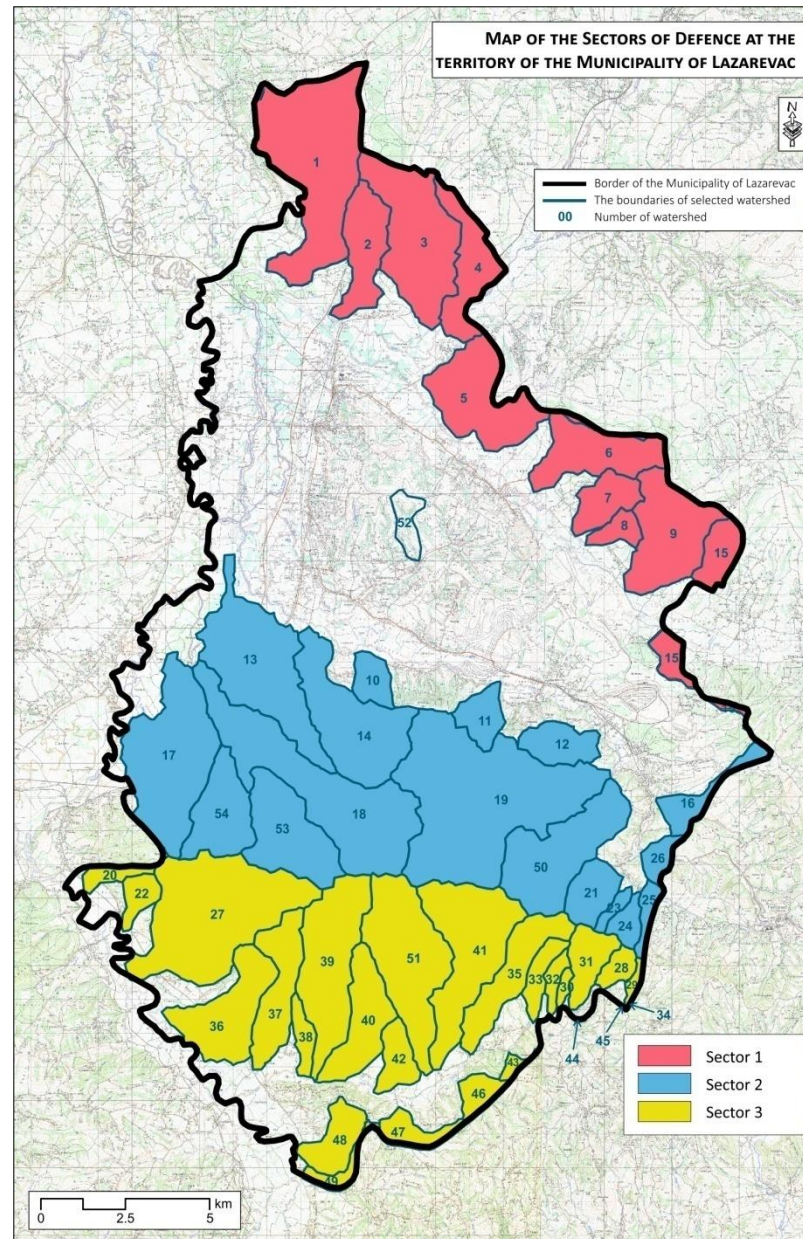


### TORRENTIAL FLOOD DEFENCE ORGANIZATION SCHEME





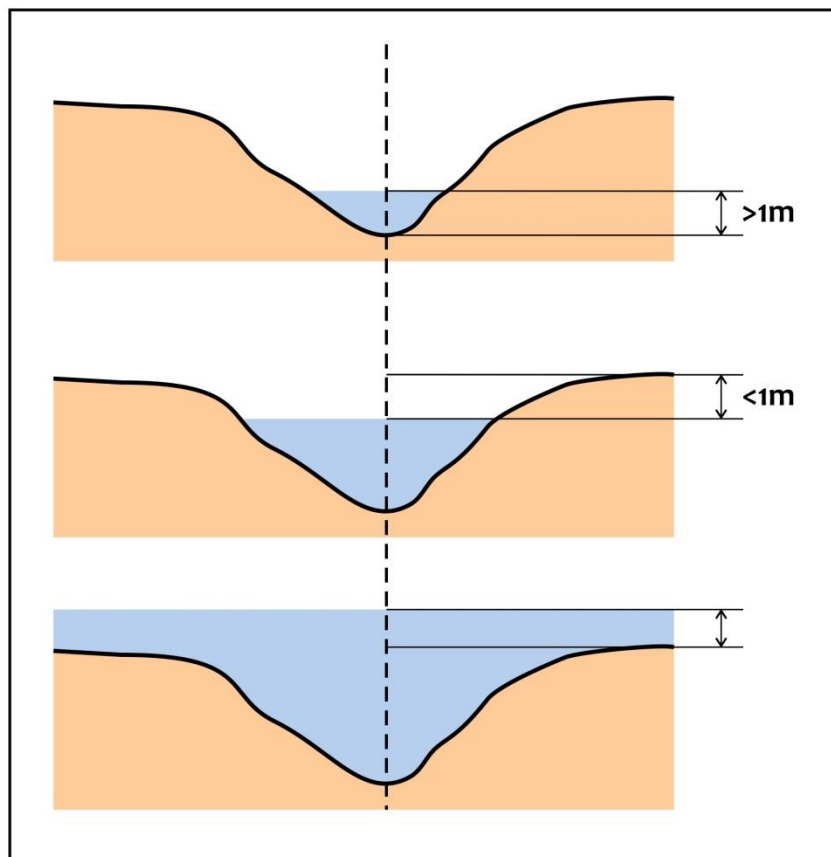
# Soil Erosion and TOrrontial Flood Prevention: Curriculum Development at the Universities of Western Balkan Countries



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CRITERIA FOR THE ANNOUNCEMENT OF THE FLOOD DEFENCE MEASURES



**Criteria 1** - for the announcement of the regular measures for flood defence: the water level is 1 m above the bottom of the streambed

**Criteria 2** - for the announcement of the emergency flood defence: the water level is less than 1 m lower than the streamside level

**Criteria 3** - for the announcement of the state of emergency for flood defence: the water level exceeds the streamside level, which leads to the flooding of the riparian area



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## **Estimated value for ETCW on the territory of municipality Lazarevac (382 km<sup>2</sup>)**

**11.460.000 € (30.000 €/km<sup>2</sup>)**



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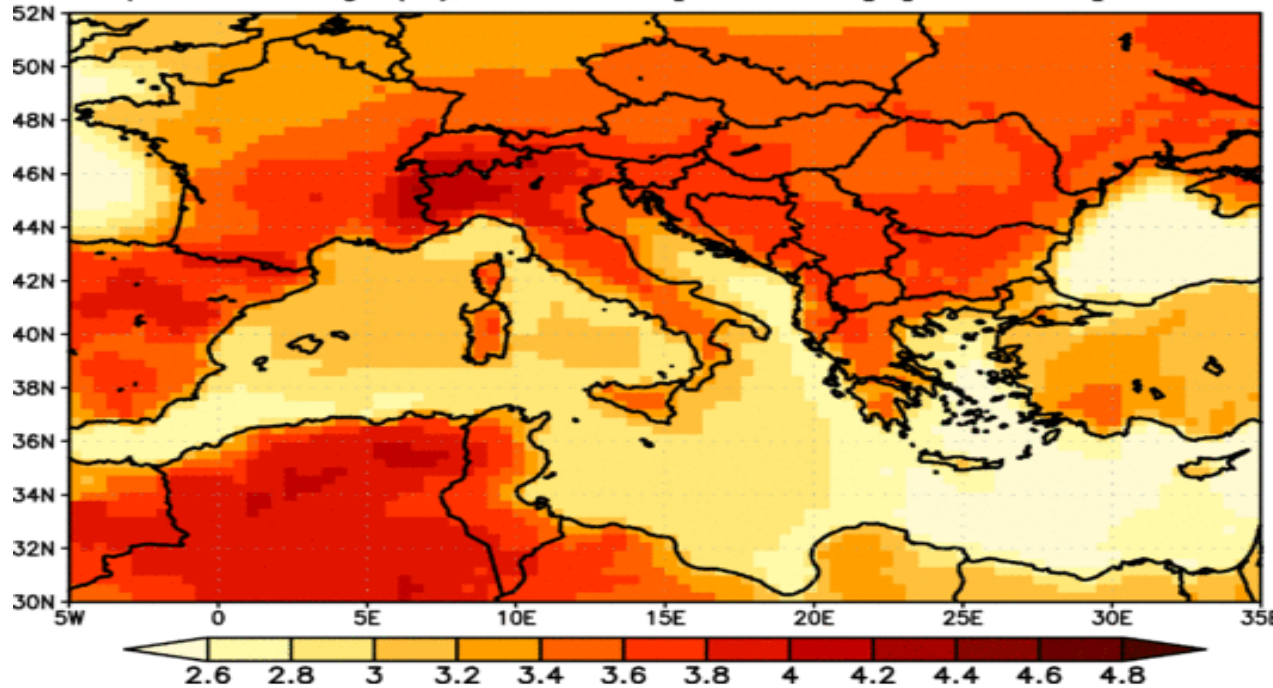




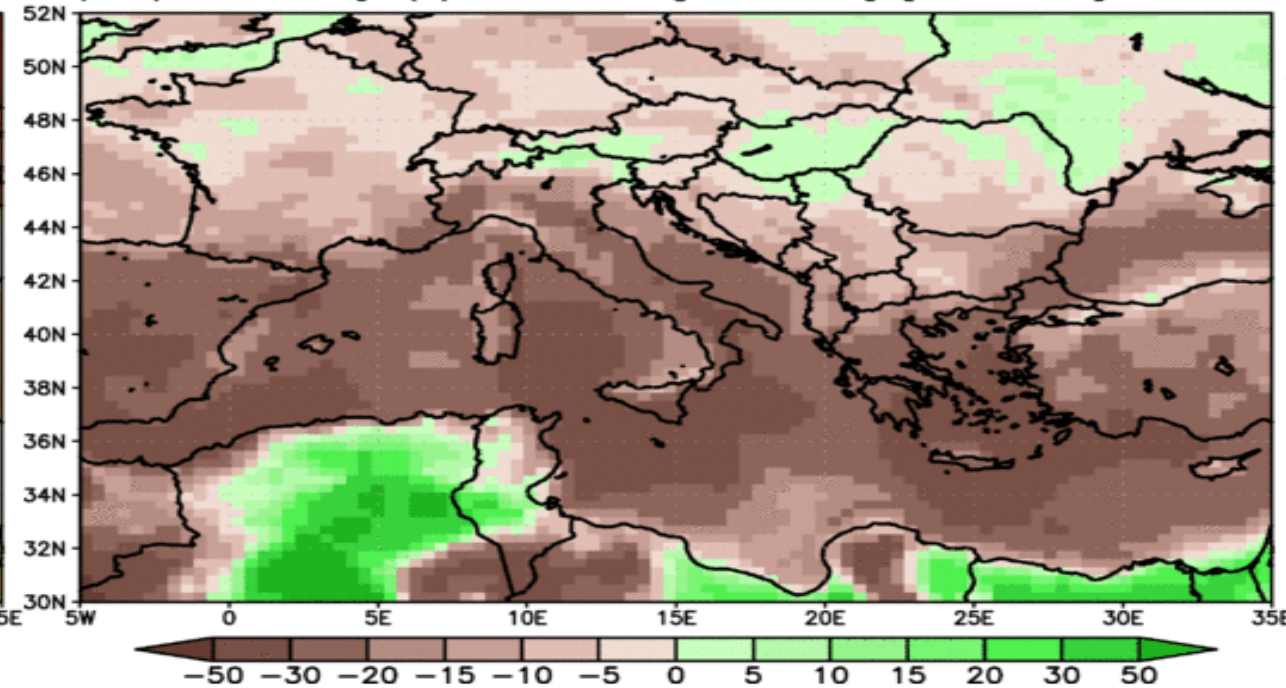
## Temperature and precipitation annual change for period 2071-2100 according to A2 scenario.

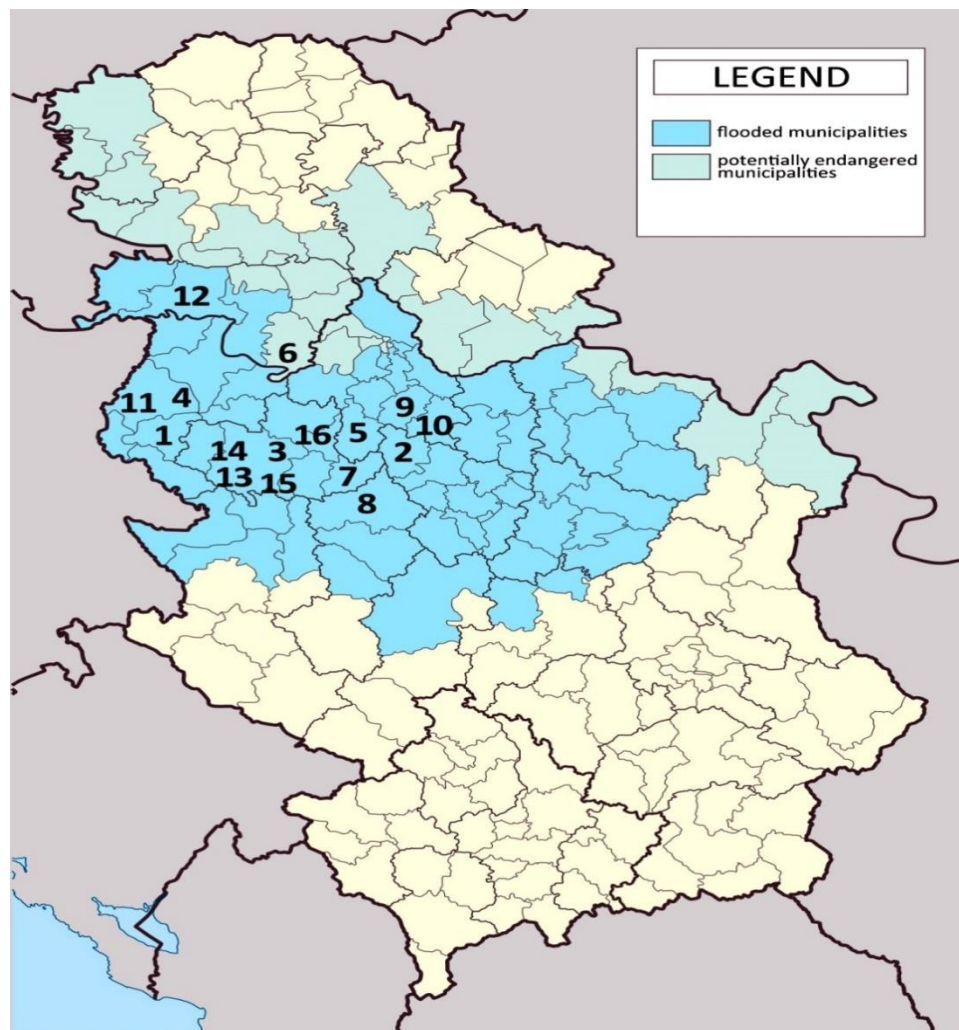
Regional climatic model Djurdjevic (SEEVECCC), University of Belgrade

temperature change (°C), ann season [2071–2100]–[1961–1990] :: a2



precipitation change (%), ann season [2071–2100]–[1961–1990] :: a2





	24h max [mm]	72h max [mm]
<b>1 (Planina)</b>	218	428
<b>2 (G.Crnuće)</b>	150.2	300.2
<b>3 (Razbojište)</b>	190	350
<b>4 (Joševa)</b>	174.1	295.1
<b>5 (Stepojevac)</b>	185.1	293.5
<b>6 (Kupinovo)</b>	140	219.4
<b>7 (Rudnik)</b>	153	277
<b>8 (G.Banjani)</b>	153.3	365.9
<b>9 (Pinosava)</b>	129	217.4
<b>10 (Koviona)</b>	140.6	201.2
<b>11 (B.Koviljača)</b>	168.2	219.5
<b>12 (S.Mitrovica)</b>	132.1	203.7
<b>13 (Brežde)</b>	148.5	251
<b>14 (Majinović)</b>	172.3	312.6
<b>15 (Struganik)</b>	158.1	269
<b>16 (Rudovci)</b>	160	241.3





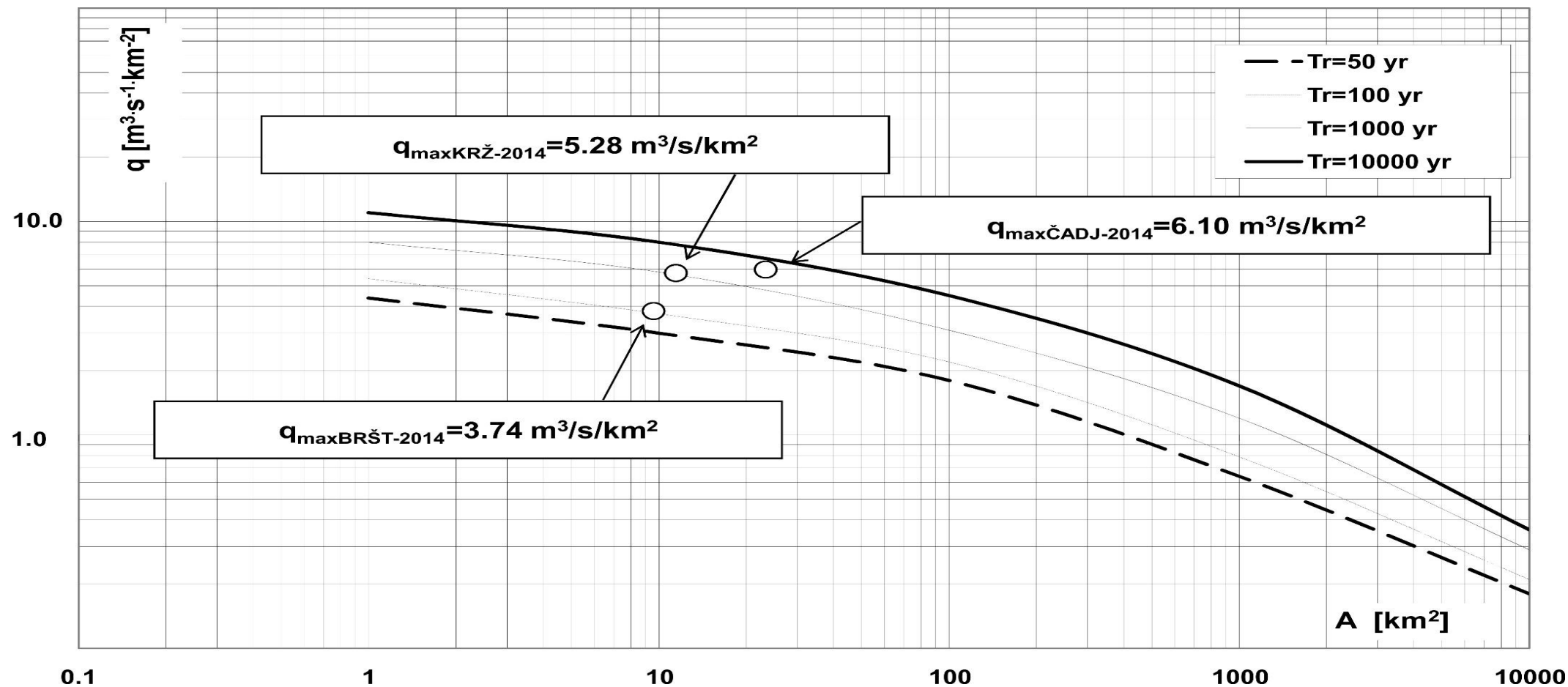
## Historical maximums of daily precipitation in the Belgrade region

Rain gauge station	Period of monitoring (year)	Daily maximum of precipitation until the end of 2013. [mm]	Daily maximum of precipitation recorded in May 2014. [mm]
Kalenić	1950-2014	<b>130.6</b> (1985)	124.2
Partizani	1949-2014	107.5	<b>160</b>
Stepojevac	1949-2014	133.6 (1974)	<b>185.1</b>
Sopot	1949-2014	94.2	<b>124</b>
Sibnica	1949-2014	83.6	<b>182.5</b>
Lazarevac	1941-2014	<b>173.6</b> (1996)	163.2
Velika Ivanča	1953-2014	75 (1999)	<b>76</b>
Dudovica	1950-2013	<b>91</b> (1996)	/
Rudovci	1951-2014	80.4	<b>160</b>





## Anvelopes of specific maximal discharge





- In the last 15 years, the frequency of occurrence and destructivity of torrential floods indicate that it is necessary to achieve a higher degree of coordination among different activities related to the problems of erosion control and torrential floods.
- In addition, it is necessary to provide stable sources of funding, with long-term investments as the only way to achieve prevention and minimize risks.





- **Integrated ETC management in torrential watersheds encompasses technical works in a hydrographic network and soil bioengineering works, especially afforestation on the slopes, within a precisely defined social, administrative and spatial framework;**
- **The main goals are: to achieve maximum security for people and their property; to be complementary with other demands such as environmental protection, sustainable soil usage, drinking water supply, local economic development, biodiversity sustaining and mitigation of climate changes effects (UNFCCC, UNCCD, LDN, SDG).**





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