RIVER LATERAL DYNAMICS AND FLOODS IN RELATION TO HUMAN COMMUNITIES. CASE STUDY: MOARA DOMNEASCĂ VILLAGE (ON LOWER TELEAJEN RIVER)

L. ZAHARIA[1], G. IOANA-TOROIMAC[1], S. CATANĂ[2], G. MINEA[1], C. DELPORTE[3]

ABSTRACT. – **River lateral dynamics and floods in relation to human communities. Case study: Moara Domnească Village (on Lower Teleajen River).** One of the challenges set at the beginning of the 21st century is living with floods and natural dynamics of rivers. In this general framework, the main goal of our paper is to elaborate a diagnosis regarding lateral migrations and floods of Teleajen River in the proximity of Moara Domnească Village (Râfov Commune, County of Prahova). Our analysis includes two approaches: a hydrological and a geomorphological one. The hydrological approach aims at analysing maximum discharges variability of Teleajen River at Moara Domnească gauging station and at showing its floods' frequency. The geomorphological approach leads to outlining the wandering area of Teleajen River based on a diachronic cartography, which takes into account documents covering the last 150 years; the boundaries correspond to the maximum extension of its channel and abandoned channels. The area overflowed in September 2005 is assessed based on drawings from the urban plans of Râfov Commune. The outcome shows that the area appropriated by Teleajen River was partially exploited by society. Therefore the village of Moara Domnească is exposed to these hazards.

Keywords: channel, wandering area, floods, Teleajen River, Moara Domnească Village.

1. INTRODUCTION

In the field of European water management, the interdisciplinary studies are one of the challenges set at the beginning of the 21st century (Newson and Large, 2006). Several approaches (*e.g.* hydrological, geomorphological) aim at living with floods and river dynamics (*e.g.* identifying areas vulnerable to floods and fluvial processes in order to take action and diminish related losses; renaturalisation and ecological reconstruction of river environments).

[1] University of Bucharest, Faculty of Geography, 1 N. Bălcescu, 010041 Bucharest, Romania, e-mail: zaharialil@yahoo.com, gabriela_toroimac@yahoo.com, gabriel.minea@gmail.com

[2] National Administration of Meteorology, 97 Bucureşti-Ploieşti, 013686 Bucharest, Romania, email: simona.catana@meteo.inmh.ro

[3] University Paul-Valéry Montpellier III, Master 2 Agriculture Managament and Territories, Route de Mende 34, 199 Montpellier Cedex 3, France, email: cdelporte89@gmail.com

Subsequently, a new concept is arising at both Global and European scale: „Room for the River". This concept of "soft" river management aspires to harmonise socio-economical demands (*e.g.* water supply, flood protection) with ecological needs (Gabor and Şerban, 2004; Şerban and Gălie, 2006; Vandemeulebrouck et al., 2009). Therefore, it becomes necessary to provide a "freedom" space for rivers, imperative to their natural evolution (Malavoi et al., 1998; Arnaud-Fassetta and Fort, 2008; Arnaud-Fassetta et al., 2009). In order to establish the dimensions of the "freedom" space, it is necessary to identify the historical wandering area and the floodplain. In this general framework, our paper aims to elaborate a diagnosis regarding lateral migrations and floods of Teleajen River in the proximity of Moara Domnească Village (Râfov Commune, County of Prahova). This study may contribute to a better understanding of the relation between human communities and river dynamics, and to mitigate the risks related to inadequate management.

The study area is chosen for two main reasons: 1) many abandoned channels can be found in the perimeter of Moara Domnească Village; 2) Teleajen River overflowed frequently (especially in the last ten years), affecting Moara Domnească Village; in the recent time the widest floods and the most dire consequences (mostly regarding crops, according to Delporte, 2011) took place in 2005. At Moara Domnească, Teleajen River leaves the piedmont of Ploieşti and enters the lowland of Gherghiţa (sub-units of the Romanian Plain; Fig 1A). The thalweg gradient is about 1 m/km; the mean annual discharge reaches 9 m^3/s. Teleajen River flows into Prahova River at about 17 km downstream from Moara Domnească. Consequently, at high discharges of the two rivers, Teleajen River flows upstream, overflowing this reach.

2. DATA AND METHODS

This paper relies on two major types of data: hydrological and cartographic. The results of the study were supplemented and validated based on field investigations (observations, interviews with people and local authorities in 2010 and 2011).

Among the hydrological data, we employ chronological series of maximum annual and monthly discharges[4] of Teleajen River at Moara Domnească gauging station[5] for the interval 1964 – 2008. These data are processed using frequency analysis.

In order to elaborate a diachronic study, we make use of several documents covering the last 150 years: the Szathmary map (1855), Ordnance Survey maps (1896 – 1899), topographic maps (1977) and aerial photos (2005). The Szathmary map (scale 1:57,600) couldn't be georeferenced, but it brings qualitative

[4] Data provided by Buzău - Ialomiţa Water Basin Administration.

[5] The watershed area of Teleajen River at Moara Domnească gauging station represents 97% of the entire watershed.

information about the hydrosystem's state of evolution at the time. The Ordnance Survey maps (scale 1:20,000) show the field reality at the end of the 19th century, although they suffered improvements, being edited and re-edited in 1930 and in 1943 (*e.g.* geodesic coordinates and planimetric details were added; names were updated). These maps have the advantage of being the first accurate documents, keeping the same cartographic projection (Lambert-Cholesky) for the entire country (Osaci-Costache, 2000; Iftimoaie, 2004; Rus et al., 2009; Crăciunescu, 2010; Crăciunescu et al., 2011). For analysis purpose, they were transformed in Stereo 70 projection (Crăciunescu et al., 2011). They are compared with more recent documents like the topographic maps (scale 1:25,000), which were transformed from Gauss-Krüger projection to Stereo 70. The aerial photos (scale 1:5,000) are employed in Stereo 70 projection also. Based on these documents, we search for information on fluvial morphology: current channel and abandoned channels of Teleajen River. We observe abandoned channels as follows: a) by their banks on Ordnances Survey and topographic maps; b) by their vegetation (dense and different from surroundings) on aerial photos. We consider that the wandering area corresponds to the maximum extension of the current and ancient channels of Teleajen River.

3. RESULTS AND DISCUSSIONS

3.1. Teleajen River's floods frequency

The analysis of the maximum annual and monthly discharges of Teleajen River at Moara Domnească shows a high frequency of important floods (discharges higher than those corresponding to the warning stages: of attention – *QA*; of flooding – *QF*; of danger – *QD*) (Fig. 1B). Thus, *QD* was overflowed by 36% of annual floods, *QF* by 58% and *QA* by 78%[6]. The bankfull discharge[7] was overflowed by 38% of annual floods. Despite the construction of Măneciu Dam on Teleajen River in 1994 (for potable and industrial water supply; having a volume of 60 million m^3), the impact on annual floods was insignificant; since 2002, four floods higher than *QD* took place (Fig. 1B); among them, the most important was registered in September 2005. The coefficient of variation of maximum annual discharges is 0.7.

On monthly scale, the most frequent annual floods were counted in July and November (16% each month) (Fig. 1C). In summer, they are the effect of heavy convective rains; in autumn, they are generated by frontal rainfalls. Contrarily, the less frequent annual floods took place in February (4%), October (4%) and September (2%); they are the consequence of less abundant precipitation

[6] QA, QF and QD correspond to 2009 values estimated by National Institute of Hydrology and Water Management.

[7] Estimated at 242 m^3/s by Ioana-Toroimac et al. (2011).

related to anticyclonic weather situations. Among the floods higher then *QF* (the most important for fluvial dynamics), 58% took place between May and August.

Concerning the flood of September 2005, we consider that it was exceptional because: 1) the maximum discharge was the second of its kind in the chronological series (after the one of 1975); 2) the floods are unexpected in September. The magnitude of the September 2005 flood is also related to flowing upstream the confluence due to the fact that Prahova River's discharge was about 660 m^3/s at Halta Prahova gauging station, higher than Teleajen River's discharge, which was about 574 m^3/s at Moara Domnească gauging station.

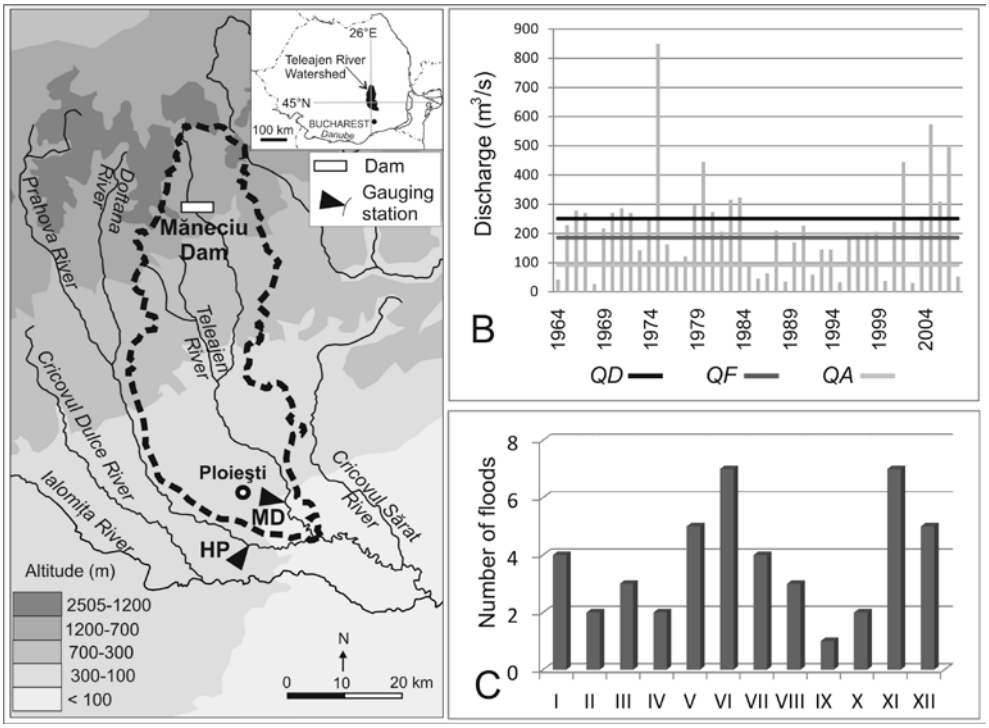

Fig. 1. ***Hydrological particularities of Teleajen River at Moara Domnească gauging station. A) Moara Domnească gauging station location within Teleajen River Watershed. MD: Moara Domnească; HP: Halta Prahova. B) Maximum annual discharges (1964 – 2008) compared with discharges corresponding to attention stage (QA), flooding stage (QF) and danger stage (QD). C) Monthly frequency of annual floods (1964 – 2008)***

3.2. Teleajen River's wandering area

In 1855, Teleajen River formed a single sinuous channel (Fig. 2B). At the end of the 19th century, Teleajen River's pattern changed in an active channel, formed of a main sinuous channel and alluvium bars devoid of vegetation (Fig. 2A). This morphology indicates a wandering pattern (with common features between braided and meandering patterns according to Church, 1983). The same

reach had a single sinuous channel with local meander loops in 1977 and 2005. Thus, we consider this temporarily fluvial metamorphosis (*sensu* Schumm, 1969) to be the consequence of important floods of 1897 which affected this region (Mustăţea, 2005).

During the 20th century, Teleajen River migrated by *ca.* 400 m towards West, threatening the village of Moara Domnească. In order to protect the community, the channel was diverted from its natural course and the ancient channel was afforested (Ioana-Toroimac et al., 2011). Between 1977 and 2005, the river cut off the meander loop located in South-West of the analysed reach (Fig. 2A). This recent evolution and the presence of all the abandoned channels show the intense dynamics of Teleajen River.

The boundaries of the wandering area must be cautiously taken into account due to several reasons: 1) the method may generate errors due to transformations of the documents (*e.g.* scanning, georeferencing, changing cartographic projections, calibrating, interpreting, digitizing); 2) other abandoned channels may not appear on maps because of their scale or on the aerial photos because of the land use; 3) they expand by erosion, especially in North-East. We can establish neither the age of the abandoned channels by using this method, nor the age of the wandering area.

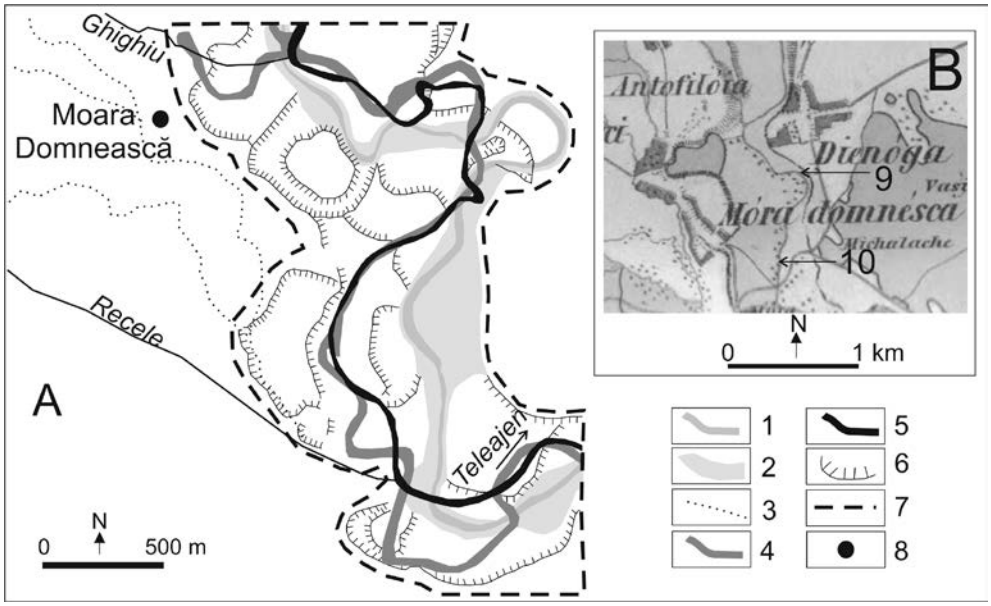

Fig. 2. ***Lateral evolution of Teleajen River. A) Outlining the wandering area. 1: Channel (1900); 2: Active channel (1900); 3: Valley (sketched drawn from Szathmary map and Ordnance Survey maps); 4: Channel (1977); 5: Channel (2005); 6: Bank represented on one of employed documents, indicating abandoned channels; 7: Wandering area boundary; 8: Center of Moara Domnească village; B) Fragment of Szathmary map. 9: South extension of active channel (1855); 10: Sinuous channel (1855).***

3.3. Moara Domnească community faced with floods and river dynamics

Based on the hypothesis of rivers occupying temporarily or even definitively their abandoned channels at high stages, the wandering area seems to be exposed to floods. In September 2005, the overflowed perimeter was greater than the wandering area (Fig. 3A).

The south part of Moara Domnească village, built between 1900 and 1977 (Fig. 3B), is located within the wandering area. The central part, more ancient, and the north one are situated outside the wandering area, in the proximity of its boundary. The village is protected against floods by a dike built after the 1975 floods. Nevertheless, this dike was submerged during the flood of September 2005, showing the lack of efficiency of this measure. It was elevated by 1 m in 2006 as protection measure against future floods (Delporte, 2011).

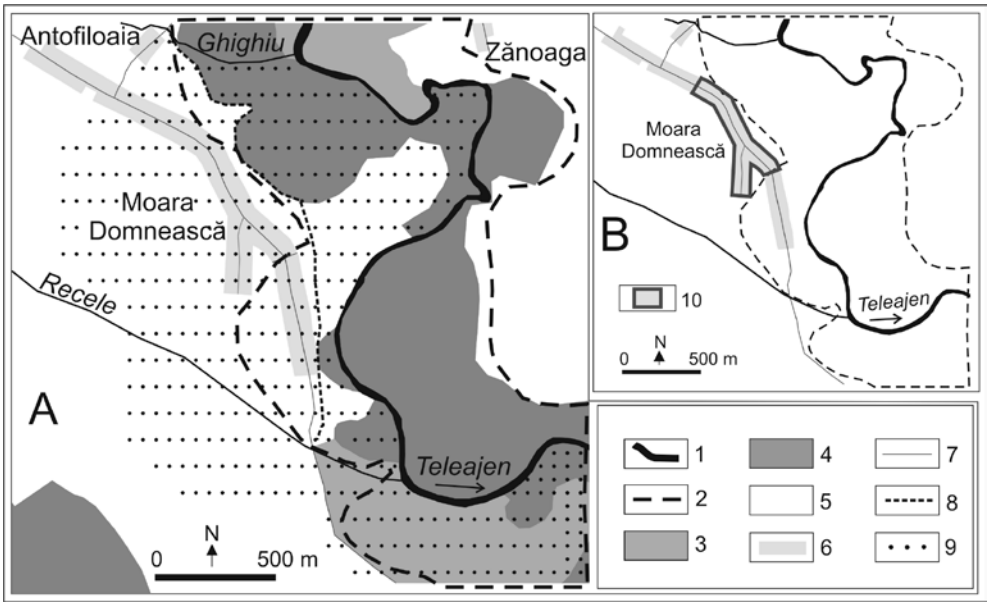

Fig. 3. ***Land use of Teleajen River's wandering area. A) In 2005 (sketched from the aerial photo of 2005). 1: Channel; 2: Wandering area boundary; 3: Pasture; 4: Forest (and shrubs); 5: Crops; 6: Built-up area; 7: District road; 8: Dike; 9: Overflowed area on the right bank in September 2005, estimated from urban plans of Râfov Commune. B: Spatial evolution of Moara Domnească Village between 1900 and 2005. 10: Village boundary in 1900.***

Several hectares of crops were overflowed in September 2005. Almost 50% of them were covered by a layer of water of 0.5 – 2 m high (Delporte, 2011). Water withdrew difficultly due to the dike. The crops situated west to the village can be affected also by propagation of floods through dry valleys crossing this area (Fig. 2A) and/or by groundwater elevation.

The biggest part of the wandering area, overflowed in September 2005, is covered by riparian forests, shrubs and pastures. The pasture is the first step in the evolution of an abandoned channel. It develops into shrubs and riparian forests. The riparian forests thickened due to human actions in the 60's, when Romania carried a river bed afforestation policy. This is a common practice which aims at preserving the quasi-natural dynamics of the river, reducing the floods' speed and the erosion (Piégay, 1996). In the last years, unorganised deforestation actions took place, which apparently diminished riparian forest functions. This kind of riparian zone management is relatively common in the region, being conducted also on Prahova River (Ioana-Toroimac, 2009).

The example of Moara Domnească is relevant for Romanian water management policy for medium rivers. In most cases, the quasi-natural dynamics of the river is preserved. As a rule, people and socio-economic facilities are protected against floods and river dynamics by structural measures (*e.g.* dikes).

6. CONCLUSION

At Moara Domnească, Teleajen River experiences relatively frequent floods (higher than the flooding stage) and important lateral migrations. Our study shows that the human community of Moara Domnească is developing partially on the area appropriated by Teleajen River. The current "freedom" space isn't adequate to the needs of the river. Therefore the village of Moara Domnească is exposed to floods and hazards related to river lateral dynamics.

7. ACKNOWLEDGMENTS

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