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Gilort river channel dynamics economic impact assessment in the 2010-2019 period
Study case: The segment between Bălcești and Târgu Cărbunești

ALEXANDRU GIUREA, LAURA COMĂNESCU

University of Bucharest, Faculty of Geography
andrei.giurea@drd.unibuc.ro

Abstract. The importance of analyzing river channel dynamics is granted by the scientific need of knowing the way of evolution in order to elaborate more accurate evolution patterns and also because the river proximity always constituted an area for developing settlements due to its resources. Therefore, river channel dynamics is closesly related to population dynamics in its vecinity and has direct effects towards them through active processes. This paper aims to identify the Gilort river channel dynamics economic impact on local comunities development, using a GIS-based analysis and high resolution spatial data.

Keywords: *Gilort, river channel, dynamics, economic impact*

INTRODUCTION

River channel dynamics is based on its characterizing fundamental elements, such as morphology and morphography of the watershed, relevant indices revealing the changes in channel configuration (braiding index, sinuosity, morphological quality index), historical evolution patterns (this patterns can be identified using analysis such as river channel occupancy or delineation of the historical migration zone) and river channel topography changes, based on the river hydrographic characteristics (liquid and solid flow volumes, drainage rate and water levels). Regarding channel dynamics, it was shown large interest on a national (Armaș et al, 2013; Feier and Rădoane, 2007; Ioana Toroimac, 2009; Grecu et al., 2014; Perșoiu et al., 2011; Rădoane et al., 2013; Zaharia et al., 2011) and international (Grovve et al., 2013; Lane et al., 1997; Langat et al., 2019; Lawler et al. 1993; Lawler et al., 1999; Pyle et al., 1997; Thakur et al., 2012; Winterbottom et al., 2000) through the relationship between local comunities development and river channel dynamics. Analyzing succesive cartographic data to obtain river planform changes was used (Rădoane et al., 2013) as a methodological approach. Gilort watershed was also studied by a hydrological (Pisleaga et al, 2019) and biodiversity point of view (Pecingina and Popa, 2017).

This paper aims to identify river channel dynamics economic impact on local communities development. As a study case, Gilort river in the Subcarpathian area, between Bălcești and Târgu Cărbunești was chosen. This area is characterized by a high population density, therefore a high impact on river channel through different economic activities. Study area is located in the Gorjului Subcarpathians, south-west of Romania, Gorj county. The length of the river, measured on thalweg is approximately 15 km.

To identify the economic impact, the study focused on identifying the erosion processes in the channel. Through lateral erosion, land surfaces located in river proximity are lost. These land surfaces have a land use, therefore an economic value.

METHODOLOGY

For analyzing the changes in river channel configuration were used two types on analysis:

- a semi-quantitative one, to show the spatial distribution of erosion and accumulation processes along the river channel;
- Topography Change Detection for the river channel in 2010-2019 period of time.

The spatial distribution of erosion and accumulation processes was realized based on river bank delineation for 2010 and 2019 (the delineation was realized using a Sentinel-2 satellite image for 2010 and an orthophotomap for 2019 – Figure 1). Data used for the bank delineation have high spatial resolution (10m for Sentinel-2 images and 0.15m for 2019 orthophotomap), therefore the delineation process have an increased accuracy. On the vectorial layers resulted, vectorial analysis tools were applied (*Difference and Intersection in QGIS 3.4*), following the principle: surfaces between river banks existing in 2010 and not existing in 2019 are considered accumulation areas: surfaces between river banks existing in 2019, but didn't exist in 2010 are considered erosion areas; surfaces existing in both years are considered not changed. Distribution of river channel processes map was the main result of this analysis. Based on the results, a series of spatial differences and processes alternation can be identified.

Figure 1. Example of bank delineation (2019 – near Bălcești)

The next step in river channel changes recognition is Topography Change Detection (TCD) analysis. It was realized using the Geomorphic Change Detection standalone software, which focus on differences and volumetric calculations between two or more raster datasets (with terrain altitude information). Primary analysis was run for the entire Gilort floodplain, using two high-resolution raster datasets (1 m spatial resolution): a Digital Terrain Model (DTM) for 2010 and a Digital Surface Model (DSM) for 2019. First result was a changes distribution map, with values between -4 m to above 20 m. This altitude difference is a result of the datasets construction: the DTM shows only the terrain irregularities, ignoring the objects on the terrain surface (such as vegetation, constructions), while DSM shows all the irregularities (including vegetation and constructions). Therefore, the differences of +20 m most likely concur with vegetation patches.

For relevant volumetric calculations, the analysis was run a second time, only for the surface between the river banks (river channel), to reveal the changes occurred through dynamic processes (erosion or accumulation). The database and applied methods are shown in Table 1.

To identify the economic impact, erosion surfaces have been overlapped to Corine Land Cover (CLC) vector layer from 2006 (this was the most recent CLC layer before the study period of time and it was important to know the previous landuse), to obtain the previous land use of these surfaces. Afterwards, a cost standard was applied for the specific land uses. Based on the cost standard an approximate economic impact was calculated.

Table 1. Data base and applied methods

Data sets	Data Source	Data Type	Method
Satellite image 2010	Sentinel-2	Raster	River bank delineation (2010)
Orthophoto map 2019	LIFE16 NAT/RO/000778	Raster	River bank delineation (2019)
DTM 2010	LIFE16 NAT/RO/000779	Raster	GCD analysis
DSM 2019	LIFE16 NAT/RO/000779	Raster	GCD analysis
Corine Land Cover	European Environment Agency	Vector	Land use identify

DISCUSSIONS

Processes spatial distribution analysis (Figure 2) reveals a series of sections where the erosion process is prevailing: in proximity of Bălcești locality (north of study area), between Bălcești and Bengești localities, between Bengești and Mirosloveni (Figure 3) and in proximity of Bolbocești locality (south of study area). In the study area it can be observed an alternation of erosion and accumulation processes. Upstream, near Bălcești, erosion and changes in river course are prevailing, through meandering or meander closing and creation of a new course. The causes for this configuration may vary. First, upstream to Bălcești is the Galbenu confluence (one of the main tributary river). Thus, both river flow and competence grow, so the erosion capacity grows. Second, the river bed is characteristic to a Subcarpathian area, with a higher slope and a higher flow rate, therefore a higher erosion capacity. To these a flash-flood event is added. It was recorded in 28 - 29 July 2014, when the flood wave exceeded 4 m height. This event determined significant changes in river channel configuration, through course alteration, meander closing and modelling a new channel or activation of old channels.

Based on this semi-quantitative analysis, the vector layer was used in order to calculate the erosion and accumulation surfaces. The results show a total of 0.5 km^2 affected by erosion and 0.4 km^2 affected by accumulation, approximately.

The Geomorphic Change Detection (GCD) analysis reveals the prevailing of lowering surfaces in the river channel, going to a maximum of -4 m. The most affected section is located between Mirosloveni and Albeni localities.

Beside the spatial distribution of lowering and rising surfaces (Figure 4), a series of calculations were made with the GCD standalone (Figure 5), such as the volume of sediment eroded and accumulated, rising and lowering surfaces, average values of topographic rising and lowering. The lowering surfaces are about 0.52 km^2 and rising surfaces are about 0.39 km^2. The results are comparable to those obtained using the previous method, therefore there is a mutual validation.

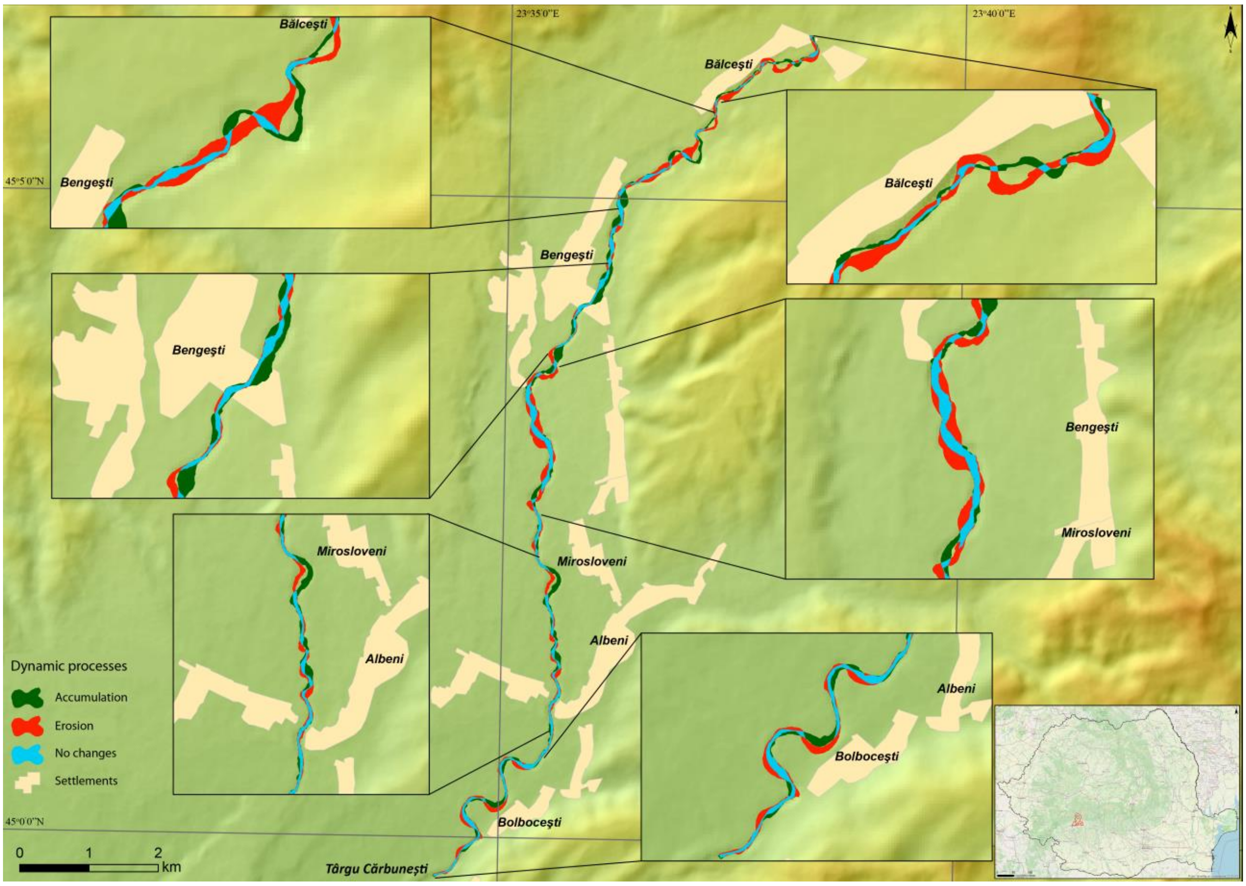


Figure 2. Spatial distribution of erosion and accumulation processes

Figure 3. Erosion example between Bengești and Mirosloveni. Photo 2019

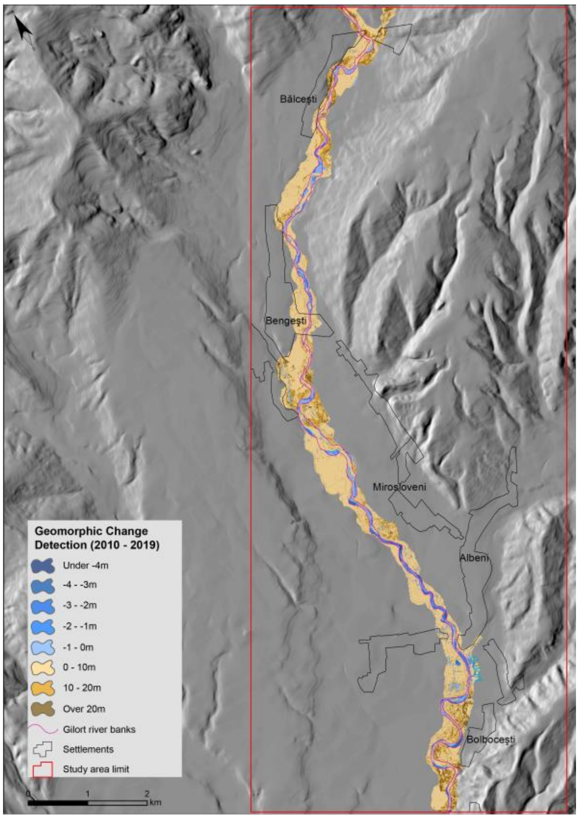
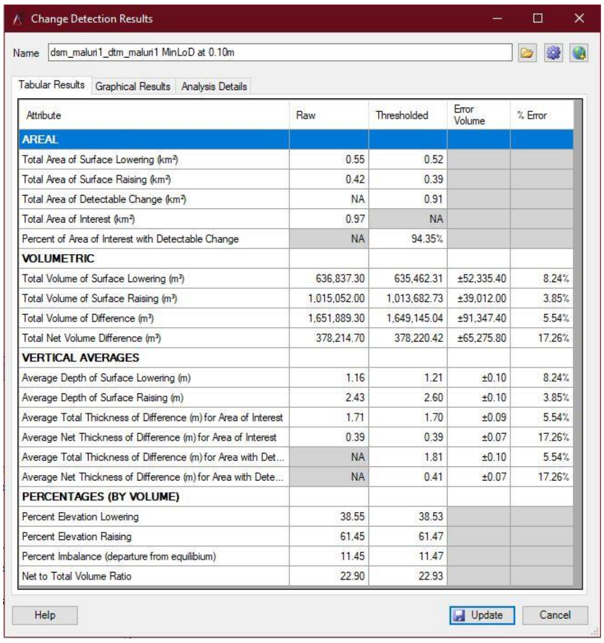


Figure 4. Spatial results of GCD



Change Detection Results

Name: dsm_maluri1_dtm_maluri1 MinLoD at 0.10m

Tabular Results | Graphical Results | Analysis Details

Attribute	Raw	Thresholded	Error Volume	% Error
AREAL				
Total Area of Surface Lowering (km²)	0.55	0.52		
Total Area of Surface Raising (km²)	0.42	0.39		
Total Area of Detectable Change (km²)	NA	0.91		
Total Area of Interest (km²)	0.97	NA		
Percent of Area of Interest with Detectable Change	NA	94.35%		
VOLUMETRIC				
Total Volume of Surface Lowering (m³)	636,837.30	635,462.31	±52,335.40	8.24%
Total Volume of Surface Raising (m³)	1,015,052.00	1,013,682.73	±39,012.00	3.85%
Total Volume of Difference (m³)	1,651,889.30	1,649,145.04	±91,347.40	5.54%
Total Net Volume Difference (m³)	378,214.70	378,220.42	±65,275.80	17.26%
VERTICAL AVERAGES				
Average Depth of Surface Lowering (m)	1.16	1.21	±0.10	8.24%
Average Depth of Surface Raising (m)	2.43	2.60	±0.10	3.85%
Average Total Thickness of Difference (m) for Area of Interest	1.71	1.70	±0.09	5.54%
Average Net Thickness of Difference (m) for Area of Interest	0.39	0.39	±0.07	17.26%
Average Total Thickness of Difference (m) for Area with Det...	NA	1.81	±0.10	5.54%
Average Net Thickness of Difference (m) for Area with Dete...	NA	0.41	±0.07	17.26%
PERCENTAGES (BY VOLUME)				
Percent Elevation Lowering	38.55	38.53		
Percent Elevation Raising	61.45	61.47		
Percent Imbalance (departure from equilibium)	11.45	11.47		
Net to Total Volume Ratio	22.90	22.93		

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Figure 5. Statistic results GCD

The volume of the eroded sediment (635462.31 m^3) is lower than the one accumulated (1013682.73 m^3), so is the average depth of surface lowering/rising (1.21 m compared to 2.6 m) as a result of tributary rivers contribution. Correlated with the surface data (higher for lowering surfaces), then the sediment is accumulated in sections with transition towards a new channel configuration (sections with lower river bed slope, pools with lower drainage rate).

Overlapping the results with Corine Land Cover land use vector layer showed that the main surfaces lost by erosion were covered with forest patches (0.7 km^2), agricultural land (0.1 km^2) and pastures (0.1 km^2). The standard costs were applied (forest patches – 5000€/ha; agricultural land – 5000€/ha; pastures – 2500€/ha) and the Gilort river channel dynamics economic impact in 2010 – 2019 is evaluated at approximately 425 000€ (Table 2).

Table 2. Surfaces lost by erosion and their cost

Land use	Surface (ha)	Standard cost/ha (€)	Cost/land use (€)
Forest patch	70	5000	350,000
Agricultural land	10	5000	50,000
Pasture	10	2500	25,000
Total	90		425,000

CONCLUSIONS

The importance of analyzing river channel dynamics is granted by the scientific need of knowing the way of evolution in order to elaborate more accurate evolution patterns and also because the river proximity always constituted an area for developing settlements due to its resources. Therefore, river channel dynamics is closesly related to population dynamics in its vecinity and has direct effects towards them through active processes. Developing and impact analysis requires current data sets with high resolution which can be modelled using specialized software.

Gilort river channel has an active dynamics, predominantly through erosion processes to the detriment of accumulation processes (given the surfaces calculated in GCD). Surfaces lost through erosion process in the period of time given are up to 0.5 km^2, while the accumulation surfaces are up to 0.4 km^2. However, the volume of sediment eroded is half the sediment accumulated, so the contribution of the tributary rivers is significant.

By the economic point of view, the impact can be quantified through the land use of the eroded surfaces. For the period of time given, Gilort river economic impact is evaluated at approximately 425 000€.

The methodological approach can be used in any study area, as long as there are high resolution data sets available (DTM, DSM, DEM) and recent satellite images, so necessary for this type of analysis.
Limitations of the method are related to the availability of high resolution data sets, necessary for the Geomorphic Change Detection. Also, the surface calculation are approximately and may vary, depending on the quality of the data sets.
Given the river channel dynamics in the 2010 – 2019 period, most likely the erosion processes will continue to affect the unprotected river banks (especially in areas where the predominant land use is agricultural). Therefore, in order to limit the economical impact of river dynamics, the local authorities should take into consideration actions to reduce river erosion in areas of interest. This can be done either with gabion walls or embankments, in order to reduce the effects of erosion, or using Engineered Logged Jams (ELJ). The latter is more eco-friendly and can also be used in order to restore natural habitats for the aquatic species in the Nature2000 site (ROSCI0362).

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