

HAZAI KIS FOLYÓK VÁROSI SZAKASZAIN A REHABILITÁCIÓS POTENCIÁL MEGHATÁROZÁSA

DETERMINATION OF RESTORATION POTENTIAL ON SMALL RIVER REACHES IN URBAN ENVIRONMENT IN HUNGARY

ERDEI TÍMEA | BOROMISZA ZSOMBOR |
DOMOKOS ENDRE | FÖLDI ZSÓFIA

ABSZTRAKT

A városi folyószakaszok a települési zöldfelületi rendszer fontos részét képezik, azonban jellemzően rosszabb állapotúak, mint a vidéki folyószakaszok, rehabilitációjuk ezért fontos feladat. Jelen tanulmány célja a hazai kis folyók városi szakaszain a rehabilitációs potenciál meghatározása a rehabilitációs feladatok megvalósításának elősegítésére. Pontozással értékeltük a rehabilitáció szükségességét és lehetőségét három rehabilitációs célra vonatkozóan: ① vízminőség javítása, ② ökológiai és hidromorfológiai adottságok javítása, ③ rekreációs és tájképi adottságok javítása. A rehabilitáció szükségességének és lehetőségének összevetésével kaptuk meg a vizsgált folyószakaszok rehabilitációs potenciálját. Az eredmények alapján feltártuk a vizsgált folyószakaszok legfőbb problémáit, amelyek a rehabilitáció szükségességére reflektálnak. Vízminőségi szempontból több esetben problémát okoznak a pontszerű szennyező források és a folyómederhez közeli mezőgazdasági területek. Ökológiai és hidromorfológiai adottságok esetében kedvezőtlen állapothoz járul hozzá a hullámtéri fás vegetáció hiánya, a meder módosíthatósága, valamint a partbiztosítással rendelkező szakaszok nagy aránya. Rekreációs és tájképi adottságok

szempontjából a rehabilitáció szükségességét növeli, ha a folyó a belterület központi elemét képezi, azonban rekreációs funkciókkal jelenleg csak kis mértékben rendelkeznek. A rehabilitáció lehetőségeit legtöbb esetben a hullámtér szélessége befolyásolja, mivel ez korlátozhatja a nagyobb területigényű beavatkozások megvalósítását. Az eredmények alapján vannak települések, amelyek több rehabilitációs cél szempontjából is jó rehabilitációs potenciállal rendelkeznek, így ezeken a településeken az összetett célokat kitűző rehabilitációk megvalósítására is jó adottságok vannak. Ilyen például Nagyecséd, Hatvan, Jászberény és Szolnok települése. A kialakított módszer segítségével feltárhatók a vizsgált települések közötti fő különbségek és prioritizálhatók az egyes rehabilitációs célok, amelyek elősegíthetik a rehabilitációs feladatok tervezését és előkészítését.

Kulcsszavak: vízfolyás, folyó, értékelés, rehabilitáció szükségessége, rehabilitáció lehetősége ①

ABSTRACT

Urban river reaches are important element in green infrastructure, but they are typically in worse condition than rural river reaches, so their restoration is an important task. The purpose of this study was to determine the restoration potential of small river reaches in urban environments in Hungary. We evaluated the necessity and possibility of restoration in terms of three restoration goals: ① improvement of water quality; ② improvement of ecological and hydromorphological characteristics; and ③ improvement of recreational and landscape characteristics. We determined the restoration potential of the examined river reaches by comparing the need and possibility of restoration. Based on the results, we revealed the main problems of the examined rivers, which reflect the need for restoration. In terms of water quality, the presence of polluting sources and the effects of agricultural areas along the river were found to cause problems in several cases. Regarding the ecological and hydromorphological characteristics, the lack of woody vegetation on the floodplain, the modified riverbed, and the large proportion of sections with bank protection all contribute to an unfavourable condition. In terms of recreational and landscape characteristic aspects, the need for restoration increases if the small river forms a central element of the urban environment, but currently has few recreational functions. In most cases, the possibility for restoration is limited by the width of the floodplain, as this can hinder the implementation of interventions that require a larger area. Based on the results, there are settlements with good restoration potential from the point of view of several restoration goals, so these settlements are also suitable for implementing restorations with complex goals (e.g., Nagyecséd, Hatvan, Jászberény, or Szolnok). Using the developed method, the main difference between the examined river reaches can be revealed and the restoration goals can be prioritized, which can sustain the planning process and preparation of river restorations.

Keywords: watercourse, river, assessment, need for restoration, possibility of restoration

INTRODUCTION

Restoring rivers to ensure a more natural condition appears as a common goal among environmental and conservation agencies in most European countries [1]. The importance of river restoration is emphasized by many plans and strategies, including the EU Water Framework Directive [2], the EU Biodiversity Strategy until 2030 [3], the European Green Deal [4], the second revision of Hungary's river basin management plan (RBMP3) [5] and the National Landscape Strategy [6]. Urban river reaches are generally in worse ecological condition than rural river reaches [7]. The UN Biodiversity Conference held in 2022 [8] formulated a sub-goal about the sustainable increase of the quality, connectivity, and accessibility of urban green and blue areas, including the aim of improving people's relationship with nature. The proper preparation of restoration projects, the development of assessment and evaluation methods for rivers, and the determination of their restoration potential are becoming more important.

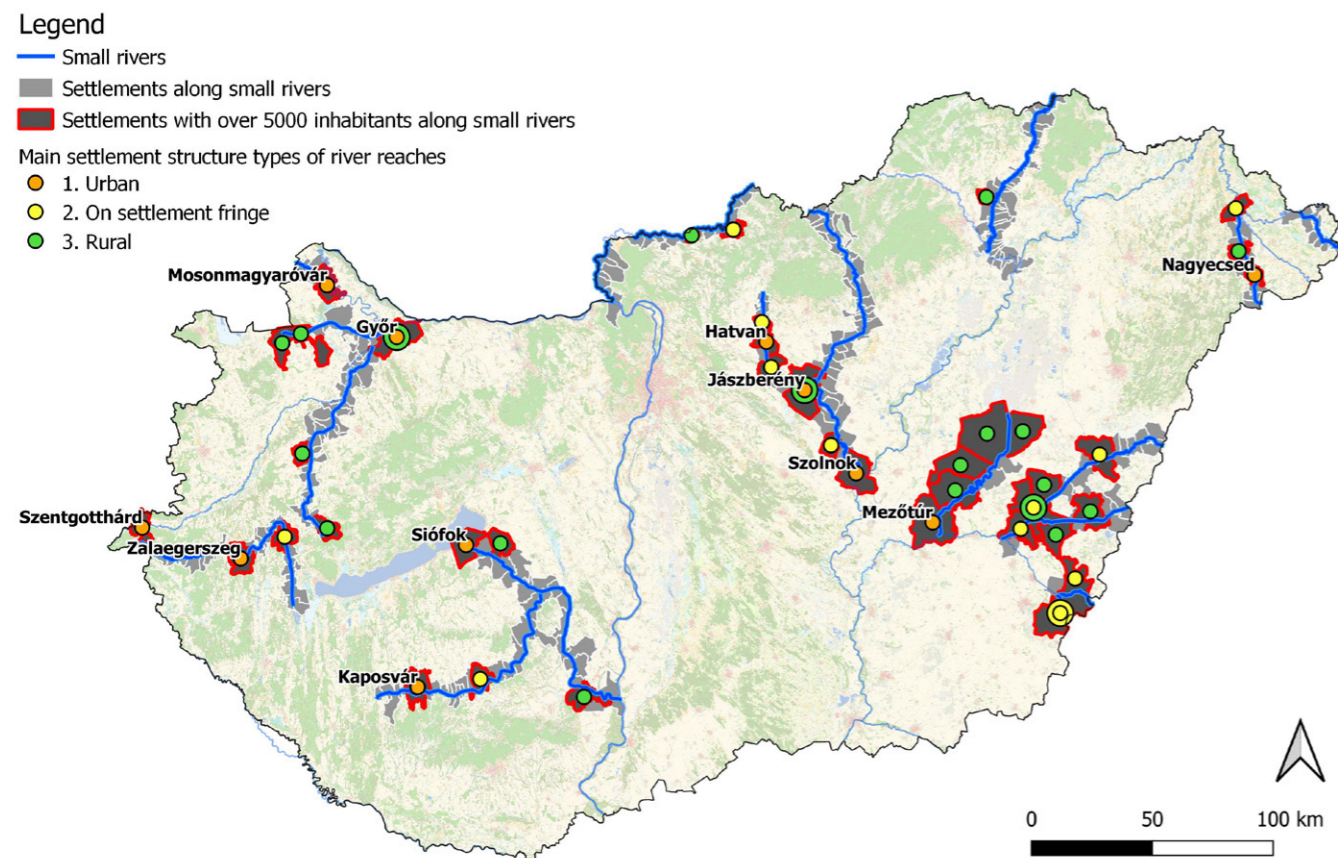
Most research projects about the restoration potential of rivers aimed to evaluate sections outside of urban areas, but little research [9-13] used methods that were or can be applied on urban river reaches. From the Hungarian literature, publications on the planning principles of landscape rehabilitation of creeks [14], hydromorphological and landscape ecological assessment of floodplains [15], or the improvement of connectivity [16] can be highlighted.

In addition to determining the restoration potential of rural river reaches, it is also important to place greater emphasis on the restoration of urban river reaches. The purpose of this research is to examine how the restoration potential of urban river reaches can be determined on a national scale, using the example of small riverside cities in Hungary.

MATERIALS AND METHODS

The research history related to this publication, including methodological details, was presented in previous publications [17, 18]. Below, we present the most important methodological elements from the point of view of the national level part of the research.

Figure 1: Settlements that are the subject of research (urban river reaches – orange dots)
Figure 2: Method of determining restoration potential
Table 1: Evaluation of the necessity and possibility of restoration



Subject of the research

The subjects of the nationwide study were small river reaches in urban environments (towns and cities with a population of over 5,000 people). Rivers were divided into three categories by size: large, medium, and small rivers. Small rivers were part of the research. Of the 28 watercourses, which are listed in the Act CXCVI of 2011 on national assets [19] and in the RBMP3 [5] as rivers, 64% belong to the analysed small river category. Small rivers have the following parameters: 50-250 km length, 500-10,000 km² catchment area, and 5-50 m³/sec annual average water flow [20].

The settlements with the chosen criteria along the 18 small rivers were selected with the help of QGIS 3.16.6 software. Based on the administrative settlement area, 329 settlements in Hungary are located along small rivers, of which a total of 39 have a population of over 5,000

people. Of these, 11 are directly linked to the river with urban river reaches, and these were the subject of the research (Figure 1).

Delineation of the evaluated river reaches

We have delineated river reaches with land use like urban areas or areas with recreational functions on the floodplain or near the floodplain. We used the CORINE 2018 land cover database [21] but updated based on Google Earth 2022 satellite images [22] to examine real land uses. From the CORINE database, we have selected land use patches typically showing residential, holiday, recreational, or community functions, as well as industrial-economic functions. We did not divide the river reaches of individual settlements into further sub-sections.



Need for restoration

	Evaluation criteria	Data source	Goal
1.	water quality (informative environmental rating index)	OKIR [23]	1
2.	presence and effect of polluting sources	RBMP3 [6]	1
3.	distance of arable land from the riverbed	CORINE [21]	1
4.	presence of water quality protection area	OTrT [28]	1
5.	ecological continuity regarding artificial structures in the channel	GDWM [29]	2
6.	hydromorphological impact of artificial structures in the channel	GDWM [29]	2
7.	degree of planform modification	GDWM [29], Arcanum [30]	2
8.	proportion of river sections affected by bank reinforcement	GDWM [29]	2
9.	proportion of riparian woody vegetation	NÖSZTÉP [24]	2, 3
10.	proportion of areas with nature conservation importance	TIR [27], N2000 [31]	2
11.	proportion of areas affected by human activity	NÖSZTÉP [24]	2, 3
12.	existing linear recreation infrastructure	OpenStreetMap [25]	3
13.	proximity and density of attraction factors	OpenStreetMap [25]	3
14.	intensity of human presence	Strava heatmap [26]	3
15.	protected areas with regard to landscape visual aspects	OTrT [28]	3
16.	river's position in the settlement structure	CORINE [21], GDWM [29]	3

Possibility of restoration

	Evaluation criteria	Data source	Goal
1.	width of the floodplain	GDWM [29]/ OTrT [28]	1, 2, 3
2.	reduction options for the impacts of artificial structures	GDWM [29]	2
3.	proportion of areas with nature conservation importance	TIR [27], N2000 [31]	3

Table 2. Determining restoration potential based on the need and possibility of restoration

Figure 3: Evaluation results – a) need for restoration, b) possibility of restoration, c) restoration potential

		Possibility of restoration		
		High	Medium	Small
Need of restoration	High	5 (significant)	4 (high)	3 (medium)
	Medium	4 (high)	3 (medium)	2 (small)
	Small	3 (medium)	2 (small)	1 (minimal)

Goal (1) - Improving water quality



Goal (2) - Improvement of ecological and hydromorphological characteristics



Goal (3) - Improvement of recreational and landscape characteristics



Need for restoration
 ○ 1 - Small
 ● 2 - Medium
 ● 3 - High

Possibility of restoration
 ● 1 - Small
 ○ 2 - Medium
 ○ 3 - High

Restoration potential
 ● 1 - minimal
 ● 2 - small
 ● 3 - medium
 ● 4 - high
 ● 5 - significant

Assessment process

In evaluating restoration potential, our goal was to compare the extent of the need and possibility of restoration in the examined river reaches. Figure 2 shows the evaluation process.

Restoration goals and criteria system of evaluation

The data sources of the evaluation were databases available at a national level, which made it possible to work with the same level of detail, thereby making the evaluation results of the examined settlements mutually comparable. The most important databases used (Table 1) contain data from between 2018 and 2023. Based on the CORINE database, data from 2018 could be evaluated [21]. The water quality data of OKIR [23] were not available from 2022 in the vicinity of all investigated settlements, so in some cases, we also considered data from 2019. The NÖSZTÉP database presents 2019 land cover data [24], which were also considered during the evaluation. The OpenStreetMap [25] and the Strava database [26] contain regularly updated data. In addition, data were used from the TIR [27], the zones of the OTrT [28], the RBMP3 [5], and the data provided by the General Directorate of Water Management (GDWM) [29].

During the analyses at the national level, three main goals were designated to evaluate restoration potential: ⊕ improvement of water quality, ⊕ improvement of ecological and hydromorphological characteristics, ⊕ improvement of recreational and landscape characteristics. In the case of these three goals, the restoration potential of the given river reaches was evaluated based on a different criteria system, which is summarized in Table 1.

Determining rehabilitation potential

The criteria were evaluated using a scoring method based on a 5-scale rating. Based on the evaluation results of the individual criteria, we aggregated the scores separately to determine the need for and possibility of restoration. This was followed by calculating the average with the number of criteria (weighting was done in some cases), so that both the need for and the possibility of restoration were given a score on a basis of a 5-scale rating. A higher score means a greater necessity or possibility of achieving the restoration goal. During the evaluation, we considered the need to realize the restoration goal of "improvement of water quality" and "improvement of ecological

and hydromorphological characteristics" to be greater, the more unfavourable the given section is. In the case of the restoration goal "improvement of recreational and landscape characteristics", the sections with better properties but fewer existing recreational opportunities received a higher score, so a greater need for rehabilitation. We considered the possibility of achieving the given restoration goal to be greater, the fewer limiting factors affect the given river reach. The necessity and possibility of restoration were compared according to Table 2.

RESULTS AND DISCUSSION

In case of the 11 analysed settlements, we separately evaluated the need and possibility of restoration based on the available national databases for the three main objectives defined in advance. The results are summarized below by goals.

Goal (1) - Improving water quality

Based on the results of the evaluation, the restoration potential is significant in the case of Jászberény (the Zagyva River), and high in the case of the cities Hatvan (the Zagyva River) and Nagyecsed (the Kraszna River) (Figure 3 - goal 1). In Jászberény and Hatvan, the presence of pollution sources contributes to the great need for restoration. In the case of all three settlements, there are also agricultural areas near the river (Figure 4). The possibility of restoration is high in Jászberény and medium in Hatvan and Nagyecsed due to the limited intervention possibilities on the narrow floodplain (e.g. buffer forest strips or the creation of wetlands along the river need a larger area).

In case of the other assessed settlements, the restoration potential is medium, except for Mezőtúr (the Hortobágy-Berettyó River), where it is minimal (here, the small restoration need is combined with limited restoration opportunities). In case of Siófok (Sió Canal) and Szentgotthárd (the Rába River), the need for restoration is great, but the narrow floodplain limits the possibilities of intervention.

Goal (2) - Improvement of ecological and hydromorphological characteristics

Four settlements - Kaposvár (the Kapos River), Nagyecsed, Szolnok (the Zagyva River), and Zalaegerszeg (the Zala River) - have great restoration potential in terms of goal 2 (Figure 3 - goal 2). The main reason for this in case of

Figure 4: Agricultural areas near the river (Hatvan, Zagyva River)
Figure 5: Temporary ecological continuity caused by an artificial structure in the riverbed (Jászberény, Zagyva River)
Figure 6: Recreational activities on the floodplain, e.g. fishing and dog walking (Szolnok, Zagyva River)

Kaposvár and Nagyecsed is the great need for restoration due to the lack of woody vegetation on the floodplain or modification of the river's course, and in Kaposvár there is also a significant degree of bank protection. In Nagyecsed, the proportion of areas of nature conservation importance increases the need for restoration.

In Szolnok and Zalaegerszeg, the need for restoration is medium. The main reasons are the temporary ecological continuity caused by an artificial structure (Figure 5), the modified planform, the small proportion of woody vegetation on the floodplain or the presence of areas affected by human use (built-up, paved, or agricultural areas) on the floodplain. The medium need in these settlements is combined with great restoration possibilities, because of the wider floodplain and the transformability of the artificial structures.

Except for Hatvan, the towns and cities all have low restoration potential, which results from either the medium restoration needs and low restoration opportunities, or the low restoration need and medium restoration opportunities. However, in the case of towns and cities with medium restoration needs, it is worth checking whether it is possible to improve the condition of the river reach through interventions with limited space requirements.

Goal (3) - Improvement of recreational and landscape characteristics

From the point of view of goal 3, the restoration potential is high in several cities: Győr and Mosonmagyaróvár (along both the Moson-Danube River), Hatvan, Jászberény, Nagyecsed and Szolnok (Figure 3 - goal 3). The assessed river reaches are central elements of the urban area in these settlements, so the rivers form an important part of the settlement's green infrastructure system. In Szolnok (Figure 6), the high need for restoration is combined with medium restoration opportunities. In Győr, Hatvan, Jászberény, Mosonmagyaróvár, and Nagyecsed, the medium restoration need is combined with good opportunities, due to the width of the floodplain and the

more limited presence of areas of nature conservation importance.

In Mezőtúr, the need and possibility for restoration is medium, and thus the restoration potential is also medium. Here, fewer people make a use of the river neighbourhood. In the case of Kaposvár and Siófok (the Sió Canal), the need for restoration is medium but the possibility of restoration is small, due to the narrow floodplain and the presence of areas of nature conservation importance. Based on these, the restoration potential is also small. Due to the medium need for restoration, it may be worth further investigating opportunities to improve the recreational and landscape characteristics which have limited space requirements.

In Szentgotthárd and Zalaegerszeg, the need for restoration is small, which is combined with small restoration opportunities, therefore the restoration potential is also small. These examined river reaches are less centrally located in the settlement, and people do not currently use riverside areas for sports.

CONCLUSIONS

The results show the settlements with the greatest potential for the different restoration goals. Settlements with high restoration potential can be highlighted, for example in Nagyecsed, Hatvan, or Szolnok, several rehabilitation goals have high potential. Among the examined goals, the improvement of water quality may depend on upstream effects, but certain measures can be taken to reduce local impacts. In the case of the other two assessed goals, the restoration possibilities are better at the settlement scale.

In terms of improving water quality, the most common reason why restoration is necessary is the presence of polluting sources, so by reducing their effects the condition of the examined river reaches could be improved. In terms of ecological and hydromorphological characteristics, one of the main reasons for the unfavourable condition is the small proportion of woody vegetation on the floodplain, the modified planform, or the unfavourable ecological connectivity because of artificial structures on the reach. The last few aspects are difficult to improve in



many cases due to the narrowed floodplain, but woody vegetation could be increased in several cases. In terms of recreational and landscape characteristics, restoration would be most impactful in those cities where the examined river section is in the central part of the urban area, people actively use the areas along the river, and there are only a few recreational functions in the area.

Few data sources are available on a national scale to examine the possibilities of restoration or the limiting factors. Based on the databases that can be used, the main reason for the limited possibilities in the analysed settlements are the narrowed floodplain. However, in several cases it is also possible to implement measures with a small area requirement, so it is important to explore these intervention options.

During the research, we explored the scope of the data that is available nationally, so that the restoration potential of the given river reach can be evaluated with the same data detail in the case of several settlements. These contain data from different dates, with different update intervals, but since they can be suitable for drawing conclusions about the restoration potential of rivers (e.g., for prioritizing restoration goals), this also draws attention to the importance of updating them at regular intervals. The results do not provide the same level of detail as if we were working with data on a study area scale, at the settlement level, but the main conclusions can still be drawn about the state of the examined river sections and the importance of the individual restoration goals. However, for the detailed preparation of river restorations, it is necessary to carry out investigations at a settlement scale, supplemented by field surveys. In addition, as a continuation of the research, by involving the locals and mapping their opinion, the developed method can be further specified and made more objective. ©

„Supported by the ÚNKP-22-3-II New National Excellence Program of the Ministry for Culture and Innovation from the source of the National Research, Development and Innovation Fund.”



This work is licensed under Creative Commons 4.0 standard licenc: CC-BY-NC-ND-4.0.

- 1 CEN Guidance standard for assessing the hydromorphological features of rivers (CEN 14614:2020)
- 2 Directive 2000/60/EC of the European Parliament and of the Council (23 October 2000) establishing a framework for Community action in the field of water policy. (2000) [online] In: Az Európai Unió Hivatalos Lapja. URL: <https://eur-lex.europa.eu/eli/dir/2000/60/oj> [2023.03.31.]
- 3 Európai Bizottság (2020): EU Biodiversity Strategy for 2030. *Bringing nature back into our lives*. pp. 1–23. [online] In: Az Európai Unió Hivatalos Lapja. URL: <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0380> [2023.03.31.]
- 4 The European Green Deal. European Commission, Brussels, 11.12.2019. COM (2019) 640 final. [online] In: Az Európai Unió Hivatalos Lapja. URL: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en [2023.03.31.]
- 5 Országos Vízügyi Főigazgatóság (2022): *Magyarország Vízügyi - Gazdálkodási Terve - 2021*. [online] In: Magyarország vízügyi-gazdálkodási honlapja. URL: <https://vizeink.hu/vizgyujto-gazdalkodasi-terv-2019-2021/vgt3-elfogadott/> [2023.03.31.]
- 6 N. P. és T. F. Földművelésügyi Minisztérium (2016): *Nemzeti Tájstratégia (2017 - 2026)*. [online] In: Magyarország Kormányának honlapja. URL: <https://kormany.hu/dokumentumtar/nemzeti-tajstrategia-2017-2026> [2023.03.31.]
- 7 Wantzen, K. - Alves, Carlos B. - Badiane, S. - Bala, R. - Blettler, M. - Cao, Y. - Kolb, M. - Kondolf, G. M. - Leite, M. - Macedo, D. - Mahdi, O. - Rothe-Neves, M. - Peralta, E. - Rotgé, V. - Rueda-Delgado, G. - Scharager, A. - Serra-Llobet, A. - Yengué, J. - Zingraff-Hamed, A. (2019): Urban stream and wetland restoration in the global south—a DPSIR analysis. *Sustainability*, 11 (18), 1–53, DOI: <https://doi.org/10.3390/su11184975>
- 8 United Nations (2022): *Decision adopted by the conference of the parties to the convention on biological diversity*. 15/4. Kunming-Montreal Global Biodiversity Framework. December, 12–26. [online] In: Convention on Biological Diversity honlapja. URL: <https://www.cbd.int/article/cop15-final-text-kunming-montreal-gbf-221222> [2023.03.31.]
- 9 Hulse, D. - Gregory, S. (2004): Integrating resilience into floodplain restoration. *Urban Ecosystems*, 7 (3), 295–314, DOI: <https://doi.org/10.1023/b:ueco.000044041.94705.52>
- 10 Boitsidis, A. J. - Gurnell, A. M. - Scott, M. - Petts, G. E. - Armitage, P. D. (2006): A decision support system for identifying the habitat quality and rehabilitation potential of urban rivers. *Water and Environment Journal*, 20 (3), 130–140, DOI: <https://doi.org/10.1111/j.1747-6593.2005.00005.x>
- 11 Francis, R. A. - Hoggart, S. P. G. - Gurnell, A. M. - Coode, C. (2008): Meeting the challenges of urban river habitat restoration: developing a methodology for the River Thames through central London. *Area*, 40 (4), 435–445, DOI: <https://doi.org/10.1111/j.1475-4762.2008.00826.x>
- 12 Guida-Johnson, B. - Zuleta, G. (2019): Environmental degradation and opportunities for riparian rehabilitation in a highly urbanized watershed: the Matanza-Riachuelo in Buenos Aires, Argentina. *Wetlands Ecology and Management*, 27(2–3), 243–256, DOI: <https://doi.org/10.1007/s11273-019-09656-5>
- 13 Zuo, Q. - Hao, M. - Zhang, Z. - Jiang, L. (2020): Assessment of the happy river index as an integrated index of river health and human well-being: A case study of the yellow river, China. *Water (Switzerland)*, 12 (11), 1–28, DOI: <https://doi.org/10.3390/w12113064>
- 14 Báthoryné Nagy I. R. (2007): *Kisvízfolyások tájrehabilitációjának rendezési elvei és módszere*. [PhD értekezés]. Budapesti Corvinus Egyetem, Tájépítészet és Döntéstámogató Rendszerek Doktori Iskola: Budapest.
- 15 Lóczy D. (2011): *A Kapos árterének hidromorfológiai és tájökölógiai értékelése*. [MTA doktori értekezés]. Pécsi Tudományegyetem: Pécs.
- 16 Erős T. - Czeglédi István (2019): *Barrierék elbontásának prioritizálása és halátjárók építésének szükségessége Magyarországon*. Szakmai jelentés.
- 17 Erdei T. K. - Boromisza Zs. - Domokos E. - Dávid Sz. (2022): *A szolnoki Zagyva szakasz rehabilitációs potenciáljának meghatározása hidromorfológiai szempontok figyelembevételével*. Hidrológiai Közöny 2022. 102 (3), pp. 33–42.
- 18 Erdei, T. - Boromisza Zs. - Domokos E. - Dávid Sz. (2022): *Comparison of two river segmentation methods in determining their restoration potential*. Polish Journal of Natural Sciences Vol 37(4), pp. 497–516.
- 19 2011. évi CXCVI. törvény a nemzeti vagyronról. [online] In: Hatályos Jogszabályok Gyűjteménye. URL: <https://net.jogtar.hu/jogszabaly?docid=a1100196.tv> [2023.03.31.]
- 20 Dévai Gy. (szerk.) (1998): *A vízi és a vizes élőhelyek sajátosságai és tipológiája*. Oktatási segédanyag. KLTE Ökológiai Tanszéke Hidrobiológiai Részleg. Debrecen.
- 21 CORINE felszínborítás adatbázis 2018 (CORINE land cover database 2018). [online] In: Copernicus program honlapja. URL: <https://land.copernicus.eu> [2023.03.31.]
- 22 Google Earth 2022 műholdfelvételek (Google Earth 2022 satellite images). [online] In: Google Earth Pro. [2023.03.31.]
- 23 Felszíni vízminőség monitoring pontok és mérési eredmények (Surface water quality monitoring points and measurement results). [online] In: Országos Környezetvédelmi Információs Rendszer honlapja. URL: <http://web.okir.hu/sse/?group=FEVISZ> [2023.03.31.]
- 24 NŐSZTÉP: Ökoszisztéma alaptérkép v4.0 (20190630) (Ecosystem base map). [online] In: Magyarország Ökoszisztéma-alaptérképének honlapja. URL: <http://alapterkep.termeszetem.hu/> [2023.03.31.]
- 25 OpenStreetMap letölthető állományai (OpenStreetMap downloadable files). [online] In: OpenStreetMap honlapja. URL: <https://dataz.openstreetmap.hu/> [2023.03.31.]
- 26 Strava heatmap. [online] In: Strava honlapja. URL: <https://www.strava.com/heatmap> [2023.03.31.]
- 27 TIR: Természetvédelmi Információs Rendszer (Nature Conservation Information System). [online] In: Országos Környezetvédelmi Információs Rendszer honlapja. URL: <https://web.okir.hu/tir> [2023.03.31.]
- 28 2018. Évi CXXXIX. törvény és 9/2019. (VI. 14.) MvM rendelet térképi mellékleteinek EOV vetületű WMS szolgáltatása. [online] In: E-TÉR - Elektronikus Térképi Tervezést Támogató Rendszer honlapja. URL: <https://www.oeny.hu/oeny/4tr/#/wms-terkepek> [2023.03.31.]
- 29 Országos Vízügyi Főigazgatóság által rendelkezésünkre bocsátott adatok (Data from the General Directorate of Water Management): vízfolyás víztestek középvonala, árvízvédelmi fővédvonalak térképe
- 30 Katonai felmérések térképei (Military survey maps). [online] In: Arcanum Térképek honlapja. URL: <https://maps.arcanum.com/hu/synchron/europe-19century-secondsurvey/> [2023.03.31.]
- 31 Natura 2000 data and maps: [online] In: European Commission honlapja. URL: https://ec.europa.eu/environment/nature/natura2000/data/index_en.htm [2023.03.31.]