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VULNERABLE AREAS, THE STREAM POWER INDEX AND THE SOIL CHARACTERISTICS ON THE SOUTHERN SLOPE OF THE LIPOVEI HILLS

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Abstract: The purpose of this study is to calculate SPI (Stream Power Index) in relation with the soil texture and to associate the obtained values with the soil permeability classes and, therefore, to identify the vulnerable areas at the action of the drainage processes, starting by the elementary processes associated with rills erosion and gullys to those ravines and torrential organisms. SPI is the product between the slope and the flow accumulation. SPI values are influenced by the slope. Thus, SPI has high values in areas with high slope and SPI has low values in areas with low slope. In the areas with the high slope, the flow accumulation is low and in the areas with the low slope, the flow accumulation is high. The high values of SPI between +1.94 and +3.49 are on the southern slope of the Lipovei Hills and represent 41.05% of the analyzed area. The inclusion of the soil texture in the SPI calculation formula indicates a medium value of SPI also on the southern slope of the Lipovei Hills and represent 42.71% from the studied territory, which corresponds, in particular, to the loamy texture. The loamy texture has moderate permeability and it is characteristic on 22.81% from the southern slope of the Lipovei Hills. Therefore, the southern slope of the Lipovei Hills is affected by the moderate ravine phenomenon and at the contact with the Timiș-Bega Plain the floods and the puddles phenomenon develops.

Keywords: Stream Power Index, slope, soil erosion, soil texture, soil permeability, Lipovei Hills, Romania.

1. INTRODUCTION

Soil erosion is one of the most critical natural hazards in very different environmental conditions, the soil being one of the most vulnerable environmental components. This complex phenomenon involve the detachment and the transport of the soil partcles, storage and runoff of rainwater, and infiltration (Römkens et al., 2002).

Over time, many mathematical expressions have been developed to quantify and to predict soil erosion, such as USLE, RUSLE, WEPP, SWAT etc. But SPI (Stream Power Index) measures the erosion power of runoff and can be used to identify the potential for the drainage processes and the gully erosion (Moore et al., 1991).

SPI are related the time rate of energy expenditure, calculate the spatial distribution of the sediment transport capacity an it computes the spatial distribution of soil loss potential, the erosive power of the flowing water (Sharma, 2010). In fact, SPI is a significant parameter which allows the identification of the gully erosion vulnerability.

SPI shows that the erosion power of runoff is high on the convex slopes, and the flow accumulation occurs at the base of the convex slopes and on the concave slopes (Wilson & Lorang, 2000). SPI is a secondary attribute obtained from two main attributes: the flow accumulation and the slope.

However, over time, the mathematical expression of SPI had many calculation variants, from the most complex to the simplest. Thus, Moore et al., 1991, and, then, Moore & Wilson, 1992, suggest the calculation formula (1) for SPI.

$$\Omega = As * \tan\beta \qquad (1)$$

where As represents the flow accumulation (m^2 / m) and β is the slope (degrees).

Due to the fact that the runoff power represents the ability of running water to create geomorphological processes, Howard & Kerby (1983) consider the main variables involved to be the slope, the flow accumulation and the lithology and propose the calculation formula (2) for SPI:

$$E = KA^{m}S^{n} \qquad (2)$$

where E represents the erosion rate, the variable K is an erosion coefficient (Whipple, 2001), A represents the flow accumulation and S is the slope.

Howard & Kerby (1983) in a study on the Badlands Virginian determine the value of the exponents m = ≈ 1/3 and n = ≈ 2/3, but Stock & Montgomery (1999) showed that the values m and n are not universally available. Subsequently, Seidl & Dietrich (1993) demonstrate that the variable K and the exponents m and n, are influenced by climatic parameters, such as the temperature change, the precipitation distribution and, not being fully understood, are often excluded from the calculation formula. Therefore, SPI (Stream Power Index) is defined as the product between the flow accumulation and the slope and it indicates the erosion power of the runoff on the surface.

Romanian researchers use SPI on a wide range, from the analysis of erosion in river basins (Prăvălie & Costache, 2014; Costache & Bui, 2019); to the analysis of susceptibility and vulnerability to landslides (Petrea et al., 2014; Roşca et al., 2016), and to gully erosion stabilization modelling (Bilașco et al., 2021), in different environmental conditions.

Tackling the issue of landslides in the Lipova Hills using GIS and geophysical techniques Șerban (2018) includes SPI in the category of landslide conditioning parameters, together with 12 other parameters.

Porosity, permeability and soil texture, are the dominant soil attributes that influence the soil erosion. Tacking account the soil characteristics variability due local conditions, identifying the erosion power of the runoff in the relation with the soil texture, the erosion power of the runoff in the relation with the soil texture and the soil permeability is an important step towards knowing these phenomena in a region pf piedmont hills, like Lipovei Hills. In the mentioned studies, this correlation is not addresseed this fact representing the novelty brought by this article.

The main purpose of this study is to identify the erosion power of the runoff in the relation with the soil texture and with the soil permeability. As a new approach, the SPI (Stream Power Index) calculation in relation with the soil texture and to associate the obtained values with the soil permeability classes is a way, to identify the vulnerable areas at the action of the drainage processes, starting by the elementary processes associated with rills and gullys erosion to those ravines and torrential organisms.

2. STUDY AREA

The study area is represented by the southern slope of the Lipovei Hills and the contact with the Timiș-Bega Plain. This territory is located in the western part of Romania and belongs of the West Hills and of the West Plain (Fig. 1).

The territory has a low general inclination from the South - West at the North - East.

The altitudes increase from the west to east, but an asymmetry can be observed on the north-south direction, due of the obvious advance of the tributaries from the right of the Bega River to the Mureș River. This is the result of the ascending movements from the end of the Pannonian and from the Quaternary (Magyar et al., 1999). The lifting movements were accompanied by the descending movements from the Timiș Plain which started in the Badenian and continued in the Sarmatian and in the Pannonian. Thus, a “geological bay” has been developed here.

The territory occupies an area of 978.97 km² and was delimited by the neighboring relief subunits, taking into account by the morphohydrographic significance of the water bodies. As such, in this area, there are two relief steps: the hill step represented by the Lipovei Hills and the contact step with the neighboring plains represented by the Vinga Plain, the Timișoara Plain, the Timișana Plain and the Bega Plain.

The Lipovei Hills, a subunit of the Banat Hills, are presented in the form of an “extended bridge”, which is why they were also called the *Lipovei Plateau* (Badea et al., IV, 1992).

In the territory formed by the southern slope of the Lipovei Hills and by the contact with the Timiș - Bega Plain, the hill step occupies an area of 790.42 km², which represents 80.74% of the surface of the studied territory. Here, the hill step takes place between 300 m and 120 m altitude.

The Lipovei Hills descend to the west until at the contact with the high Vinga Plain. The Timiș - Bega Plain is represented by the Timiș Plain and Lugoj Plain (Posea, 1997).

In the analyzed territory, the plain step occupies an area of 188.55 km², which represents 19.26% of the surface from the studied territory. Here, the altitudes of the plain step are around 100 m.

The plain step is crossed by the Bega River and by its tributaries of right (Gherteamoș, Chizdia, Miniș,

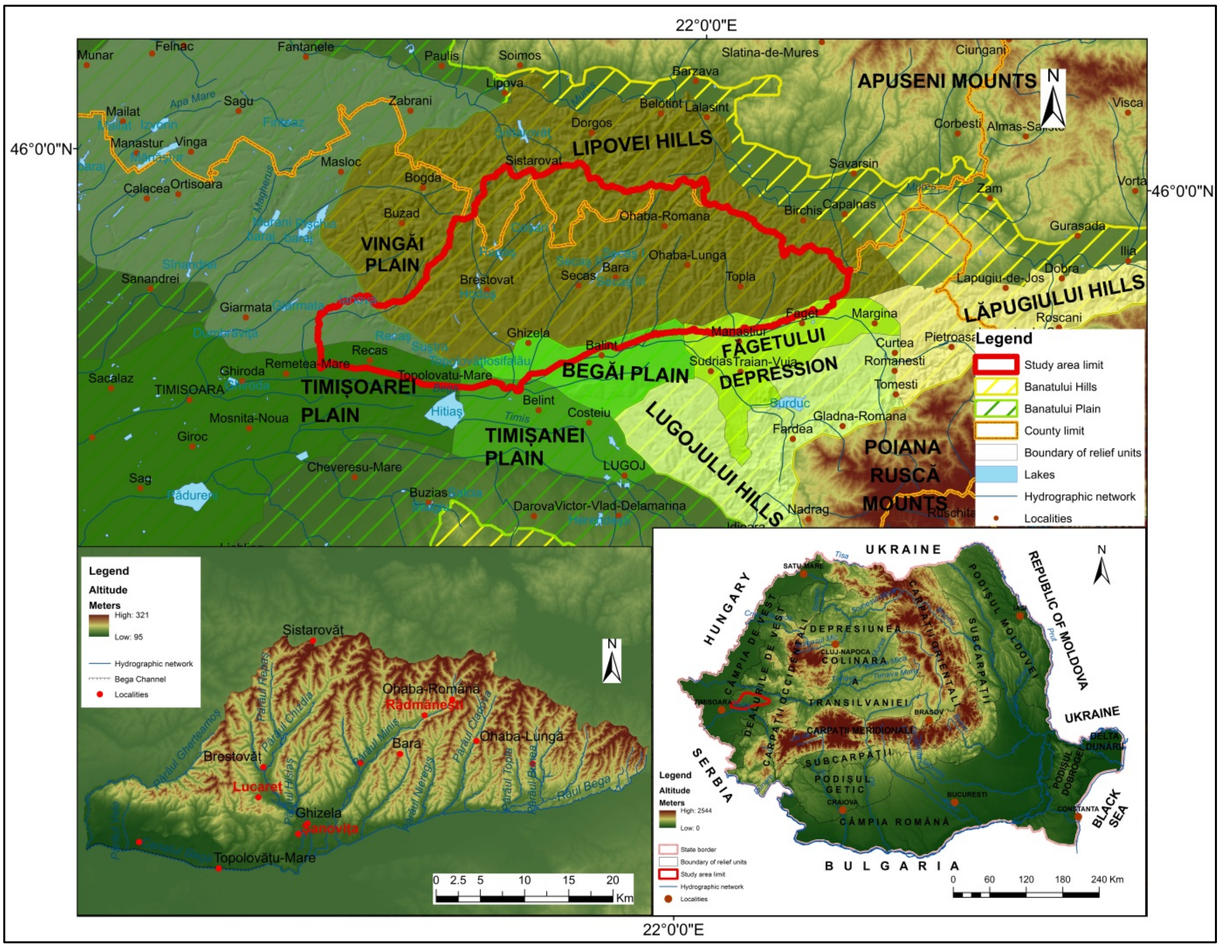

Figure 1. Location of the study area and reporting to the neighboring relief units.

Cladova, etc.). Thus, from the north, therefore, from the highest part of the studied territory, there are a series of elongated interfluves, sometimes dominated by rounded peaks, separated by the wide valleys (Gherteamoș, Chizdia, Miniș, Cladova, Pădureni, etc.), which descend to the Bega River, so, to the part with the lowest altitudes within the studied territory.

The minimum altitude of 95 m is recorded in the southwest of the territory, and the maximum altitude of 318.22 m from Cugla Peak is recorded in the northeast of the territory.

These tributaries create a dense network of valleys with a width of 1 km and they serve to the deep penetration of the plain into the hill unit in the form of "bays".

The wide valleys determine the attribution of certain surfaces from them to the plain step, but also the disappearance of some characteristic elements of them, such as some terraces.

In this situation, the boundary between the southern slope of the Lipovei Hills and the Timiș – Bega Plain is not precise. Thus, the study area extends to the Bega River.

3. DATA USED AND METHODS

To identify deep erosion, the present study considers the application of the SPI calculation method proposed by Howard & Kerby (1983). Thus, to obtain the SPI, a Digital Elevation Model of the land with a resolution of 10 m was used.

From DEM, with the help of the *Surface* function, the slope was obtained (Fig. 2.a). The unit of measurement for the slope is expressed in degrees.

The slopes less than 3° are predominant in the plain unit and on the bottom part of the valleys Gherteamoș, Chizdia, Miniș, Fădimac, Nieregiș, Cladova, Topla, Bunea, Sârbeni etc., while the slopes greater than 13° are present in the high part of the southern slope of the Lipovei Hills and represents 5.27% from the surface of the study area.

At the same time, it is necessary to specify the classes of slopes with values between 6.01 and 9°, because it represents 24.96% of the area. Slope classes of 3.01 and 6° correspond to 20.64% of the territory and, last, but not least, those with values between 9.01 and 13° are characteristic for 17.88% of the analyzed territory.

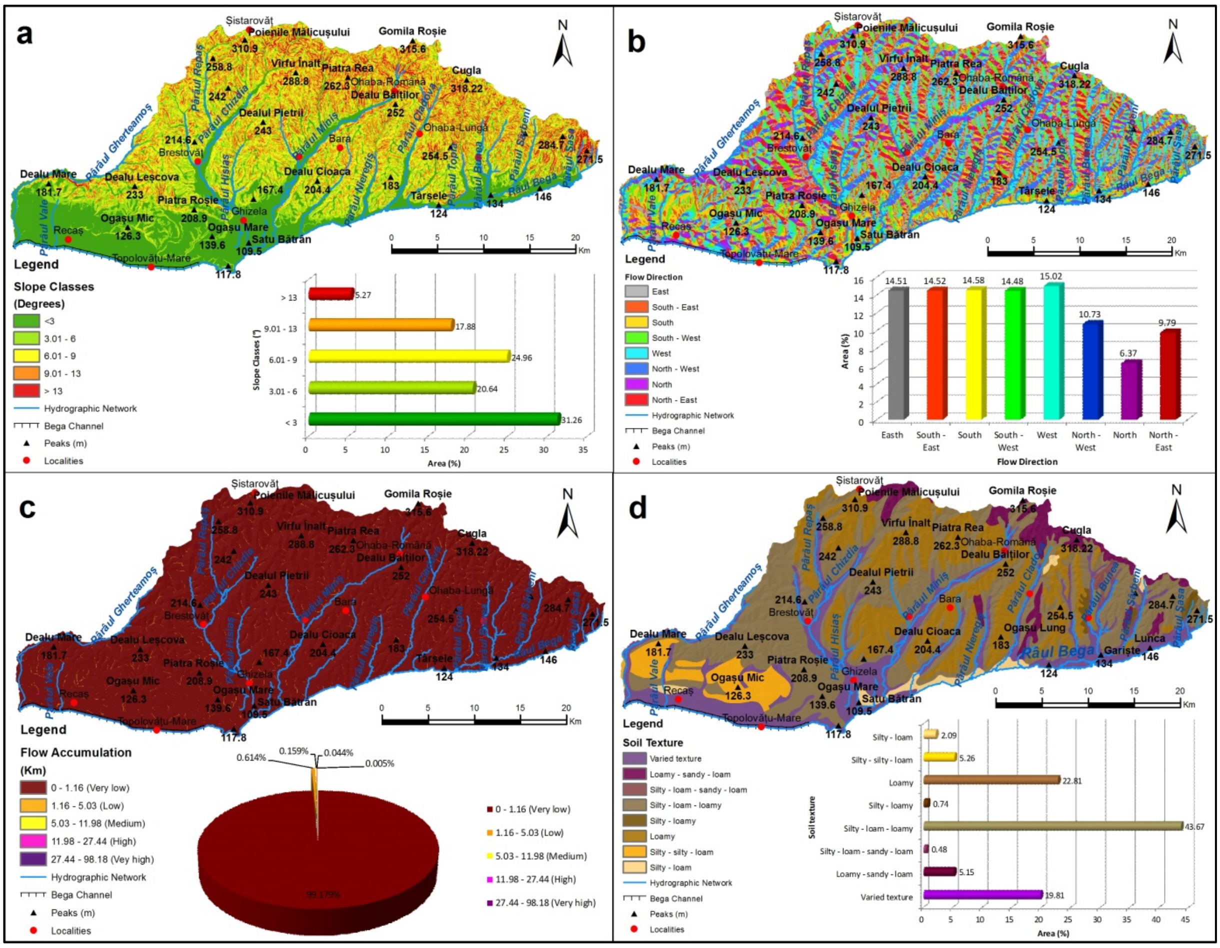

Figure 2. The data used to identify the vulnerable areas at the drainage actions: a. the slope map; b. the flow direction map; c. the flow accumulation map; d. the soil texture map.

Through the *Hydrology* function, also from DEM, flow direction was obtained (Fig. 2.b) through which, ordinarily, eight flow directions (Jenson & Domingue,1988) were identified, of which the predominant ones are those to the west, representing 15.02% of the study area.

The other flow directions are also important, because each of these represents approximately 14% of the surface. With the except of the flow direction to the north-west which it is accounting for 10.73% of the analyzed area and to the one to the north-east which is present on 9.79% and, respectively, to the one to the north which is characteristic for 6.37% of the study area.

From the flow direction, also by using the *Hydrology* function, the flow accumulation was obtained (Fig. 2.c), which shows that the accumulation of runoff takes place at the base of the slopes in the form of colluvio-proluvial glacis, and even at the bottom of valleys: Gherteamoș, Chizdia, Miniș, Fădimac, Nieregiș, Cladova, Topla, Bunea, Sârbeni, Șasa etc.

Regarding the share of this primary attribute, the very low values of the flow accumulation between 0 km and 1.16 km represent 99.179% of the surface. The low and medium values of the flow accumulation between 1.16 km and 5.03 km and between 5.03 km and 11.98 km are specific for 0.614% of the surface, and, respectively for 0.159% of the surface. The high values, between 11.98 km and 27.44 km occupy 0.044% of the surface and the very high values between 27.44 and 98.18 km represent only 0.005% of the surface.

Obtaining the Stream Power Index consisted in introduction of the calculation formula (1) proposed by Moore et al., 1991, and, then, Moore and Wilson, 1992, through the *Map Algebra* function in ArcGIS (Dilts, 2015) in the form of the mathematical expression (3).

SPI=Ln(flowaccum+1)*(tan(((slopedeg)*3.141593)/180)) (3)

where: flowaccum is the flow accumulation raster and slopedeg is the slope raster. The value of 3.141593 is the mathematical constant π and the value of 180 represents the cell size and, usually, these values are used to turn the slope from degrees to radians (Jenness, 2006).

Another important primary parameter to achieve the main objective of this study is the soil texture, at scale 1:200 000 (Fig. 2.d) and additional information (Ianoș & Pușcă, 1998). In this case, the silty-loam-loamy texture is predominant on 43.67% of the territory and the loamy texture is present on 22.81% of the surface. Within the main valleys, there is a varied texture that represents 19.81% of the surface.

The soil texture permeability is another important parameter in determining of runoff capacity. From the soil texture, according to Panagos et al., 2014, using the specific permeability class of the soil texture (Table 1), through the *Reclassify* function, the permeability of the soil was obtained.

Table 1. Soil permeability classes estimated from major soil textural classes (Panagos et al., 2014).

Permeability class (p)	Texture
1 (fast and very fast)	Sand
2 (moderate fast)	Loamy sand, sandy loam
3 (moderate)	Loam, silty loam
4 (moderate low)	Sandy clay loam, clay loam
5 (slow)	Silty clay loam, sand clay
6 (very slow)	Silty clay, clay

Applying the calculation formula of the Stream Power Index (2) proposed by Howard & Kerby (1983), the soil texture was calculated in relation with SPI by entering the mathematical expression (4), using the *Map Algebra* function, from the ArcGIS software.

$$SPI=K*(Ln(flowaccum+1)*(tan(((slopedeg)*3.141593)/180))) \quad (4)$$

where: K is the erosion coefficient that refers at the soil texture, respectively, at the soil permeability, flowaccum is the flow accumulation raster and slopedeg is the slope raster. The value of 3.141593 is the mathematical constant π and the value of 180 represents the cell size and, usually, these values are used to turn the slope from degrees to radians (Jenness, 2006).

The erosion coefficient K refers to the soil texture influenced by the quantity of the atmospheric precipitation recorded in each season (Seidl & Dietrich, 1993).

The determination of the SPI values in relation with each type of soil texture and with each class of soil permeability, was performed through extracting and through reclassifying them according at the initial values of the Stream Power Index. On the same way, the determination of the SPI values in relation with each class of slopes and with each class of flow accumulation, was performed through extracting and through reclassifying them according at the initial values of the SPI.

4. RESULTS AND DISCUSSION

By applying the Stream Power Index calculation formula proposed by Moore et al., 1991, and, then, Moore & Wilson, 1992, it was found that the low values of SPI characterize the small slopes and the high values of SPI characterize the large slopes. Therefore, regarding to the SPI in relation with the slope classes, it was found that the low values of SPI between -1.77 and -0.30 characterize the very low slopes (< 3 degrees) on an area of 42.13% (Table 2).

Table 2. The Stream Power Index in the relation with the slope classes.

Slope (°)	SPI	Area (%)
< 3 (Very low)	-1.77 - - 0.30 (Low)	42.13
3.01 – 6 (Low)	+1.94 - +3.49 (High)	49.13
6.01 – 9 (Medium)	+1.94 - +3.49 (High)	65.29
9.01 – 13 (High)	> +3.49 (Very high	60.26
> 13 (Very high)	+1.94 - +3.49 (High)	60.67

The high values of SPI, between +1.94 - +3.49 characterize the following classes of slopes: the low slopes between 3.01 and 6 degrees on an area of 49.13%, the medium slopes between 6.01 and 9 degrees on an area of 65.29% and the very high slopes (>13 degrees) on an area of 60.67%.

The very high values of SPI (> +3.49) characterize the large slopes between 9.01 - 13 degrees on an area of 60.26%.

Table 3. The Stream Power Index in the relation with the flow accumulation classes.

Flow accumulation (Km)	SPI	Area (%)
27.44 – 98.18 (Very high)	> +3.49 (Very high)	99.83
11.98 – 27.44 (High)	> +3.49 (Very high)	97.52
5.03 – 11.98 (Medium)	> +3.49 (Very high)	97.69
1.16 – 5.03 (Low)	> +3.49 (Very high)	93.23
0 – 1.16 (Very low)	+1.94 - +3.49 (High)	38.15

Regarding to SPI in relation with the flow accumulation, it was found that SPI has very high values (> +3.49) from a low flow accumulation of 1.16 km to a very high flow accumulation of 98.18 km on a medium surface of 97.07% (Table 3).

The very high values of SPI (> +3.49) which represent 13.52% of the surface of the studied territory and the high values of SPI between +1.49 and +3.49 which represent 41.05% from the surface are located on the southern slope of the Lipovei Hills.

SPI has high values between +1.94 and + 3.49 in case of very low flow accumulation (<1.16 km) on a area of 38.15% (Fig. 3.).

The very high values of SPI (>+3.49) which represent 13.52% of the surface of the studied territory and the high values of SPI between +1.49 and +3.49 which represent 41.05% from the surface are located on the southern slope of the Lipovei Hills.

The medium values of SPI between -0.30 and +1.94 characterize 25.03% from the surface and are found at the base of the slopes, and, especially, at the contact area of the southern slope of the Lipovei Hills with the Timiș-Bega Plain.

The low values of SPI between -1.77 and -0.30 are representative for 15.63% of the surface and the very low values of SPI (< -1.77) represent only 4.77% of the study area, located in the plain unit.

Applying the calculation formula of the Stream Power Index (2) proposed by Howard & Kerby (1983), it was found that SPI is directly influenced by the erosion coefficient that refers to the soil texture (K).

The permeability of the soil texture was obtained through reclassifying the soil texture, according to Panagos et al., 2014. Thus, the very slow permeability class of soil is present on 5.26% from the studied area and the slow permeability class of soil predominates on 46.49% of the surface (Fig. 4).

The low moderate permeability class of the soil is present on 20.29% of the surface and the moderate permeability class of the soil is present on 22.81% of the area, while the fast moderate permeability class of the soil characterizes 5.15% of the study area.

Regarding to the relationship between SPI and the soil permeability, it was found that SPI has high values from 9.19 to 15.89 on an area of 25.85% from the very low permeability (Table 4, Fig. 5). Also, SPI has high values from 9.19 to 15.89 on a surface of 42.71% from the slow permeability.

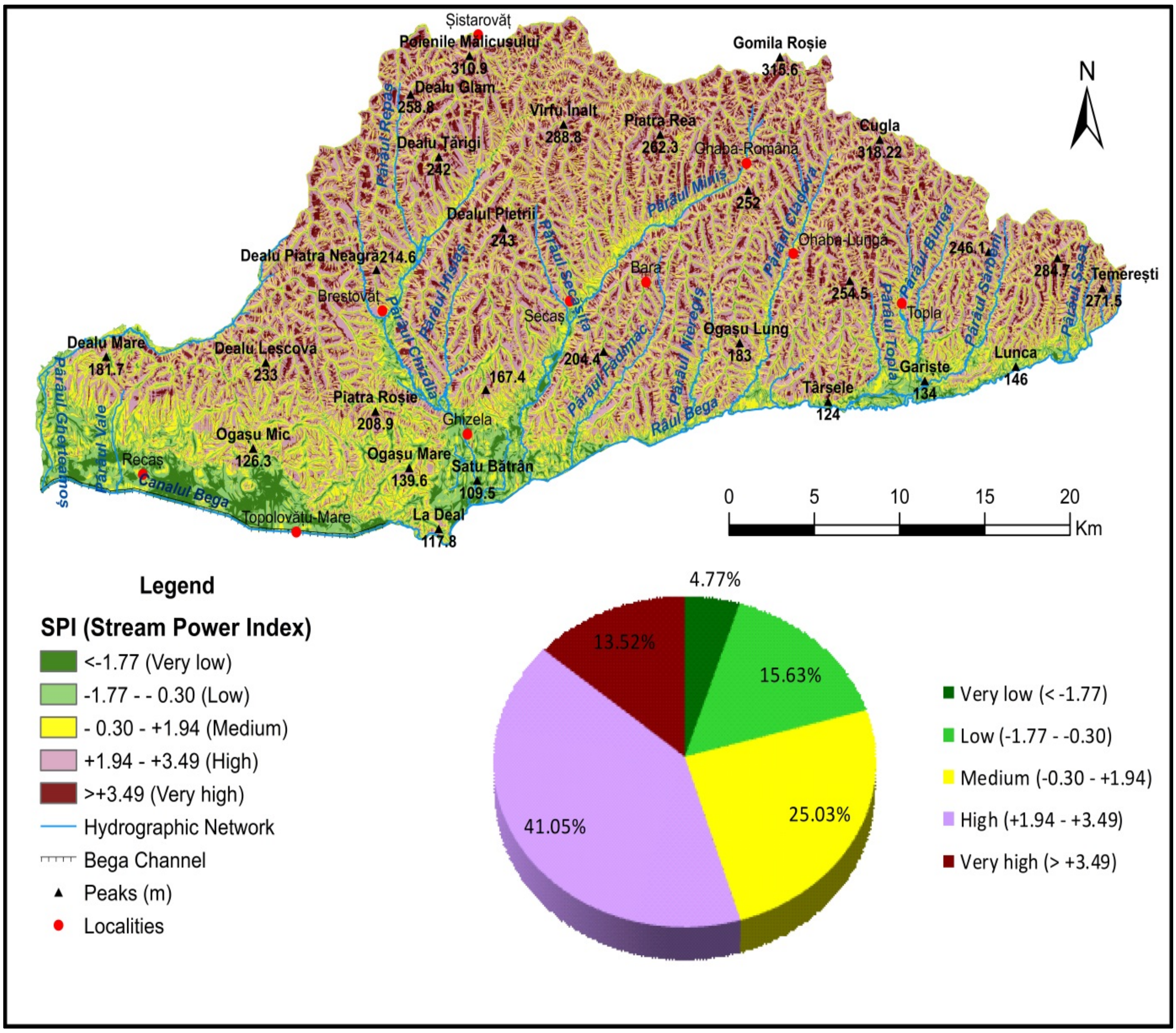

Figure 3. The Stream Power Index map on the southern slope of the Lipovei Hills.

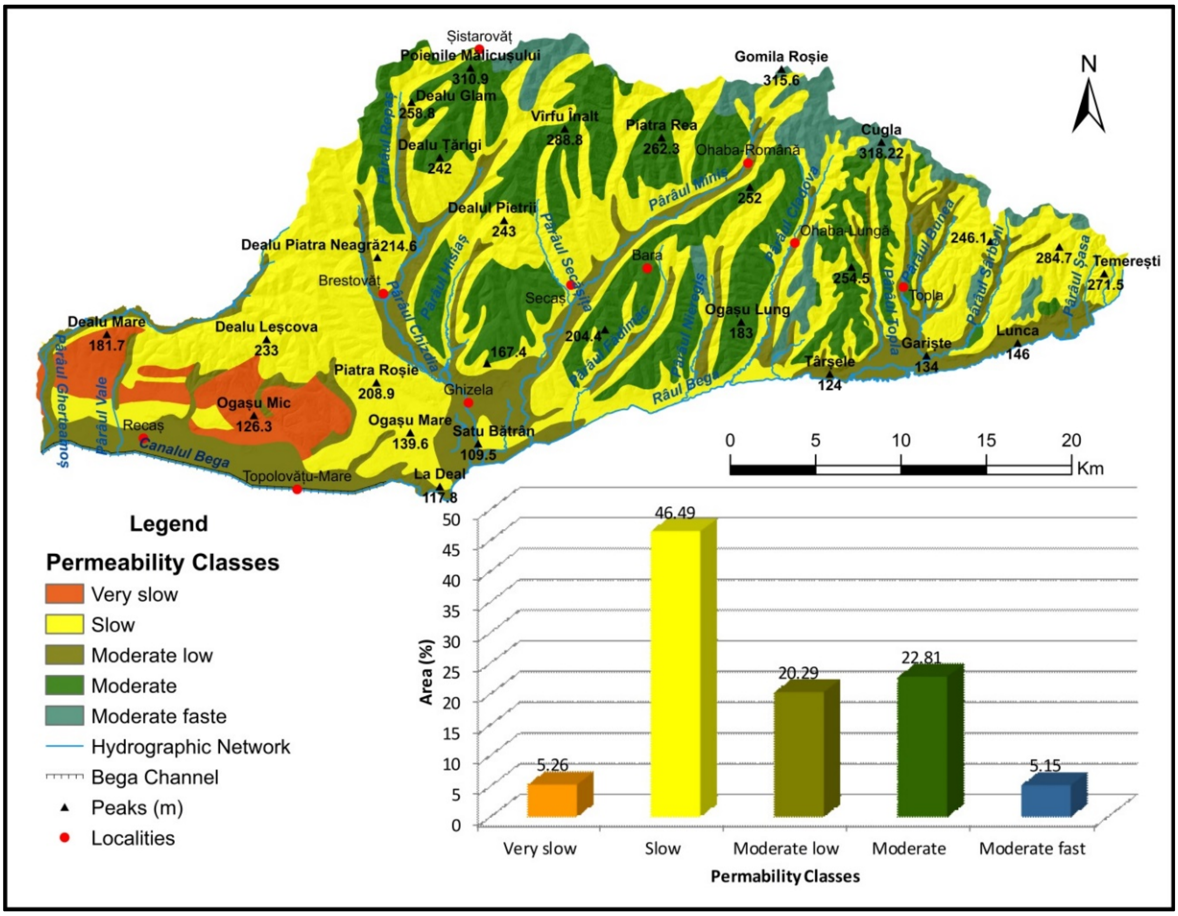

Figure 4. The permeability classes map on the southern slope of the Lipovei Hills.

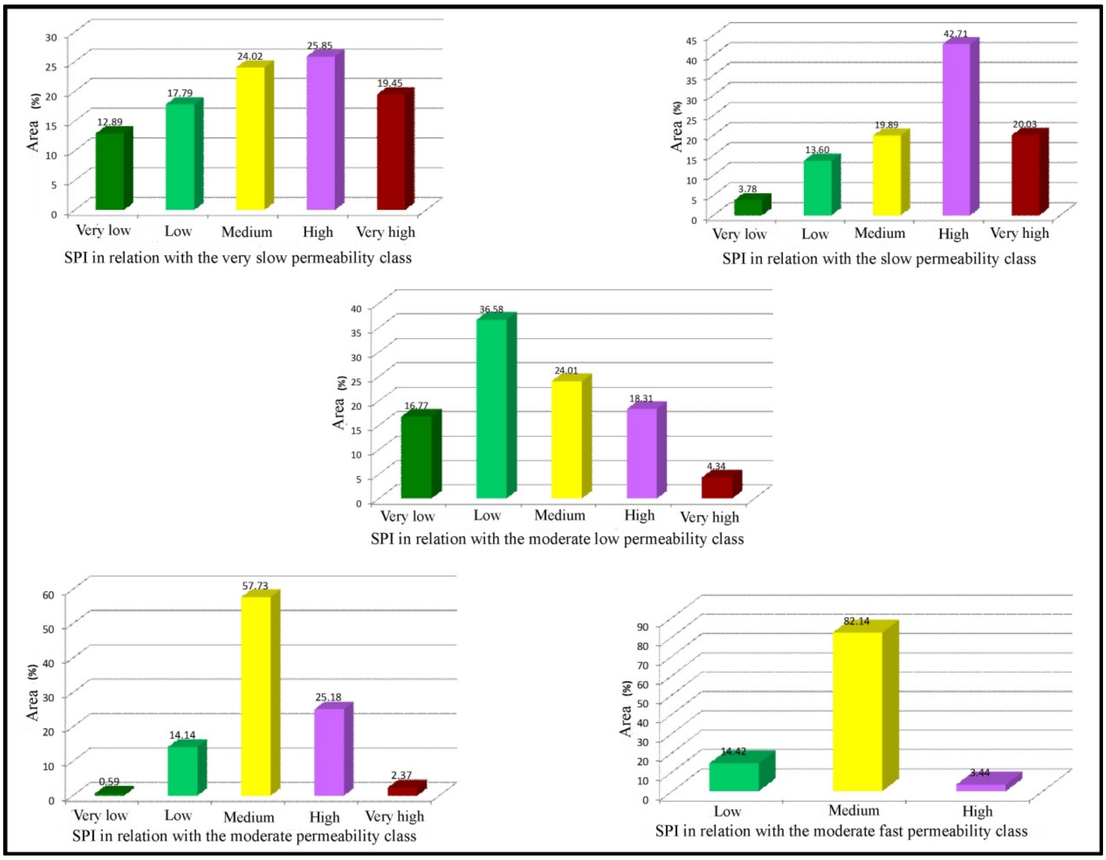

Figure 5. SPI in relation with the soil permeability.

Table 4. SPI in relation with the soil permeability.

Permeability	SPI	Area (%)
Very slow	+9.19 – +15.89 (High)	25.85
Slow	+9.19 – +15.89 (High)	42.71
Moderate low	-6.90 - -2.49 (Low)	36.58
Moderate	-2.49 – +9.19 (Medium)	57.73
Moderate fast	-2.49 – 9.19 (Medium)	82.14

SPI has low values between -6.90 and -2.49 on an area of 36.58% from the moderate low permeability.

SPI has medium values between -2.49 and +9.19 on a surface of 57.73% from the moderate permeability. Also, SPI has medium values between -2.49 and +9.19 on an area of 82.14% from the moderate fast permeability.

In relation with each type of soil texture, SPI has low values between -7.41 and -0.93 on a surface of 35.84% from the varied texture (Table 5, Fig. 6.).

Table 5. SPI in relation with the soil texture.

Soil texture	SPI	Area (%)
Varied texture	-7.41 - -0.93 (Low)	35.84
Loamy – sandy - loam	-0.93 – +6.89 (Medium)	84.99
Silty – loam – sandy - loam	> +15.83 (Very high)	40.99
Silty – loam - loamy	+6.89 - + 15.83 (High)	52.04
Silty - loamy	> +15.83 (Very high)	55.42
Loamy	-0.93 – +6.89 (Medium)	73.50
Silty – silty - loam	> +15.83 (Very high)	33.21
Silty - loam	-0.93 – +6.89 (Medium)	27.63

SPI has a medium value from -0.93 to +6.89 on an area of 84.99% from the loamy - sandy – loam texture. On a surface of 73.50% from the loamy texture, SPI has a medium value from -0.93 to +6.89 and, also, on an area of 27.63% of the silty-loam texture.

The Stream Power Index has a high value from +6.89 to +15.83 on an area of 52.04% from the silty - loam - loamy texture.

SPI has a very high value (> +15.83) on an area of 40.99% from the silty - loam - sandy - loam texture. SPI has a very high value (> +15.83) on a surface of 55.42% from the silty - loamy texture and, also, on an area of 33.21% from the silty - silty - loam texture.

Overall, the distribution of SPI values in relation with the soil texture from the southern slope of the Lipovei Hills and the contact with the Timiș-Bega Plain (Fig. 7) coincides with the soil permeability classes depending on the texture, established by Panagos et al., (2014). Thus, on only 4.36% of the analyzed surface, SPI has very high values (> +15.23) that corresponds, for the most part, to the silty - silty - loam texture defined through very slow permeability (Table 6).

Table 6. SPI in relation with the soil texture and the soil permeability.

Soil texture	Permeability	SPI	Area (%)
Varied texture	Moderate slow	< -7.41 (Very low)	4.37%
Silty – loam - loamy	Slow	+6.89 - +15.23 (High)	33.22%
Loamy	Moderate	- 0.93 - + 6.89 (Medium)	42.01%
Silty – silty - loam	Very slow	> + 15.23 (Very high)	4.36%
Silty - loam	Slow	-7.41 - - 0.93 (Low)	16.04%

On 33.22% of the researched area, SPI has high values between +6.89 și +15.23. These being specific, to a large extent, to the silty-loam-loamy texture identified by slow permeability. So, the very high and the high values of SPI on the soil texture with very slow, respectively, slow permeability, indicates the vulnerable areas at the action of the drainage processes, starting by the elementary processes associated with rills erosion and gullys to those ravines and torrential organisms (Fig. 8.a.)

The SPI medium values (-0.93 - +6.89) is characteristic for 42.01% of the studied territory, which corresponds, especially, to the loamy texture and moderate permeability.

Low values of SPI, between -7.41 and -0.93 are on 16.04% of the analyzed territory and corresponds, mainly, to the silty-loam texture characterized by moderately slow permeability. Just on 4.37% of the researched territory, SPI has a very low value (< -7.41) that overlaps, particulary, to the varied textures with moderately slow permeability.

The very low and low values of the Stream Power Index justify the maintenance of the water in the plain unit after the discharges of the flowing waters Chizdia, Miniș, Cladova, Bega and others.

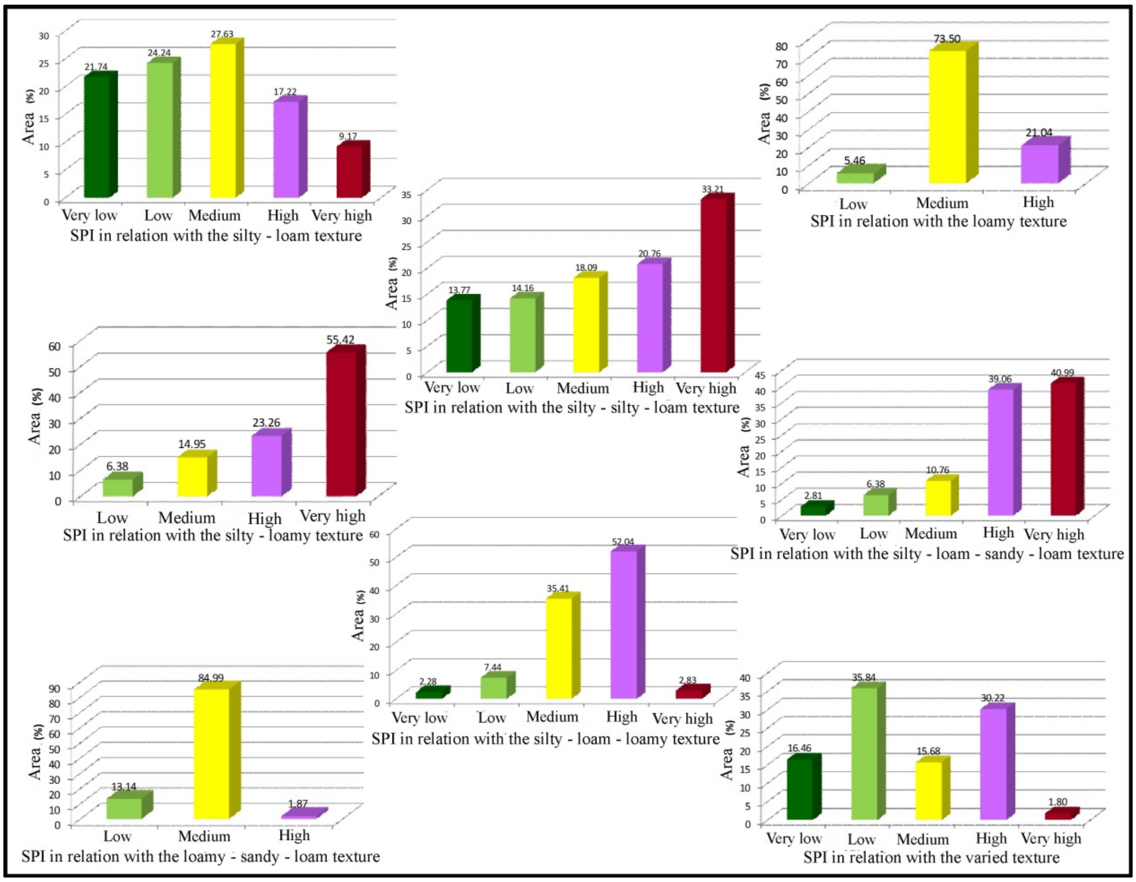

Figure 6. SPI in relation with the soil texture.

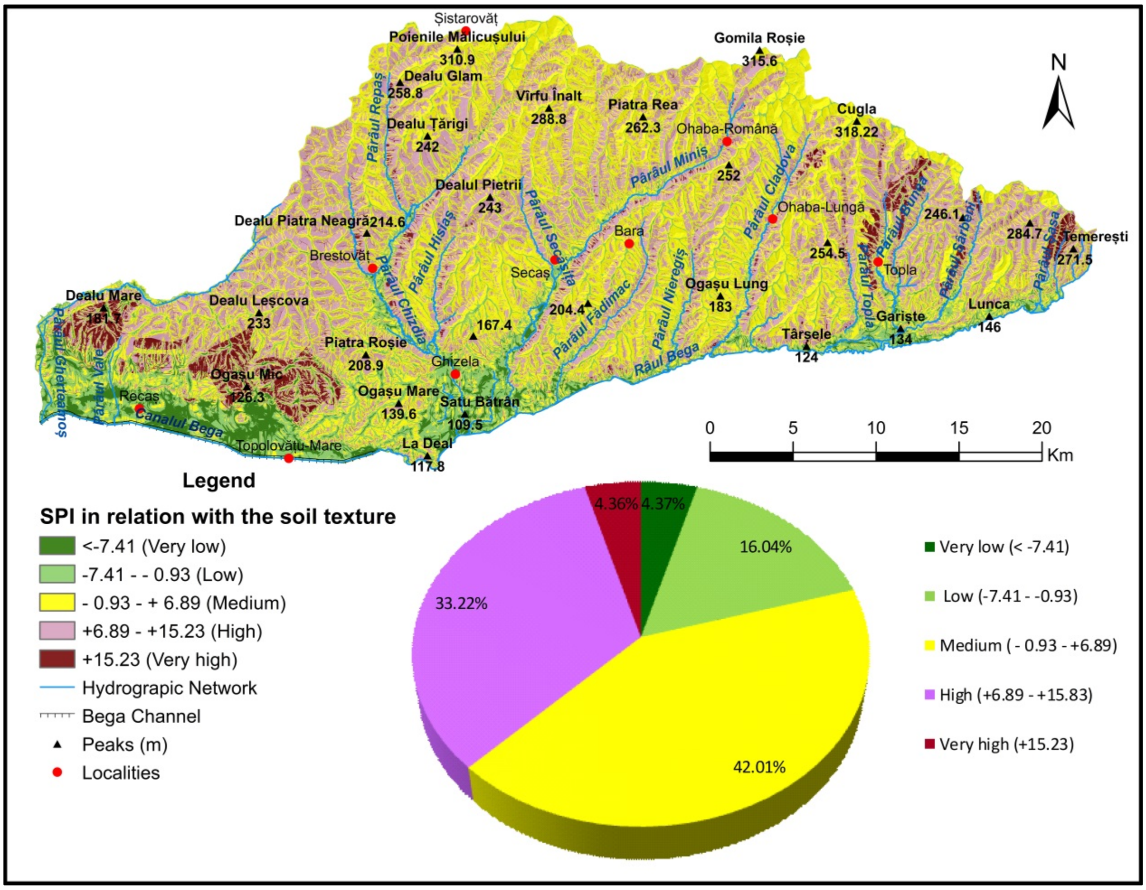

Figure 7. The map of SPI in relation with the soil texture on the southern slope of the Lipovei Hills.

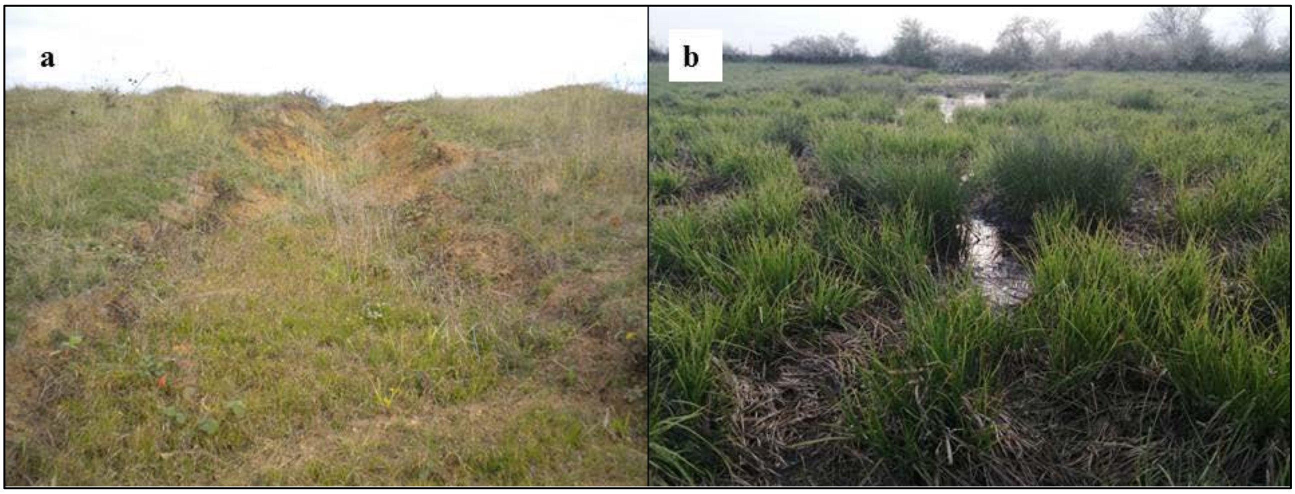

Figure 8a,b. Gully on the southern slope of the Lipovei Hills, near Crivobara village; b. The vegetation specific to the puddle phenomenon in the alluvial plain of Chizdia River.

Moreover, the puddle phenomenon is also indicated through the installation of hydrophilic vegetation from the *Cyperacee*, the *Sparganiaceae* and the *Thyphaceae* families (Fig. 8.b).

5. CONCLUSIONS

The Stream Power Index indicates the erosion power of runoff on surface and for the identification of deep erosion influenced by drainge actions. This study use the SPI calculation method proposed by Howard & Kerby (1983) and the formula proposed by Moore et al., (1991) and, then, by Moore & Wilson (1992). It was found that the high values of SPI from the southern slope of Lipovei Hills are characteristic for 41.05% of the surface.

Therefore, SPI values are certainly influenced by the slope. So, the high and the very high values of SPI characterize the highest slopes. Here, the intensity of water drainage processes is high and the surface erosion and the linear erosion develops. Thus, a wide range of landforms are formed, from the elementary forms, rills and gullys, to the torrential organisms.

The low and very low values of SPI characterize the smallest slopes form the base of the slopes, from the bottom of the valleys and from the flat surfaces of the plain unit. Here, because the slopes are low, the intensity of the water drainage processes is low and the flow accumulation is high. But SPI has a very high value (> +3.49) on a very high flow accumulation with values between 27.44 km and 98.18 km. So, in these areas, the floods occurs as a result of the discharge of water streams Gherteamoș, Chizdia, Miniș, Cladova, Bega etc.

By introducing the erosion coefficient K, which refers to the soil texture in the calculation formula of the Stream Power Index, it was found that SPI is directly influenced by this. Thus, SPI has a medium value from -0.93 to +6.89 on the 42.01% of the studied territory which coincides with the loamy texture, defined by moderate permeability.

It was also found that high values of SPI on the very slow permeability and on the slow permeability, favor the gully erosion and even torrents.

Overall, the distribution of SPI values in relation with the soil texture from the southern slope of the Lipovei Hills and the contact with the Timiș-Bega Plain coincides with the soil permeability classes depending on the texture, established by Panagos et al., in 2014.

Because, the very high and the high values of SPI in relation with the soil texture are characterized by the presence of a large streams of water that descend with a very high speeds on the high and the very high values of slopes it is found that the southern slope of the Lipovei Hills is affected by moderate ravines.

The low and the very low values of the SPI correspond mainly to the soil textures with moderate slow permeability in the contact area with the Timiș - Bega Plain. So, this fact justifies the water retention after floods due to the water discharges of water streams through the running waters of Chizdia, Miniș, Cladova, Bega and, not only, in the plain unit.

The use of the relation between the Stream Power Index and the soil texture through the correlation with the soil permeability it was succesfully applicated to identify the vulnerable areas at the drainage actions on the southern slope of the Lipovei Hills and the contact with the Timiș-Bega Plain.

In conclusion, due the relation between SPI and the soil texture it was found that the southern slope of the Lipovei Hills is affected by the moderate gullys and ravines phenomenon. At the contact with the Timiș-Bega Plain there are floods especially in low alluvial plains, due to discharges of hydrographic network in the period of high precipitations, followed by the puddles phenomenon.

One of the main limitations in this study is the representations scale of soil types and the identification of their texture and specific permeability. It is obvious that at the level of detail, the validation in the field leads to much better results, including the establishment of K values. Despite these limitations, producing the SPI (Stream Power Index) map in relation with the soil texture and the soil permeability classes maps can be a useful tool for sustainable management, the soil conservation and reduction soils erosion and degradation.

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