THE ROLE OF WETLANDS IN FLOOD PROTECTION PROCESSES IN THE LANDSCAPE – CASE STUDY

Marián Dobranský[1], Peter Bujanský[1], Gao Zhenjun[2]
[1] Technical University of Kosice, Faculty of Civil Engineering, Vysokoškolská 4, 042 00 Košice, Slovakia
[2] Three Gorges University, No. 8, Daxue Road, Yichang City, Hubei Province

https://doi.org/10.11118/978-80-7509-904-4-0336

Abstract
In the past, in Slovakia, from the point of view of flood protection, riverbeds were modified with technical elements. The most common solution was the so-called channelization of the riverbed. This modification of the channel straightening, removed the natural meanders of the river, increased the longitudinal slope of the riverbed, and accelerated the outflow from the threatened area. Nowadays, from the point of view of water retention in the country, only the revitalization of riverbeds may not be sufficient to achieve water management during droughts, but also during floods. The design of wetlands in the territory of old, historical, and forgotten riverbeds can create a system for retaining water in nature, thanks to the regulated flood wave, regulation of the inflow and outflow of water from the wetland to existing as well as restored branches of a river. Wetlands, as a valuable ecosystem, can also have recreational and educational value for the wider public, either in the form of tourist-educational trails, lookout towers with the aim of observing bird territories or as part of cycling tracks.

Key words: flood defence measures, flood hazard map, revitalization, recreation, Slovakia

Introduction

Wetlands are defined in the legal system of Slovakia in Act no. 543/2002 Coll. on the Preservation of Nature and Landscape as amended. According to § 2 letter g), Act no. 543/2002 Coll. a wetland is an area with swamps, fens or bogs, a wet meadow, natural flowing water, and natural stagnant water, including a water course and water surface with ponds and water reservoirs (2002).
The most common definition of a wetland in Slovakia is based on the Ramsar Convention on Wetlands. Under the text of the Convention (Article 1.1), wetlands are defined as; areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters (Ramsar, 1971). According to the above-mentioned document, five major wetland types are recognized:

- marine (coastal wetlands including coastal lagoons, rocky shores, and coral reefs)
- estuarine (including deltas, tidal marshes, and mangrove swamps)
- lacustrine (wetlands associated with lakes)
- riverine (wetlands along rivers and streams)
- palustrine (meaning “marshy” - marshes, swamps, and bogs).

State nature protection has a smaller division of wetlands according to importance: Nationally Important Wetlands (N), Regionally important wetlands (R) and Locally significant wetlands (L) This organization also defines Wetland mapping methodology in Slovakia. The inventory of wetlands has been taking place in the Slovak Republic since 1992. Its methodology is based on Ramsar categorization and Ramsar criteria, it was prepared simultaneously with the methodology for habitat mapping and uses some similar approaches. The inventory of wetlands in the current phase enables the identification of some important sites, but the overall inventory of wetlands is a long-term program that will continue for several years. The methodology is prepared by summarizing several years of experience in evaluating data from this inventory. Formularies for the inventory of wetlands were issued by the Slovak Union of Nature and Landscape Protectors in 1992 and will be supplied on request by the Wetlands Mapping Centre, where, if necessary, map documents can also be obtained.
There are two starting situations when mapping the wetlands:

- we have a certain wetland processed for the last year(s) and we need to enter the results into the formulary sheet.
- we have only selected the wetland location and we are waiting for research (botanical or zoological, or both). Only as a supplement to the field survey, we recommend the processing of data about the given location from the literature, with appropriate citation of the literary source.

We currently do not have targeted methodology about artificial (human made) wetlands or their usability from the point of view of flood protection. The aim of the study is to point out the possibility of using the retention properties of potential wetlands along rivers and streams but does not to prove the error of old or historical proposals or to challenge their roles. On the contrary to point out improvements to the current changes and rules, whether from the point of view of hydrology, ecology, ichthyology, or biodiversity of the areas addressed. To clarify this statement few examples are given:

- not every resolved build-up had a proposed flow adjustment for the same flood condition, and the targeted n-year flow values differed. Nowadays, almost all designs are evaluated for event of 100-year flow flood.
- riverbeds were modified with technical elements as semi-vegetative or concrete blocks.
- so-called channelization of the riverbed. This modification of the channel straightening, removed the natural meanders of the river, increased the longitudinal slope of the riverbed, and accelerated the outflow from the threatened area.

Material and methods

Various solutions for surface water flow management are currently being sought. The critical problem is not only solving the runoff conditions during extremely high flows during floods, but also the opposite, retaining water in nature during droughts. It is wetlands that can play a key role in reducing the water volume of a flood wave and subsequently ensuring the distribution of water during dry periods.

First, we must explain the issue of the state of flood defence measures near or in town-residential area of cities in Slovakia. The most frequently used type of protection in the given built-up areas are stream-channel regulation, a river levee (dike), or a protective wall if the areas for construction are so small that the body of a river levee does not fit into the given line (Fig. 1).

Modern trends try to avoid these criteria as much as possible. It is obvious that the built-up density of cities plays a key role in the design decision-making process.

Fig. 1: Comparison of stream-channel regulation of the Hornád river in the Košice. (Left map: The military mapping in 1920 – 1950. Right map: ZBGis map 2023)

The aim of the research is to point to more modern environmental solutions that can increase safety and protection against floods. Artificial wetlands can be one of the options for modifying (or even part of the repairing) existing flood protection measures. Similar to controlled flooding area, wetlands would be designed upstream above the proposed built-up area. Finding the right location for swamps should be an open debate with all affected state authorities and professional organizations dedicated to the issue. The second most important input information when searching for a location can be historical sources and map documents, in which it is possible to find mentions of wetlands or at least trace the alignment of the riverbed before it was channelled. Terrain depressions, old riverbeds (which may already be filled in or reclassified as agricultural land), have an impact on the future development of the wetland, both in terms of the ability to retain water in the country, but also the usability of its retention volume.

Results

The first and basic task is to solve the existing regime of the water level around interest for targeted flow of the flood. As a result, the maps of the flood hazard should correspond to the corresponding

volumes of flood waves during extreme flows. Example of the flood map can be shown in Figure 2., where part of such document is publicly accessible in the map portal of the Slovak Water Management Corporation. If these maps and information about the flood in a specific area are not accessible, it is necessary to evaluate them in a hydrodynamic model.

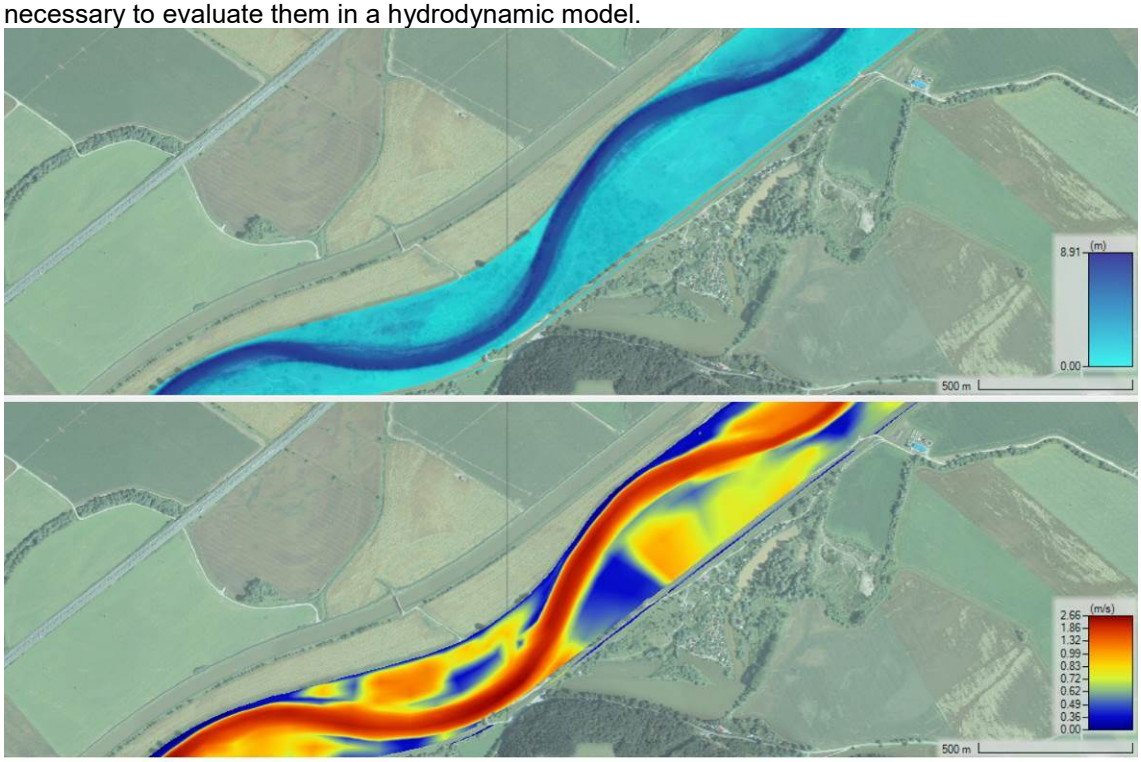

Fig. 2: Example of the flood map, evaluated in a hydrodynamic model for targeted 100y-flow.

The second step should be the characterization of the territory for the design of an artificial wetland, which would include three basic parameters: water withdrawal for the wetland, the maximum volume of water per area of the treated territory and, finally, the possibility of manipulating the water level. Manipulation of the water level either from the point of view of the flood protection or subsidizing the flow during dry periods.

Water withdrawal for the wetland would be adapted to the surrounding terrain, needs and circumstances as and especially when water retention is necessary. For instance, a modified, regulated riverbed, which partially fulfils flood protection, can supply water for the wetland through an inlet structure or some regulation through flood protection structure as the wall or the levee. An important calculation and design in this part will be the process and time interval of filling the wetland retention space so that it is safe and non-destructive. At the same time, to maximize the given space, but not to create new potential flood threat for the study area.

The debate about the retention properties of wetlands should be divided into parts in terms of not only extreme conditions but also for normal daily operation. This would be the readiness of the water level regime either for the expected decrease in precipitation defining the dry season, but also the possibility of lowering the water surface elevation with the aim of maximizing retention during ongoing flood. The requirement to completely drain and dry the wetland must be feasible if necessary.

The method of releasing and draining flood waters from the wetland must be safe and gradual so as not to create new dangerous flood scenarios. The use of excess flood water can help to revitalize historical, currently dried branches, or support the flow of existing river or stream branches. Like the withdrawal of water to a wetland, the regulation of the water surface elevation around the wetland can also be set by an outlet structure.

The last step could be beatification of wetland, as a valuable ecosystem, which can also have recreational and educational value for the wider public with lookout towers with the aim of observing bird territories. New protective levees can form of tourist-educational trails or cycling tracks.

Conclusion

Whether in Slovakia or in other countries that want to solve the problem with floods, we are also looking for new, more ecological solutions than we did in the past. The terminology of artificial or human-made wetlands is still a fresh topic, but more attention is being paid to it. The restoration of

branches and wetlands near large rivers, such as the Danube, is a priority in our territory. However, we can see the potential of these artificial wetlands in smaller lowland streams, where the volume of the flood wave may not have high values, but the low longitudinal slope of the stream ensures a slow outflow from the territory. The untargeted and unregulated spill-over of water from riverbed into agriculturally used zones can be replaced by staged filling of wetlands with a positive result and increased protection against flood (Zeleňáková, 2015, 2018). We are aware that the retention values of wetlands are not equal to the values of reservoirs and controlled flooding area. However, a system of several wetlands, whose level regime will be interconnected with each other but also with the river, can reduce the critical peak of the flood wave to such an extent that the threat from spill-over is minimal or non-existent.

References

Act no. 543/2002 Coll. on the Preservation of Nature and Landscape (in Slovak). Slovakia, 2002
Ramsar Convention of Wetlands. Ramsar, Iran, 1971
ŠOP SR (State Natural Protection of Slovak Republic and its official webpage) Prehľad mokradí Slovenska podľa okresov (in Slovak). URL: https://www.sopsr.sk/cinnost/biotopy/mokrade/MokrSlov/prehladokresy.htm
ŠOP SR (State Natural Protection of Slovak Republic and its official webpage) (in Slovak). URL: https://www.sopsr.sk/cinnost/biotopy/mokrade/MokrSlov/metodika.htm
[1] Zeleňáková, M., Purcz, P., Hlavatá, H., Blišťan, P. (2015). Climate Change in Urban Versus Rural Areas. *Procedia Engineering*, 119: 1171-1180.
Zeleňáková, M., Junáková, N. (2018): Environmental impact assessment of Vechec flood protection. In: J. Fialová (Ed.), Public recreation and landscape protection - with nature hand in hand: Conference proceeding. Brno, Czech Republic: Mendel University, 2018: 148-153.

Acknowledgement

This work has been supported by project of the Ministry of Education of the Slovak Republic APVV-20-0281 Mitigation of hydrological hazards - floods and droughts – by exploring extreme hydroclimatic phenomena and project SK-CN-21-0043 Study on the technology of attracting fish at the entrance of dam fishway.

Souhrn

V minulosti se na Slovensku z hlediska protipovodňové ochrany upravovala koryta řek technickými prvky. Nejčastějším řešením byla tzv. kanalizace koryta. Tato úprava napřímila koryto, odstranila přirozené meandry řeky, zvětšila podélný sklon koryta a urychlila odtok z ohroženého území. V dnešní době nemusí z hlediska zadržování vody v krajině stačit k dosažení vodohospodářského efektu v době sucha, ale i při povodních, pouze revitalizace říčních koryt. Návrh mokřadů v území starých, historických a zapomenutých říčních koryt může vytvořit systém pro zadržování vody v přírodě, a to díky regulované povodňové vlně, regulaci přítoku a odtoku vody z mokřadu do stávajících i obnovených ramen řeky. Mokřady jako cenný ekosystém mohou mít i rekreační a vzdělávací hodnotu pro širší veřejnost, ať už v podobě turisticko-naučných stezek, rozhleden s cílem pozorovat ptačí teritoria nebo jako součást cyklostezek.

Contact:
Ing. Marián Dobranský
E-mail: marian.dobransky.2@tuke.sk