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# EXTRACTING THE CURVE-NUMBER MAP OF WATERSHEDS IN GIS

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**Abstract: One of the important factors in establishing water resources for a watershed is determining the amount of runoff resulting from precipitation. This paper is to determine the curve number – CN for the River Barzava basin, located in the western part of Romania. Based on using soils and LULC data in GIS, reflecting spatial heterogeneity in these data across the watershed, it been established CN.**
**Keywords: catchment, curve number, GIS, land cover**

## 1. INTRODUCTION

Surface runoff is an important hydrologic variable used in water resources studies. The rainfall-runoff process is complex. The number of the flow curve (also called a curve number or simply CN) is an empirical parameter used in hydrology to predict direct runoff or infiltration from excess precipitation. It is widely used (Beven, 2012; Vannasy and Nakagoshi, 2016) and is an effective method for determining the approximate amount of direct runoff from a rainfall event in a particular area. CN (Curve Number) is a dimensionless index, which can take values between 0 and 100. CN depends on both the land use and the hydrological group of the soil and reflects the potential for water runoff on different lands.

A Geographic Information System is able to provide various tools for performing complex spatial analysis. Specifically, spatial analysis is defined as the process of manipulating spatial data, in order to extract new information and significance from the original data.

## 2. METHODOLOGY

Sherman (1949) was the first person who suggested the empirical relationship between rainfall and runoff in the form of unit hydrograph. Following these studies, Department "Soil Conservation Service" (1972), devised a method to calculate the losses of the shower (Chaw, 1988). Soils are classified into four HSGs (A, B, C and D) based on infiltration rate.

There are four hydrologic soil groups: A, B, C and D and definition of each is given in Table 1.

**Table 1**. Hydrologic soil groups

| Soil Group Characteristics | Hydrologic Soil Group |
|---|---|
| Soils having high infiltration rates, even when thoroughly wetted and consisting chiefly of deep, well to excessively drained sands or gravels. These soils have a high rate of water transmission. | **A** |
| Soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission. | **B** |
| Soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine texture. These soils have a slow rate of water transmission. | **C** |
| Soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high-water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission. | **D** |

Calculate the curve number (eq. 1) for each drainage basin by area-weighting the land use-soil group polygons within the drainage basin boundaries. The basic equation for curve number calculation is as follows:

$$CN = \frac{\sum_{i=1}^{n}(CN_i \times S_i)}{\sum_{i=1}^{n} S_i} \quad (1)$$

where:

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CN - the area-weighted curve number for the drainage basin.
$CN_i$ - the curve number for each land use-soil group polygon.
$S_i$ = the area for each land use-soil group polygon.
n = the number of land use-soil polygons in each drainage basin.

To standardize the curves, the curve without the dimension of CN number obtains in the range 0 and 100. For impermeable surfaces, CN = 100, and for natural surfaces included CN < 100.

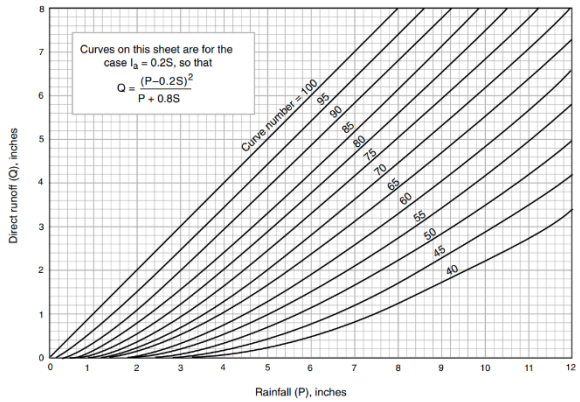


**Figure 1.** SCS runoff equation solution (Soil Preserving Service, 1972)

Watershed curve numbers are estimated based on land use, hydrologic condition, and hydrologic soil group for ungagged watersheds from standard tables (NRCS, 2001).

The nature of the soil affects the rate of increase of floods and their volume. Map with soil types was obtained with the ArcGIS program. The land use map was generated from Landsat ETM+ data from 2006 with a resolution of 30 m.

The Curve number is generated in ArcGIS through the union between the land use, the soil, and the DTM of the basin.

## 3. RESULTS

Banat catchment area is situated in the western part and southwestern part of Romania, and it covers a surface of 18,320 km$^2$ and Barzava River catchment made part of its. The Barzava River (Figure 2) springs from the Semenic Mountains, characterized by a narrow valley, with an average slope of 15 m / km (Figure 4).

Downstream of the confluence with the river Gropos, the river changes its direction of flow to the west of the city of Reșița, the river basin of the river Barzava together with its tributaries has an area of approximately 1202 km2.

Physical and chemical properties of soil, especially texture, and Structure and Soil depth influence disposition of water by way of infiltration, storage and runoff.

The average annual temperature is between 10 - 12 ° C in the plain area, and 3 - 5 ° C in the mountain area. Atmospheric precipitation is unevenly distributed, and the highest discharge occur in April and May, when rainfall was at high level

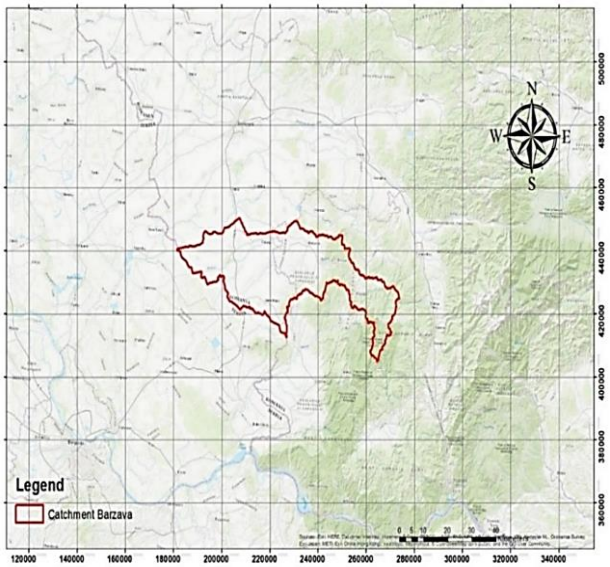


**Figure 2**. The study area - Barzava River Basin

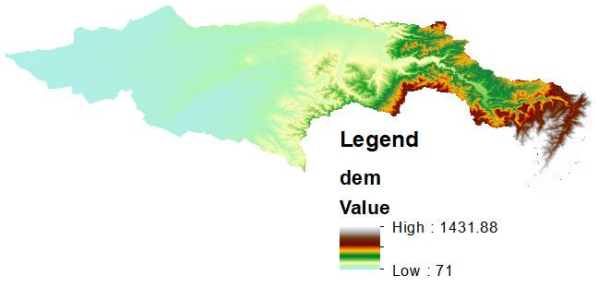


**Figure 3**. DEM map of Barzava River Basin

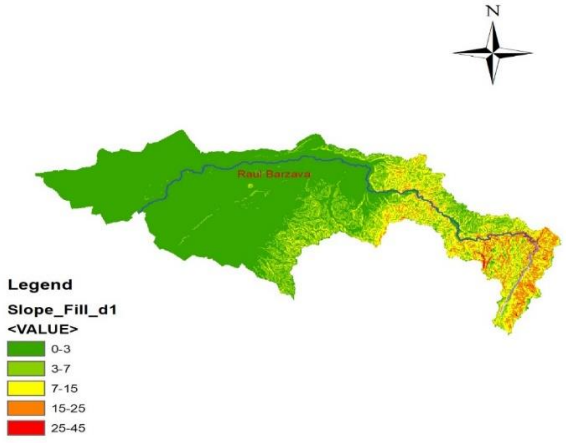


**Figure 4**. The slope map of Barzava River Basin

The number of the flow curve (also called a curve number or simply CN) is an empirical parameter used in hydrology to predict direct runoff or infiltration from excess precipitation.

The number of the drainage curve is based on the hydrological soil group of the area, land use, and hydrological status.

Group A comprises coarsely textured soils, which have the lowest runoff potential, Group B are soils with medium texture, deep soils or with medium depth, well-drained soils, Group C are soils with a layer that prevents the downward movement of water on the

profile and soils with a moderately fine towards fine structure, while group D soils have a fine (clayey) texture, having maximum runoff potential, respectively minimum infiltration.

Corine Land Cover 2006 was used to make the land use / cover map of the Barzava catchment (Figure 5, Figure 6 and Figure 7). The types of soils are varied. On entire Bârzava hygrographic basin, following specialized analyses, there are a variety of brown soils, chernozems, luvisols, gleic soils, etc.

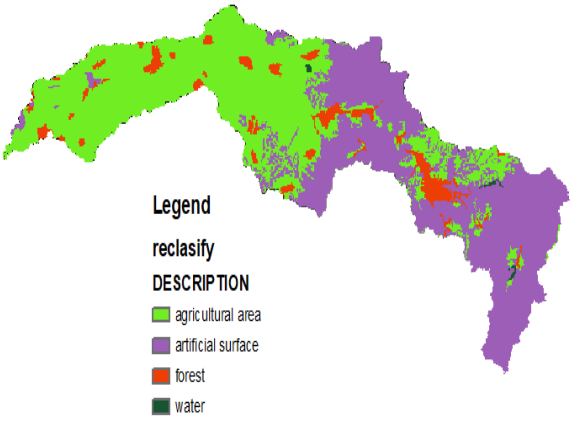


**Figure 5**. The land cover map of River Barzava

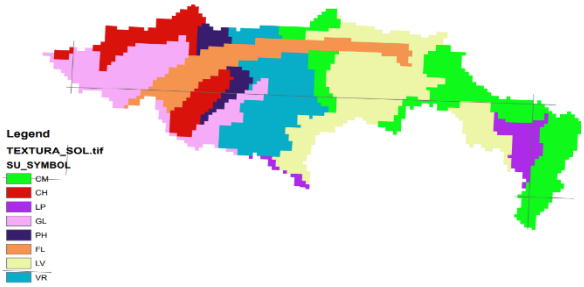


**Figure 6.** The Soil texture of River Barzava

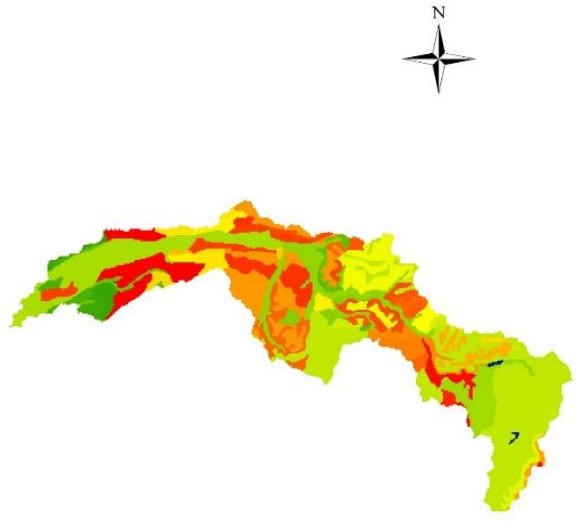



**Figure 7**. The soil map of River Barzava

The land cover is predominated, in the plain part, with non-irrigated arable land and towards the mountains deciduous forests predominate. In the Ghertenis lateral accumulation area, there is a mix between Arab lands and pastures.

The lack of a wooded land and the existence of pronounced slopes cause, in rainy times, runoff from the slopes triggering strong floods and consequently

material damage. Gătaia, Bocșa and Denta more often affected by floods.

Based on the digital terrain model, the necessary layers for export in the HEC-HMS program were created. Concentration time is determined by Kirpich's relationships (2) and (3) based on the characteristics of the basin.

$$Tc = 0.0078\left(\frac{L^{0.77}}{S^{0.385}}\right) \quad (2)$$

$$Tlag = 0.65TC \quad (3)$$

where:
L – represents the length of the riverbed (m);
S – represents the slope %.

**Table 2.** The parameters of catchment area

| T_USDA_TEX | FID_GRUPE_ | Id_1 | gridcode_1 | SoilCode |
|---|---|---|---|---|
| silty clay | 287 | 288 | 13 | D |
| silty clay | 363 | 364 | 3 | D |
| silty clay | 113 | 114 | 4 | D |
| silty clay | 140 | 141 | 4 | D |
| silty clay | 164 | 165 | 4 | D |
| silty clay | 166 | 167 | 4 | D |
| silty clay | 167 | 168 | 4 | D |
| silty clay | 168 | 169 | 4 | D |
| silty clay | 179 | 180 | 4 | D |
| silty clay | 180 | 181 | 4 | D |
| silty clay | 194 | 195 | 4 | D |
| silty clay | 205 | 206 | 4 | D |
| silty clay | 287 | 288 | 13 | D |
| silty clay | 363 | 364 | 3 | D |
| loamy sand | 53 | 54 | 13 | A |
| loamy sand | 62 | 63 | 13 | A |
| loamy sand | 63 | 64 | 13 | A |
| loamy sand | 64 | 65 | 4 | A |
| loamy sand | 65 | 66 | 4 | A |
| loamy sand | 66 | 67 | 4 | A |
| loamy sand | 69 | 70 | 3 | A |
| loamy sand | 77 | 78 | 3 | A |
| loamy sand | 81 | 82 | 13 | A |
| loamy sand | 85 | 86 | 4 | A |
| loamy sand | 102 | 103 | 3 | A |
| loamy sand | 103 | 104 | 4 | A |
| loamy sand | 104 | 105 | 13 | A |

Soil date, land cover and humidity were modelled, resulting the map of CN value for Barzava catchment

(Figure 8). The database on land use characteristics is derived from the Corine Land Cover database, adapted to the requirements of the SCS-CN method implementation.

Land use represents the surface conditions in a drainage basin and is related to the degree of cover. The soil moisture condition in the drainage basin before runoff occurs is another important factor influencing the final CN value. In the Curve Number Method, the soil moisture condition is classified in to three Antecedent Moisture Condition (AMC) Classes:

AMC I: The soils in the drainage basin are practically dry (i.e. the soil moisture content is at wilting point).

AMC II: Average condition.

AMC III: The soils in the drainage basins are practically saturated from antecedent rainfalls (i.e. the soil moisture content is at field capacity).

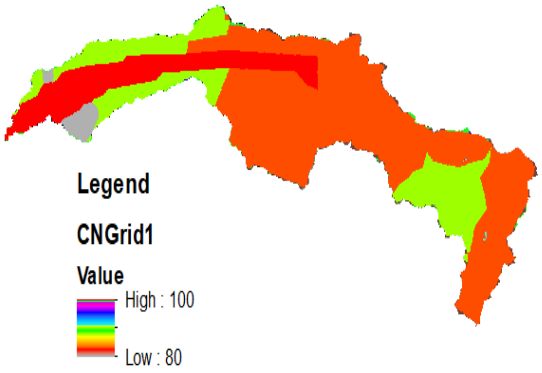


**Figure 8**. The curve number of River Barzava

**Table 3**. CN Look Up

Table

cnlookup1

| Rowid | OBJECTID | FIELD1 | LUVALUE | DESCRIPTION | A | B | C | D |
|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 4 | Water bodies | 10 | 10 | 10 | 10 |
| 2 | 0 | 0 | 1 | Forest and semi natural area | 37 | 60 | 73 | 80 |
| 3 | 0 | 0 | 2 | Agricultural areas | 70 | 80 | 87 | 90 |
| 4 | 0 | 0 | 3 | Artificial surfaces | 61 | 75 | 83 | 87 |

The effects of floods often depend on the time distribution of the runoff, meaning a quantity of precipitation can produce a high flood on certain areas or a minimal flood on other areas of the river basin. In hydrology, this time distribution is determined by estimating the concentration time, which is defined as the time required for water to travel from the farthest point of the water basin to its outlet.

## 4. DISCUSSIONS. CONCLUSIONS

The Digital Elevation Model (DEM) was used, which was processed in the ArcGIS program for the delimitation and capture characteristics of the Barzava river basin. The results from the land pre-processing it was use for extracting the hydrological parameters of the river basin. The determination of the parameter CN (Curve Number) is made according to the characteristics of the basin that generate the runoff such as soil type, land use, soil surface conditions and previous moisture conditions.

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