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Wetlands in Serbia: Past, present and future

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Abstract: Within the territory of the Republic of Serbia, most wetland areas are situated in the north of the state. This is predominantly because of relief features which comprise lowland terrain intersected by the alluvial plains of large rivers such as the Danube, Tisza and Sava. The area also represents the southern part of the Pannonian plain. Extensive works on land reclamation - drainage of wetlands and canalizing rivers, contributed to the formation of large plots of fertile arable land - cultural steppe. Whereas in the 18th century, wetlands were covering 50% of the territory, nowadays remaining wetlands occupy only around 5%. However, these represent significant biodiversity islands and due to this are declared as protected RAMSAR areas of international importance. There are 11 RAMSAR areas in Serbia, of which 8 are in the territory of the Vojvodina Province. Despite protection these are still under pressure from pollution originating from outside borders, climate changes and invasive species. Monitoring water quality at three wetland special nature reserves in the period 2015–2019 revealed that in most cases it was below required water quality standards. In response to these changing conditions, managers of protected areas in Serbia are conducting active measures of protection. Finally, wetlands provide many benefits, and those could be designated as ecosystem services. The concept is helpful for better estimation of benefits, and making comprehensive future planning on how to maximize its benefits and simultaneously achieve sustainability goals. The ecosystem services–based methodology developed during the IDES project, could be useful tool for future planning of management activities.

Keywords: land reclamation, RAMSAR sites, active protection, ecosystem services, inland wetlands

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Introduction

According to Brinkman and Blokhuis (1986), "wetlands have been defined as areas that have free water at or on the surface for at least the major part of the growing season. The water is sufficiently shallow to allow the growth of a wetland crop or natural vegetation rooted in the soil." The flat terrain and abundance of water make wetlands so attractive for performing a wide range of activities which satisfy human needs. Therefore, usually by applying land reclamation measures, wetlands have been drained converted to fertile land or urbanized. Intensive conversion and disappearing of wetlands on a global scale has occurred in the past few centuries since 1700 AD. Especially intensive loss of wetlands has happened in the past century, i.e. a loss of 64–71% of wetlands since 1900 AD ((Davidson, 2014)). It is worth mentioning that for inland wetlands the losses were larger and faster in comparison to losses of coastal natural wetlands. Nevertheless, the benefits of wetlands are numerous: water purification, buffering flooding events, provision of food and fibre, biodiversity conservation, carbon dioxide sequestration, and recently more often emphasized climate change mitigation.

The northern part of the Republic of Serbia, Autonomous Province of Vojvodina - APV (further in the text Vojvodina Province) includes southern parts of the Pannonian plain

which are intersected by alluvial terrain surrounding large lowland rivers - the Danube, Tisa and Sava. For centuries these rivers were crucial for the formation of wetland conditions either by flooding or by meandering and changing their river beds, leaving remains of different inland wetland types. Therefore, floodplains can be defined as areas adjacent to a water body that are prone to flooding events at least one time a year, thus supporting wetland conditions for living organisms adopted to such changes in hydrological regime.

The paper aims to provide an overview of wetlands in Serbia focusing especially on its northern part, since most of the wetlands are located on the territory of Vojvodina Province. Furthermore, attention will be paid to: (1) past actions done to transform the landscape from wetlands to arable land, (2) present conditions characterized by ruminants of former wetlands and (3) prospects for improving their conditions in future.

History of land reclamation in northern parts of Serbia

A few centuries lasting, extensive and planned activities on the territory of Vojvodina resulted in the complete transformation of landscape and habitats. Extensive works on land reclamation - drainage of wetlands and canalizing rivers, contributed to the formation of large plots of fertile arable land - cultural steppe. The transformation simultaneously contributed to diminishing areas under wetlands. In the 17th and at the begging of the 18th century (Figure 1), wetlands covered 50% of the territory (Dragovic et al., 2005).

The history of land reclamation activities started in the Roman period during the reign of the Roman emperor Probus (276–282). The first works on the evacuation of excess inland waters were done around the city of Sirmium (today Sremska Mitrovica town) by digging two canals that could collect the water originating from the Fruška Gora mountain and conduct it to the Sava River. The canals exist even today. Those have been reconstructed, but have the same purpose. Later on at the beginning of the 18th century, the first large canals have been constructed. In the year 1718 began the construction of a canal – representing an artificial riverbed of the river Begej, in the length of 70 km from Timisoara (today Romanian city) to the village Klek in Serbia. The works were lasting for 5 years, but the goal has not been fully achieved, since the middle part of the Banat Region in Vojvodina has not been completely protected from inland waters. The second big project was building the Great Bačka Canal, which has the role to connect the River Danube with Tisa. In the 70s of the 18th century until completion of the works on this project in 1801, Hungarian engineer Kiss József, was devoted to the construction and supervision of works. The canal not only drained large areas under wetlands in the Bačka Region but enabled navigation and shortened transportation of goods which was previously done only along the Danube and Tisa River. The efforts to further draining within the Vojvodina Province by constructing canals continued during the 19th century and culminated in the second half of the 20th century by finishing works on the Hydrosystem Danube-Tisa-Danube (HS DTD). Simultaneously with digging canals, protective dikes have been constructed along major lowland rivers.

Before construction of HS DTD floods caused by inland waters have been significantly deteriorating arable land and have been causing losses of plant production. It has been recorded that on the territory of districts Bačka and Banat in Vojvodina Province severe floods were caused by inland waters in 1942 (Figure 2). The flood had affected more than 450 000 ha of arable land (Dragović et

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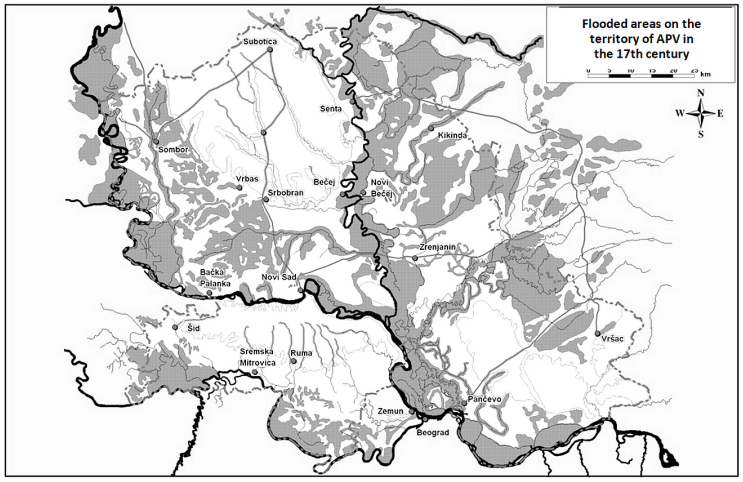

Figure 1: Flooded areas on the territory of Vojvodina Province in the 17th century (PWMC VV, 2023).

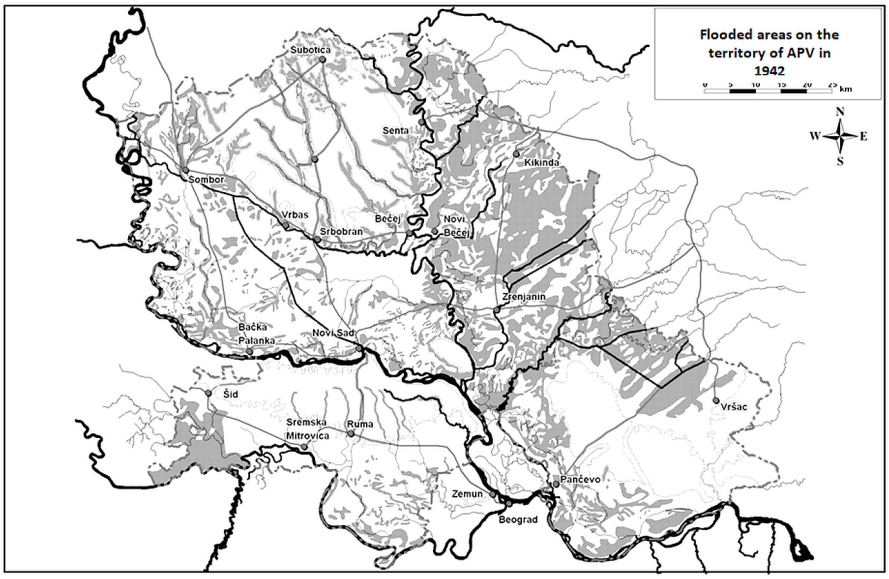

Figure 2: Flooded areas on the territory of Vojvodina Province in 1942 (PWMC VV, 2023).

al., 2005). Whereas in 1956 from the same reason 230 000 ha were devastated, while 800 000 ha were overwetted (Pantelić, 2002). Due to the completion of so extensive land reclamation works even during periods of high precipitation water management within the territory could have been successfully managed (Figure 3). Systematic works on drainage resulted in the fact that most of the area has been converted into arable soil contemporarily occupying 92% of the territory or nearly 2 million ha, while nowadays remaining wetlands occupy only around 5% (Dragovic et al., 2005).

At the end to conclude: two main activities – draining wetlands by *constructing canals* and canalizing rivers by *building protective embankments* resulted in:

- 960 km in length of huge canals of the Hydrosystem Danube-Tisa-Danube, of

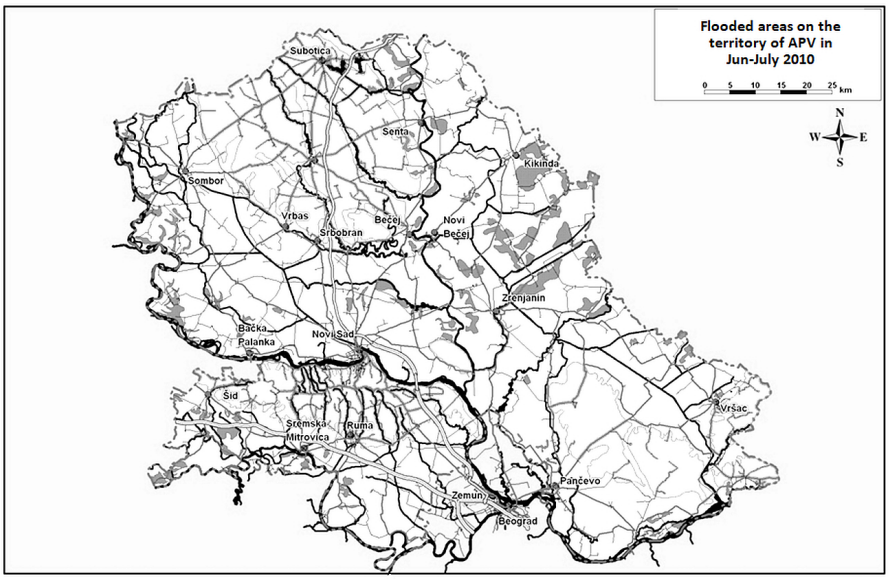

Figure 3: Flooded areas on the territory of Vojvodina Province in 2010 (PWMC VV, 2023).

which around 600 km are navigable;
- construction of small amelioration canals in lenght of 20 703 km;
- building protective dikes along huge rivers such as the Danube, Tisa, Sava, Tamiš and Begej, in lenght of 1362 km;
- establishing good air-water regime on arable land, enabling production of cultivated crops on around 2 million ha (PWMC VV, 2023)); while
- present areas under wetlands occupy only 0.33% of the territory (CLC, 2018).

Present remains of wetlands in Serbia

Since significant areas under wetlands have been lost for centuries on the territory of northern Serbia, present remains could be found mostly in the floodplains of large lowland rivers within the Pannonian plain. Only Vlasina and Pestersko polje is located away from this geographical unit (Figure 4). Vlasina is located in the southeast of the country near the border with Bulgaria, comprising a Vlasinsko reservoir (created in 1949) and surrounding hills, wet meadows, peat bogs, and the valley of the River Vlasina. Pestersko polje is close to the border with Montenegro and is the largest and highest karst field of the Balkan Peninsula. It originated from a lake which vanished with the erosion of the karst leaving peat bogs and small flooded areas exposed, thus creating a diverse landscape (Ramsar, 2023).

Even if they occupy relatively small areas these are significant and unique islands of biodiversity. Therefore, these wetland sites are declared as protected areas of national or even international importance. The idea that habitats are not compliant with countries' borders and that especially migratory birds are periodically migrating was an initial idea for establishing the Ramsar Convention. The convention is also known as "The Convention on Wetlands", an intergovernmental environmental treaty established on 2nd February 1971 in Ramsar, Iran by UNESCO, and come into force on 21st December 1975 (Ramsar, 2023). Under the convention, wetland sites of importance for migratory birds, are proclaimed as Ramsar Sites.

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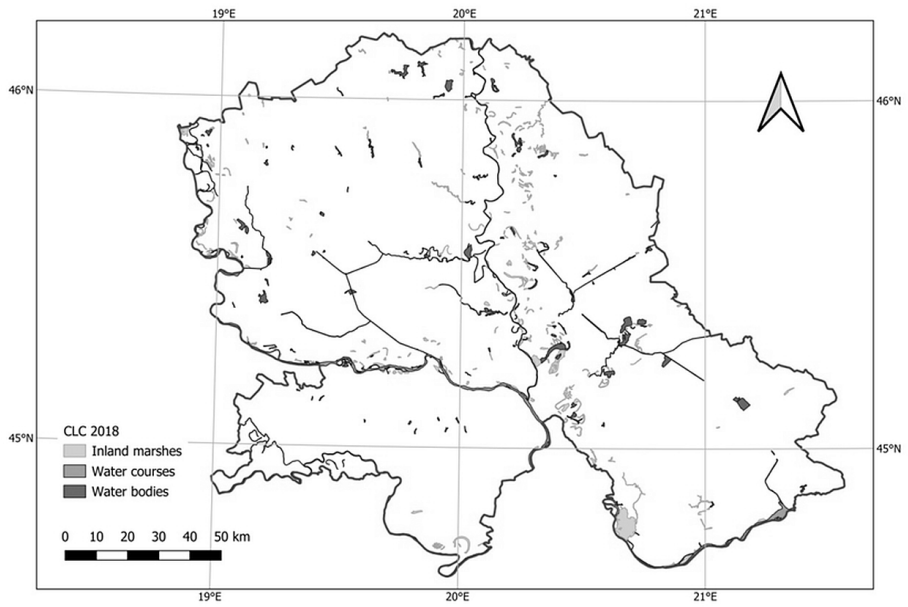

Figure 4: Wetland areas in Vojvodina Province, Serbia (*CORINE Land Cover (CLC)*, 2018).

In Serbia, the convention entered into force on the 27th of April 1992. Serbia currently has 11 sites designated as Wetlands of International Importance (Ramsar Sites), with a surface area of 130 411 ha ((Ramsar, 2023; for Nature Conservation of Serbia, n.d.)). Although there are 7 such sites located in the territory of Vojvodina Province their total area is smaller in comparison to the rest of Serbia, because the area of the Djerdap is larger than the sum of the rest of Ramsar areas in Serbia (Table 1).

Concerning the fact that the territory of Serbia is 8 860 800 ha, the territory under wetlands is represented only by 1.37% (1213 ha), whereas in Vojvodina Province of 2 163 00 ha, wetlands are represented by 0.33% (*CORINE Land Cover (CLC)*, 2018). According to Corine Land Cover (2018), there are three types of wetland areas within Serbia's territory, i.e. inland marshes, water courses and water bodies (Table 2).

Even in so small areas, anthropogenic pressure is still present. One of the factors is pollution originating from anthropogenic sources, and not limited by the borders of protected areas (e.g. air pollution or diffuse pollution loads from adjacent arable land). Currently, apart from anthropogenic pressure, climate changes reflected in longer and more severe drought periods are affecting wetlands. In addition, such a situation favours invasive species, thus causing changes in community composition and decreasing the biodiversity of native species.

Apart from pollution, other factors are disturbing wetland habitats. The most significant is that due to climate change, there is a trend of increasing drought periods and deficiency of precipitation, making wetlands extremely vulnerable. Furthermore, such a situation favours invasive species, thus changes in communities' composition and decreasing the biodiversity of native species (Grabić, Ljevnaić-Mašić, et al., 2022). In response to these changing conditions managers of protected areas in Serbia are conducting active measures of protection, which focus not just on sole isolation and protection of habitats, but rather active eradication of invasive species and taking actions to improve the water regime within protected wetlands (Grabić, Benka, et al., 2022).

Table 1: Ramsar sites in Serbia (Ramsar, 2023).

No.	Ramsar site name	On the territory of VP	Site no.	Designation date	Area (ha)l
1.	Djerdap	No	2442	08-06-2020	66 525
2.	Koviljsko-Petrovaradinski Rit	Yes	2028	08-03-2012	8 292
3.	Zasavica	No	1783	13-03-2008	1 913
4.	Vlasina	No	1738	13-11-2007	3 209
5.	Gornje Podunavlje	Yes	1737	13-11-2007	22 480
6.	Pestersko polje	No	1656	19-03-2006	3 421
7.	Labudovo okno	Yes	1655	19-03-2006	3 733
8.	Slano Kopovo	Yes	1392	14-05-2004	976
9.	Stari Begej – Carska Bara	Yes	819	14-03-1996	1 767
10.	Obedska Bara	Yes	136	28-03-1977	17 501
11.	Ludaško Lake	Yes	137	28-03-1977	593

Table 2: Wetland areas within the territory of the Republic of Serbia (*CORINE Land Cover (CLC)*, 2018).

Region	Type of wetland area (ha)			Total
	Inland marshes (CLC code 411)	Water courses (CLC code 511)	Water bodies (CLC code 512)	
Vojvodina Province	257	297	167	721
Whole Serbia	301	641	271	1213

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Water quality at three wetland special nature reserves

Whereas water quality (WQ) in large rivers such as the Danube and Tisa has been satisfactory on average belonging to a 2nd to 3rd WQ class (Salvai et al., 2022; Josimov Dundjerski et al., 2017; Grzywna et al., 2023), in some reaches of the HS DTD it has been significantly deteriorated by different point and diffuse pollution sources causing occasional fish kills and WQ classified as 5th class, or out of classes (Grabić, Ćirić, et al., 2016; Grabić et al., 2011). In Serbia, there is a state network of monitoring stations controlling WQ in watercourses, especially along the country's borders. However, the network rarely includes sampling sites at ponds and wetland areas. At those water bodies monitoring is performed under the jurisdiction/initiative of local authorities, for scientific purposes and is not done regularly. Due to such circumstances, we have voluntarily conducted monitoring at three protected wetlands. The monitoring of WQ was conducted in the period 2015–2017 at three wetlands, and special nature reserves: SNR Ludaš Lake, SNR Obed Pond and SNR Carska Pond. The monitoring revealed that in most cases it was below required water quality standards belonging to 3rd, 4th class or even was out of class, according to the water quality criteria of Serbian by laws on ecological status, in line with the WFD of the EU (Grabic et al., 2018; Grabić, Ćirić, et al., 2016). During the monitoring period, there were dry and humid years. For example, in 2017 a severe drought caused unfavorable hydrological conditions at Obedska Pond (Ilić et al., 2018) and Carska Pond (Zemunac et al., 2018). In 2017 total precipitation at the measuring station Zrenjanin, close to Carska Pond, was only 368.3 mm (RHMS RS – Republic Hydrometorological Service of the Republic of Serbia, n.d.). This resulted that the low water level in the pond was 40 cm lower than the average level for the summer period, influencing also bad water quality (personal observation of the author; (Grabic et al., 2018)). At Ludaš Lake phytoplankton overgrowth is evident, either by visual observation or by the use of remote sensing and multispectral cameras (Grabić et al., 2019), and through WQ parameters it was reflected in elevated concentrations of total phosphorus and nitrogen, whereas orthophosphates, nitrites and nitrates were low and close to zero, indicating that all nutrients were embedded in phytoplankton. In addition, the pH value measured around noon was high – above 8.5-9 also pointing to intensive photosynthetic activity (Grabic et al., 2018). Besides, agriculture represents significant pressure on protected wetland areas since the leaching of pesticides and surplus fertilizers affects WQ, again in the case of Ludaš Lake (Mezei et al., 2017).

Prospects and future challenges in managing wetlands in Serbia

Apart from WQ issues wetland areas in Serbia are facing additional threats such as invasive species (Grabić, Ljevnaić-Mašić, et al., 2022; Grabić, Benka, et al., 2022). In addition, autochthonous species as in the case of common reed (*Phragmites australis* (Cav.) Trin ex Steud.) may expand and become a nuisance, e.g. the Ludaš Lake (Grabić, Benka, et al., 2016). Furthermore, climate changes expressed in extreme weather events are also evident in wetland areas. In response to climatic changing conditions, managers of protected areas in Serbia are conducting active measures of protection, which focus not just on sole isolation and protection of habitats, but rather on active control of invasive species and taking actions to improve water regimes.

Wetlands provide many benefits, and those could be designated as ecosystem services

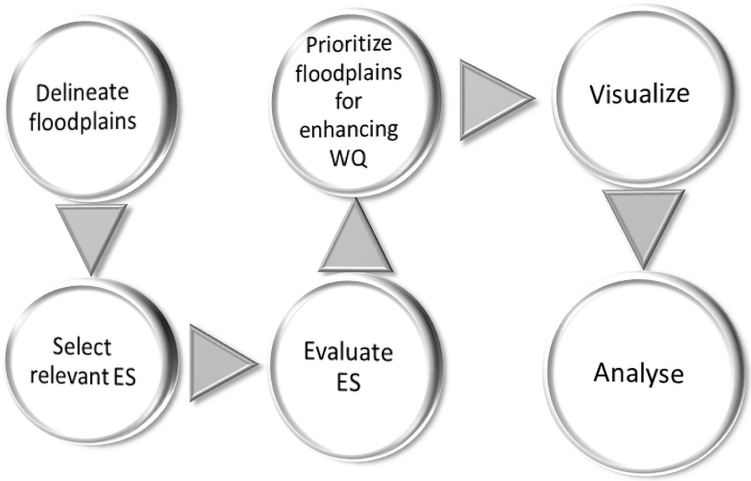

Figure 5: . Phases in the process of ES assessment using IDES tool.

(ES). The concept is helpful for better estimation of benefits, and making comprehensive future planning on how to maximise its benefits and simultaneously achieve sustainability goals. Furthermore, the relatively innovative concept of ES aims to evaluate the benefits posed by natural habitats, even in monetary terms. The ecosystem services–based methodology developed during the IDES project, tested in Serbia on wetlands within the Special Nature Reserve Koviljsko-petrovaradinski rit, showed to be a useful tool (Benka et al., 2022). Phases in conducting mentioned ES-based methodology are presented in Figure 5.

Although, manmade structures, constructed wetlands have proven to be efficient in municipal wastewater water purification (Josimov-Dundjerski et al., 2015) simultaneously contributing to landscape diversity in Vojvodina's landscape where arable plots are dominating. Finally, areas under wetlands in Serbia are being more appreciated, which brings some optimism concerning the Serbian wetlands issue. An argument to support this statement is that new areas are being proclaimed as protected, e.g. Backo Podunavlje was proclaimed as a biosphere reserve in 2017 (UNESCO, n.d.) and Djerdap was designated as the Ramsar area in 2020 (Ramsar, 2023).

Conclusion

Wetlands are an important and multifunctional part of northern Serbia's landscape which contribute to biodiversity, alleviate extreme hydrologic events, and recently contribute to mitigating climate changes. Ramsar sites in Serbia represent significant biodiversity islands. However, protected areas are still under a lot of pressure, e.g. pollution from outside borders, climate changes - getting drier and invasive species are amongst the most prominent threats. Although small in the area at present, occupying only about 1% of Serbia's territory, or 0.37% of the Vojvodina Province, there is a need of preserving existing wetlands and wisely manage them in future. Future management strategies have to be based upon clever acting focused on strengthening wetland health and supporting its biodiversity. Examining and appreciating ecosystem services and planning, to simultaneously satisfy wetland habitats and human needs, concerning various ecosystem services, has to be imperative.

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References

Benka, P., Grabić, J., Ilić, M., Srđević, B., & Srđević, Z. (2022). Koviljsko-petrovaradinski rit Special Nature Reserve (KPR), Serbia. In J. Stäps, A. Gericke, A. Lungu, & B. Stammel (Eds.), Ecosystem services in floodplains and their potential to improve water quality (p. 124-130). Katholische Universität Eichstätt-Ingolstadt. doi: 10.17904/ku.edoc.30670

Brinkman, R., & Blokhuis, W. (1986). Classification of the soils. In A. Juo & J. Love (Eds.), The Wetlands and Rice in Subsaharan Africa. Nigeria: IITA.

CORINE Land Cover (CLC). (2018). version 20.

Davidson, N. C. (2014). How much wetland has the world lost? Long-term and recent trends in global wetland area. Marine and Freshwater Research **65**(10), 934. doi: 10.1071/mf14173

Dragovic, S., Maksimovic, L., Pantelic, S., & Pantelic, P. (2005). History of drainage and irrigation in Vojvodina–The Province of Serbia and Montenegro. Integrated land and water resources management in history, German Water History association (), 133-150.

Dragović, S., Maksimović, L., Radojević, V., Cicmil, M., & Pantelić, S. (2005). Historical development of soil water regime management using drainage and irrigation in Vojvodina. Vodoprivreda **37**(4-6), 287-298.

for Nature Conservation of Serbia, I. I. (n.d.). Ramsar areas. Retrieved 25.05.2023, from https://www.zzps.rs/wp/ramsarska/?script=lat

Grabić, J., Benka, P., Ćirić, V., Lugonja, P., & Antonić, N. (2016). The assessment of common reed expansion (Phragmites australis (Cav.) Trin ex Steud.) on the Ludaš Lake using Satellite Imaginery. In 6th International Psu – Uns Bioscience Conference IBSC 2016, 19-21st September (p. 131-132). Novi Sad, Serbia.

Grabić, J., Benka, P., Ljevnaić-Mašić, B., Vasić, I., & Bezdan, A. (2022). Spatial distribution assessment of invasive alien species Amorpha fruticosa L. by UAV-based on remote sensing in the Special Nature Reserve Obedska Bara, Serbia. Environmental Monitoring and Assessment **194**(9), 599. doi: 10.1007/s10661-022-10273-8

Grabić, J., Bezdan, A., Benka, P., & Salvai, A. (2011). Spreading and transformation of nutrients in the reach of the Becej-Bogojevo Canal, Serbia. Carpathian Journal of Earth and Environmental Sciences **6**(1), 277-284.

Grabić, J., Ćirić, V., Benka, P., & Đurić, S. (2016). Water Quality at Three Special Nature Reserves in Vojvodina, Serbia: Preliminary Research. In The International Conference Air and Water - Components of the Environment (p. 50-57). Cluj-Napoca, Romania: Babeş-Bolyai University. doi: 10.17378/AWC2016_07

Grabic, J., Duric, S., Ciric, V., & Benka, P. (2018). Water quality at special nature reserves in Vojvodina, Serbia. Croatian Journal of Food Science and Technology **10**(2), 179-184. doi: 10.17508/cjfst.2018.10.2.05

Grabić, J., Ivošević, B., Đurić, S., Panić, M., Bigermajer, S., & V., R. (2019). Remote Sensing Method for Assessment of Phytoplankton in Aquatic Environment. In International Conference on Water Sciences – 21st Century Water Management in the Intersection of Sciences (p. 281-287). 22rd March, Szarvas, Hungary.

Grabić, J., Ljevnaić-Mašić, B., Zhan, A., Benka, P., & Heilmeier, H. (2022). A review on invasive false indigo bush (*Amorpha fruticosa* L.): Nuisance plant with multiple benefits. Ecology and Evolution **12**(9), e9290. doi: 10.1002/ece3.9290

Grzywna, A., Grabić, J., & Różańska-Boczula, M. (2023). Occurrences of water quality assessment using Improvised Water Quality Index at Danube River, Serbia. Desalination and Water Treatment **285**(1), 67-77. doi: 10.5004/dwt.2023.29307

Ilić, M., Grabić, J., Bursić, V., Petrović, A., Mezei, M., & Zemunac, R. (2018). The impact of drought on water quality at Special Nature Reserve Obedska bara. In 20th Euroregional Conference on Environmet and Health, DKTM, 7 – 8th September (p. 24). Arad, Romania.

Josimov Dundjerski, J., Savic, R., Grabic, J., & Blagojevic, B. (2017). Water Quality Trends of the Tisa River Along its Flow Through Serbia. In Annual Set The Environment Protection/Rocznik Ochrona Środowiska (Vol. 19, p. 17-35).

Josimov-Dundjerski, J., Savić, R., Belić, A., Salvai, A., & Grabić, J. (2015). Sustainability of the Constructed Wetland Based on the Characteristics in Effluent. Soil & Water Research **10**(2), 114-120.

Mezei, M., Bursić, V., Vuković, G., Grabić, J., Zeremski, T., Gvozdenac, S., & Petrović, A. (2017). The effects of agriculture on water quality of SNR "Ludaš lake". In ECO-Conference „Environmental protection of urban and suburban settlements", 27-29 September (p. 73-79). Novi Sad, Serbia.

Pantelić, P. (2002). The Role of Hydrosystem Danube-Tisa –Danube in Drainage. Hydrosystem Danube-Tisa-Danube – 25 years after. Novi Sad: Monograph.

PWMC VV. (2023). Public Water management Company Vode Vojvoine . Archive centre, Novi Sad, Serbia.

Ramsar. (2023). Serbia. Retrieved 25.05.2023, from https://www.ramsar.org/wetland/serbia

RHMS RS – Republic Hydrometorological Service of the Republic of Serbia. (n.d.). Yearly Bulletin for 2017. No. QF-E-004. (in Serbian). Retrieved 25.05.2023, from http://www.hidmet.gov .rs/data/klimatologija/latin/2017.pdf

Salvai, A., Grabic, J., Josimov-Dundjerski, J., Zemunac, R., Antonic, N., Savic, R., & Blagojevic, B. (2022). Trend Analysis of Water Quality Parameters in the Middle Part of the Danube Flow in Serbia. Ecological Chemistry and Engineering S **29**(1), 51-63. doi: 10.2478/eces-2022-0006

UNESCO. (n.d.). Backo podunavlje bisphere reserve, serbia. Retrieved 25.05.2023, from from:https://en.unesco.org/biosphere/eu-na/backo-podunavlje

Zemunac, R., Grabić, J., Bursić, V., Petrović, A., Mezei, M., Grnya, I., & B., L.-M. (2018). Influence of drought on water quality at Special Nature Reserve Carska Bara. In The fourteenth Regional Conference EnE18, Conference Proceedings EnE18: Nature protection-Nature-Responsive Development, June 5th (p. 47-51). Belgrade, Serbia.

 DOI: https://doi.org/10.18380/SZIE.COLUM.2024.11.1.19