ASSESSING THE IMPACT OF BUIDLING WETLANDS FOR RAINWATER RETENTION ON THE SOCIETY DEVELOPMENT IN THE SOUTH-EAST OF SLOVAKIA

Maria Hlinkova[1], Martina Zelenakova[2] and Hany F. Abd-Elhamid[3,4]

[1] *Institute of Technology, Economics and Management in Construction, Faculty of Civil Engineering, Technical University of Kosice, 04200 Kosice, Slovakia*
[2]*Institute for Sustainable and Circular Construction, Department of Environmental Engineering, Faculty of Engineering, Technical University of Kosice, 04200 Kosice, Slovakia*
[3]*Department of Water and Water Structures Engineering, Faculty of Engineering, Zagazig University, Egypt,*
[4]*Department of Environmental Engineering, Faculty of Engineering, Technical University Košice, 04200 Košice, Slovakia*
E-mail: maria.hlinkova@tuke.sk

ABSTRACT

Wetlands are all habitats whose existence is conditioned by the presence of water in Central Europe's natural conditions.These areas are with marshes, bogs, fens, peat bogs, and waters, natural or artificial, permanent or temporary, standing or flowing. This means that wetlands include all areas of both natural and artificial origin where the water surface is at or near the land surface or where shallow water covers the surface, as well as streams, rivers, and reservoirs. Wetlands represent a particular ecology that depends on landscape processes. In order to establish a space for rainwater retention in the intravillan of the hamlet of Pribenk, two wetland areas were interconnected that form a functional unit of wetland are being constructed, as described in this study. The technological approach involves building a bioretention system, which consists of creating wetlands within the village and integrating them into a continuous irrigated region with a shallow water surface that is intended for rainwater retention. The highest water level is anticipated to reach +98.13 m above the sea level, for instance, following more intense rains. This option gives the people of the village of Pribenk the chance to develop an area that would satisfy the needs of the European Union for the preservation and protection of water in the nation, lower the temperature of the immediate area during the hot summer months, and last but not least develop a relaxing space. Wetlands perform a number of essential tasks for both humans and the natural system.

Keywords: wetlands, water retention measure, rainwater retention.

1 INTRODUCTION

Wetlands are systems that are composed of plants, water, and natural filters (e.g., gravel, sand or soil). They are wet areas or parts of wet areas in the landscape. Wetlands can also be called marshes, bogs or fens due to the plants, water and geographical conditions. Wetlands are a transitional zone between terrestrial and aquatic systems. They can occur in low-lying areas or on steep slopes with low soil permeability. Wetlands are distinguished by their high water content, allowing only plants adapted to moist to wet environments to thrive (Kadlec and Wallace, 2008). Wetlands fulfill several functions that are important not only for nature but also for humans. The value of some wetlands even increases due to anthropogenic activity, especially due to the influence of the farmers. Paradoxically, it turns out that in some places wetlands are overloaded by human influences, and thus their value decreases.

The value of wetlands also depends on their location in the country and the hydrological, geographical, and meteorological conditions in which they are located (Mitsch and Gosselink, 2000). Wetlands represent a specific ecosystem that is dependent on landscape processes. Among the important conditions under which wetlands are located are the periodicity of flooding, the depth of indicators and water saturation, the basic chemical and physical parameters of water, plant populations and the assessment of the adaptation of plants to a flooded environment. Wetlands also provide other functions such as protection against floods, groundwater supplied through flora, banks stability , sediments and nutrients retaintion. They also serve as an ecosystem for specific species of plants and animals, clean water, and animals help mitigate the negative effects of climate change (Zelenakova at al., 2019).

Wetlands are crucial hydrologic and ecological components of watersheds. They can decrease stream flow volumes and peak discharges to receiving stream channels through their storage role and sustaining distinctive plant and animal species. Additionally, they can lower the amount of sediment delivered to receive waterways and raise the caliber of water released into streams and rivers (Harbulakova et al.,, 2014). Wetlands are hydrologically important to the environment in which they are found because they are areas that are inundated or saturated with groundwater or surface water. They serve as important wet habitats since they are home to distinctive plant and animal groups. They carry out various protective roles and offer an appropriate biodiverse environment (Zelenakova and Harbulakova, 2014).

In the natural conditions of Central Europe, all biotopes whose existence is conditioned by the presence of water are considered wetlands. These areas have marshes, fens, bogs, natural or artificial, permanent or temporary, standing or flowing water. It means that wetlands include all territories of natural as well as artificial origin where the water level is on the surface, close to the surface of the soil, or where the surface is covered by shallow water, as well as streams, rivers, and water reservoirs. The significance of wetlands is closely linked to their functions in the ecosystem, which also become indispensable for humans.

The impacts of wetlands:

- For the preservation of the diversity of living organisms, which is conditioned by the diversity of habitats arising depending on the level of groundwater.
- As natural water purifiers, they participate in the removal of chemical and organic waste, nutrients and sediments, and retain water in the country.
- As a flood control mechanism and protection against erosion, they are a source of drinking water and utility water.
- Socioeconomic in the production of wood, grazing, fish farming, and last but not least, as the basis of human recreational and tourist activities (Ministry of Transport of the SR. 2020).

The management of rainwater and wetlands in urban areas can be based on the principle of retaining rainwater in the environment where it falls. Current practice is oriented towards the fastest possible removal of rainwater from the territory of inner-city areas. Innovative solutions based on the artificial retention of rainwater in the city's structures during periods without rain allow this water to be used to improve the microclimate of the city, irrigate parks, or be recycled for other city needs. Several technological solutions are available to improve the quality of the environment, which are often used in developed countries. In the world, these systems are often labeled as BMPs (best management practices), i.e., best practice technologies for rainwater and groundwater management.

Wetlands are thought to be seriously threatened by climate change. Wetland biogeochemistry and function may change due to altered hydrology and rising temperatures to the point where some crucial functions may no longer be provided. For instance, they won't be able to purify water any more, and they might start to deteriorate and leak nutrients into surface waterways. Furthermore, because of higher rates of decomposition than primary production (photosynthesis), their role as a carbon sink may shift to that of a resource (Salimi et al, 2021).

Wetlands are crucial for maintaining the earth's ecosystems, which control water supplies, modify local climates, and provide humans with food, among other things. However, wetlands face significant problems as a result of human activity and other natural changes, such as area loss, function deterioration, and a decline in biodiversity, so certain wetlands urgently need to be restored (Cai et al, 2021).

The main aim of this paper is to assess the impact of construction of water retention measure: two interconnected wetland areas that will form a functional unit of wetland that will create a space for rainwater retention in the intravillan of the village of Pribenik in the east of Slovakis.

2 MATERIALS AND METHODS

2.1 Description of the study area

The village of Pribenik (Hungarian: Perbenyik) is located in south-eastern Slovakia in the Trebisov district. Figure 1 shows the location map of the assessed area (Pribenik Village). It is located on the boarder between Slovakia and Hungary.

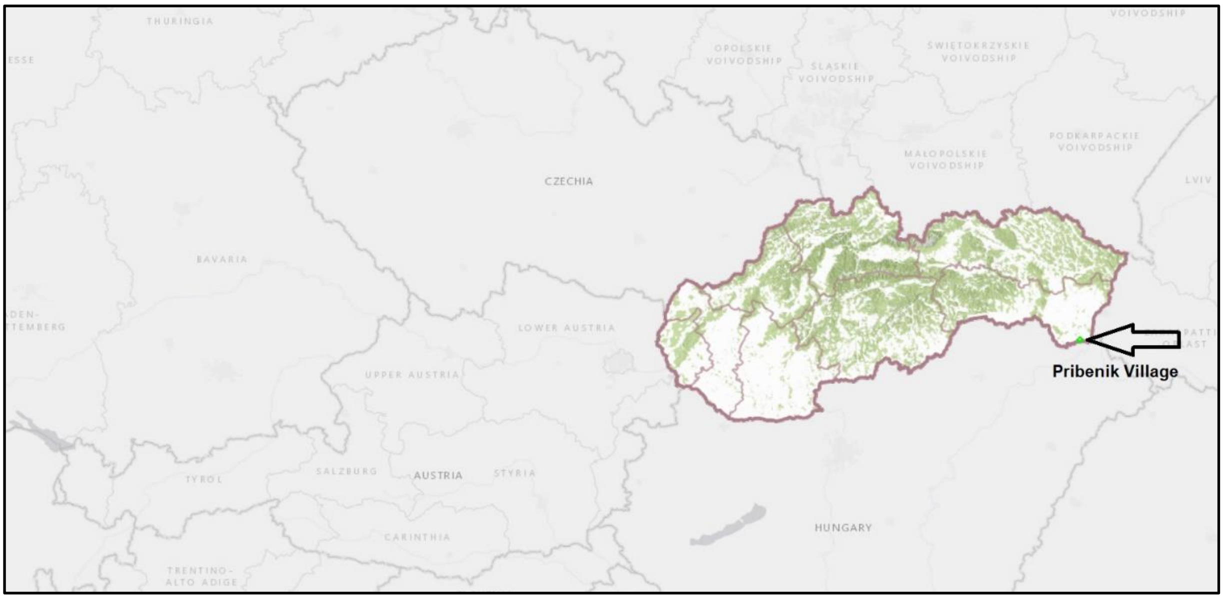

Figure 1. Location map of the assessed area – Pribenik Village.

2.2 Geographical conditions

According to the geomorphological division of Slovakia, the studied area belongs to the East Slovak Lowland, a subdivision of the East Slovak Plain, section Medzibrodská Plain. The study area is characterized by flat relief with minimal differences in altitude. In the place of the implemented engineering-geological boreholes, the surface elevation is about 98,00 m above the mean sea level; it was derived using the application "Google Earth Pro". From a geological point of view, the investigated area and its immediate surroundings were built by Quaternary sediments. Quaternary sediments are dominant in the area, mainly fluvial and aeolian sediments. Fluvial sediments occur in the form of river and stream valley floodplains (alluvial terraces) and are represented by silty, clayey sediments of the alluvial facies, fine-sand silts (clays), and fine-grained sands, in which a dark gray to black horizon of buried alluvial soil is formed at the base. The aeolian sediments are deposited in the form of dunes and overflows of various forms (loaf-shaped plans) and are mainly represented by fine-grained yellow and light brown sands (Landscape atlas, 2023).

2.3 Hydrological conditions

The studied area is a part of the hydrogeological region QN (104 Quaternary) of the south-eastern part of the East Slovak Lowland. The Quaternary upper groundwater aquifer is composed of fluvial sediments and fine-grained sands, where inter-grain permeability is the determining type of permeability. The groundwater level is stressed. At the time of the exploration works, groundwater was encountered at a level of approximately 4.0 m a.s.l. in a layer of cohesionless, sandy soils. After the drilling work was completed, the groundwater level in borehole VP-1 was measured at a depth of 1.45 m a.s.l. The groundwater has the character of being stressed. The laboratory results showed that the groundwater was neutral, moderately hard, and highly mineralized (1490 mg/l).

From the hydrological point of view, the territory belongs to the Bodrog sub-basin (hydrological order number 4-30) and the Bodrog basic basin up to the confluence of the Latorica and Ondava (hydrological order number 4-30-11). The territory concerned is drained in the southern part by the Somotorský canal, which is joined on the right side by the Krčavský, Pribenícky and Dobrianský canal. The Dobrosemiansky brook flows through the southern border of the cadastral territory of the municipality. According to the runoff regime, the watercourses of the area can be classified as upland-lowland areas with a rain-snow runoff regime. The highest water levels are at the beginning of spring in the months of February, March and April, the lowest water levels are in the month of September. The average annual specific runoff in the time period 1931-1980 (Atlas of the Landscape of the Slovak Republic, 2002) ranged from 1 to 3 $l.s^{-1}.km^{-2}$, the minimum specific runoff 364 daily ranged from 0.1 to 0.5 $l.s^{-1}.km^{-2}$ and the maximum specific runoff in the interval with a probability of recurrence once in 100 years ranged from 0.2 to 0.4 $m3.s^{-1}.km^{-2}$ (Landscape atlas, 2023).

2.4 Climate conditions

According to the climatic division of Slovakia, the study area belongs to a warm climatic region, characterized by an average of more than 50 summer days per year with a daily maximum air temperature above 25° C and a January average air temperature below -3° C. Within the warm area, the territory belongs to the T3 district warm, dry, with cold winters. In the west, it is in immediate contact with the warm, slightly dry, flat, slightly rugged district. In the study area, the air temperature in January averages -4 to -3 °C; in July, it is 19.0 to 20.0°C. The average annual number of summer days is 59; frost days are 105. The number of days with snow cover ranges from 40 to 60 days (SHMU, 2022).

2.5 Geological conditions

In terms of the regional geological subdivision of the Western Carpathians, the main regional geological units of the first order in the Trebiov district are the Zempln Hills, the intra-mountain basins, and the neovolcanics. The Trebiov Basin and Roava Bay represent intra-mountain basins and basins (subunit East Slovak Basin). Neovolcanics (a subunit of the Slanské Hills Neovolcanics) are represented in the territory of the district by the Strechovská stratovolcano, the Bogota stratovolcano, and the Milica stratovolcano (Vass el al, 1988). Pre-Carboniferous formations crystalline rocks rise to the surface, which together with the Upper Carboniferous, Permian, Lower, and Middle Triassic formations build the Zempln Hills and form the bedrock of the Tertiary-Quaternary period. The Byt'an Formation, which rises to the surface southeast of the Byt' Spa, represents the Proterozoic.The rock units of the Zempln Group (Upper Carboniferous-Permian) rise to the surface in the Zempln Hills. In the direction from the bedrock to the stratigraphic overburden, the Zempln Group consists of six lithostratigraphic units: the erhovsk, Luhynsk, Tany, Kaovsk, Cejkovsk, and ernochovsk strata. The Mesozoic (Triassic) is represented by the Luany and Ladov Formations. On the pre-Tertiary bedrock, it is assumed that sandy-clayey or sandy-silty sediments corresponding to the Inner Carpathian Palaeogene or Carpathian Paleogene are present (Banacky et al, 1988).

3 METHODOLOGY AND TECHNICAL SOLUTION

The technical solution consists in the construction of a bioretention system: wetlands in the village's intravillan and their integration into a continuous watered area with a shallow water surface, designed for rainwater retention.The maximum water level (e.g., after heavier rainfall) is expected to be +98.13 m above sea level. Before the actual implementation, removing excess shrubs and trees and depositing humus for later use is necessary. The whole excavation area is divided into three height levels and two separate watered areas. The areas will have a pedestrian crossing (ford) in the central part (height level +97,63 m a.m.s.l.) made of cross-cut oak sleepers and will act as a whole with a total watered area of 24.50 m^2. In the vicinity of the ford, there will be concentrated planting of wetland plants that can tolerate water conditions. The landscape architect and the land manager should discuss their planting and design. Along the entire perimeter of the wetland, a stone embankment with a width of at least 2.0 m is proposed, which will create a gradual entrance to the water surface with a total area of approximately 650 m^2 (see Figure 2).

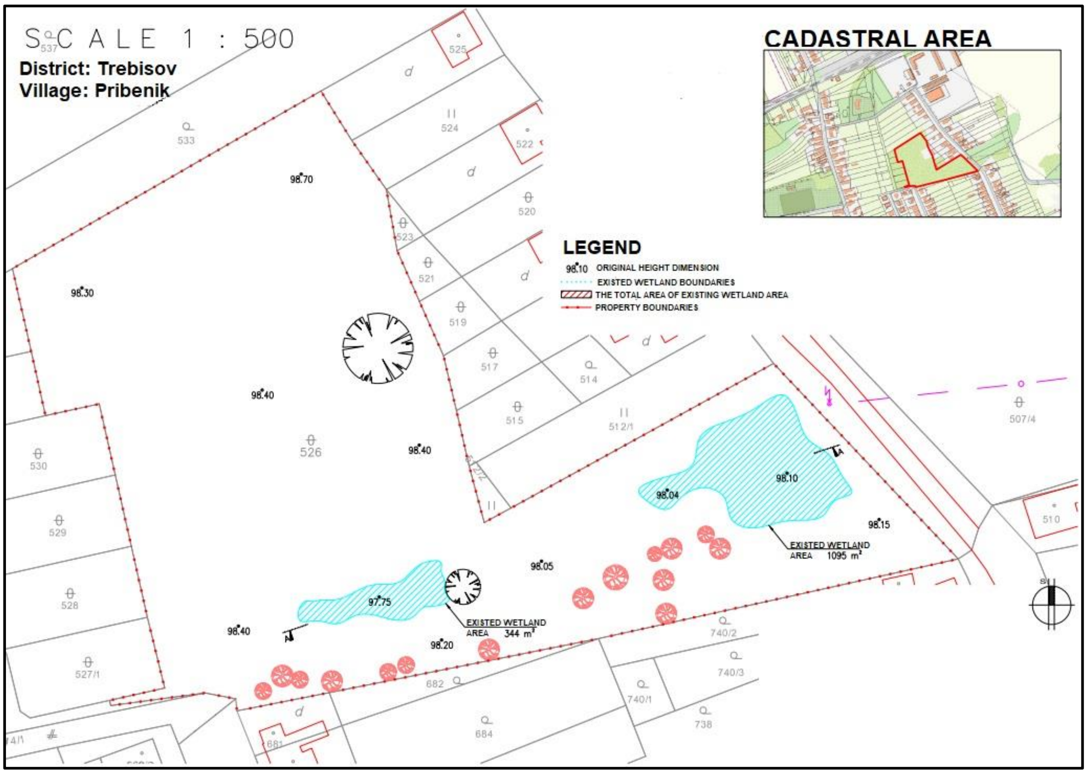

Figure 2. Original state of the study area

Figure 2 shows the original state of the study area. Existing water and marsh areas are waterlogged from groundwater seepage. Prior to the commencement of work, the removal of trees and shrubs encroaching into the wetland areas is required. The following earthworks were carried out in the area includes:

- the removal of grasses and reeds with relocation and stockpiling,
- removal of shrubs and trees, removal of deciduous trees, removal of stumps,
- removal of topsoil with relocation, excavation and excavation of the undrained pit and trenches,
- horizontal relocation of branches and spoil,
- horizontal relocation of tree trunks and stumps,
- placement of spoil on the landfill site, modification of the plain and sloping of the permanent slopes in the trenches.

Figure 3 shows the proposed design of the assessed area. Along the entire perimeter, a proposed stone dike is necessary to stabilize the shoreline in a width of about 2.0 m. Permanently watered volume h=1,85-1,45m. The proposed ford with a passage for pedestrians is formed by oak sections in the central part of the proposed wetland system. It is advisable to supplement the entire space with aquatic plants and plants that tolerate the aquatic environment.

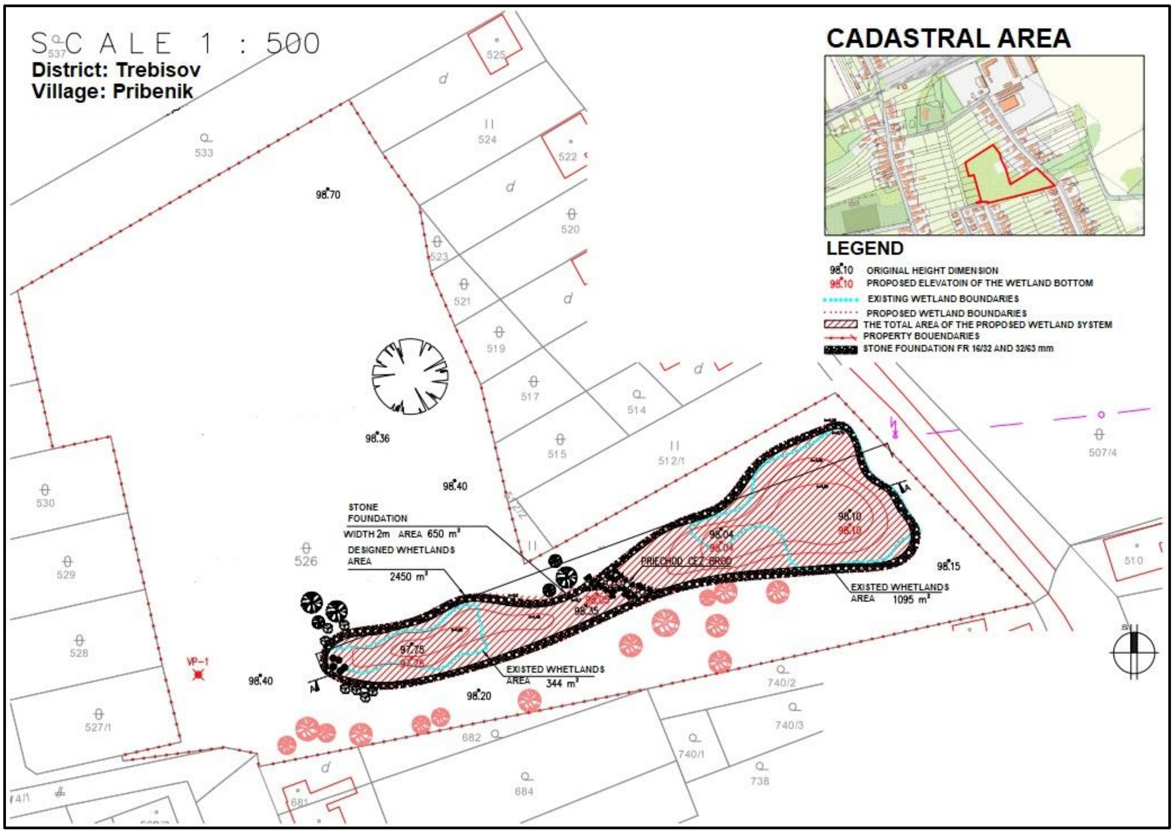

Figure 3. The proposed solution for the study area

4 RESULTS

the proposed solutions to construct wetlands in the assessed environment bring many benefits, both direct and indirect, not only to the inhabitants but also to the natural environment. Among the direct benefits in the assessed location can be considered:

- the maintenance of the water level, which provides suitable conditions for the life of new species of vegetation and fauna
- mitigates the dry season and alleviates flood risks in the village by retaining excess water,
- provides space for recreational and tourist activities in the designed location.

At the same time, the air quality in the area will be improved by humidification, groundwater supplies will be replenished, and water will be naturally purified. the wetland also has the potential to create an educational environment as part of the tourist development of the municipality through the presentation of existing species of plants and animals.

CONCLUSION

Wetlands are regions that are perpetually or occasionally under water or flood. Therefore, wetland areas can be considered bodies of water connected to regions with a lot of water. A wetland is an environment in which there are species that depend on surface water or, at the very least, very high groundwater levels for their survival. In order to establish a space for rainwater retention in the intravillan of the village of Pribenik, two interconnected wetland areas that form a functional unit of wetland are being constructed, as described in this study. The presented solution offers the environment a wide range of advantages, including an improvement in the standard of the outdoor environment as a whole. One of the immediate advantages at the site under consideration is the maintenance of the water level, which creates favorable conditions for the survival of new species of fauna and vegetation. As an advantage we can consider also reduces the risk of flooding in the village and the dry season by holding onto excess water, and provides space for recreational and touristic activities in the area under consideration. Wetlands are swamps full of mosquitoes that make our lives unpleasant and can also bring us benefits. The restoration of wetlands is therefore useful not only for the preservation of these rare habitats and their threatened species but also for forestry, hunting, and fishing. Wetlands primarily retain water in the landscape. They capture water from precipitation, which is then only gradually released from them, it evaporates and flows away. Well-functioning, undisturbed wetlands thus contribute to the reduction of climatic extremes (droughts, heat waves, and heat storms) and significantly reduce the likelihood of floods. In the summer, they also cool and moisten their surroundings. This solution offers the inhabitants of the village of Pribenk the opportunity to create a space that would meet the requirements of the European Union for the protection and retention of water in the country, reduce the temperature of the surrounding environment in the hot summer months, and, last but not least, create a pleasant place for relaxation.

AKNOWLEDGEMENT

This work was supported by the Slovak Research and Development Agency under the Contract no. APVV-20-0281. This work has been supported by project of the Ministry of Education of the Slovak Republic ID 20210812131460210: Tvorba zelených zón na TUKE a zvyšovanie povedomia o zmene klímy.

REFERENCES

Banacky V. et al. Geological map of the southern part of the East Slovak Lowland and Zemplin Hills. GUDS, 1988.

Cai, Y., Liang, J., Zhang, P., Wang, Q., Wu, Y., Ding, Y., and Sun, J. Review on strategies of close-to-natural wetland restoration and a brief case plan for a typical wetland in northern China. Chemosphere, 285, 131534, 2021.

Harbulakova V.O., Zelenakova, M., Valkova, J. The revitalization of a locally important wetland. Public recreation and landscape protection – with man hand in hand? Conference proceeding, Krtiny, Czech Republic, 2014.

Kadlec, R., and Wallace, S. Treatment wetlands. CRC press, 2008.

Landscape Atlas. Available online: https://app.sazp.sk/atlassr/

Ministry of Transport of the Slovak Republic. Analysis of the possibilities fot the use of wetland areas for the needs of sustainable forms tourism, manual for destination management Ramsar site, 2020.

Mitsch, W. J., and Gosselink, J. G. The value of wetlands:importance of scale and landscape setting. Ecological economics, 35(1), 25-33, 2000.

Salimi, S., Almuktar, S. A., Scholz, M. Impact of climate change on wetland ecosystems: A critical review of experimental wetlands. Journal of Environmental Management, 286, 112160, 2021.

Slovak Hydrometeorological Institute (SHMU). Available online https://www.shmu.sk/sk/?page=1&id=meteo_num_laef_egram

Vass D. et al. Regional geological subdivision of the Western Carpathians and the northern outcrops of the Pannonian Basin in the territory of the Czechoslovak Socialist Republic 1:500 000, 1988.

Zelenakova, M., Fialova, J., Negm, A. M. Assessment and Protection of Water Resources in the Czech Republic. Springer, 2019.

Zelenakova, M., Harbulakova, V.O. Restoration of wetland Čičky in Slovakia. 3rd International Conference – Water resources and wetlands. 8-10 September, Tulcea, Romania, 2014.