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Morphometric analysis of debris flow basin of Harsovska river (Southwest Rila, Bulgaria)

Морфометричен анализ на селеви потоци в басейна на река Хърсовска (Югозападна Рила, България)

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Abstract. The analysis of morphometric properties of a river basin and identification of the correlation between the specific topography and the processes of debris flow is crucial for identifying the areas with a high ecological risk. Results of the fieldwork and analysis in the GIS environment show the high risk of debris flow for the Harsovska river basin.

Keywords: Southwest Rila, debris flow, morphometric analysis, catchments.

Introduction

Harsovska river as part of the Struma river basin has been characterized by repeated debris flow occurrences. The latest most impactful event was a flood on the July 2, 1954 with a 5–6 m flood wave that caused the death of 13 people. Both left and right tributaries of Struma river generate debris flows, which frequently cause deaths and damages to the infrastructure (Kenderova, Vasilev, 1997; Kenderova et al., 2013; Baltakova et al., 2018; Nikolova et al., 2018). Anti-erosion activities for mitigation of the ecological risk are accomplished by strengthening the slopes through afforestation (*Pinus nigra*, *Populus sp.*, *Betula sp.*) and construction of rock-retaining facilities (barrages and counter-barrages) in the 60s and 70s of 20th century and continued in nowadays.

The main purpose of this study is to analyze selected morphometric properties of the Harsovska river basin and to identify the relationship between the specific topography and the processes of debris flow. The following morphometric parameters were considered in this study, to assess the

processes in the river basin: area and shape of the basin, slopes, local elevation range (LER), drainage network length, drainage density, stream frequency, etc.

Study area and methods

The study area is the Harsovska river subbasin (Fig. 1), situated in the Blagoevgradska Bistritsa river basin (Southwest Rila, Bulgaria). The basin has NW-SE direction, which follows the main slope orientation of this part of the Rila Mountain. The Harsovska river basin has an area of 31.44 km² and an elongate, asymmetrical shape with more developed upper part. The source of the river starts from the location of about 1375 m asl and flows into the Blagoevgradska Bistritsa at about 461 m.

For the analysis of morphometric parameters of the river basin, 30 meters STRM digital elevation model (DEM) [USGS, NASA] were used and transformed into 10 m in ArcGIS environment. Topographic maps at a scale 1:50 000 were used for digitalizing the drainage network. Further calculations were executed in GIS environment.

Fig. 1. Map of the study area

Results and discussion

Harsovska river basin is one of the main tributaries of Blagoevgradska Bistritsa. The largest part of the river basin area (79.6%) is developed in height between 700 m and 1200 m, as the average elevation is 902 m, whereas the lowest parts of the basin, up to 500 m are only 17.5% of the territory (Table 1). The mean slope inclination of the basin is 14.83° , whereas more than 76% of the basin has an inclination between 8° and 30° . The area of inflow of the major left tributary – Marulevska river (SSW of Gorno Harsovo village) in Harsovska river is characterized with the highest inclination rates in the river basin ($30\text{--}55^\circ$). The drainage network of the river basin is highly developed, much more than the average, and its average density is 7.49 k/km^2 .

The average local elevation range is relatively high – 223.4 m/km^2 . It is highest in the NE part of the basin, between the Kolov Chukar, Kyorova Chuka, and Beli Vrah peaks where it reaches 407 m/km^2 . The central (between the villages of Parzhovo and Shopovtsi) and northern (due to the flat hill on which Tachovtsi, Stoychovtsi, and Mratvano villages are located) parts of the Harsovska river basin

have the smallest LER. The LER in these areas is between 120 and 220 m/km^2 .

Generally, with a higher LER are the right tributaries ($260\text{--}400 \text{ m/km}^2$), whereas the left ones are characterized with lower values ($190\text{--}230 \text{ m/km}^2$).

The prevailing drainage pattern in the study area is dendritic and in the separate sections of the basin – the parallel type. The connection between the two types is with a mosaic-like relief. This type of river network is formed as a result of parallel flowing rivers on equal resistance-built rock slopes. A tributary with this type of drainage pattern starts from 1150 m, south of the nameless peak (1175.5 m), located between Kolov Chukar and Kyorova Chuka peaks in the right part of the catchment.

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Table 1. Morphometric parameters of the Harsovska river basin

Morphometric properties	Harsovska river
Catchment area (km ²)	31.44
Source of the river (m asl)	1 375
River outflow (m asl)	461
Mean altitude of the basin (m)	902
Mean local elevation range of the basin (m/km ²)	223.4
Mean slope inclination of the basin	14.83°
Length of the basin (km)	11.0
Maximum width of the basin (km)	4.8
Length of the river long profile (km)	12.89
Types of drainage pattern	dendritic, parallel
Drainage network length (km)	235.75
1 st order (km)	153.53
2 nd order (km)	44.48
3 rd order (km)	21.12
4 th order (km)	13.07
5 th order (km)	3.55
Total count of the tributaries	857
Count of 1 st order tributaries	700
Count of 2 nd order tributaries	129
Count of 3 rd order tributaries	23
Count of 4 th order tributaries	4
Count of 5 th order tributaries	1
Mean length of the 1 st order tributaries (km)	0.22
Mean length of the 2 nd order tributaries (km)	0.34
Mean length of the 3 rd order tributaries (km)	0.92
Mean length of the 4 th order tributaries (km)	3.27
Mean length of the 5 th order tributaries (km)	3.55
Drainage density (km/km ²)	7.49
Stream frequency (count/km ²)	27.25

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