NIRAJ RIVER'S CHANNEL MIGRATION: A RESPONSE TO HYDRO-CLIMATIC VARIABILITY

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ABSTRACT. – Niraj River's channel migration: a response to hydro-climatic variability. Morphometric variables that are specific to Niraj River bear changes along its length due to a series of factors: liquid and solid discharge variation, river slope, the riverbed deposits type, land use changes and engineering works carried out on the riverbed. It can be seen an asymmetric evolution overtime concerning the meanders changing rate in concordance with environmental changes (precipitation quantity, debit, land use). Nevertheless, the lack of annual cartographic materials by comparison with the debit and precipitation data is a barrier in making a direct correspondence between altitude, erosion rate, precipitation and flow. For highlighting the flow variability in time and space of the Niraj catchment we used monthly mean and maximum discharges recordered at Cinta and Gălesti hydrometric stations as well as pluviometric data from stations across studied hydrographic basin between 1970-2009.

Keywords: Channel migration, maximum discharge, floods, trend analysis, Niraj River.

1. INTRODUCTION

The hydrographic basin represents an opened geographic system which releases energy, informational and material exchange with the environment. Setting up the geomorphologic system with its subsystems: riverbed, slope, interfluves – as shown by J. Chorley and B.A. Kennedy, (1971), implies modelling agents action and morphogenetic systems which act over the relief through erosion, transport and accumulation in cascading system. Hydrographic basin functioning as a hydrological system requires longitudinal material and energy exchanges (longitudinal connectivity), lateral exchanges with the major riverbed (lateral connectivity) and vertical ones with groundwater and atmosphere.Thus the water flow and river deposits changes might cause an alteration in the minor riverbed geometry: raising the solid and liquid flow leads to riverbed width, width/depth ratio and meanders wavelength increase but, in the same time, it causes a sinuosity index and slope decrease.

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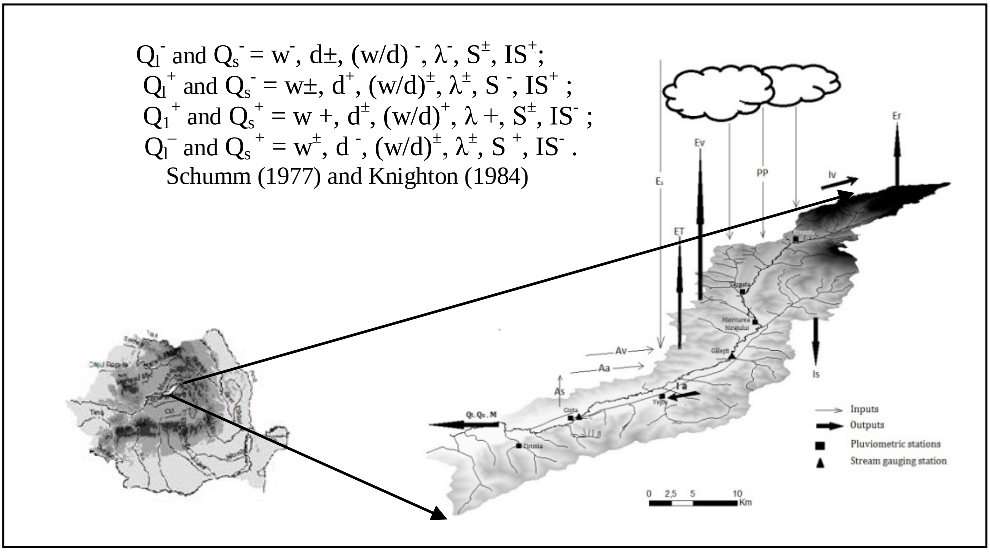

Fig. 1: ***Mass and energy exchange scheme between the Niraj river catchment area and environment*** where: Q_l – liquid discharge; λ - wavelength ; Qs - sediment discharge; w - riverbed width; d - riverbed depth ; S - slope ; IS - sinuosity index; Es = direct solar radiation; PP - precipitation; As - underground inputs; Iv - wind output, Aa - anthropic inputs, Ia – anthropic output, Av = wind input; M - chemical discharge; Is - underground outputs; Iv - wind outputs; Ev - evapotranspiration; ET - terrestrial energy; Er - reflected energy. (Zăvoianu, 1978)

The solid and liquid discharge decrease has an opposite effect, which means riverbed width decreasing, minor riverbed depth lessen, width-depth ratio and meanders wavelength decrease, but also a rise of sinuosity index (fig.1). Experts who have studied rivers from different geographic regions come out with results that show that rivers always tend to modify their morphometric characteristics depending on hydraulic elements. Thus it is shown a continuous process of ensuring a dynamic equilibrium. A.S. Shumm (1977) analyzed the control factors of rivers morphography and dependent/independent variables whose quality might change over time. Thus, it was desired to identify an ascertainable database for every variable and threshold values, as “a form of maintaining system order through fluctuations” (Ichim and colab., 1989).

2. STUDY AREA, DATA AND METHODS

The research focuses on the Niraj River, a tributary of the Mures river, with a length of 82 km and a catchment area of 658 km^2, located in the center of Romania. For highlighting the flow evolution in time and space for the Niraj River catchment we used monthly average and maximum discharges registered at Cinta and Gălesti hydrometric stations as well as pluviometric data from stations across Niraj hydrographic basin (Eremitu, Vărgata, Bereni, Miercurea Nirajului, Vețca, Cinta and Tirimia) between 1970-2009. In order to ensure continuity and as a consequence of representativeness, Targu Mures station, situated near the analysed area was added. The data used in this study belongs to the National Institute of Hydrology and Water Management and Romanian National Meteorological Administration Institute. Nevertheless, the lack of annual cartographic materials by comparison with the debit and precipitation data is a barrier in making a direct correspondence between altitude, erosion rate, precipitation and flow. Assessments will be carried out at the trend and the average rates of sinuosity index change. We used Austrian Military Map, 1:200000 from (1910), Topographic maps, 1:25000 (1970), and SPOT 5 Images (2008) georeferenced with a common projection: Stereo70.

3. RESULTS AND DISCUTIONS

3.1 Trends and temporal variation of precipitation

By analysing the variation of annual average precipitation it is obtained an overview image of both the excedentary and deficitary periods from pluviometric point of view for the Niraj basin.

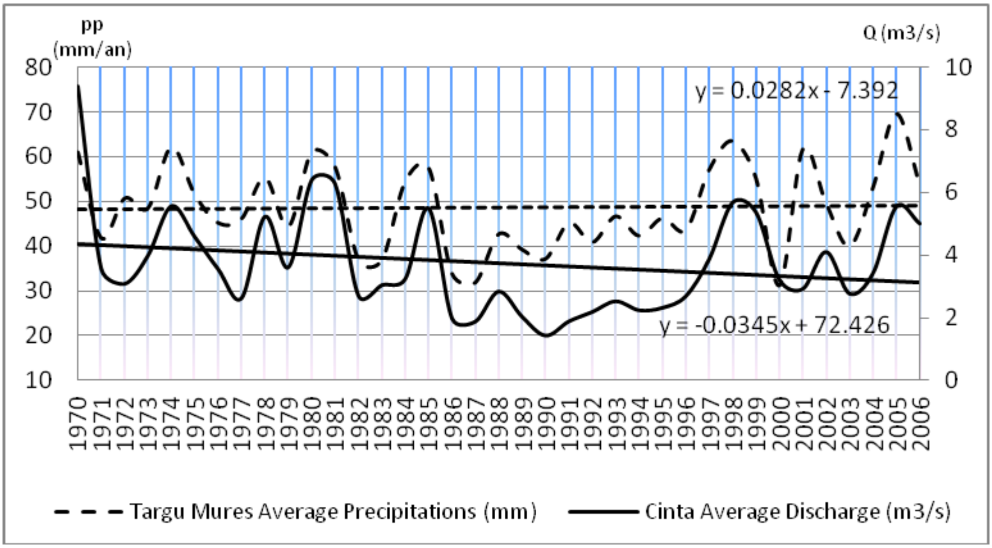

Fig. 2: ***Linear trend in mean precipitation and discharge between 1970-2006***

The annual precipitations variability analysis shows a certain cyclicity of droughts and accentuated humidity periods. For the entire period (1970-2009) it can be observed a stationary trend for Targu Mures station (fig 2) with pronounced interdecal variability (table 1). Analyzing by decades it can be remarked a synchronicity in the rainfall quantity between 1970-1979, all other periods being characterized by a great variability from one hydrometric station to another.

The physic-geographic factors represented by relief particularities through altitude, orientation and fragmentation assign variety for meteorological phenomena, rainfall being distributed irregularly in the Niraj river basin, a higher rain intensity being noticed as altitude gets higher; (fig.3) at Eremitu pluviometric station, situated at an altitude of 490 meters, the greatest quantity of 24 hours precipitations (100,8 mm) were recorded in May, 13, 1970, while at Cinta, located at 302 meters altitude, the greatest amount of rainfall was registered in June, 18, 1998 and it was of only 57.9 mm.

Table 1: ***Decadal average precipitations quantity and deviation to the multiannual average***

Pluviometric Station (altitude)	Multiannual average mm/year (1970-2009)	Decadal average / Deviation to the multiannual average (mm)							
		1970-1979		1980-1989		1990-1999		2000-2009	
Eremitu (490)	941	980,8	- 39,8	935,5	5,5	939,7	1,3	870,9	70
Vărgata (370)	766	701,1	64,9	777,9	- 11,9	749,5	16,5	853,6	- 88
Miercurea Nirajului (350)	607	-	-	-	-	626,1	- 19,1	581	26
Bereni (362)	671	-	-	798,0	- 127	621,3	- 127	-	50
Vețca (385)	635	675,0	- 40	671,8	- 36,8	641,9	- 6,9	-	-
Cinta (302)	577	-	-	577	0	577,6	- 0,6	-	-
Tirimia (310)	578	565,4	12,6	601,5	- 23,5	-	-	-	-
Târgu Mureș (368)	587	608,6	- 21,6	543,5	43,5	547,1	39,9	624,3	- 37

The maximum quantity of precipitation can reach exceptional values especially in summer time because of the torrential rainfalls which are specific to this season (June, July and August months with a 69.8% share) being followed by Autumn months with 33%.

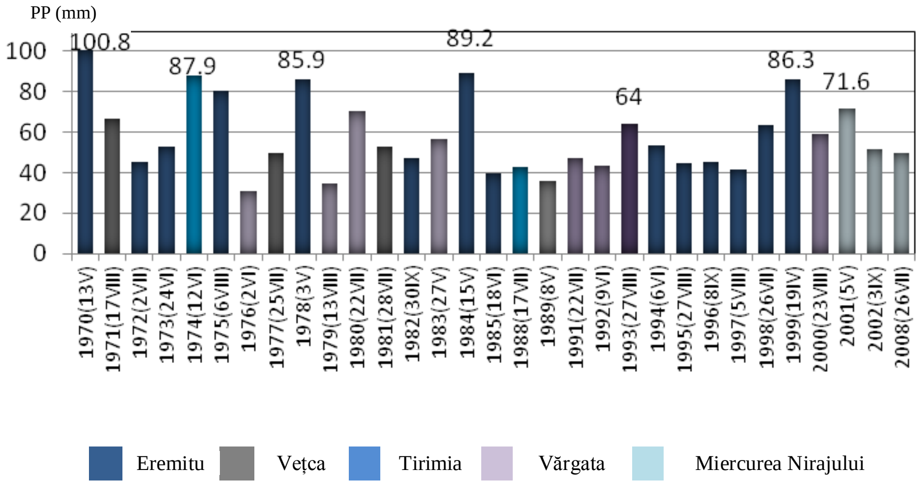

Fig. 3: ***Maximum 24 hours precipitations in Niraj River Catchment***

3.2. Trends and temporal variation of liquid discharge

As a result of the excessive rainfalls, the Niraj river basin is exposed to flash floods. In the mean annual runoff variation of the analysed period it was not observed a cyclic periodicity but, there were a succession of periods with high run offs followed by periods with low run offs. 1955-1960, 1965-1985, 1998-2006 are periods when high debits were recorded, 1970 being the peak. This last year was characterised by heavy rainfalls which caused flash floods followed by material and human loses. The periods with a low flow are: 1960-1964 but also 1986-1996. By analysing the decadal variability of the average annual discharge it can be observed a downward trend in 1970-1979, 1980-1989 and a growing one for 1990-1999 and 2000-2009.

Table 2: ***Characteristic data of discharge quantity and deviation to the multiannual average***

Gauging Stations	Q_{med} (1970-2009) (m^3/s)	Q_{max} (m^3/s)	Q_{min} (m^3/s)	Decadal average/Deviation to the multiannual average (m^3/s)							
				1970-1979		1980-1989		1990-1999		2000-2009	
Gălești	2,902	7,461 1970	1,140 1990	3,59	-0,67	2,84	0,08	1,63	1,29		
Cinta	3,608	9,397 1970	1,437 1990	4,52	-0,92	3,59	0,01	3,02	0,58	3,86	-0,26

The maximum flow represents the most important moment of a river's flow because of its possible negative effects which it induces (accelerated steam bank erosion and sediment supply, land loss). By analysing the temporal variability of the maximum liquid discharge (Fig. 4) it can be observed a correspondence between the rainfalls quantity variation and their correspondent debits periods.

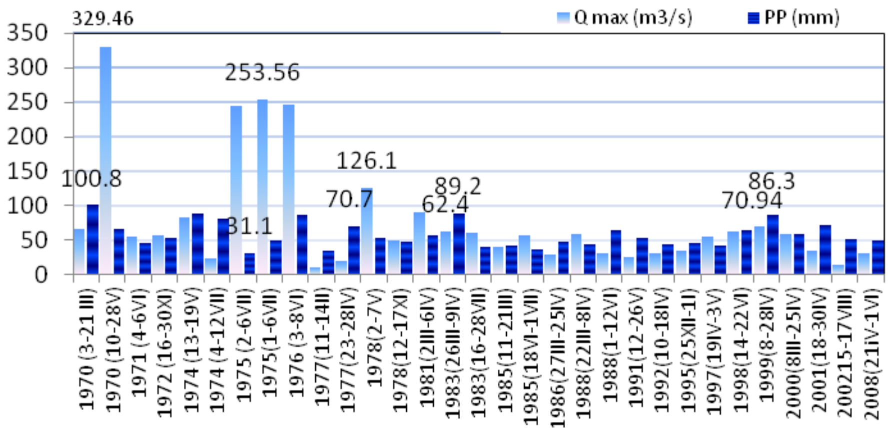

Fig.4: ***The maximum discharge value observed during annual flood events at Cinta***

3.3. Niraj River's channel migration

The literature treats channel migration in relationship with magnitude/intensity and extreme flood events frequency (Stover, 2001; Wellmeyer & colab, 2003; Wallick, 2007; Crosado, 2008; Zaharia & colab., 2012, Pandi& Horvath, 2012). Because the Niraj flash floods analysis was realised in a previous study (Rosca, 2011), we will focus on the effects of these extreme periods over the riverbed. The riverbed changes might suddenly appear, as a result of flash floods and/or trend constant evolution (Rădoane, 2005). Thus, it is necessary to identify the meander rate temporal-spatial variation.

Between 1970 and 2008, results indicate that sinuosity of the main stream declined from 1,59 (specific to meander river) to 1,17 (specific to sinuosity river) with variations at local level (fig. 5). Meander numbers has also decreased from 251 in 1970 to 218 in 2008. In figure 5 it can be seen the cut-off meander position that involve the development of a new channel across the floodplain, depending on the soil erosion degree, type of vegetation and intensity of the floods.The cut-off ratio criteria was calculated as the ratio between the length of the meander and the length of the short-cut channel (Joglekar, 1971). According to Joglekar, a bend cut-off increases when the cut-off ratio approaches the critical value characteristic for the studied river, determined on the basis of historical data. For Niraj river the cut-off ratio varies between 1,1 and 1,8. In the first example we can see a natural cutoff and the formation of an ox-bow lake near to Ungheni city.

The way the river imposes its dynamic behavior, depending on local evolution trends, is expressed by changes in the flow direction through draw off, meanders loop progressive increase (throughout the entire river, 61% of the meander loops have expanded and only 39% have decreased) and drainage basin width changes. From the cartographic materials, between 1970-2008, a widening process of the riverbed and a decrease of its width as a result of solid flow can be seen throughout the entire river. According to Hooke classification (1977), along Niraj river there are migration sectors by extension, translation and rotation (fig.7).

4. CONCLUSIONS

The hydro-climatic processes make quantitative and qualitative changes, thus generating their own characteristics which define specific geographic entities. Having this database we can identify the areas with accentuated meandering over the analysed period as well as those sectors which are exposed to change when hydrologic and anthropic extreme events occurs. For a clear image over the hydroclimatic factors influencing riverbed dynamic, the precipitation and liquid discharge trends in Niraj River catchment were analyzed. The trend of rainfall and flow is in a constant growth, contrary to afforestation index (29,8% in 1970 versus 24,7% in 2008) which places the analyzed region in the weak ecological balance category, affected by human pressure. Systemic observations over Niraj' meanders morphometric parameters allowed river trends evolution identification during 1910-2008 as a response of variation control factors: sinuosity index change and changing river category from that of meandered rivers to the sinuosity ones. In certain sectors it can be seen a decrease in the dynamic character through cut-off and in others a pronounced dynamic.

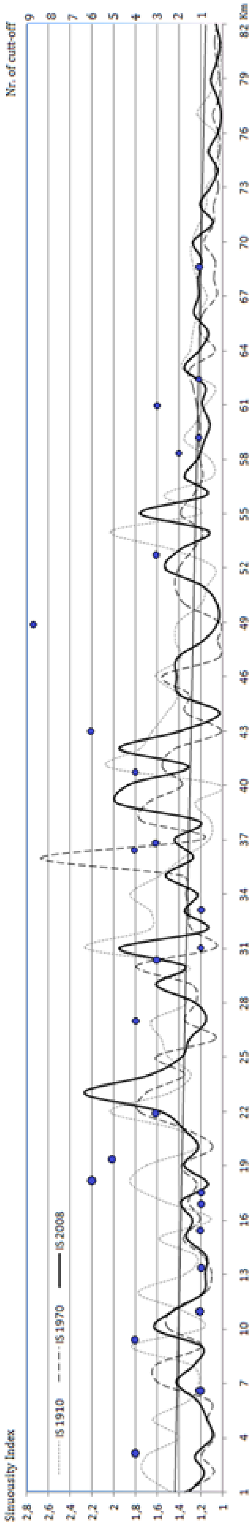

Fig. 5: *Sinuosity index variation along Niraj River between 1910 and 2008*

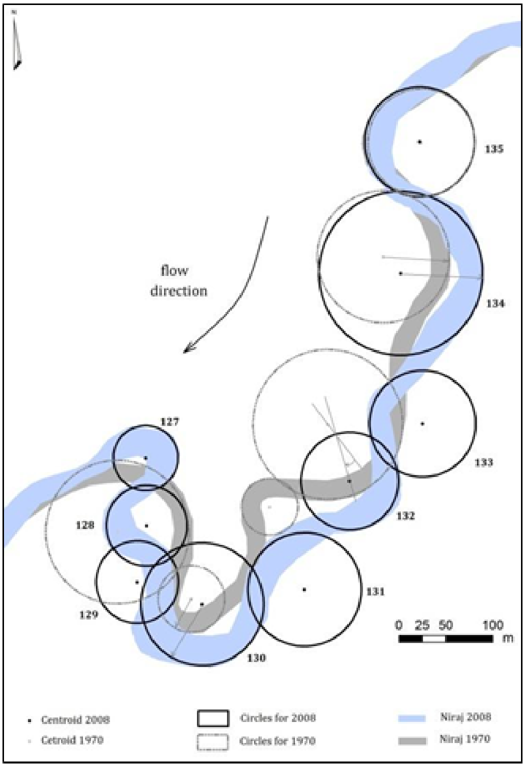

Fig. 6: *Style of change of meander bends between 1970-2008 of the Niraj River*

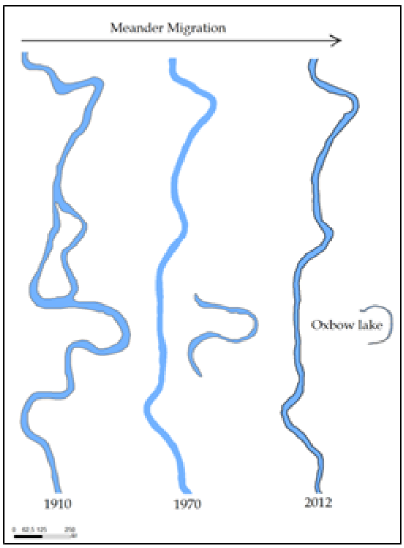

Fig.7: *Progressive change and cut-off of meander leading to development of an ox-bow lake*

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