VULNERABILITY TO CHANNEL MIGRATION OF THE NIRAJ RIVER

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***Abstract**: **Vulnerability to channel migration of the Niraj river.** The aim of this paper is to analyze the changes in the geometrical characteristics of the Niraj river. In order to determinate the zone exposed to the migration of the river we tried to identify the channel migration zone and we study the historic migration zone base on a composite area defined by the channel location in 1910, 1960, 2008, so we obtained the zone of channel occupation for a 100 years' timeframe. Therefore, for delineating the channel migration we digitized polygons for the bank full channel for each time series, and merge them in the same polygon. For anticipated future migration beyond the historic corridor boundary, we added to the channel migration zone an erosion polygon, based on the geological, and land-use characteristics. As a result we obtain a complex set of data which will allow for practitioners to use it in different contexts like: to predict the rate and extend of meander migration, evaluating the risk to existing facilities - necessaries for design countermeasures against the negative effects.*

Keywords: Channel Migration, Niraj River, G.I.S., Vulnerability

1. INTRODUCTIONS

The hydrographic basin can be regarded as a laboratory for the geomorphologic analysis. Its components are so closely related to each other that a change to one of them leads to minor or major changes of the others components. Man as atrophic factor, tried to stop or diminished some of the modifications from the basin which had negative impact, but most of the time those actions has a chaotic consequence translated into natural disasters.

The aim of this paper is to analyze the changes in the geometrical characteristics of the Niraj River. Starting from identifying areas with high mobility we can get information about elements necessary for sustainable river channel and catchment management.

Meandering is the dynamic process of changing the geometric characteristics as a result of fluvial erosion and that of sediment accumulation over time (Leopold, L., B., Langbein, W.B., 1966). The meandering degree is dependent on hydro-climatic factor, resistance to riverbed erosion, direct anthropic agent through engineering works and indirectly through the land use and massive deforestation.

Because often the settlements are built inside the limit of the 100 year flood insurance, we need to identify the existing structures situated near to the river, where active channel migrations may posed a potential hazard.

2. STUDY AREA

The research focuses on the Niraj basin area (658 km^2), located in the center of Romania, in the Mures basin (fig.1). By analyzing the Niraj hydrographic basin it can be seen that due to features like geology, climate and position this has been since ancient times a well populated area. Therefore, the modifications of anthropic and natural origin have influenced and still do the morphology, especially the morphometry of the area analyzed. As we shown in a previous article (Roşca, 2011), the Niraj River, despite continuous development works it's still represent a flood risk for the settlements nearby.

The river morphology adjusted after each energy input: flashflood, anthropogenic adjustment of the riverbed, deforestation and

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land use changes. The most obvious examples can be seen in the riverbed. There is a high density of settlements: 5 settlements/100km², 28 being located on the fluvial terraces near the valley which demonstrates the necesity of this study.

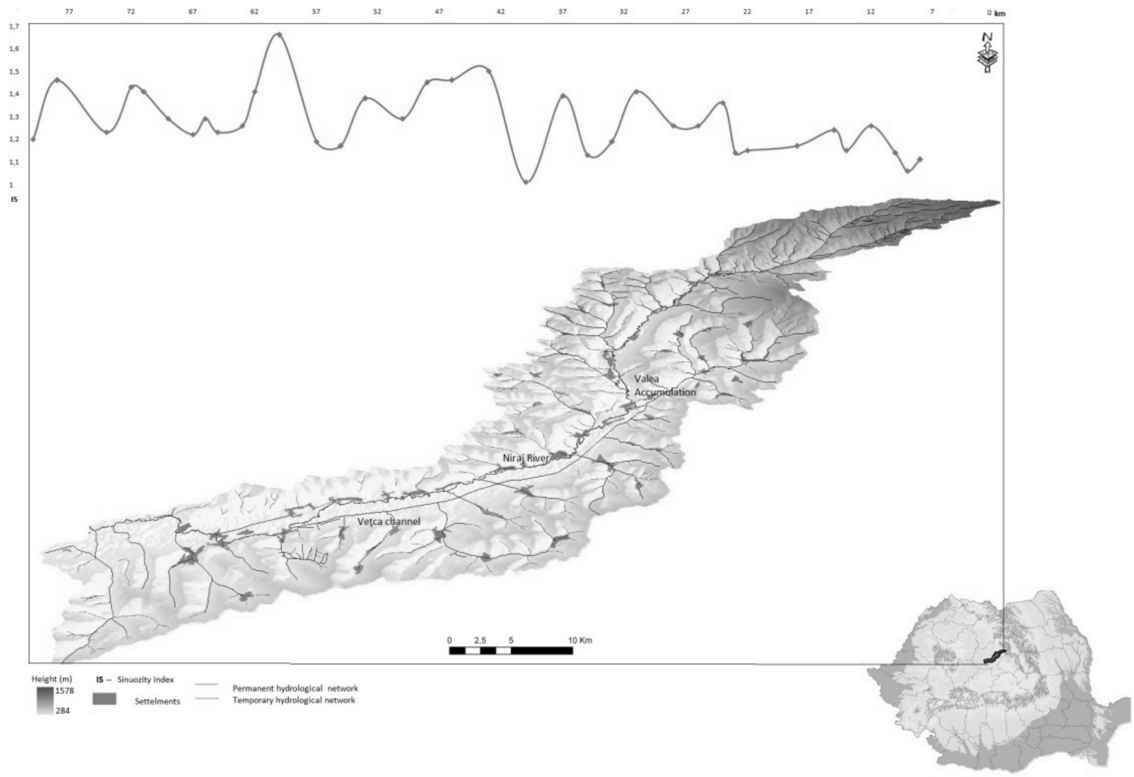

Fig. 1: Niraj drainage basin location and the variation of sinuosity index

3. METHODOLOGY

In order to evaluate the vulnerability to channel migration we have used the methodology applied by Water Engineering and Technology, 1988 for 89 rivers from U.S. This method involves analysis of curvatures radius and migration rate measurement using the G.I.S. mapping software developed by ESRI.

Geographic Information Systems (G.I.S) offers us the possibility to identify the quantitative and qualitative characteristics of the studied geographic system in present day by analyzing land data, previous to the studied period on information obtained from cartographic data, but it also offers us the possibility to determine areas that might have a great potential risk of recurrence and occurrence of the identified processes.

For predicting the position of a bend in the future we must know the historical meander pattern changes. We used Topographic maps, 1:25000, from 1970, and SPOT 5 Images from 2008 georeferenced with a common projection: Stereo70. For obtaining the database we digitized the riverbed for each maps. For reducing the potential errors is important to identify some common points (intersection of roads, building, high hills etc), and the inflection points for every loop needed in the overlay process. For obtaining the radius curvature we have used a circle fitting to the bend centerline for each meander loop and we added the centroid for each circle (fig. 2).

The radius of curvature and centroid position of the circle will be used to measure the channel migration for the period between: 1970-2008, represented with red arrow. (Fig. 2)

The rate of change of the radius of curvature for the bank is definite by:

$$\Delta R_{CA} = (R_{C2} - R_{C1})/Y_A \text{ where}$$

ΔR_{CA} = Rate of change in radius of curvature

during period A (m/year)
R_{C1} = Radius of curvature of bank in year 1
R_{C2} = Radius of curvature of bank in year 2
Y = Number of years in period A

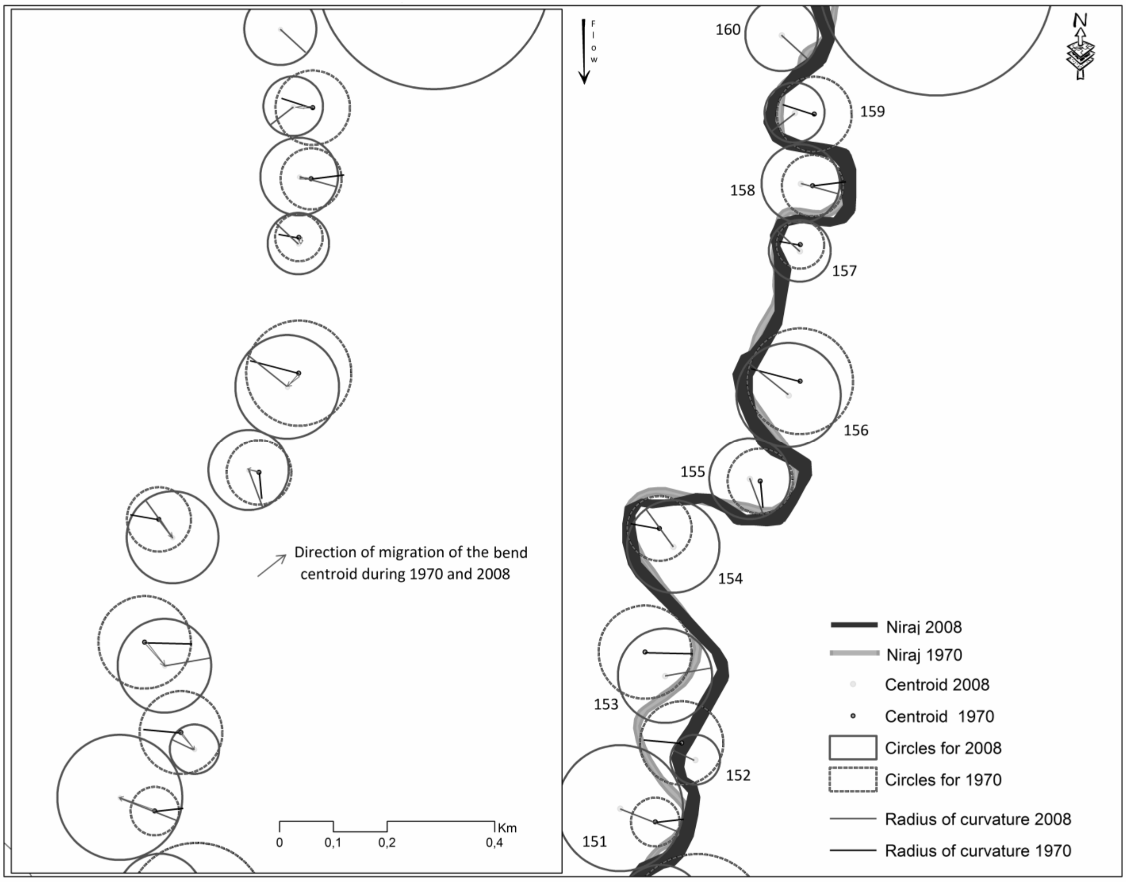

Fig. 2: Meander migration measuring between 1970-2008

In order to identify vulnerable areas, it has been analyzed resistance to erosion according to geologic and vegetal protection factor as was described by Pandi, G., 1997, methodology for the NW Romania. For developing the medium geological resistance map we used the Geological Map, scale 1:200000, combining rocks according to "Regulative classification in terms of the capacity to resist dislocation" which states 16 groups with values between 2,5 to 10. (Table.1)

Table no. 1: Resistance to erosion geological groups

Resistance coefficient	Rocks types	Area (km²)
2,5	Sands, Gravels, Clays of upper Holocene	118,3
3	Sands, Gravels, Deluvial deposits of lower Holocene	0,91
3,5	Sands, Gravels, Clays of Pleistocene	18,7
4	Marls, Clays, Sands, Gravels, Tuffs of Pliocene	416,9
4,5	Marls, Conglomerates, Gypsum, Tuffes, Clays, Sands of Miocene	1,34
7	Vulcanocene-sedimentary conglomerates	85,9
10	Andesite	22,35

In order to determine the influence of the vegetation cover over the resistance to erosion it was developed a map of plant protection using the Corine Landcover, 2006, raster data.

Table no.2: Vegetal protection groups

Protection coefficient	Vegetal association	Area (km^2)
1	Land occupied by nonirrigate agriculture, with significant areas of natural vegetation	127,8
2	Pasteurs and agricultural areas	259,1
3	Transitional woodland-schrub	32,9
4	Fruit trees and berry plantations,vineyards	67,9
7	Coniferus forest	7,1
7,5	Mixed forest	10,6
8	Broad-leaved forest	152,9

The erosion resistance indicator, considering the two factors – geology and vegetal protection, in a lower percentage is obtained as:

$$RE = RG * PV^{0,5},$$

Where: RE – Erosion resistance
RG – Geological resistance
PV – Vegetal protection

4. RESULTS AND DISCUSSIONS

The studies on the dynamics of riverbeds showed that radius dynamic analysis of the radius of curvature can be used to evaluate channel stability. (Brice,1977, Harvey, 1989, Lagasse, & all, 2004) Thus we have evaluated for the Niraj river every meander loop for every time period for which we have cartographic data. Along with drawing and measuring radius of curvature and its rate of change from 1970 to 2008, we have analyzed loop meanders quantitative parameters: wavelength and amplitude necessary for understanding the process. (Table 3)

Table no 3: The morfometrical characteristics of meanders

Nr. of meander	Length of the river (km)	Wavelength (m)		Amplitude (m)		Radius of Curvature (m)		The rate of change of RC (m)
		1970	2008	1970	2008	1970	2008	
151	32,05	615	301	121	125	46	114	1,789
152	32,3	414	294	125	74	79	43	- 0,947
153	32,02	442	453	160	166	87	86	-0,026
154	31,6	617	347	247	288	63	59	-0,105
155	31,3	574	326	248	244	58	74	0,421
156	31,05	422	388	91	113	98	94	-0,105
157	30,7	301	281	102	106	43	56	0,342
158	30,3	347	208	152	159	55	70	0,395
159	30,5	355	296	144	135	68	64	-0,105

Where RC = Radius of Curvature

Niraj river presents four types of loop form: simple, compound, symmetrical and asymmetrical with high dynamics from one period to the next one. Thus we have observed that a series of meander loops have closed, in 1970 there were 251 and in 2008 their number decreased to 218. Of these, 171 showed a high mobility.

A positive value of the rate of change indicates an expansion (increasing radius) of the value of radius curvature for 1970-2008 period and those with a negative value shows a decrease of radius curvature. Throughout the entire river, 61% of the meander loops have expanded and only 39% have decreased, but the situation differs locally due to changing of the hydrographic basin characteristic parameters as well as varying degrees of anthropic intervention. Another morphometric indicator of the river, the sinuosity index, proves the data veridical. Sinuosity of the Niraj river was calculated from the ratio of channel length to straight-line valley length. Results indicate that sinuosity of the main stream declined from 1,59 (specific to meander river) to 1,17 (specific to sinuosity river) between 1970 and 2008.

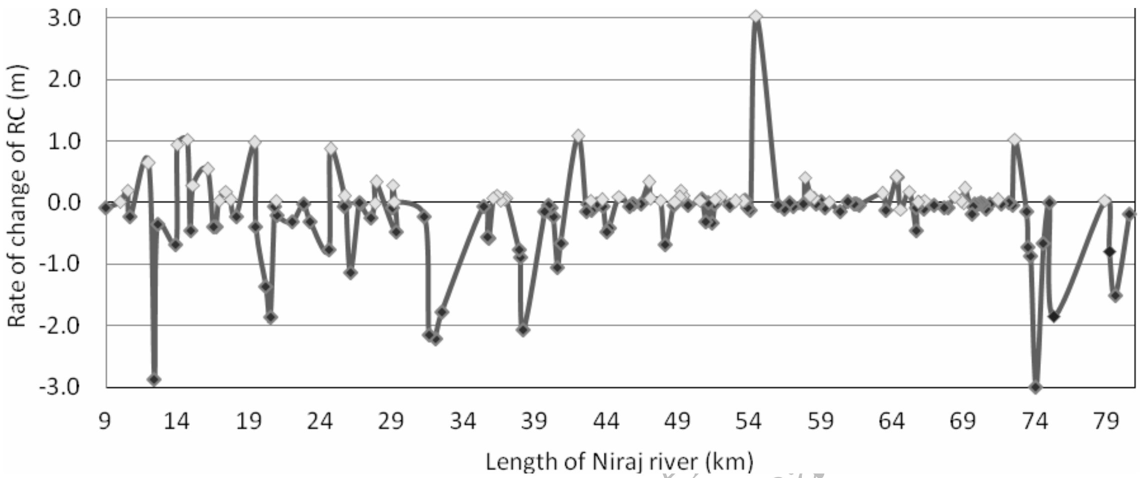

Fig. 3: Variation of the rate of change of RC during the period of record (1970-2008)

In the upper Niraj basin (after the confluence of the Niraj Mic with the Niraj Mare), which corresponds from km 9 to the 38th, the river has an increased energy due to the high slope and that of high water intake, which causes reorganization to the riverbed; this section of the river corresponds to the piedmont part of the Gurghiu mountain and that of the Sub-Carpathian relief, which has a geology that passes from volcanogenic sedimentary deposits to deluvio-proluvium ones consisted of sand, gravel and leosoil deposits.

In this sector it can be found both expansions of the meanders and also areas of decreasing. As it can be observed in the middle sector, channel migration has a small variation; exception are cases when man intervened by embanking the river in order to protect people houses situated nearby.

The inferior sector, which is closer to the confluence, being developed on a low slope and geology dominated by gravel, marl and clay receives a higher degree of meandering. Thus, it can be observed cases when the radius of curvature has positive values, which corresponds to the meander expansion from this sector between 1970 to 2008.

For Niraj River we can observe that the stable meanders are characterized by a large value of RC but the meander with high dynamic had a smaller value of RC but the amplitude increases.

Using the method proposed by Pandi (1997) for determining resistance to erosion we have identified the regions characterised by low values, i.e. between 2.5 – 3.5 which defines the deposits located nearby the minor river bed, in the inferiror basin especially; here prevails holocene deluvio-proluvium deposits, the specific vegetation being that of a floodplain with a large extention of non-irrigated agricultural land.

In the upper basin, the resistance to erosion is characterized by average values because of geology (graves, sand and leosoil deposits from Upper Pleistocene), due to high vegetal protection coefficient and that of index roughness. The meandering area was identified depending on the lateral evolution, altitude and adjacent areas slope. It can be observed that its width grows as the confluence with the Mures river approaches.

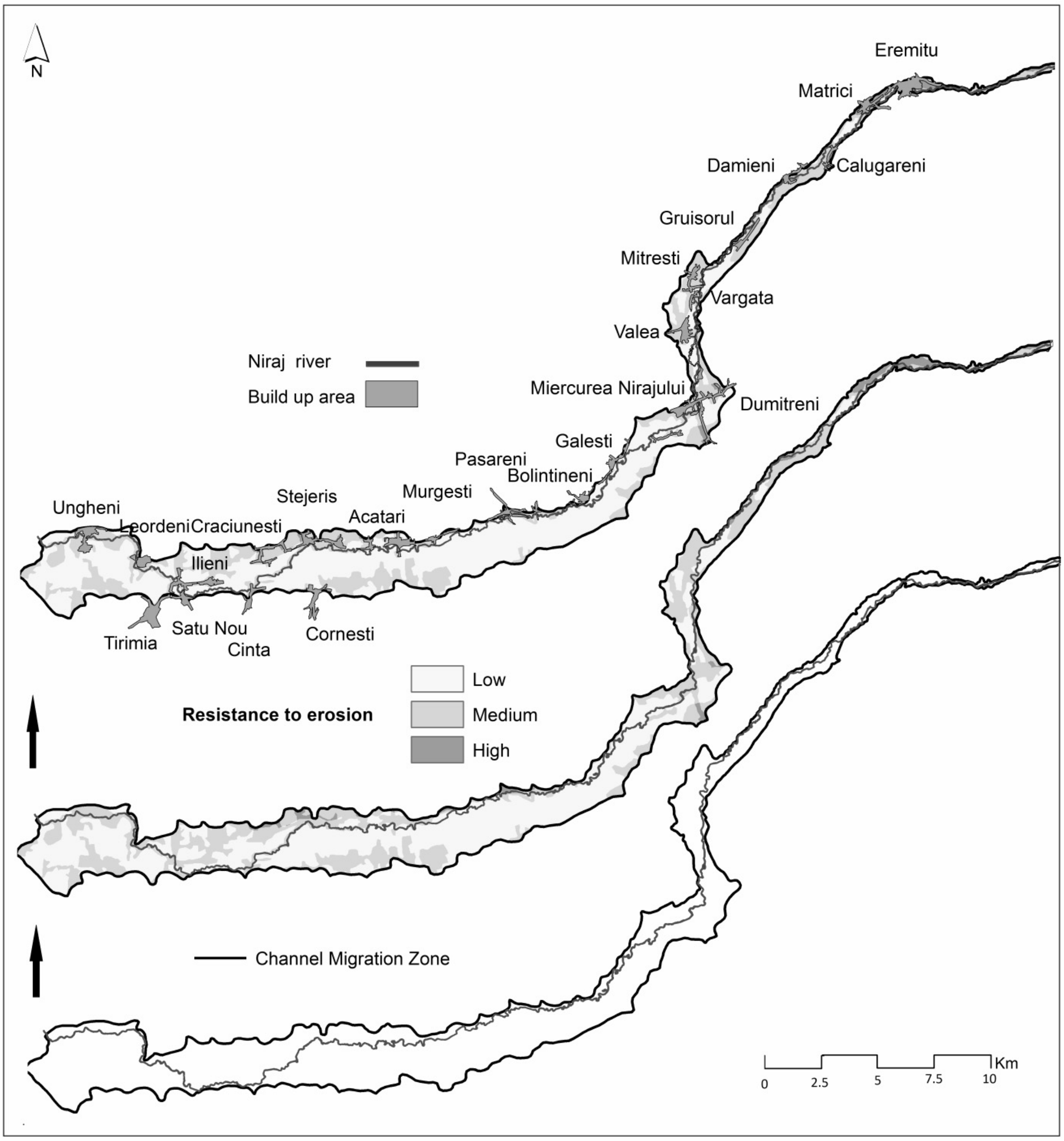

Fig. 4: Identification of the built up area exposed to meander migration

Thus, benefitting from the erosion resistance raster, the meandering area and knowing the average migration rate of the river, we have identified the built-up areas of the settlements which being situated nearby the river are highly exposed to river bed migration: Acățari, Păsăremi, Murgeşti, Leordeni.

5. CONCLUSIONS

Having this database, there can be identified areas with pronounced meandering over the analyzed period and also those sectors which are exposed to dynamics when extreme hydrologic or anthropic events occur. It should be way of raising awareness for the inhabitants concerning the risks they face and also an evaluative way of the best protective measures against those phenomena. The problem of optimal river management is still open.

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