USING GIS TECHNIQUES FOR IDENTIFICATION OF THE SURFACES WITH FLASH-FLOOD RISK POTENTIAL WITHIN THE AREA UPSTREAM OF POIANA UZULUI RESERVOIR

Ioana-Delia MIFTODE, PhD. Student, University "Alexandru Ioan Cuza" from Iaşi, Faculty of Geography and Geology, e-mail:miftodeioanadelia@yahoo.com
Gheorghe ROMANESCU, Prof. PhD., University "Alexandru Ioan Cuza" from Iaşi, Faculty of Geography and Geology, e-mail: romanescugheorghe@gmail.com

Abstract: *Knowing the value of the flash flood potential index (FFPI) is significant, because there are included in the GIS environment various physical and geographical and anthropic factors playing an essential role in the flash flood occurrence: lithology, slopes, profile curvature, soil texture and the land use. In the mountainous region situated upstream of the Poiana Uzului reservoir, an area with a potential very high risk of flash flood sums up a total surface of 49.36 km^2; the area with a potential high risk of flash floods sums up a total surface of 99.31 km^2. The highest percentage of the total studied area is exposed to an average risk of flash floods. The Uz hydrographic basin is situated in an area with a potential high risk of flash floods. The map thus obtained displays the spatialization divided into five risk classes (very high, high, average, low, and very low). The surfaces the most exposed to flood generation are concave surfaces, surfaces that include high slopes, hard rocks, a low degree of forestation, clay soils. The areas identified as being critical, concerning the potential of flash flood generation, presented an elevated risk for other related phenomena – in this case, the floods.*

Keywords: *anthropic factors, physical-geographic factors, FFPI, floods*

1. Introduction

The current changes occurred in the climatic (thermal, and pluviometric) and hydrologic regime constituted the main argument of numerous researches from the hydrographic basins of the Carpathians Mountains (Birsan et al., 2014; Chirila et al. 2008; Cojoc et al. 2015, Costache et al. 2015, Mic et al., 2015, Mihu-Pintilie, Romanescu et al., 2011, Serban et al. 2016; Sevianu et al., 2015, Stancalie et al. 2012, Tirnovan et al., 2014a,b). Most studies aimed at areas subjected to flooding (Romanian bibliography). The river engineering built during the communist era, and less often lately, did not stop the substantial effects of hydrological risks. The analysis of risky hydrological phenomena represent a real concern for scientists from all the world's nations due to their ever increasing worldwide frequency in the last decades (Barbulescu, Maftei, 2015; Hapciuc et al., 2015; Romanescu, 2005; Romanescu, 2006; Romanescu G, Lasserre F. 2006; Romanescu et al., 2011 a.; Romanescu G., Nistor I. 2011; Tîrnovan et. al, 2014; Romanescu, 2003). The floods represent one of the main hydrologically dangerous risky phenomena with grave consequences socially and economically (Čech, Čech, 2013; Corduneanu et al., 2016a,b; Gaume, Borga, 2008; Gaume et al., 2009; Komínková et al., 2015; Li et al., 2015; Lóczy et al., 2014; Mu, Mu, 2013; Raška, 2015; Simić et al., 2014; Solín et al., 2011; Yang et al., 2014).

The Uz hydrographic basin has faced catastrophic floods in the first decade of the XXIst century at the same time of the floods occurring in the entire area of the Oriental Carpathians mountains: 2001, 2002, 2004, 2005, 2006, 2007, 2008, 2010, 2011. The highest flows have been recorded during the summer of 2005 when the river Siret has registered a record of the Romanian historical flow historical recorded (4650 m^3/s) (Romanescu, 2006; Romanescu, 2009; Romanescu, Nistor, 2011).

The geographical setting of the Uz hydrographic basin. The Uz hydrographic is situated in the eastern part of Romania as a part of the Oriental Carpathian mountains. The basin has a surface of 475 km^2 and falls between 26°00'16" and 26°30'56" eastern longitude and between 46°08'44" and 46°23'27" northern latitude (Fig. 1). It has two reservoirs, one natural pond (Balatau, situated on the Izvorul Negru river), as well as an anthropic lake (Poiana Uzului, situated on the Uz river, downstream of the Cremenea locality and upstream of Darmanesti locality).

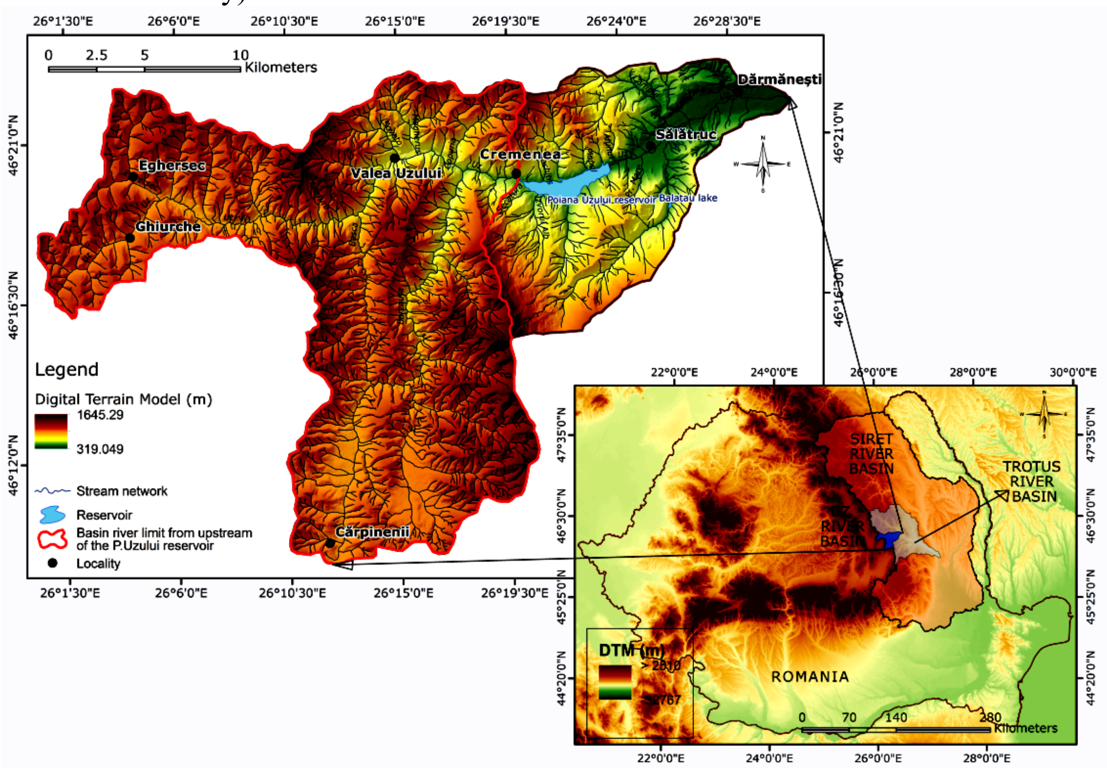


Fig. 1. The geographical setting of the Uz hydrographic basin

The studied area upstream of Poiana Uzului has a total surface of 338.6 km^2, is represented by the hydrographic basin situated upstream of the Poiana Uzului lake.

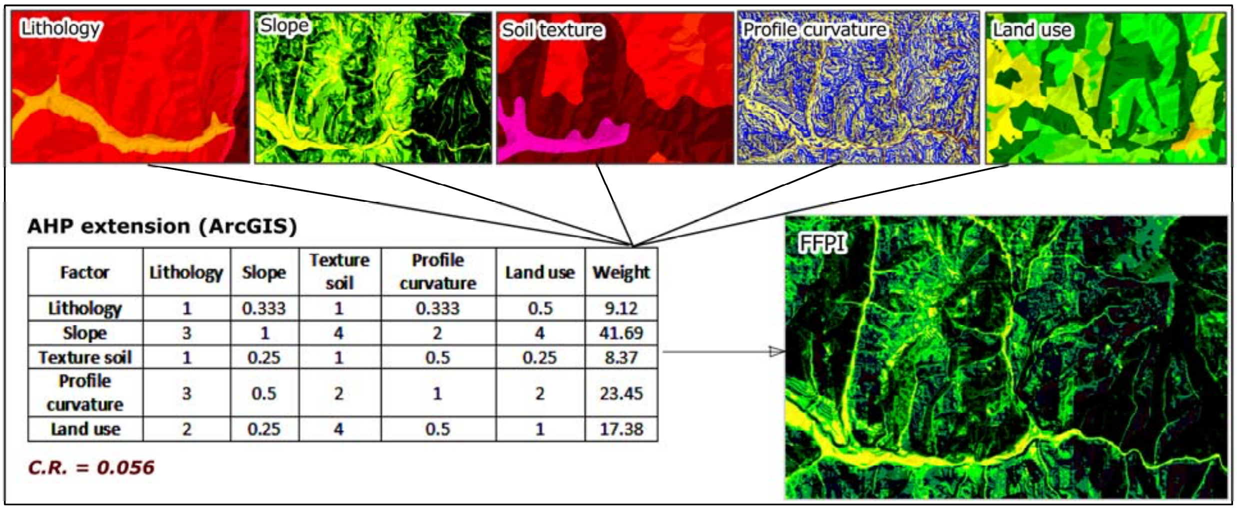
The river Uz and its most important tributaries had an important role in the fragmentation of the landscape. Uz is the right tributary of the river Trotus and springs from the Ciucului Mountain from an altitude of 1175.33 m. It traverses the hydrographic basin over a length of 46 km and meets the river Trotus at the Darmanesti locality, at an altitude of 320.43 m (Miftode, Romanescu, 2016; Miftode et al., 2016).

2. Database and methodology

The hydrological data was taken from the Siret Water Basin Administration and from the Hydroelectrical power plant in Poiana Uzului (Siret Water Basin Administration, 2015). Some historical data were taken from the Romanian specialty literature (Birsan et al., 2014; Cojoc et al., 2015; Costache et al., 2015; Cojoc et al., 2014; Chendeș et al., 2015; Minea, Romanescu, 2007). The cartographic is based on ortophotoplans 1:5000, topographical plans 1:5000 etc. Based on these the CLC 2012 has been created – for the use of the terrain and the Terrain Numerical Model (DTM 1:5000). The licensed program which have been used were: ArcGIS, the AHP extension (ArcGIS) (processed), TNTmips and R2V (vectorized), Google Earth and CorelDRAW X3.

3. Results and discussions

The GIS techniques can determine how the physical and geographical factors influence the surface drain. In the Uz hydrographic basin are also included the localities. The surface drains present an elevated potential in the case of terrains occupied by pastures, deforested zones, built-up areas. The spatial modelling led to the establishment flooding potential index. This index (FFPI) has been proposed by Smith in 2003 and for the river Colorado in the USA. Subsequently, it has been improved and computed for the majority of important rivers (Chendes et al., 2015). Five factors have been selected which influence the draining process namely: lithology, slope, soil texture, profile curvature and the land use. The ArcGIS program offered the possibility for the conversion in the raster format (Fig. 2).



Factor	Lithology	Slope	Texture soil	Profile curvature	Land use	Weight
Lithology	1	0.333	1	0.333	0.5	9.12
Slope	3	1	4	2	4	41.69
Texture soil	1	0.25	1	0.5	0.25	8.37
Profile curvature	3	0.5	2	1	2	23.45
Land use	2	0.25	4	0.5	1	17.38

Fig. 2. The conceptual diagram for generating the FFPI index values distribution map in the Uz hydrographic basin upstream of Poiana Uzului reservoir

For the lithology the highest percentage (96%) is represented by the fourth class (the flysch class). The other classes are occupied by sands, clays, marls, shales (Fig. 3). The slope has an essential component, contributing greatly to the rapid response of the basin and with a greater influence over the potential of rapid flooding. The highest percentage is hold by slopes between 23.1° and 30.7° and occupies 39% of the area. These can be found in the high mountain region (Bărzăuța sub-basin, Bașca area, mountainous north of Poiana Uzului reservoir). Slopes between 0° and 16° can be found on the Bodoc Plateau (south of Uz hydrographic basin) in the Carpinenii area, and in a slightest measure, in the Ghiurche zone (Fig. 4).

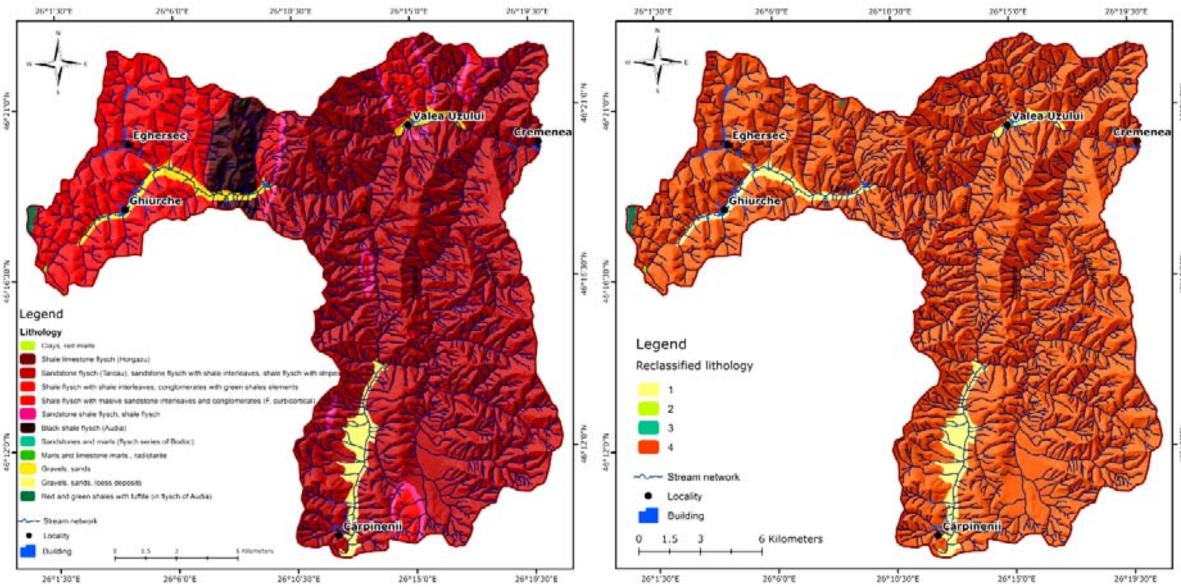


Fig. 3. The lithological map in the Uz river basin, upstream of the Poiana Uzului reservoir

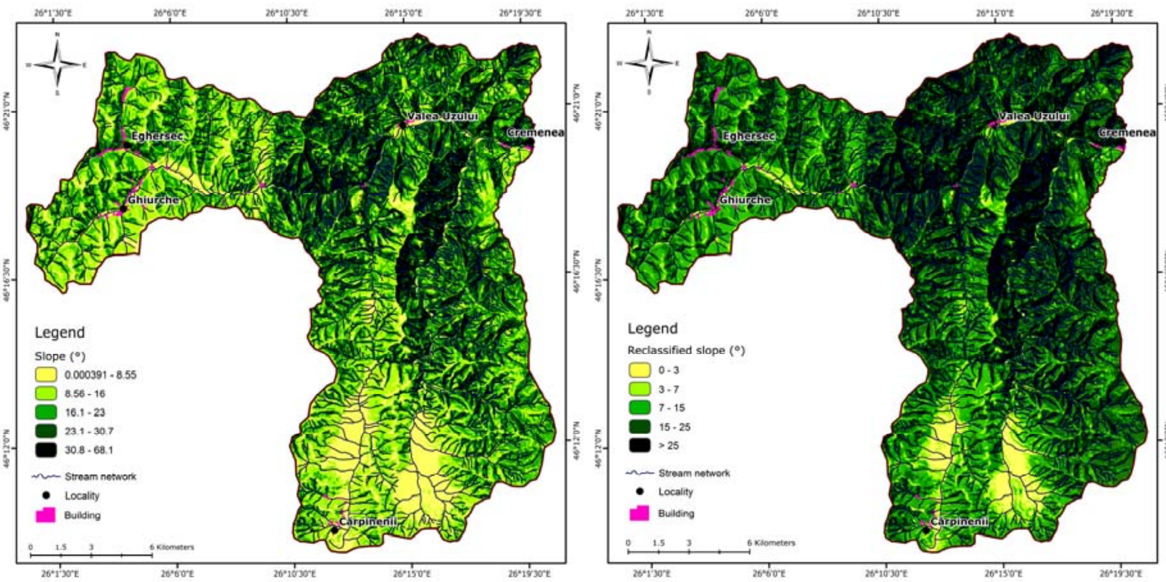


Fig. 4. The map of the slopes in the Uz river basin, upstream of the Poiana Uzului reservoir

The soil as a geographical factor that has a direct influence over the drainage process through: texture, degree of permeability and structure. In the case in which the soil texture is rough, the degree of permeability rises. Thus, the water infiltrates faster in soils with an average or rough granulometry, and slower in those with a fine granulometry. The soils with a low permeability favours a rapid drain.The highest percentage is represented by soils with a sand-clay...loamy texture, clay texture and varying texture (39%) found in the Valea Uzului zone, a part of Eghersec and Carpineni. The percentage of 34% is found in class three (clay... clay-loam) and is mainly found along the river valleys situated upstream of Salatruc (on the Basca river valley, Balatau lake, etc.) (Fig. 5).

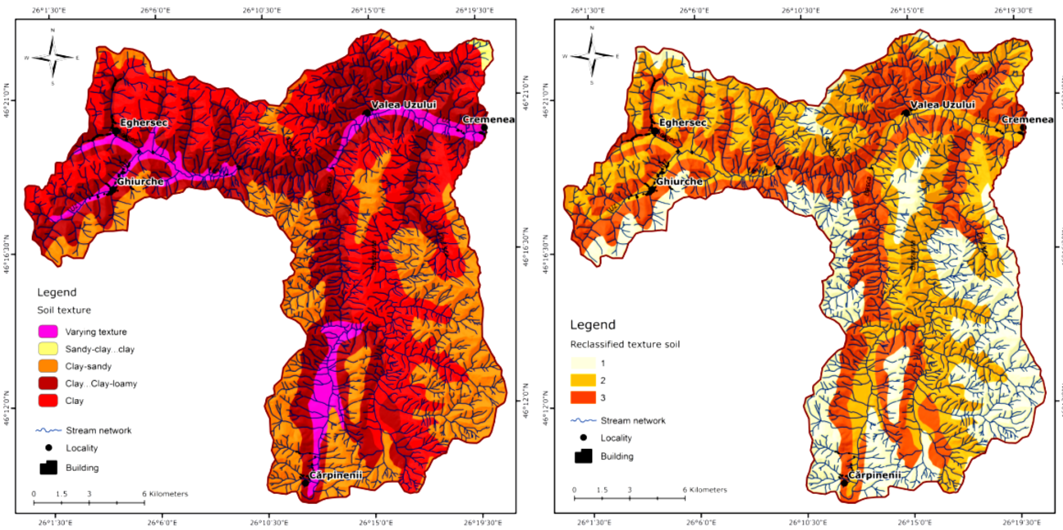


Fig. 5. The map of soil texture in the Uz river basin, upstream of the Poiana Uzului reservoir

The map of profile curvature highlights the convexe and concave surfaces. The convex mountain slopes are represented by negative values, being described by accelerated drains. The concave slopes are represented by positive values and decelerated drains. The unit measure used for the profile curvature are radians and meters. The erosion processes are more intense on convex slopes, while on concave slopes the phenomenon of sedimentation apppears. The convex surfaces represent 10%, the quasi horizontal 41% and the concave 49% (Fig. 6).

For the creation of the land usage map of the land use map, which highlights the anthopic influence on the basin, a raster type layer have been used, taken from the website *http://land.copernicus.eu/pan-european/corine-land-cover* (Fig. 7). On the areas occupied by forests, with a dense vegetation and with deep rooted plants or with high strains, the drain is hampered (Petrisor, 2015; Petrisor et al., 2015; Zoran et al., 2014).

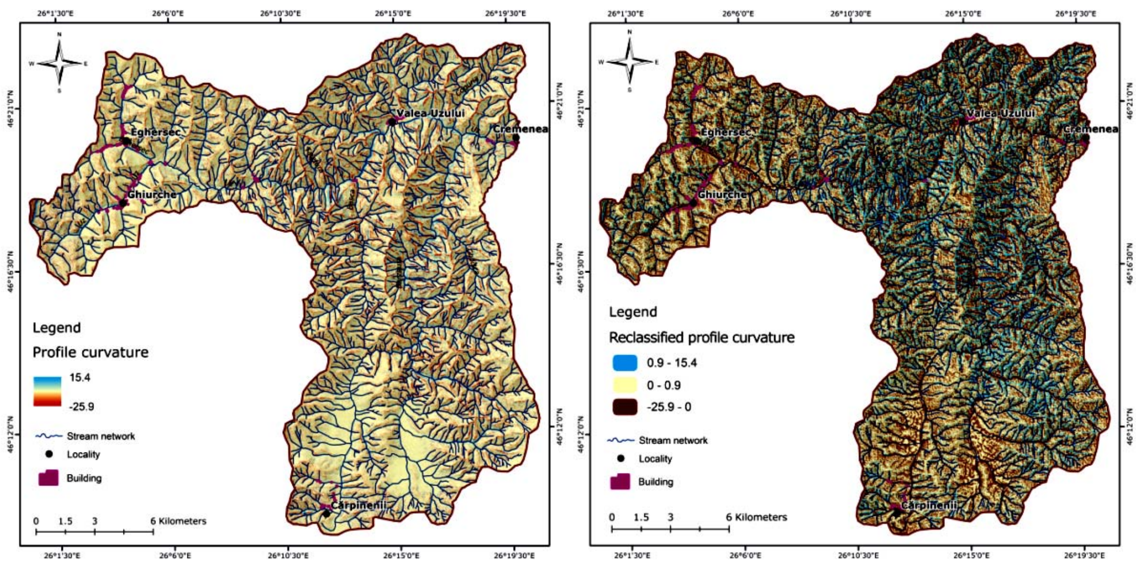


Fig. 6. The profile curvature map in the Uz river basin, upstream of the Poiana Uzului reservoir

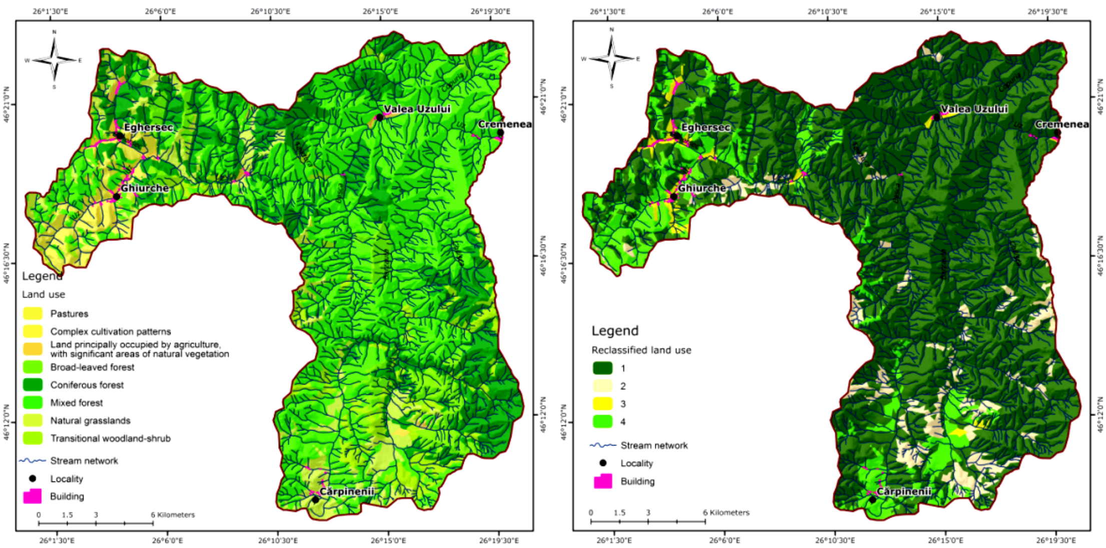


Fig. 7. The land use map in the Uz hydrographic basin, upstream of the Poiana Uzului reservoir

The studied area is covered in hardwood forests, coniferous forests, mixed forests, streams and water accumulations in a 80% rate. The transitional woodland-shrub are only at a 6% rate. The cultivated land has a 2% percentage. Pastures and natural meadows can be found in the Ghiurche, Eghersec, Carpinenii, Cremenea localities at a rate of 12% (Fig. 8).

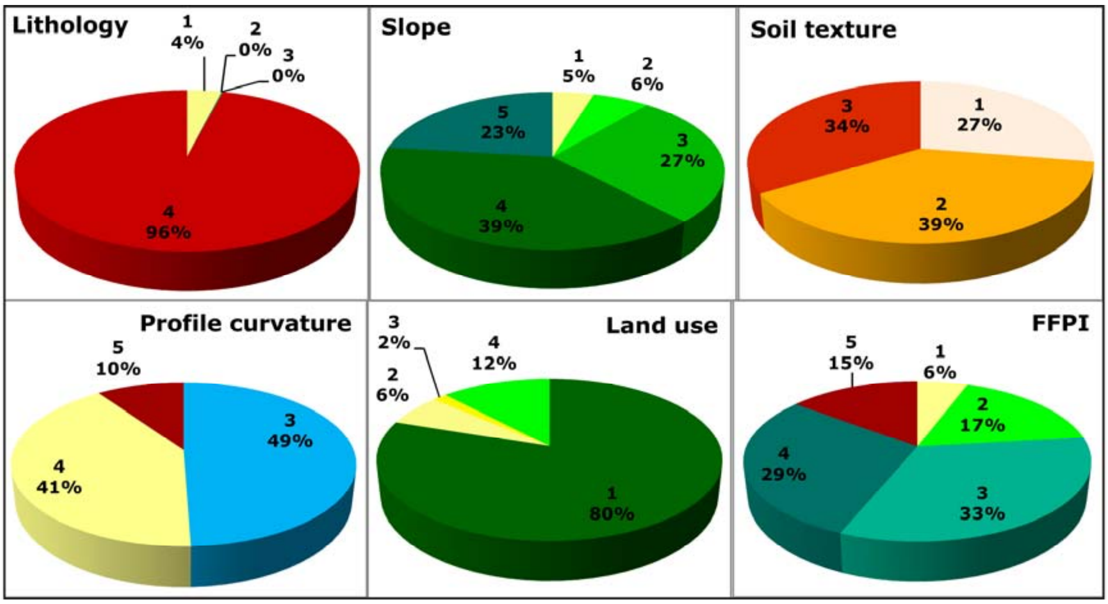


Fig. 8. The percentage of surfaces related to each reliability class of the physical and geographical factors and the FFPI index

The fiver rasters have been combined using the ArcGIS program. Each factor has been divided into five classes of valor depending on the degree of reliability. Using simple comparison concerning previous studies, there have been established criteria converted into numerical values. After the reclassification the reliability has been achieved depending on their influence over the surface drain (Table 1).

Following the automatic application of the formula, using the AHP extension (ArcGIS), previously indicated, the map has resulted which highlights the spatial representation of the potential value index of the surface drain (Fig. 9). The values of the index have been in grouped in classes at equal intervals. The first class corresponds to the index that represents the very low values of the surface drain (1.47-2.34) and that occupy 6% of the surface (aprox. 18.99 km^2) and can be found in the areas with small slopes and near the confluences (Table 2).

Table 1. The classification of physical and geographical factors, natural and anthropic, for obtention of the FFPI index in the basin, upstream of Poiana Uzului reservoir

Factor\Scor bonitare	1	2	3	4	5
Litologie*	Gravels, sands; Gravels, sands, loess deposits	Clays, red marls; Marls and limestone-marls radiolarite	Red and green shales with tuffite (Audia); Sandstones and marls (flysch series of Bodoc)	Shale limestone flysch (Horgazu); Sandstone flysch (Tarcău), sandstone flysch with shale interleaves, shale flysch with stripes; Shale flysch with shale interleaves, conglomerates with green shales elements; Shale flysch with massive sandstone interleaves and conglomerates (F. curbicortical); Sandstone shale flysch, shale flysch; Black shale flysch (Audia)	-
Panta (°)*	0-3	3-7	7-15	15-25	>25
Curbura în profil	-	-	-25.9 – 0	0 – 0.09	0.9 – 15.4
Textura solului*	Water; Clay-sandy	Clay; Sandy-clay...loamy; Varying texture	Clay...clay-loamy	-	-
Utilizarea terenului*	Broad-leaved forest; Coniferous forest; Mixed forest	Transitional woodland-shrub	Complex cultivation patterns; Land principally occupied by agriculture, with sgnificant areas of natural vegetation	Pastures; Natural grasslands	-

The second class highlights the areas with a potential low index for the 17% of the basin's surface (59.24 km^2). The highest percentage is represented by the index with average values found between 2.88 and 3.25 corresponding to a surface of 274.5 km^2 (33%). The areas with a high percentage of the surface drains occupy aproximatively 99.31 km^2 (29%) and are situated in the mountainous contact areas, zones wih high slopes (>15°). The very high potential has a 15% percentage of the total surface and corresponds to class five.

The potential of surface drain is average, and is asssociated to flood risk. This fact is proven by the average values of the index. The highest exposure is owned by the Valea Uzului, Ghiurche, Carpinenii and Cremenea localities. The current study identifies the zones most exposed to flood risk.

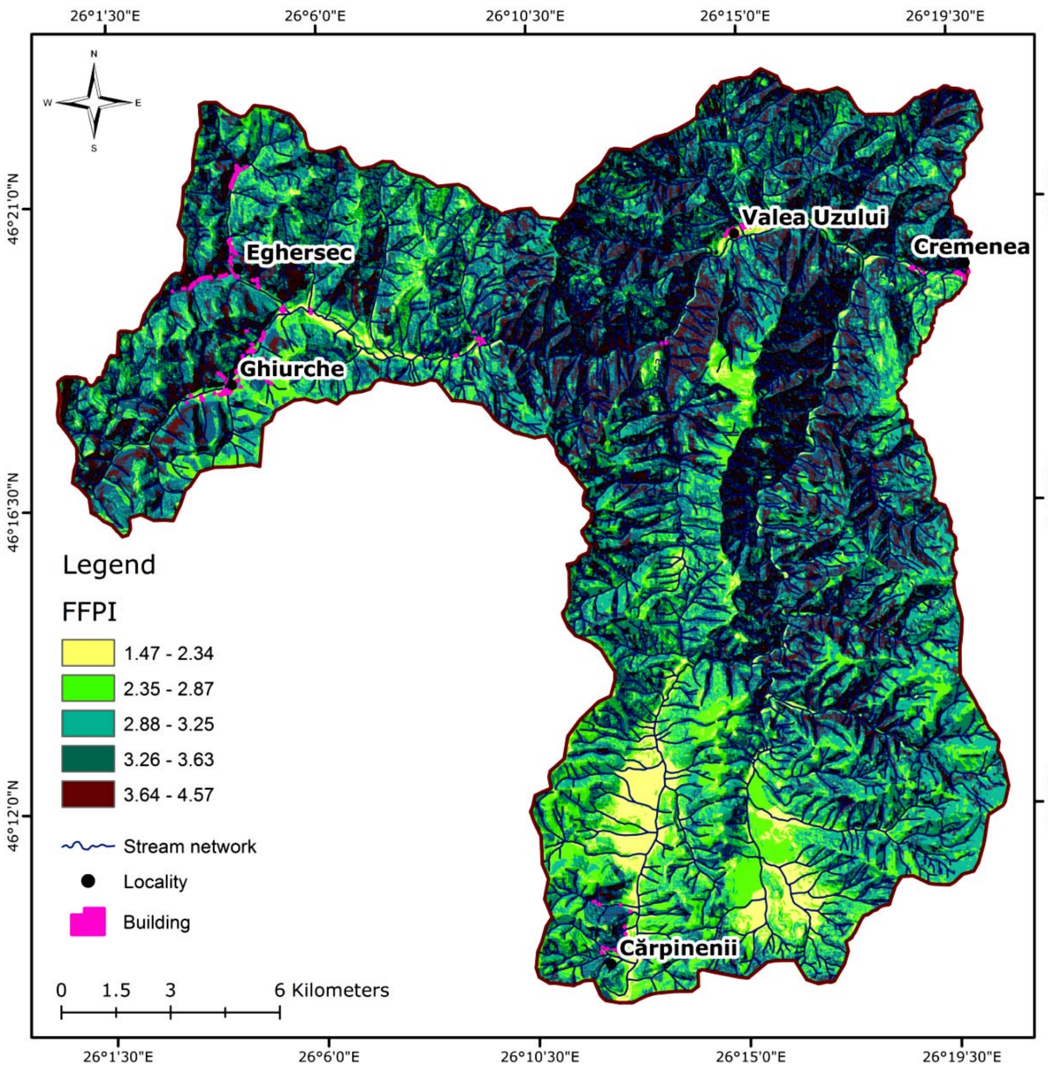


Fig. 9 – The distribution of the FFPI values in the Uz river basin, upstream of the Poiana Uzului reservoir

Table 2. The reliability and the degree of the flash flood potential index

Reliability record	1	2	3	4	5
FFPI value class	1.47 – 2.34	2.35 – 2.87	2.88 – 3.25	3.26 – 3.63	3.64 – 4.57
FFPI degree	Very low	Low	Average	High	Very high

The distribution of the surfaces related to each reliability class proves that the highest surface in the studied area corresponds to an average index value (111.68 km^2) and the smallest surface (18.99 km^2) corresponds to a very low index. The FFPI index correspond to one surface of 99.31 km^2, while the highest correspond to a surface of 49.36 km^2. A low drain potential index can be found on a 59.24 km^2 (Fig. 10).

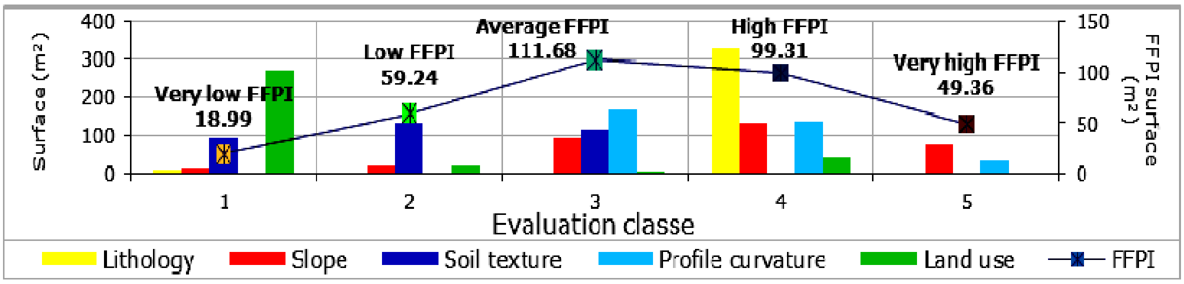


Fig. 10. The distribution of the surfaces related to each reliability class

4. Conclusions

The area of the Uz hydrographic basin is situated upstream of Poiana Uzului lake and occupies a zone with an elevated flood risk. It is highlighted by the fact that the average and high values of the FFPI index hold a 33% and 39% percentage of the total surface. The highest value of the FFPI index holds 15% of the surface. The localities most exposed to flash flood are Cremenea, Eghersec and Cărpinenii. The localities with low exposure are Ghiurche and Valea Uzului. The study proves that the use of GIS techniques brings an important contribution in identifying the values with different degrees of flash flood risk and in the efficient management of crisis situations. Maintaining the wooded areas is paramount and the control of the flows via the small micro-hydro-power plants on the Uz river is recommended.

5. References

1. *Barbulescu, A., and Maftei, C. – Modeling the climate in the area of Techirghiol Lake (Romania). Romanian Journal of Physics, 60(7–8), 1163–1170, 2015.*
2. *Birsan, M.V., L. Zaharia, V. Chendes, and E. Branescu. – Seasonal trends in Romanian streamflow" Hydrolical Processes, 28(15):4496–4505, 2014.*
3. *Čech, M., and Čech, P. – The role of floods in the lives of fish-eating birds: predators loss or benefit?, Hydrobiologia, 717(1), 203-211,2013.*
4. *Chendes V., Corbus C., Petras N. – Characterisyics of April 2005 flood event and affected areas in the Timis-Bega Plain (Romania) analysed by hydrologic, hydraulic and GIS methods. 15th International Multidisciplinary Scientific GeoConference. SGEM2015, 1: 121-128, 2015.*
5. *Chirila, G., C. Corbus, R. Mic, and A. Busuioc – Assessment of the Potential Impact of Climate Change upon Surface Water Resources in the Buzau and Ialomita Watersheds from Romania in the Frame of Cecilia Project, Ohrid, FY Republic of Macedonia, BALWOIS 2008, 1-7, 2008.*
6. *Cojoc G.M., Tîrnovan A., Obreja F. – Modern means of monitoring the hydrological regime in the Siret River Basin (Romania). Georeview, 24: 38-53, 2014.*
7. *Cojoc, G., G. Romanescu, and A. Tirnovan – Exceptional floods on a developed river. Case study for the Bistrita River from the Eastern Carpathians (Romania)" Natural Hazards, 77(3):1421-1451, 2015*
8. *Corduneanu, F., Bucur, D., Cimpeanu, S.M., Apostol, I.C., and Strugariu, Al.– Hazards Resulting from Hydrological Extremes in the Upstream Catchment of the Prut River. Water Resources, 43(1), 42-47, 2016*
9. *Corduneanu F., Vintu V., Balan I., Crenganis L., Bucure D. 2016 – Impact of drought on water resources in north-eastern Romania. Case study – the Prut River. Environmental*

Engineering & Management Journal (EEMJ), 15(16):1213-1222, 2016.

10. *Costache R., Pravalie R., Mitof I., Popescu C. – Flood vulnerability assessment in the low sector of Saratel catchment. case study: Joseni village. Carpathian Journal of Earth and Environmental Sciences, 10 (1): 161-169, 2015.*
11. *Dumitriu, D. – Geomorphic effectiveness of floods on Trotuş river channel (Romania) between 2000 and 2012. Carpathian Journal of Earth and Environmental Journal, 11(1), 181-196, 2016*
12. *Gaume, E., and M. Borga – Post-flood field investigations in upland catchments after major flash foods: proposal of a methodology and illustrations" Journal of Flood Risk Management, 1(4):175–189, 2008.*
13. *Gaume E., Bain V., Bernardara P. şi Borga M. – First Year HYDRATE Report Project, WorkPackage 1 on Flash Flood Primary data analysis. HYDRATE document, 2009.*
14. *Hapciuc O.E., Minea I., Romanescu Gh., Tomaşciuc A.I. – Flash flood risk management for small basins in mountain-plateau transition zone. Case study for Suceviţa catchment (Romania). International Multidisciplinary Scientific GeoConference – SGEM. Bulgaria, 301 – 308, 2015.*
15. *Komínková, D., Nábělková, J., and Vitvar, T. – Effects of combined sewer overflows and Storm water drains on metal bioavailability in small urban streams (Prague metropolitan area, Czech Republic). Journal of Soils and Sediments, 1-15. DOI:10.1007/s11368-015-1327-8, 2015.*
16. *Li, Z., Zhang, Y., Zhu, Q., He, Y., and Uao, W. - Assessment of bank gully development and vegetation coverage on the Chinese Loess Plateau. Geomorphology, 228(1), 462-469, 2015.*
17. *Lóczy, D., Mátrai, I., Fehér, G., and Váradi, Z. – Ecological Evaluation of the Baja-Bezdan Canal (Hungary-Serbia) for Reconstruction Planning. Water Resource Management, 28(3), 815-831, 2014.*
18. *Mic, R.P., Corbus, C., and Matreata, M. – Long-term flow simulation in Barlad river basin using Romanian Hydrological Model Consul. Carpathian Journal and Earth and Environmental Sciences, 10(4), 147-158, 2015.*
19. *Miftode I.D., Romanescu G., Profir O. – The morphometric aspects of the Uz hydrographic basin. Lucrările Seminarului Geografic "Dimitrie Cantemir", 41, 37-46, 2016.*
20. *Miftode I.D., Romanescu G. – The variation of the liquid monthly average flow in the hydrographic basin of the Uz river. Lucrările Seminarului Geografic "Dimitrie Cantemir", 41, 27-36, 2016.*
21. *Mihu-Pintilie, A., and Romanescu, G. – Determining the potential hydrological risk associated to maximum flow in small hydrological sub-basins with torrential character of the river Bahlui. Present Environment and Sistainable Development, 5(2), 255-266, 2011.*
22. *Minea I., Romanescu G. – Hidrologia mediilor continentale. Aplicatii practice. Casa Editoriala DEMIURG, Iasi, 2007.*
23. *Mu, Y., and Mu, X. – Energy conservation in the Earth'scrust and climate change Journal of the Air & Waste Management Association, 63(2), 150-160, 2013.*
24. *Petrisor, AI., Grigorovschi, M., Meita, V., and Simion-Melinte, C.P. – Long-term environmental changes analysis using CORINE data. Environmental Engineering and Management Journal, 13(4), 847-860, 2014.*
25. *Petrisor, A. – Using corine data to look at deforestation in Romania: distribution & possible consequences. Urbanism Architecture Constructions, 6(1), 83-90, 2015.*
26. *Raška, P. – Flood risk perception in Central-Eastern European members states of the EU: a review. Natural Hazards, 79(3), 2163-2179, 2015.*

27. *Reti, K.O., Malos, C.V., and Manciula, I.D. – Hydrological risk study in the Damuc village, the Neamt county. Journal of Environmental Protection and Ecology, 15(1), 142-148.*
28. *Romanescu G. – Hidrologie generala. Editura TERRA NOSTRA, Iasi, 2003.*
29. *Romanescu G. – Inundatiile – intre natural si accidental. Riscuri si catastrofe, 2, 130-138, 2003*
30. *Romanescu G. – Riscul inundaţiilor în amonte de lacul Izvorul Muntelui si efectul imediat asupra trăsăturilor geomorfologice ale albiei. Riscuri şi catastrofe, 4, 117-124, 2005.*
31. *Romanescu G. – Inundatiile ca factor de risc. Studiu de caz pentru viiturile Siretului din iunie 2005. Editura Terra Nostra, Iasi, 2006.*
32. *Romanescu G, Lasserre F. – Le potentiel hydraulique et sa mise en valeur en Moldavie Roumaine. In: Brun A., Lasserre F. (eds.) Politiques de l'eau. Grands principes et realites locales. Presses de l'Universite de Quebec, 325-346, 2006.*
33. *Romanescu G, Romanescu Gabriela, Stoleriu C., Ursu A. – Inventarierea şi tipologia zonelor umede şi apelor adânci din Podişul Moldovei. Editura Terra Nostra, Iaşi, 2008.*
34. *Romanescu G. – Siret river basin planning (Romania) and the role of wetlands in diminishing the floods. WIT Transactions Ecology and the Environment, 125, 439-453, 2009.*
35. *Romanescu G, Nistor I. – The effect of the July 2005 catastrophic inundations in the Siret River's Lower Watershed, Romania. Natural Hazards, 57, 345-368. Doi: 10.1007/s11069-010-9617-3, 2011.*
36. *Romanescu G, Jora I, Stoleriu C. – The most important high floods in Vaslui river basin – causes and consequences. Carpathian Journal of Earth and Environmental Sciences, 6(1), 35, 2011a.*
37. *Romanescu G, Stoleriu C, Romanescu AM. – Water reservoirs and the risk of accidental flood occurrence. Case study: Stanca-Costesti reservoir and the historical floods of the Prut river in the period July-August 2008, Romania. Hydrological Processes, 25, 2056-2070, 2011.*
38. *Romanescu G, Nistor I. – The effect of the July 2005 catastrophic inundations in the Siret River's Lower Watershed, Romania. Natural Hazards, 57, 345-368. Doi: 10.1007/s11069-010-9617-3, 2011*
39. *Serban G., Rus I., Vele D., Bretcan P., Alexe M., Petrea D. – Flood-prone area delimitation using UAV technology, in the areas hard-to-reach for classic aircrofts: case study in teh north-east of Apuseni Mountains, Transylvania. Natural Hasards, 82(3), 1817-1832, 2016.*
40. *Sevianu, E., Stermin, A.N., Malos, C., Reti, K., Munteanu, D., and David, A. – GIS modeling for the ecological restoration of a nature reserve: Legii lake and valley (NW Romania) - A case study. Carpathian Journal of Earth and Envronmental Sciences, 10(4), 173-180, 2015.*
41. *Simić, S., Milovanović, B., and Jojić-Glavonjić T. – Theoretical model for the identification of hydrological heritage sites. Carpathian Journal of Earth and Envronmental Sciences, 9(4), 19-30, 2014.*
42. *Smith, G. – Flash flood potential: determining the hydrologic response of ffmp basins to heavy rain by analyzing their physiographic characteristics. A white paper available from the NWS Colorado Basin River Forecast Center web site at http://www.cbrfc.noaa.gov/papers/ffp_wpap.pdf, 2003.*
43. *Siret Water Basin Administration.– Report. Siret Water Basin Administration: Bacau, 2015.*

44. *Solín, Ĺ., Feranec, J., and Nováčk, J. – Land cover changes in small catchments in Slovakia during 1990-2006 and their effects on frequency of flood events. Natural Hazards, 56, 195-214, 2011.*
45. *Stancalie, G., V. Craciunescu, A. Nertan, and D. Mihailescu. – Contribution of satellite data to flood risk mapping in Romania, 2012 IEEE International Geoscience and Remote Sensing Symposium (IGARSS), 899-902, 2012.*
46. *Tîrnovan A., Cojoc G.M., Romanescu Gh., Obreja F. – Predicting the potential index of major floods production in the Suha basin (Suha Bucovineană), 2th International Conference – Water resources and wetlands. Tulcea, 539 –545, 2014a.*
47. *Tirnovan, A., Romanescu, G., and Cojoc, G.M.– The impact of Heavy Rainfall in the Hydrological regime of Suha River Basin in 2006. Present Environment and Sustainable development, 8(2), 21-31, 2014b.*
48. *Yang, H.C., Wang, C.Y., and Yang, J.X.– Applying image recording and identification for measuring water stages to present flood hazards. Natural. Hazards, 74(2), 737-754, 2014.*
49. *Zoran, L.F.V., Dida, AI., and Zoran, M.A. – Monitoring land use/cover changes on the Romanian Black Sea Coast. Proc. SPIE 9245, Earth Resources and Environmental Remote Sensing/GIS Applications V, 92451J (October 23, 2014). Doi:10.1117/12.2067192; http://dx.doi.org/10.1117/12.2067192, 2014.*
50. *http://land.copernicus.eu/pan-european/corine-land-cover.*