HYDROGEOMORPHOLOGICAL RISK ANALYSIS MODELS IN EXPERIMENTAL RIVER BASINS. CASE STUDY: BĂICENI-CUCUTENI MUSEUM GULLY (OII VALLEY WATERSHED)

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Abstract. Analysis models proposed in this paper represent a part of the results obtained from monitoring of the hydrogeomorphological risk potential identified in Băiceni – Cucuteni Museum gully. This activity started in 2008 when a series of detailed morphometric measurements were performed with high quality instruments. In 2010 were added some hydrometric measurements, which are designed to predict potential risk events associated with the maximum flow occur. The monitoring process is still carried out to detect morphology dynamics at seasonal, annual and multiannual scale. Our objective is to propose a model that can be extrapolated to other experimental river basins with small dimensions. Also, the results obtained wish to support any dispose plans of this area in order to efficiently reduce the risk caused by accelerate erosion and possible overflows.

Keywords: *exceeding probability, maximum flow, gully, soil erosion, hydro-geomorphological risks.*

1. Introduction

Natural risks phenomena, being hydrological (negative hydrological events associated with the maximum flow occur) or geomorphological (gullying) are intensively studied worldwide. In the case of negative hydrological events associated with the maximum flow occur, the international literature gives a great help in understanding and analysing these events: Walter 1990; Jordan and Jennings 1991; Blynth and Biggin 1993; Perry and Combs 1998, in Romania and especially in the eastern part (Moldavian Plateau) those who studied these processes: Pantazică 1971; Roș u and Creț u 1998; Romanescu 2003, 2005, 2006; Romanescu and Nistor 2010; Romanescu et al. 2011; Mihu-Pintilie et. Romanescu 2011.

Strict research on gully was performed by Nicu & Romanescu (2011), who have determined the hydrostatic level and ground-water level from the upper part of the gully with GPR (Ground Penetrating Radar) technology as well as by Mihu-Pintilie & Romanescu (2011) who studied hydrological risk potential. With this paper we propose combining first two research methods in a more complex one, where we will use total station for the topographical measurements (morphometric parameters of the gully) and the existing methodology to calculate the maximum flows with different probabilities of occurrence.

Regarding gullying process, the international literature is consistent in research methods: De Oliveira 1990; Batts et al. 2003; Poesen et al. 2002, 2003; Wu et al. 2008.

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Although a lot of measures are undertaken against soil erosion, in Romania around 7.3 million ha (30.8%) are affected by erosion, of which about 3 million ha are affected by moderate to heavy erosion and 840,000 ha are affected by extreme erosion (Zachar 1982). Especially in the eastern part of the country, the erosion processes intensity is a high one, because of intense deforestations, heavy rains with high intensity, existence of a friable geological layer (clays, sands, marl, etc.), agricultural work improperly executed, all these factors contributing to the occurrence and strengthening of depth erosion processes. The following authors have an approach on the study of depth erosion, with complex researches and soil erosion prevention measures: Băcăuanu 1968; Băloiu 1975; Rădoane et al. 1995, 1999; Ioniță 1997, 2000 a,b; 2006; 2007; Hurjui 2000.

2. Regional settings

Băiceni-Cucuteni Museum gully is situated within Oii Valley (Bahlui) watershed. Its basin is located in the north-eastern part of Romania, overlaying mainly over the Moldavian Plain. Exception is made by the upper part of the basin, who is part from the Suceava Plateau, in this contact area between the plain and plateau is located the gully who will be the main subject of this paper (figure 1). It represents a part of the relief subunit known as Dealul Mare.

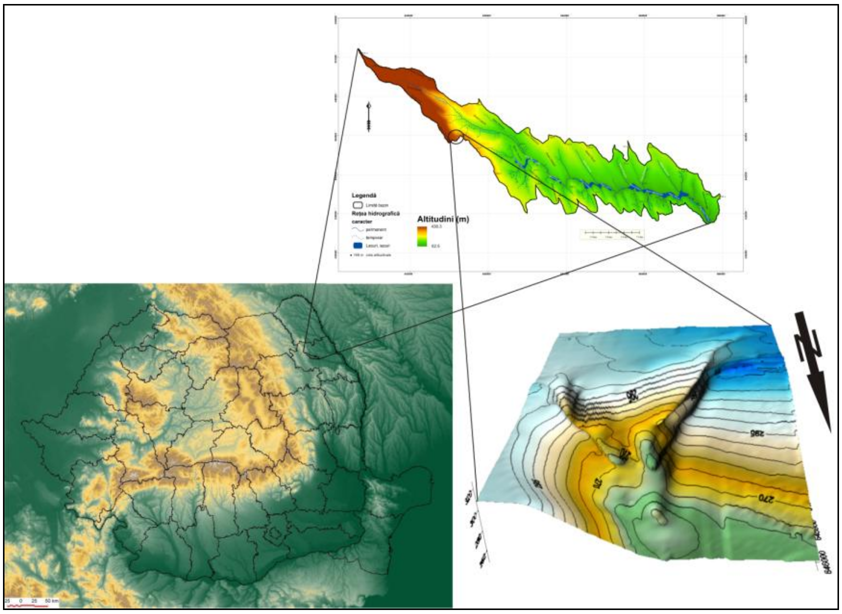

Figure 1: Location of Oii Valley watershed and Băiceni-Cucuteni Museum gully in Romania

The geological cover who is visible in the interior part of the gully is made of Sarmatian (Basarabian) deposits. The sediments are composed by an alternation of marl, sands and clays with sandstone-limestone and Oolithical limestones insertions, with a thickness of about 1000 m. From the geomorphological point of view the gully is located at the lower part of Cucuteni structural plateau (310 m), with nort-eastern orientation. Structural plateaus of this region have considerable heights: Viteazul (340 m), Tinos (342 m), Laiu (375 m), Băiceni (420 m), with an increasing height from SE to NW.

The water course which is draining the gully has an intermittent character, the main water suppliers are rainfalls, snow melting and coast streams visible in the interior of the gully and which are flowing in Băiceni stream, that is the main course of Oii Valley.

3. Materials and methods

To point out gully dynamics, and especially above the main gully thalweg evolution, relating to the two flanking banks but also measurements regarding negative events associated with maximum flow, we used modern instruments like Leica Total Station TCR 1201 (figure 2), ortophotoplans from 2005 and the field observations. Gully measurements started since 2008 when was realized first detailed DEM 1:500 m scale; these measurements will continue for the thalweg and gully banks. All measurements are in STEREO 70 projection system (Romania’s official projection system). Points measured with total station have been overlayed on the ortophotoplan to track thalweg dynamics (figure 3). For data processing we used ArcMap 9.3, AutoCAD 2008 and Microsoft Excel software.

Figure 2: Hydrological and geomorphological total station measurements

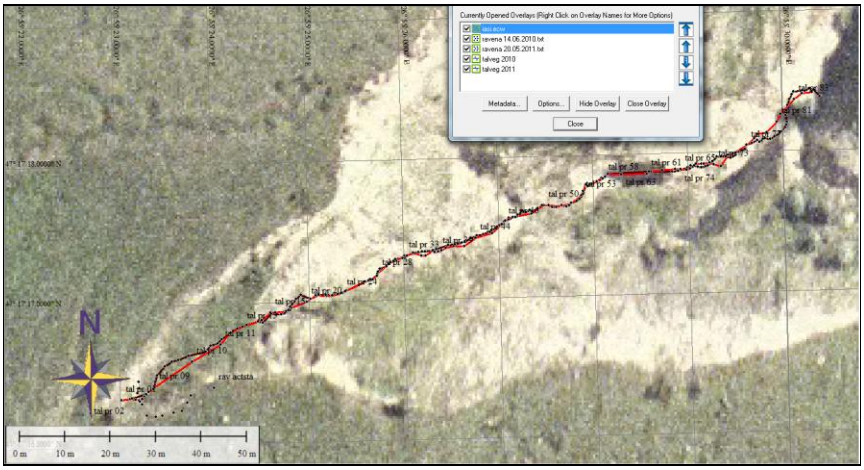

Figure 3: Overlaying total station measurements

Since we are dealing with a small catchment area (< 10 km²), the rational formula method was used to determine the maximum flows with different probability of exceeding:

$$Q_{1\%} = K \cdot \alpha \cdot i_{1\%} \cdot F$$

where: $\boldsymbol{K}$ = 1,67 is a coefficient of transforming the rain intensity from mm/min in m/s and of the surface from km² in m²; $\boldsymbol{\alpha}$ is the runoff coefficient; $\boldsymbol{i_{1\%}}$ is the average intensity of the calculation rain with 1% probability of exceeding and $\boldsymbol{F}$ is the catchment area in km².

For flow calculation we had to determine a series of characteristic elements for this area: length and slope gradient, length and riverbed slope, soil texture as well as the land use.

4. Results and discussions

After a series of measurements performed with the Total Station on the changes for the thalweg dynamics of the main gully, we can observe a change in the upper part of the thalweg with a deviation of about 2.6 m from SE towards NW, in the middle part with deviations not large than 1 m and near the junction with the second's gully thalweg with deviations from 1 to 2 m; in the middle part and the final part of the thalweg deviations come from NW towards SE (the slope is affected by a landslide, fig. 4)

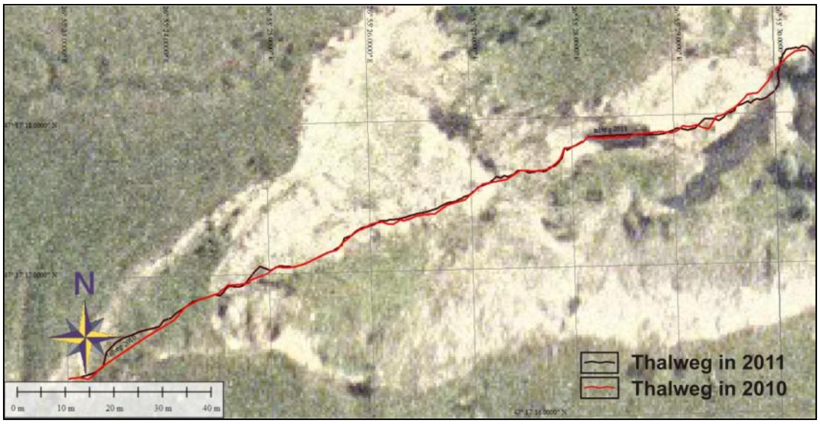

Fig. 4: Main gully thalweg evolution between 2010 and 2011

These deviations are a cause of the dislocated material from the upper part of the right bank of the gully (figure 5) which has deposits on the thalweg level. Although a significant volume of material has been displaced, our predictions for thalweg change in direction were not quite confirmed; this is because of a coast stream with a strong enough flow (especially during the summer when torrential rains occur), but also a high slope which supports the deposited material transfer (clays and sands mainly) outside gully perimeter.


Figure 5: Dislocated material from the main gully bank sliding in the thalweg

Along with field measurements to point out erosion amplitude we made some suggestive photos in different years and seasons, who show an intensive erosion activity (figure 6).

Figure 6: Main gully sector dynamics along a 7 years period

Băiceni – Cucuteni Museum gully is characterized by a weak hydrological activity along the entire year. The main negative hydrological events, associated to maximum flow, occur accidentally. These ones occur when rains are heavy, especially during summer months or in the beginning of the dry season, when water has pluvio-nival origin.

The torrential character of these phenomena is also influenced by the streams from the base of the banks, thanks to the intense infiltration process. This fact is reflected in the minor riverbed configuration which has relatively high depths for such a small catchment.

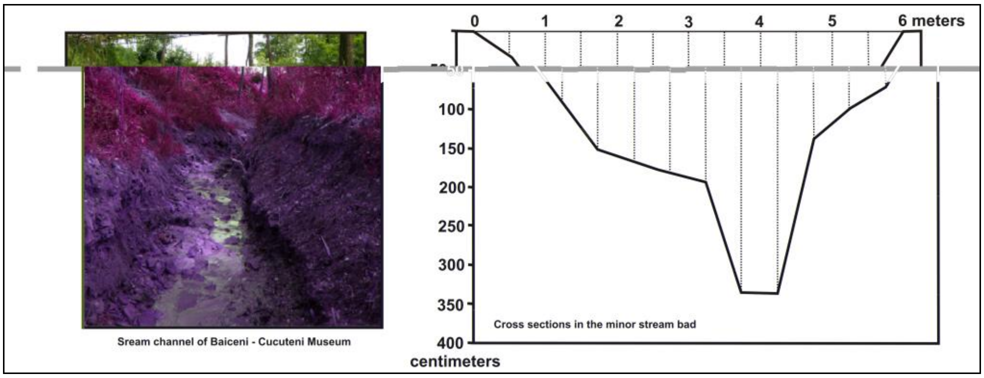

Figure 7: Cross section in minor bed of Băiceni-Cucuteni Museum gully

The shape of the basin plays an important role in the formation and the spreading of overflows. Thus the coefficients calculated on the morphometric elements basis, bring out an oblong shape of the valleys, with a watershed particular to small basins that are in the beginning stage of development. (Table 1).

Table 1: Main morphometric elements of Băiceni-Cucuteni sub-basin

No.	Băiceni – Cucuteni Museum gully	Value	Measure unit
1.	Asymmetry coefficient	0,46	-
2.	Shape factor	0,04	-
3.	Circularity ration	0,14	-
4.	Extension ration	0,74	-
5.	Watershed development coefficient	1,25	-
6.	Shape ration	0,21	-

Being a small basin we choose to apply the reduction formula to determine maximum flows with probability $Q_{1\%}$, proposed by Diaconul et al, 1999.

Thereby, being almost entirely covered by degraded fields and pastures, also with an average soil texture, the maximum flow with 1% probability of occurring is:

$$Q_{1\%} = K * \alpha * i_{1\%} * F$$

$$Q_{1\%} = 1,67 * 0,43 * 2,61 * 0,047 = 0,88\ m^3/s$$

On the basis of this flow with probability of exceeding of $Q_{1\%}$, we calculated the maximum flows with different probabilities (table 2).

Table 2.:Maximum discharge with different overflow probabilities

p%	0,01	0,05	0,1	0,2	0,3	0,5	1	2	3	5	10	20
Q m^3/s	2,8	1,95	1,66	1,45	1,24	1,08	0,88	0,70	0,56	0,49	0,36	0,25

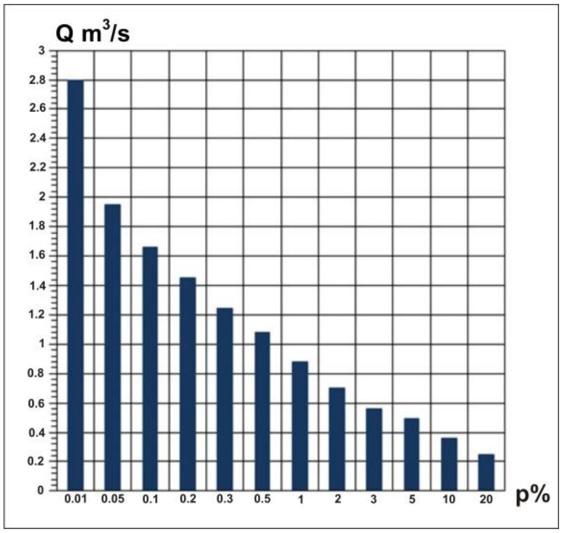

Figure. 8: Maximum flow values based on probility to occur

Therefore, Băiceni-Cucuteni hydrographical sub-basin is characterized by a weak hydrological activity during all year seasons, even if it has a small catchment area, when heavy rains occur it presents risk potential associated to maximum runoff (Mihu-Pintilie et Romanescu, 2011).

The main threatened elements in the case of a flow occurring with probability $Q_{1\%}$ are agricultural lands downstream, two small bridges over the brook, as well as a significant number of buildings and household annexes which are inappropriately built in the vicinity of the riverbed.

5. Conclusions

Băiceni – Cucuteni Museum gully represents an experimental basin to monitor risks induced by accelerate erosion. The determination model of hydro-geomorphological dynamics has confirmed the existence to a sum of factors which are in a close relation with deep erosion, torrentiality and waterflow system.

Regarding the monitoring period, the obtained results confirmed the fact that the erosion has an essential role in the morphological changes. This fact can be found in the negative hydrological events associated to maximum flow which had a high frequency in last years. The dependence between erosion and known overflows is relevant and proportional.

It is very important to know how these specific risks can develop to the study area because extrapolating to other sectors it could be possible to resort to an antierosional model without implementing previous expensive monitoring programs.

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