

Flood vulnerability reduction. Case study: Tazlău river basin, downstream of its confluence with Tazlău Sărat

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Abstract: The issue of water management as well as its impact on the community has been both a challenge and a concern of the European Union, which lead to adopting the Directive 2007/60/EC with the purpose of establishing a framework for the assessment and management of flood risks, by which the member states had to identify the areas for which they conclude that potential significant flood risk exist or likely to occur and to develop flood risk management plans and measures to reduce the consequences of flooding. In this respect, the Siret Water Basin Administration has declared the area of the Tazlău river, as a significant flood risk area (A.P.F.S.R.) (***) A.B.A Siret). The Tazlău River is a left-bank tributary to the Trotuș River, passing through the ten communes and partially through the outside the built-up areas of Onești city. Recent studies have shown the benefits of reservoirs and floodplains, as these provide the most effective way to buffer the effect of floods by slowing and spreading the discharge of a river (Băloi, 1980). By restoring and improving an existing lateral floodplain in the Tazlău River basin, in order to store part of the floodwaters that cause significant adverse consequences, will reduce the flood vulnerability of its crossings.

1. Introduction

Tazlău River is a left tributary of Trotuș river, it springs from Tazlău Mountains and flows into Trotuș river upstream from Gura Văii village. Its entire river basin is linked to this geographical position, shaped as a depressionary grove which widens from upstream towards downstream, drained by its tributaries. Terrain heights of the basin range from 1438 m near its springs to 183 m at the confluence with Trotuș river. Present geomorphological processes, particularly erosions and extremely active landslides, take place due to friable rocks, alternating impermeable layers of rocks, steep slopes, heavy deforestation and a very complex human impact on the area. A mild temperate continental climate occurs in the area, with an average annual temperature of 4-6°C in the mountainous area and 7-8°C in its valleys with high precipitation rates per year of 580 l/m² at Scorțeni, 696 l/m² at Balcani and 765 l/m² at Tazlău, with an increase in the western mountainous region. (Brânduș, 1981; Cartacuzencu et. al, 2014) (Figure 1).

To ensure a constant water flow towards Borzești Thermal Plant and Borzești Petrochemical Plant, a 12.5 mil. m³ reservoir was built on Tazlău river, downstream

Helegiu village and upstream the confluence with Trotuș river. After recording long periods of drought during the years 1983,1984,1985,1986,1987,1988,1989 and 1990, followed some years marked by extreme hydrological phenomena. In the summer of 1991, following heavy rainfalls of 148 l/m^2 , the dam gave way, the resulting flood claiming huge number of human lives and economic losses. The upstream gauging station, Helegiu, recorded a water discharge of $1560 \text{ m}^3/\text{s}$. A similar situation took place in July 2005, precisely between 11th and the 20th day of that month, when heavy rainfall generated a discharge of $1556 \text{ m}^3/\text{s}$ at the same gauging station. On a probability distribution scale, this discharge is equivalent to a 100 year flood. (Cojoc et al., 2014, Mustatea, 2005, Romanescu, 2009, Romanescu et al., 2011, ***A.B.A Siret, Table 1). Previous studies which have addressed HEC-RAS modeling for flood risk analysis, over representative river courses in Romania, have proven its' efficacy (Armas et al., 2017; Arseni et al., 2020; Chendes et al., 2015; Iosub et al., 2016; Hirtan R.I., 2015; Sabau et. al, 2018; Purdel et. al, 2006).

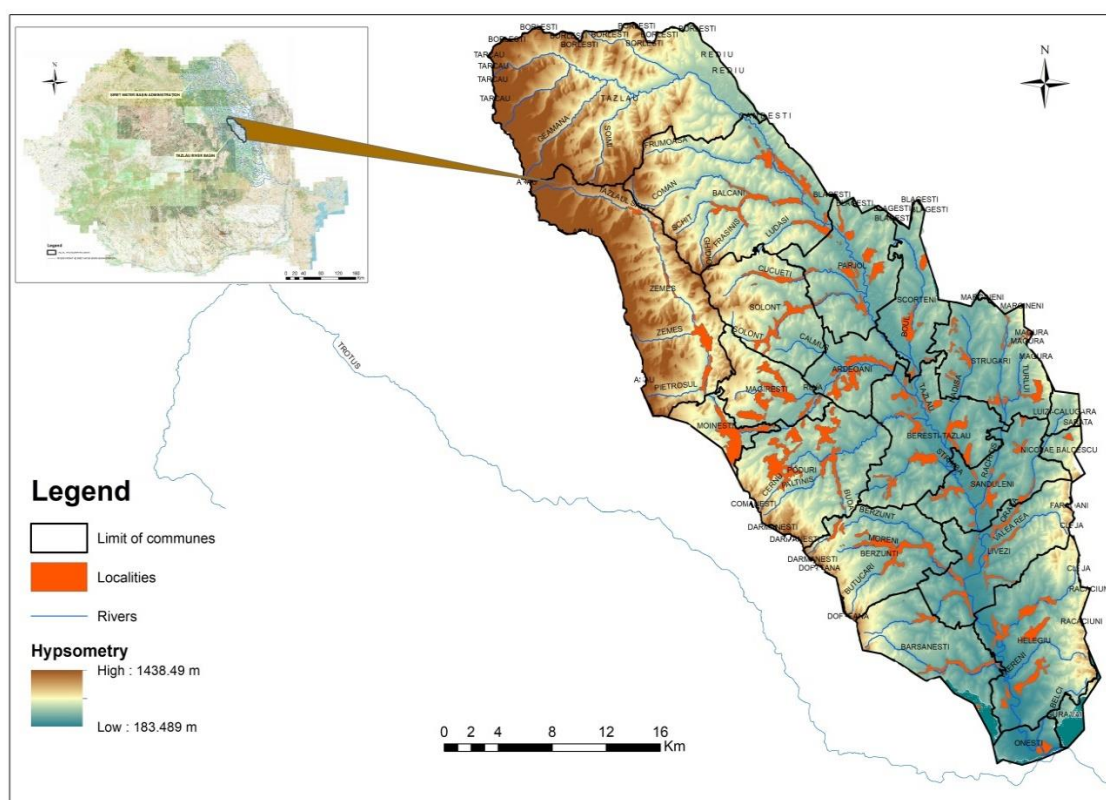


Figure 1. Geographical location of Tazlău river basin

Table 1. The recurrence interval of floods at Helegiu gauging station

Probability (%)	1	2	5	10
mc/s	1560	1230	702	577

2. Materials and Methods

The study area is situated downstream of the confluence of Tazlău river (hydrological unit code XII.1.69.33) and its tributary, Tazlău Sărat (HUC XII.1.69.33.10) and it covers several villages: Berești-Tazlău, Sănduleni, Livezi, Helegiu and Onești (Enea et al., 2014, 2015, 2017).

The four gauging stations in Tazlău river basin, Tazlău, Scorțeni, Lucăcești (Tazlău Sărat river) and Helegiu are monitored by Siret Water basin Administration. Discharge

measurements began in 1957 with twice a day records of air and water temperature, gauge height and rainfall rate (Paveluc et al., 2019, ***A.B.A Siret).

In order to decrease flood risk, several types of mostly structural measures have been proposed and implemented over the years, in an attempt to reduce this sector's vulnerability. But these scarce measures applied to a small number of sectors proved to be of little benefit. In present times, taking into account the globally approved plan to promote ecofriendly measures, several options to reduce flood risk have been analysed. Considering the physical and geographical features of the study area, restoring and improving two existing floodplains would have a major positive impact on preserving and protecting the social and economic resources (Olariu et al, 2014).

In this regard, we used primary data recorded at the gauging stations, the recurrence intervals of floods, orthophoto maps from the year 2012, 2018 edition of CLC spatial data, 1:30 resolution digital terrain model, ArcMap 10.x GIS and HEC-RAS 5.x software and the process involved the following steps:

- a) identifying the structures vulnerable to the 100-year flood;
- b) analysis and identification of areas suitable for a floodplain;
- c) determining the 100-year flood elements
- d) analysis of the two floodplains and their effect on reducing the maximum discharge

3. Results

In order to identify the flooded structures when confronted to a 100-year flood and to ensure the viability of the proposed measures, the social and economic structures involved have been vectorized using the existing orthophoto maps. By overlaying these vectors and the 100-year flood area limit resulted after modeling the 1560 m³/s discharge in HEC-RAS, we found that 424 structures are affected during such a scenario (Albu et al. 2018, 2020, Tîrnovan et al., 2014, Tîrnovan, 2016, Figure 2, Figure 3).

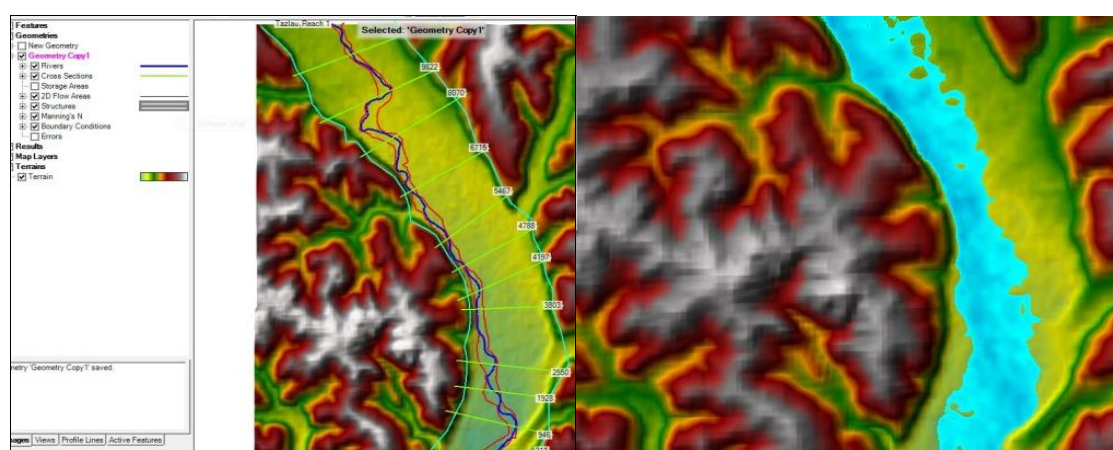


Figure 2. Modeling results of a 1560 m³/s discharge of Tazlău river across the study area

The second step in the process was the analysis of land use in the study area and identifying the areas used for pastures and cultivation. This has been accomplished by using existing orthophoto maps and land use shape file. The area was clipped using ArcMap 10.x tools and the results were two distinct areas suitable for a floodplain that were able to store a great amount of water volume during high or historic discharge of the Tazlău river. (Figure 4, Figure 5, Figure 6). The resulting areas, related to the two polders are 4.09 km², distributed as follows: 2.45 km² Berești-Tazlău polder and 1.64

kmp Orășă polder. Based on the DTM with a resolution of 1:30 m, was determined the volume of the two concavities suitable for polders. The elevations up to which the volumes were calculated were: 268 m for the Berești-Tazlău section, resulting in a 7.7 m³ volume and 258 m for the Orășă section, with a 4.7 m³ volume (Figure 7).

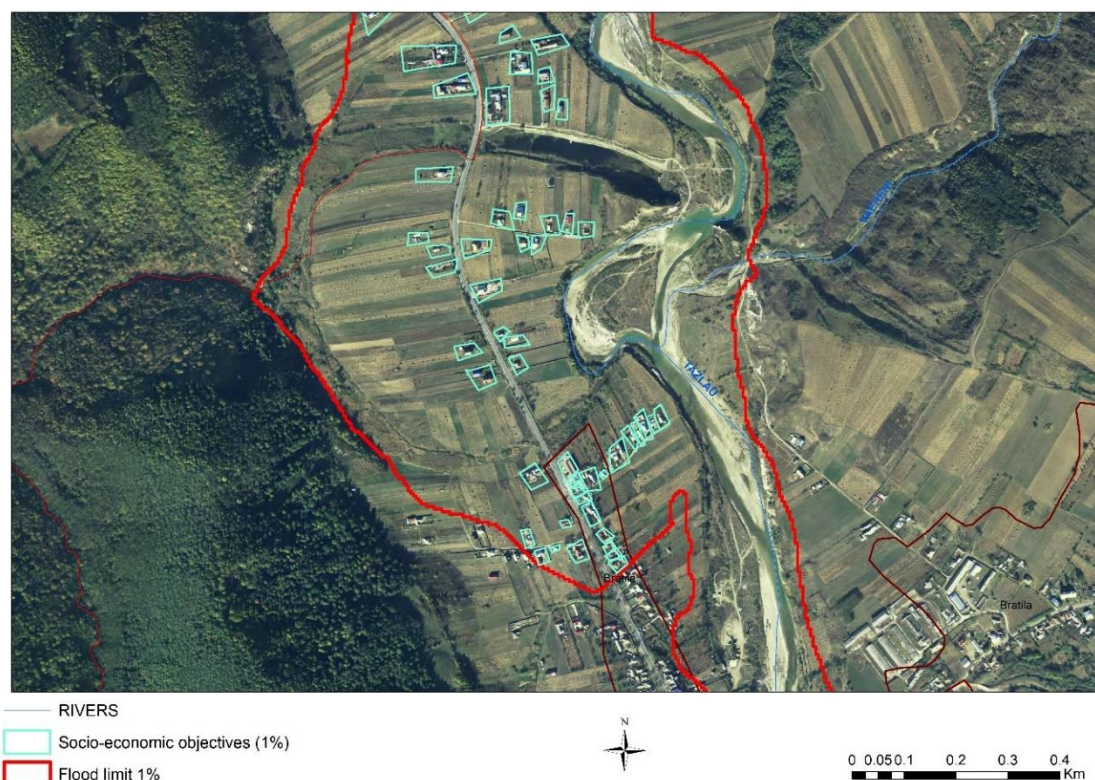


Figure 3. Identification of flooded structures in the Tazlău river valley, downstream its confluence with Tazlău Sărat river

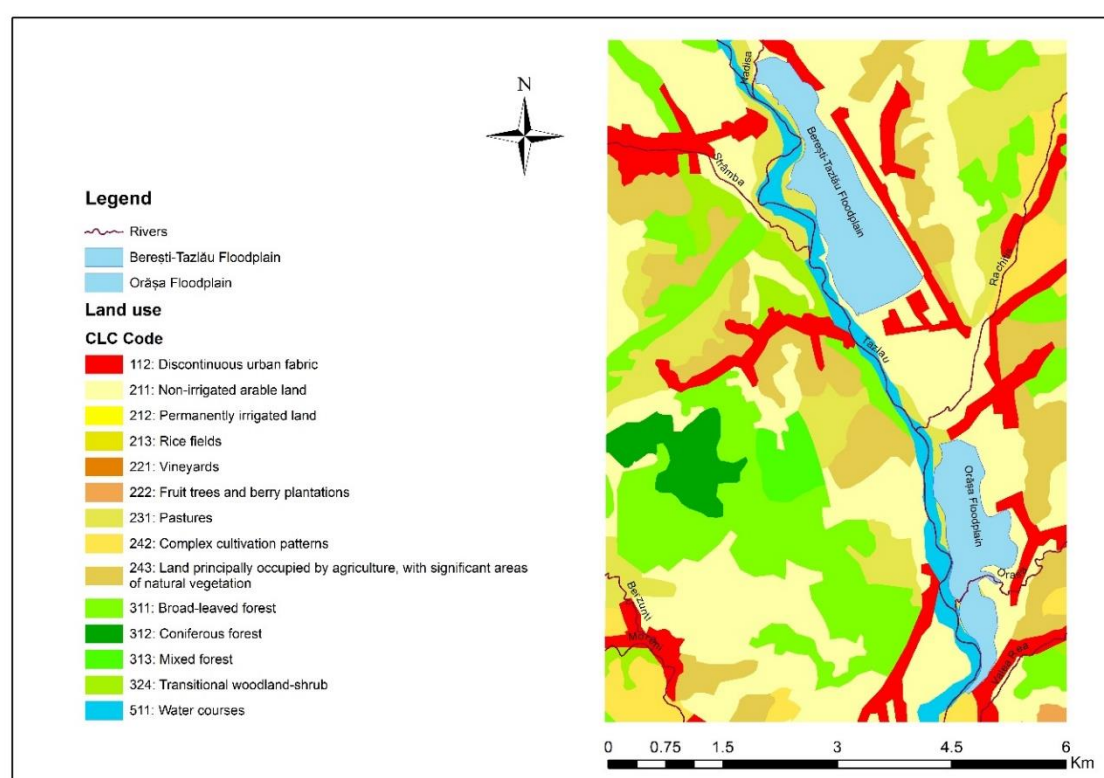


Figure 4. Geographical position of the proposed polders in Tazlău river basin

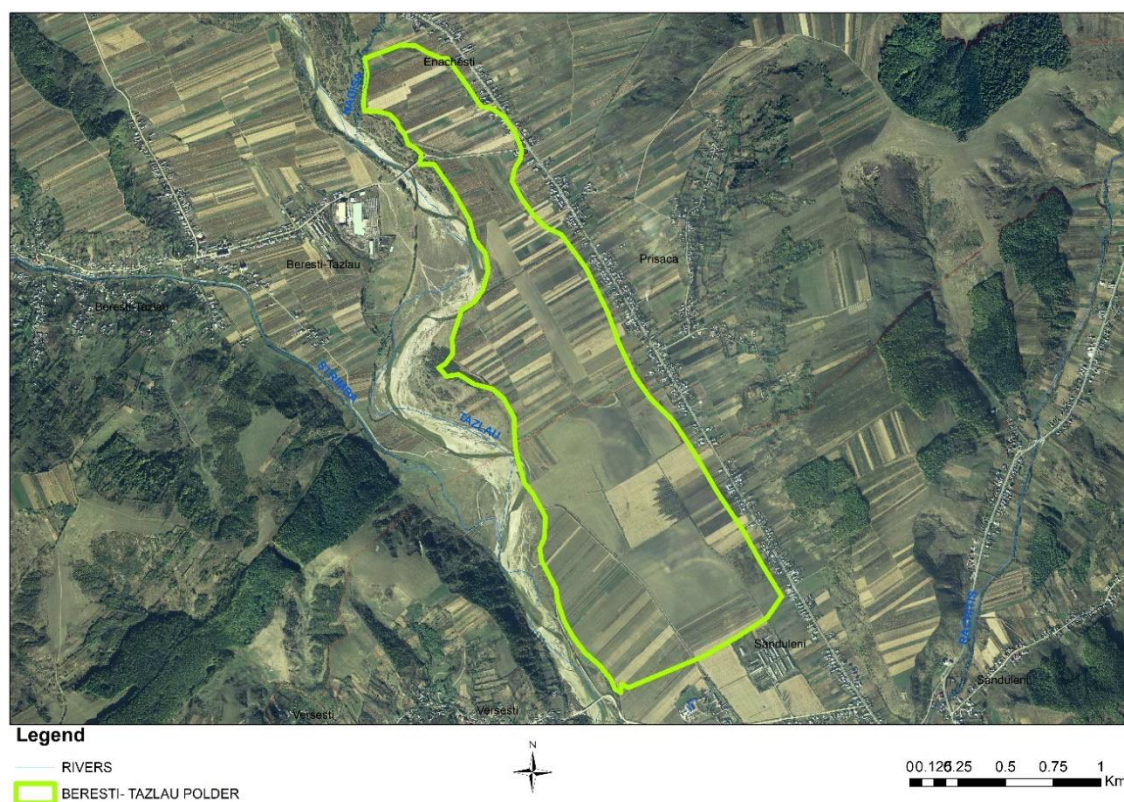


Figure 5. Geographical position of areas suitable for polders

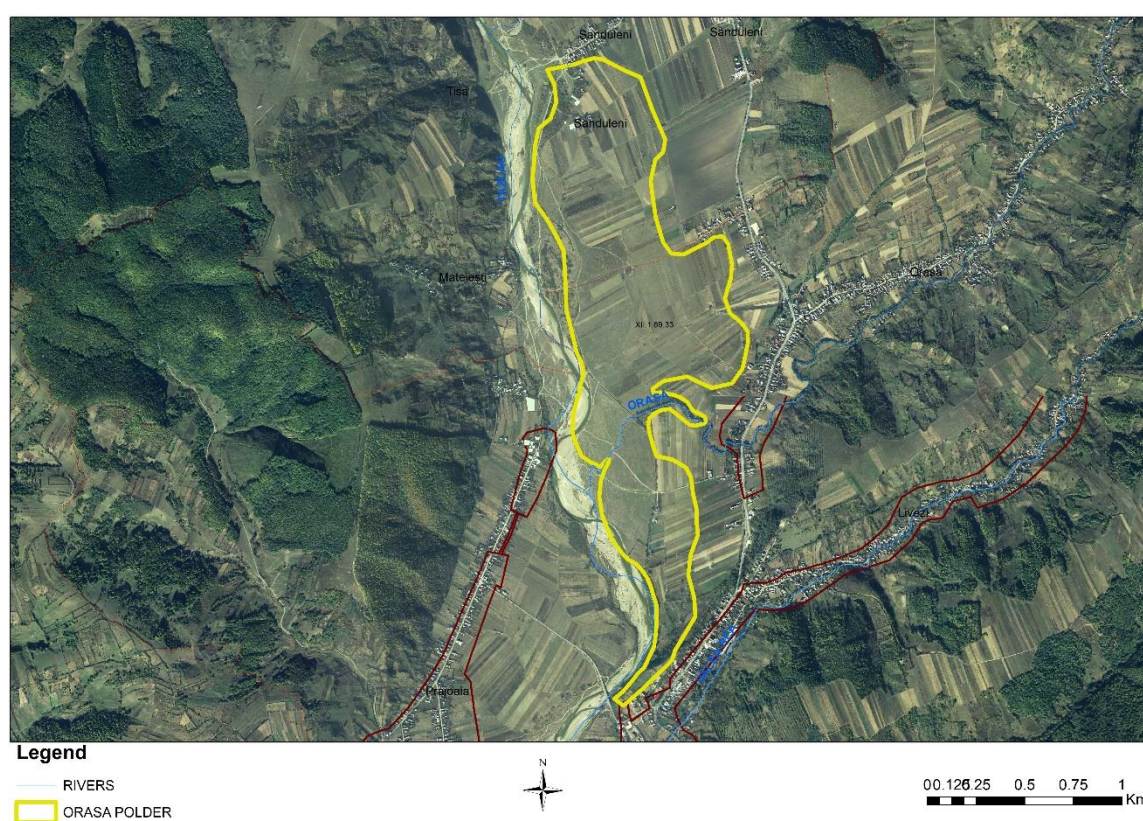


Figure 6. Geographical position of areas suitable for polders

The analyses of the most significant floods registered in the Tazlău river basin highlighted the fact that they generally extend throughout the basin, and the highest intensity is downstream of the confluence of the Tazlău river with the Tazlău Sărat due

to the convective rains that form in this area. In order to demonstrate the viability of the two polders, based on the floods recorded in 2005, the volume of the flood recorded in July, 2005 was determined according to the existing formulas in the specialized literature (Figure 8, Albu et al., 2018, Pișotă I., 2003):

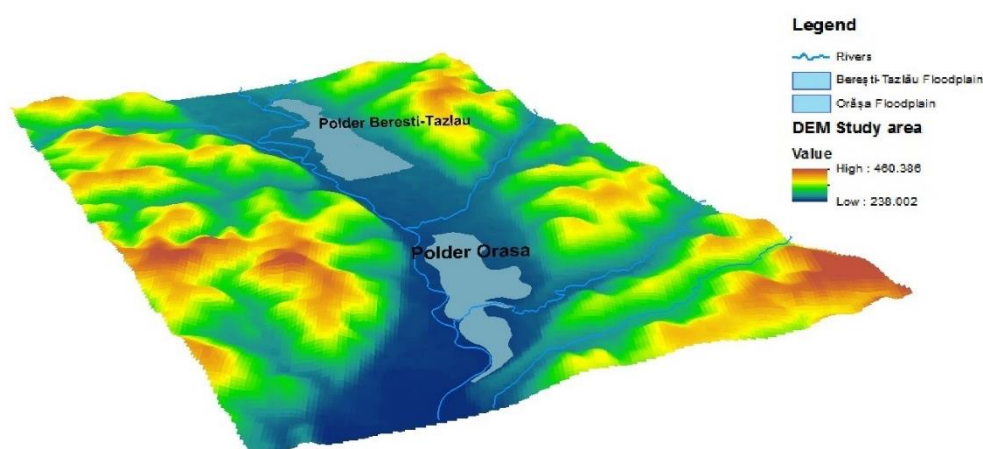


Figure 7. Morphometric characteristics of surfaces suitable for polders

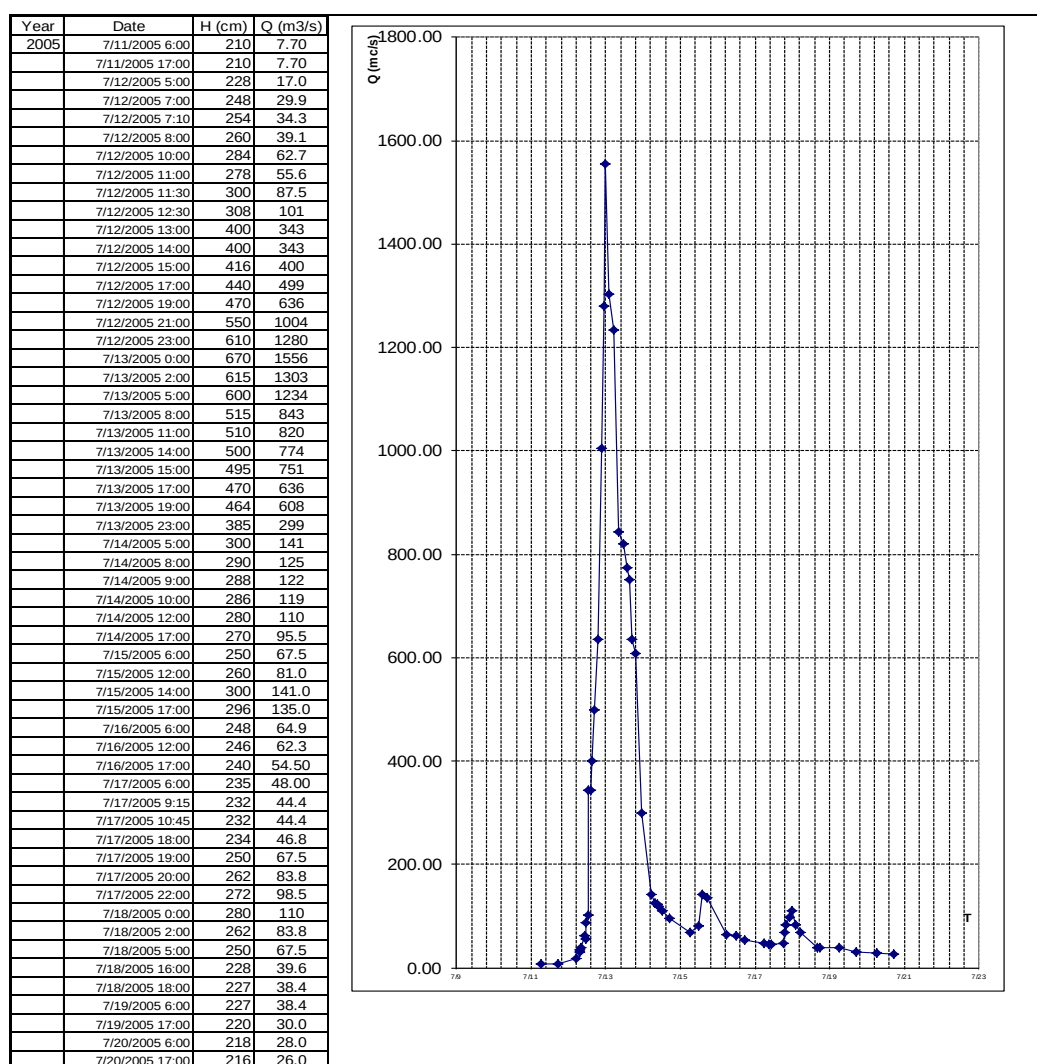


Figure 8. The historical flash floods on Tazlau river at Helegiu hydrometrical station, July, 2005

Flood volume (W), the volume is calculated using the relation: $W = Q_{\max} \cdot T_t \cdot \gamma \cdot 3600$, W = maximum volume of the flood (in m^3); $Q_{\max}$ = peak flow (in m^3 / s); T_t = total time (in hours); γ = the shape coefficient of the flood.

Flood shape coefficient (γ):

$$\gamma = \frac{W}{(Q_{\max} - Q_b) \cdot T_t}$$

where: W = flood volume (in m^3); $Q_{\max}$ = peak flow (in m^3 / s); Q_b = base flow (in m^3 / s), T_t = total flood time (in seconds).

4. Discussion

Following the resulting on the characteristics of the flood, respectively the increase time, the decrease time, the total time, the shape of the flood, etc., it resulted that this flood had a volume of 33 million cubic meters.

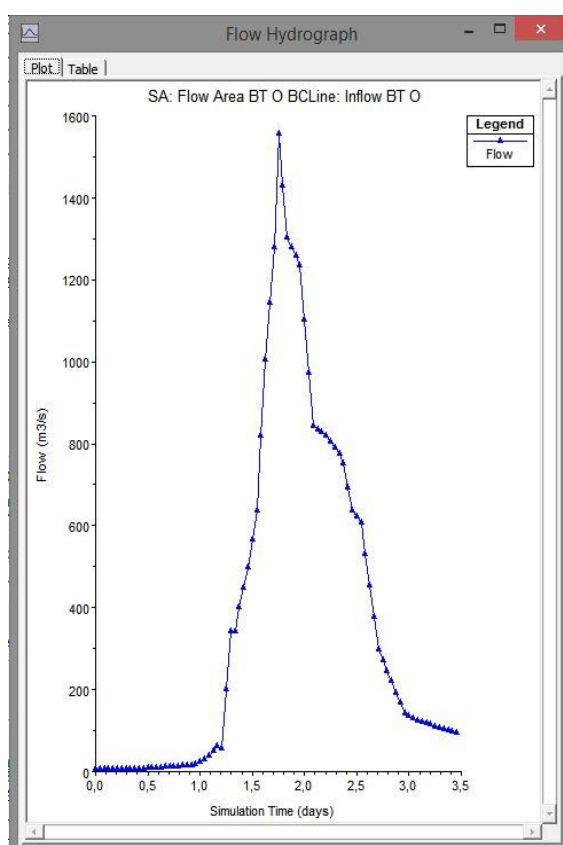


Figure 9. Running the flow with a probability of 1% before and after the polders

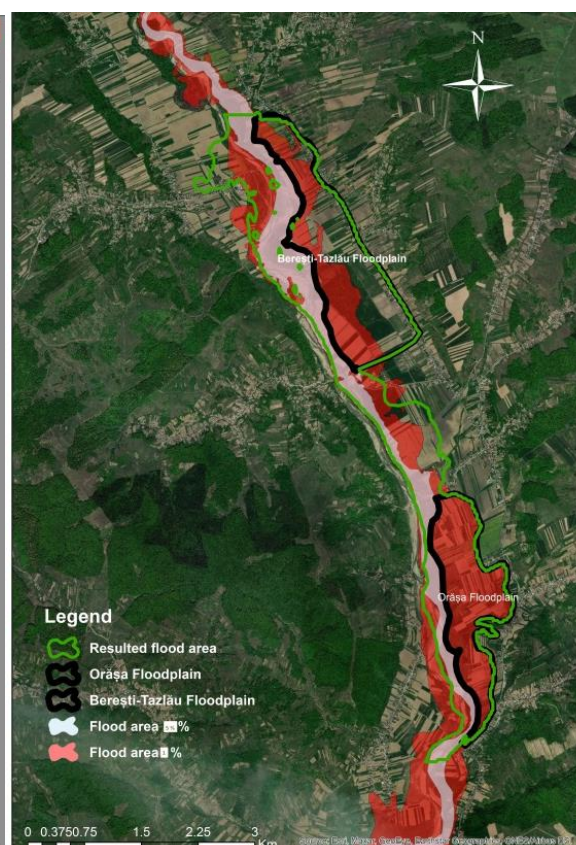


Figure 10. The results of running

Given that the total of the two polders can retain about 30% of the volume of a historical flood, it would reduce the flow from insurance of 1% to insurance of 5%.

Through clearing and reprofiling works, these polders could have their storage capacity increased by another 30%, mineral aggregates could be capitalized, and the residual material compacted and grassed. These areas, which are mostly privately owned, could be used economically, and in case of floods to take over the calculated volume, so that the remaining flow of about 800 cubic meters can be transited without causing damage to the objectives socio-cultural and without generating significant erosions (Iosub et al., 2019). The compensation of the owners regarding the agricultural

damages produced on the lands destined to the polders, will be done according to the regulations in force (Figure 9, Figure 10).

By overlapping the results obtained from the modeling with the polder system with the .shp file of the socio-economic objectives, it resulted that 68 objectives out of 424 remain floodable (Figure 11).

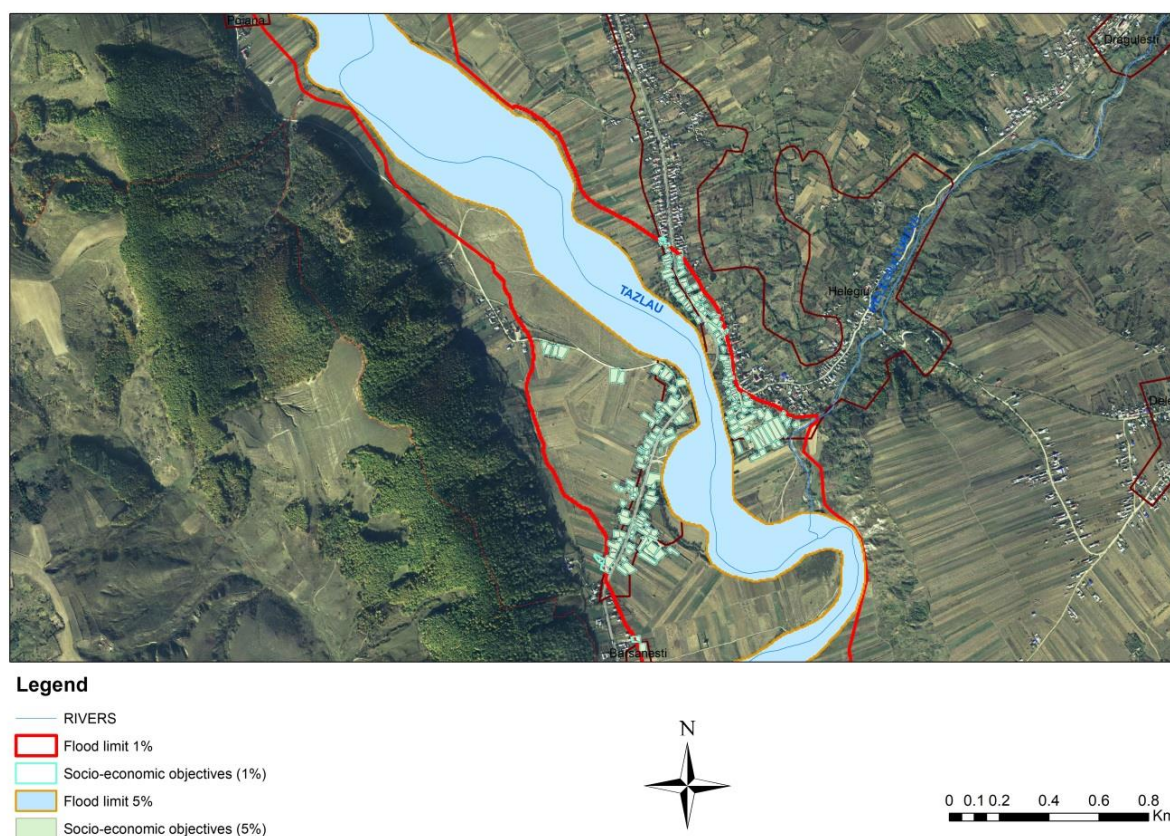


Figure 11. The difference between the flooded objectives before the construction of the polders and after their achievement

5. Conclusions

In the current context, when compliance with the Water Framework Directive is one of the major and indispensable objectives in water resources management, the choice of optimal strategies requires increased attention in order to maintain or improve the quality of water bodies. In this regard, the arrangement of these two polders, the correlation of the works for clearing the watercourses from the Tazlău river basin, the arrangement of the torrents through green measures in order to reduce erosion, as well as the application of flood prevention measures regarding the information of the population, is the optimal flood reduction strategy of the effects of these in this river basin. At the same time, this approach can be a flood risk management strategy and a method of sustainable economic recovery with significant benefits for all stakeholders involved.

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