RESEARCH PAPER

INTEGRATED TRANSBOUNDARY TISZA RIVER BASIN MANAGEMENT REINFORCEMENT BY NATURAL WATER RETENTION MEASURES

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ABSTRACT. Interdependency between river basin water retention capacity and different types of water erosion is well documented and recognized by researchers and practitioners. Erosion adverse effects on sustainable water and land management from local (catchment/ drainage scale) to river basin level are various and generated by natural and anthropogenic drivers. The solutions and measures to address these issues span across Multilateral Environmental Agreements, sectoral policies and legal framework. Consequently, the effective cooperation among different sectors, stakeholders and decision makers is required from local catchment to transboundary river basin level. Natural water retention measures (NWRM) multi-functionality in addressing water-related challenges by integrating different policy objectives at the river basin scale, increased their relevance identification in river basin management plans. Selected NWRM with medium to high benefits with respect to erosion reduction, sediment delivery, flood risk reduction, etc., are summarized. The main steps in flood risk management, "win-win" measures identification by Tisza countries and NWRM included in the Integrated Tisza River Basin Management Plan (2019) are presented. Well-structured data collection approach for different policies integration instead of underlying differences and discrepancies is a good starting point for the productive shared river basins management and governance. If the implementation of the NWRM have potential downstream cumulative effects on low flow water regime the mechanism for evaluation of potential consequences has to be established and defined.

KEYWORDS: enatural water retention measures, flood risk win-win measures, integrated river basin management, transboundary cooperation

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INTRODUCTION

From local hydrologic unit to the large transboundary river basins (Amur, Nile, Danube, Mekong, and so on) complexity of water management and governance is generated by various issues and constrains e.g., extreme events, land use, demand by sectors, natural features, availability, lack of cooperation, etc. Two fundamental forms of water and people relation are benefits of various water use and water adverse effects due to damages and dangers to life and the economy (Jevđević 1946). Increase in multipurpose water use demand by humans and intensive development generates increase in water demand and pollution (Miloradov 1992). Water resources management practice around the world is challenged by serious problems (Simonović 2008). According to Dimkić at al. (2008) abundance, exploitation and sustainable development are three main water management phases. Paradigm change is generated by number of issues that can be addressed by adaptive and integrated water management (Wostl-Pahl et al. 2008) to enable flexibility given the high level of uncertainty with respect floods, droughts, rainfall frequency and intensity, etc. Integrated water resources management (IWRM) concept integrates a large number of processes and their components such as the hydrological cycle, natural characteristics of the basin, environmental sustainability, economic development, institutional and legal framework (Mayfield et al. 2004). The new doctrine - IWRM (Figure 1) is incorporated in policy and legal frameworks at the national, transboundary, and global level to combat increasing pressures on water resources (water scarcity, pollution, climate changes, extreme hydrological events, land use changes, etc.).

Erosion adverse effects on human society and environment accompanied with economic and social consequences are recognized as important for water

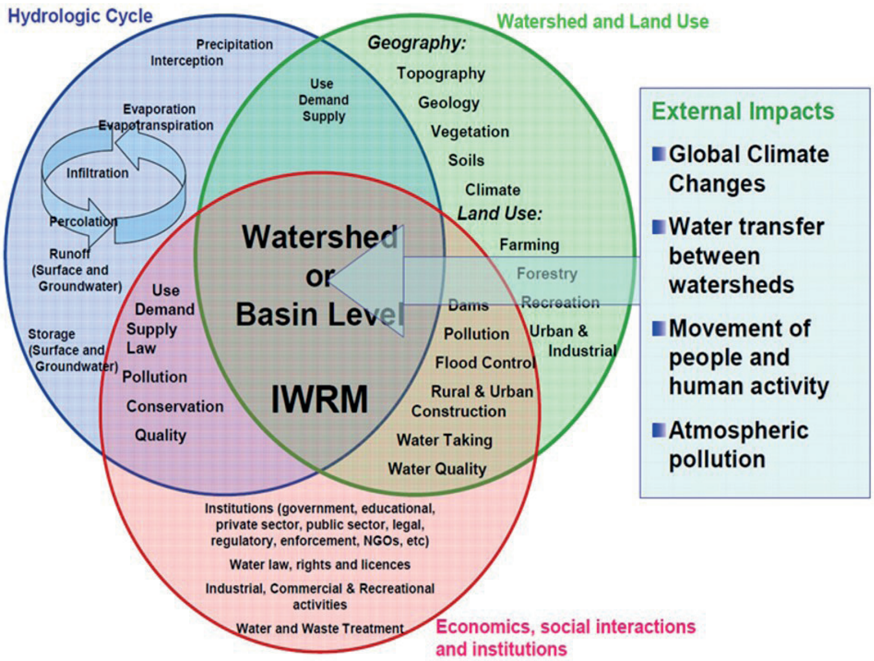

Fig. 1. Conceptual IWRM integration diagram. Source: Mayfield et al. 2004

management with negative impact on water quantity and quality management. Soil erosion by water is estimated to incur a global annual cost of eight billion US dollars to global GDP (Sartori et al. 2019) and falling land productivity due to erosion associated with rice production, is a major driver of the increased water abstraction in Asia. Its consequences span across sectors (water, forestry, environmental protection, spatial planning, disaster risk reduction) and administrative boundaries. Lack of erosion control at the local or country level in the upper part of the river basin generates risks to achieve water management objectives and goals downstream e.g., reservoir sedimentation, landslides, water courses hydromorphology, water quality deterioration that might be decreased if erosion control measures are implemented. Topography, rainfall patterns, land cover and practices are some of the significant factors of relevance for sediment yield and increase in sediment quantity can be a strong signal of various changes that includes watering and erosion, precipitation pattern and frequencies, and human activities (Jaiyeola and Bwapwa 2015). Among the other sources land degradation results in increased erosion intensity, causing elevated sediment loads and enhanced sediment deposition in reservoirs and channels within the river system, environmental and socio-economic losses by decreasing soil fertility, increasing the maintenance costs in hydropower plants and irrigation schemes (Ayele et al. 2021). Land use and land cover (LULC) planning should consider possibilities and constrains to land use practices that reduce erosion to tolerable limits based on soil characteristics, relief, and landowners' socioeconomic aspects (Calegario et al. 2023).

Improved natural water retention capacity by restoring or enhancing natural functioning of ecosystems and the services they provide is achieved by NWRM implementation. The great majority of these measures are qualified as "win-win" solution since their implementation reduce flood risk and support WFD (EU Water Framework Directive) environmental objectives[1]. The integrated and coordinated planning under the WFD and FD (EU Floods Directive) has the potential to identify win-win measures that can deliver on the objectives of both policies[2] and beyond (Green infrastructure, biodiversity, etc). Integrated water management concept is transposed in Republic of Serbia legal framework and implementation advanced for large transnational river basins (Danube, Sava, Tisza) while the action is still pending for sub-basins and their sub catchments (Matić and Simić 2017). The objective of this paper is to underline benefits of the selected NWRM and their identification as the win-win measures that interlink flood risk management and environmental objectives for reinforcement of the integrated Tisza River Basin water management.

ECOSYSTEM SERVICES AND NATURAL WATER RETENTION MEASURES

Ecosystems services (ESS) are benefits provided by ecosystems to society which directly contribute to our well-being and economic wealth (Millennium Ecosystem Assessment 2005). People rely on ecosystems to provide many water related services and hydrologic ecosystem service (HESS) domain includes ESS positive impacts on water regime and water resources, from the supply of water for household use to the mitigation of flood damages (Brauman et.al. 2007). Burkhard et.al. (2009) specified four ESS benefits categories i.e., supporting (nutrient cycling, soil formation), provisioning (supply of drinking water, food, fuel, genetic resources), regulating (regulation of floods, erosion, sediment production, runoff, climate, water purification, etc) and cultural (tourism, recreation, knowledge, and aesthetic experiences).

Their multi-benefits recognition is apparent given the substantial increase in number of publications, implemented or ongoing projects, and their integration in sectoral policies and frameworks in last few decades. Additionally, different definitions and concepts (Eco-DRR,

[1] International Commission for the Protection of the Danube River -ICPDR (2020). Coordinating the WFD and the FD: Focusing on opportunities for improving efficiency, information exchange and for achieving common synergies and benefits, https://www.icpdr.org/sites/default/files/nodes/documents/discussion_paper_coordinating_wfd_and_fd.pdf

[2] EU Commission (2014): Links between the Floods Directive (FD 2007/60/EC and Water Framework Directive (WFD 2000/60/EC), https://op.europa.eu/en/publication-detail/-/publication/5e8ddc30-ed98-47f3-872c-de78851c721f

NWRM, Nature-based Solutions - NbS, Ecosystem-based Adaptation - EbA, etc.) based on ecosystems, their services and benefits are evident (Matić and Karleuša 2022). Estrella and Saalismaa (2013) explain ecosystem-based disaster risk reduction (Eco-DRR) as the "sustainable management, conservation and restoration of ecosystems to reduce disaster risk, with the aim of achieving sustainable and resilient development". Excerpt from study by Sudmeier-Rieux et al. (2019) presented in Table 1 include diverse ecosystems contribution to natural hazards disaster risk mitigation.

For all presented ecosystems and their services contribution to hazards mitigation benefits are primary within regulation and include other aspects (provision, supporting and cultural) regardless spatial distribution. Both floodplains and mountain forests reduce speed and volume of runoff, mitigate droughts, reduce erosion. The reduction rate and mitigation efficiency are more or less site, landscape specific. Governments formally agreed on a definition of nature-based solutions (NbS-NBS), (NbS) as "actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems, which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services and resilience and biodiversity benefits"[3].

River basin of any size represents mosaic comprised of various terrestrial and aquatic ecosystems and their services. Study of coherence and inconsistency of European instruments for integrated river basin management (Evers and Nyberg 2013) indicates that the management of water and land resources is poorly connected and achievements of IWRM goals requires consideration of measures that will better connect water management and land use planning. NWRM primary function is enhancing and/or restoring the retention capacity of natural and man-made terrestrial and aquatic ecosystems to deliver a range of services and multiple benefits to people while contributing to the achievement of the objectives of different environmental strategies and policies, e.g., EU Water Framework Directive, EU Flood Directive among the others (Strosser et al. 2015). The NWRM application supports green infrastructure, improves the quantitative status of water bodies, reduces the vulnerability to floods and droughts and restore the natural functioning of ecosystems and the services they provide (Jaritt et al. 2016). Runoff generation primarily depends on the precipitation intensity and distribution and hydrologic unit capacity to retain water (from small catchment to large river basins). Efficient natural capacity to retain precipitation results in more uniform surface water runoff regime with respect to quantity and speed (Jevđević 1956). Subsequently, erosion decrease, infiltration increase, among the other benefits of well-functioning retention capacity to mitigate extreme events. Pećinar (1969) indicated that in watersheds with noticeable terrain slopes, evident torrential flows and intensive erosion processes, the maintenance of existing forest areas and the afforestation of new ones are of great importance and emphasized that lower and denser forests are much more effective for erosion control so the restoration of the forests is necessity.

Research indicated that for forest cover coefficient (ratio of the area covered by forests and basin area) closer to 1 the water regime in the catchment is more uniform and there are less fluctuations in the water level on the basin outlet profiles (Gavrilović 1972). Evidences of the forests ESS benefits for low water regime within Zapadna (Western) Morava River Basin (the largest share of renewable internal - domicile fresh water resources in Serbia) are presented in study by Simić and Matić (2018).

River basin water balance is significantly impacted by terrestrial water storage that is reduced in European part of Russia by approximately 150 mm for 2002-2015 period based on study of Grigoriev et al. (2018) and according to authors it is caused rather by a decline in the storages of surface and ground waters then to changes in soil waters. The function and significance of the river basin retention capacity for water regime and water management are many fold and the understanding of basin retention opportunities gets more and more importance in contemporary water management due to its favourable contributions to sustainable development and integrated water resources management goals achievement (Matić 2019). Evaluation of green infrastructure and agro-environmental measures (filter buffer strips among the others) implementation indicate significant increase in retention of sediments and Total N(nitrogen) and Total P (phosphorus) in Sutla River pilot sub-basins (Ćosić-Flajsig et al. 2023).

Given the benefits of natural water retention capacity there is increasing awareness of various sectors (water, agriculture, forestry, spatial planning, etc), stakeholders and public authorities for measures that mimic natural processes to mitigate anthropogenic and natural adverse effects and provide diverse benefits (NWRM). Based on available knowledge, data and information provided on EU NWRM platform[4], implementation of these measures (53) contributes in IWRM concept implementation at the local scale, support transboundary river basin management and maintain or improve ecosystem services. Excerpt of NWRM with medium to high ESS benefits (Figure 2) are provided for illustrative purposes.

The number of ESS approaches, concepts and definitions is increasing while clear evidence and quantification of multi-functional benefits are missing to great extent. Multi-benefits of the natural water retention

Table 1. Natural hazard mitigation by selected ecosystems

Ecosystem	Hazard mitigation *
Mountain forests Vegetation on hillsides	Floods reduction by peak runoff control Drought mitigation Erosion reduction Increased slope stability
Wetlands Floodplains Lakes and Riverine	Flood control Reduce speed and volume of runoff Realise wet season flows during drought periods

*ESS benefits

[3] The fifth season of the United Nations Environment Assembly. 2022. The UNEA-5 resolution, https://www.unep.org/resources/resolutions-treaties-and-decisions/UN-Environment-Assembly-5-2

[4] Natural Water Retention Measures, http://nwrm.eu

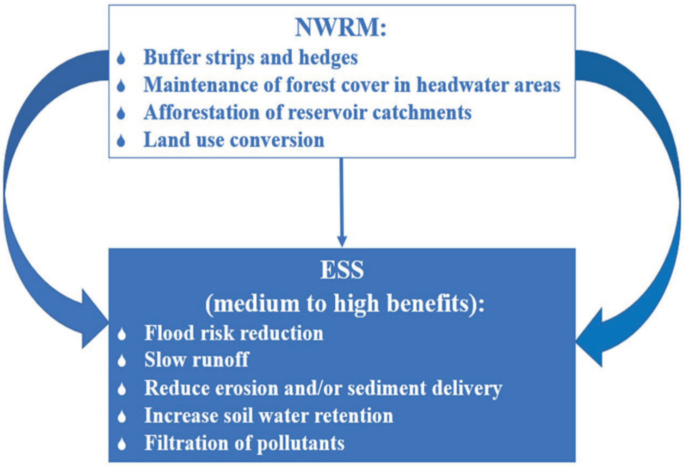

Fig. 2. Schematic display of ESS provided by NWRM based on Catalogue of NWRM[5]

measures for sustainable and integrated river basin management are well documented and quantified by hydrologic analyses. Due to international policy processes and large amounts of funding pledged by both public and private entities, the number of Nature Based Solutions interventions is increasing exponentially and the term NBS is being mainstreamed beyond expectations, for better and for worse, as it is subject to misuse and abuse, and has proponents and opponents (Nehren et al. 2023). The main reason for before mentioned might be advocating NBS as the all-inclusive novel solution superiority against other ESS domain and concepts. Although the benefits provided by NWRM and other ESS concepts and approaches (Eco-DRR, NBS, etc) are numerous, the constraints associated with low-probability events, land ownership, potential space limits in urban areas, etc., should be underlined and mentioned in the planning documents. In addition, their integration with the existing infrastructure has to be elaborated comprehensively (Matić and Karleuša 2023).

STUDY AREA AND METHODOLOGY

Danube River Basin (DRB), the most international river basin in the world, is shared by 19 countries. In 1994, the Danube countries that have territories more than 2,000 km^2 within the DRB signed the Convention on Cooperation for the Protection and Sustainable Use of the River Danube-Danube River Protection Convention[6] (International Commission for the Protection of Danube Rived-ICPDR, 1994). The three main areas for action include the protection of water and associated ecological resources, the sustainable use of water as well as the management of floods and ice hazards within the DRB. All contracting parties (including non-EU members) agreed to coordinate EU WFD[7] and EU FD[8] implementation and participate in the development of a River Basin Management Plan the key tool for implementing the WFD and Flood Risk Management Plan for DRB (Mair and Vasiljević, 2013) as the integral part of integrated river basin management. The largest sub-basin of the DRB is Tisza River Basin (157,186 km^2) shared by five countries (Figure 3).

Transboundary Tisza River Basin (TRB) cooperation

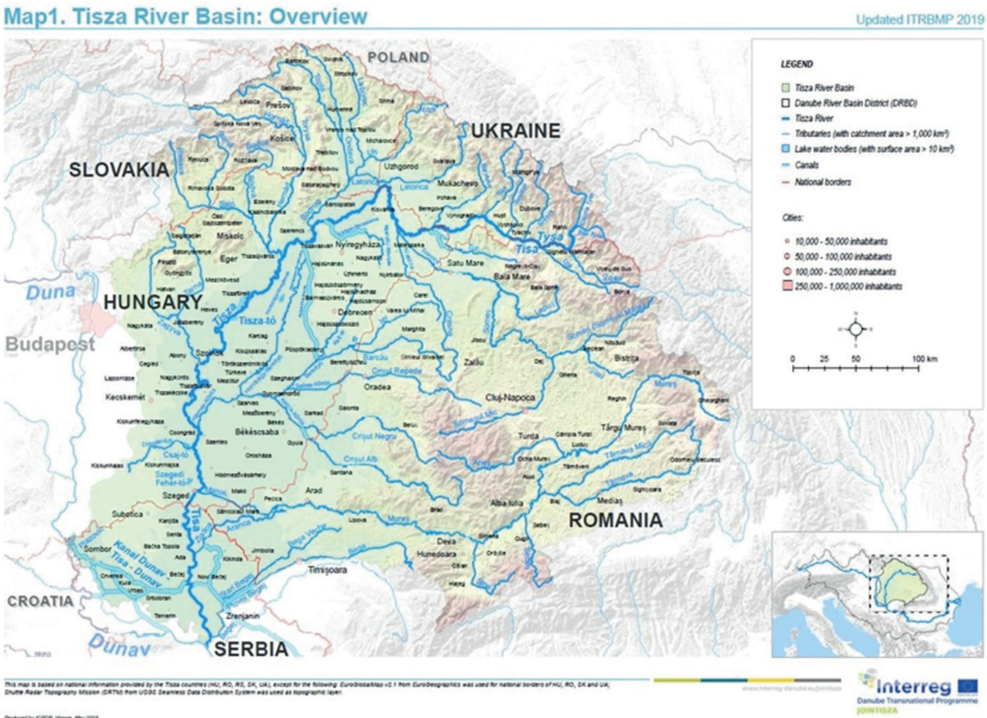

Fig. 3. Tisza River Basin. Source: Updated ITRBMP (Integrated Tisza River Basin Management Plan) 2019[9]

[5] Catalogue of NWRM, https://www.nwrm.eu/measures-catalogue
[6] Danube River Protection Convention: https://www.icpdr.org/about-icpdr/framework/convention
[7] Water Framework Directive (2000/60/EC), https://environment.ec.europa.eu/topics/water/water-framework-directive_en
[8] Floods Directive (2007/60/EC), https://environment.ec.europa.eu/topics/water/floods_en
[9] Updated ITRBMP 2019, https://www.icpdr.org/sites/default/files/nodes/documents/updated_itrbmp_2019.pdf

under the umbrella of the ICPDR started by signature of Memorandum of Understanding[10] and establishing of the ICPDR Tisza Group (ICPDR TG). In 2010 Tisza countries agreed[11] on preparing a sub-basin plan (ITRBMP), which integrates issues on water quality and water quantity, land and water management, floods and droughts[12].

The first ITRBMP (2011) is one of the first river basin management plans that responds to EU Water Framework Directive objectives, considers the ICPDR Flood Action Programme, and reflects the principles of Integrated Water Resources Management (Van Nood et al. 2011). The ITRBMP (2011) introduces water quantity and quality issues interlinkage (Figure 4) identified by ICPDR Tisza Group as a relevant for integrated Tisza River Management and provides comprehensive analysis of pressures from pollution, river engineering works, floods and droughts.

Water quantity and quality issues interlinkage presented above are elaborated in details in Updated ITRBMP 2019 and measures agreed by Tisza countries are presented. ITRBM includes TRB flood risk management plan elements and corresponding measures of basin wide relevance. In addition, flood risk management measures that support WFD environmental objectives, namely win-win measures are identified by Tisza countries based on agreed criteria and included in the updated ITRBMP (2019). The simplified synthesis of the main steps in flood risk management win-win measures identification of these measures are presented in Figure 5.

Incorporated "win-win" measures in ITRBMP Update 2019 are comprehensively elaborated by Tisza countries officially nominated technical experts with respect to field of action and category to emphasize NWRM concept within the TRB following ICPDR procedures and Memorandum of Understanding for TRB (Matić et al 2021).

RESULTS AND DISCUSION

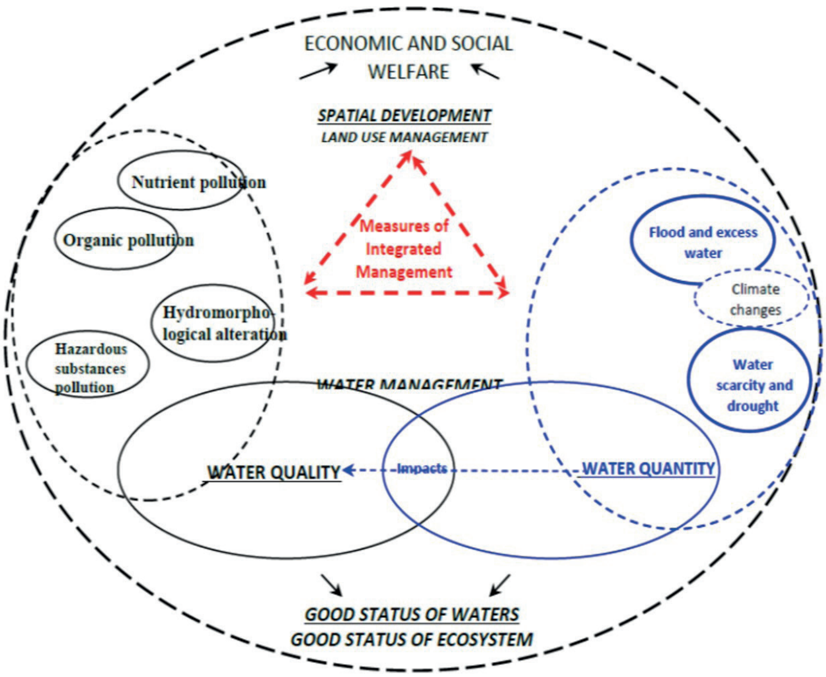

Fig. 4. Inter-linkages between the water quality and water quantity related issue within the TRB identified by ICPDR TG. Source ITRBMP 2011

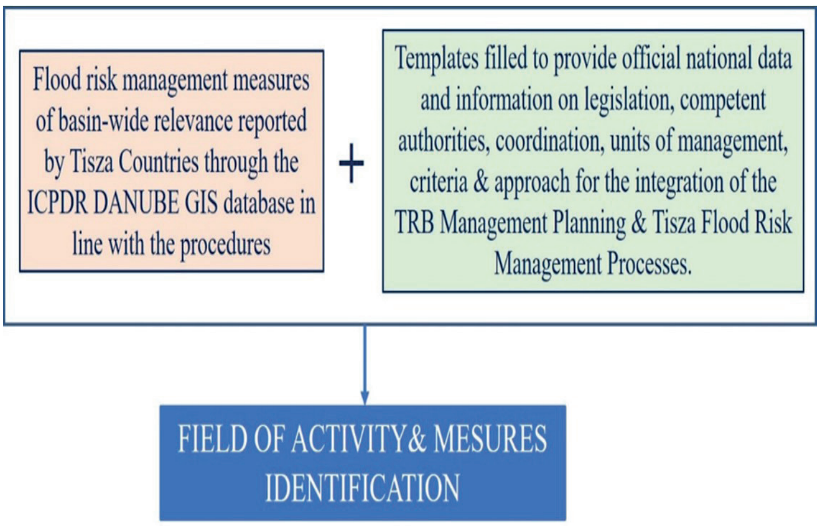

Fig. 5. Methodology for "win-win" flood risk management measures identification

[10] Towards a River Basin Management Plan for the Tisza River supporting sustainable development of the region memorandum of Understanding, https://www.icpdr.org/sites/default/files/FINAL%20-%20Tisza%20-%20MoU%20-%20signature.pdf

[11] Ministerial Statement Towards the Development and Implementation of the RBM Plan for the Tisza Basin (2010), https://www.icpdr.org/sites/default/files/Adopted_Statememt_Tisza_Final.pdf

[12] https://www.icpdr.org/danube-basin/sub-basins/tisza-basin

Table 2. Field of action, category and number of "win-win" TRB flood risk management measures

Field of action	Category	Number
Prevention	Organizational measures (legislative, institutional)	15
Protection	Natural water retention measures (associated to watercourses, wetlands, natural lakes, in line with Directive 2000/60 /EC) and other measures that advocate for increase of retention capacity	36
Public Awareness	Measures to increase community awareness	2
Preparedness	Preparedness measures /Improved preparedness to reduce the floods adverse effects	9
Response and Recovery/ Reconstruction	Post event recovery measures	3

Total number of "win-win" measures of basin wide relevance identified by Tisza countries in line with national policies and legal framework is 65. Summary results for "win-win" flood risk management measures (Table 2) identification clearly indicate natural water retention capacity and NWRM contribution to integrated water resources management at the transboundary river basins level since they connect water and land management. All proposed measures within flood risk management protection field of action (35) are measures that have the potential to increase water retention and provide regulating ESS (e.g., flood risk reduction) benefits with medium to high level. In addition to improved regulating ESS, the majority of measures, e.g., afforestation of the reservoir catchment support provisioning ESS (supply of drinking water, food, fuel, genetic resources) ESS services. NWRM for floodplain restoration and management provides all ESS categories e.g., supporting by nutrient cycling, provisioning, cultural and different regulating benefits (erosion and sediment delivery reduction, flood risk reduction).

The identified NWRMs type of measures are: Measures to restore retention areas (flood plains, wetlands etc.), Natural water retention measures in urban areas, Natural water retention measures by changing or adapting land use practices in forest management (improving forest management in floodplains, maintaining the forests area in catchments of A.P.S.F.R.[13], maintaining and expanding forests in perimeter zones of the reservoirs, expanding the forests in the receiving basins of A.P.S.F.R. - afforestation outside of the forest area), other water retention measures (mainly structural). More details with respect to measures to restore retention areas and other water retention measures are available in Annex 12 of ITRBM (2019) and plan. "Downstream cumulative effects of retentions along the Tisza in Hungary should be evaluated in the frame of bilateral cooperation between Hungary and Serbia"[14] according to disclaimer associated with win-win measures that support maintenance or increase of the natural water retention capacity. This statement is accepted by all Tisza countries to eliminate potential conflict of interest between upstream and downstream country and it is integral part of the Updated ITRBMP (2019) comprised of plan, maps, and annexes and endorsed by high-level Memorandum of Understanding (2019) signature.

All TRB selected NWRMs have moderate to high level of benefits resulting from water retention capacity significance in addressing the great numbers of issues that have to be solved by water management e.g., flood risk reduction, decrease in runoff speed and quantity, reduce erosion and/or sediment delivery, increase soil water retention, pollutants filtration, water demand and supply, etc. The present information and data underline the recognition of multi-benefits provided by NWRM and their role within the integrated water resources management concept and other ecosystem-based approaches and concepts. Finally, they are not "all-inclusive solution" and their efficiency is greatly affected by extreme events frequency.

CONCLUSIONS

Water management objectives achievement requires effective cooperation among sectors and policies given the essence of water as a resource. Natural water retention measures provide framework that support integration of many policies from local to transboundary level required for integrated water resources management due to number of their ecosystem services benefits e.g., flood and drought mitigation, erosion control, pollutants filtration, water purification, improved soil water retention, ground water recharge, among the others. For less frequent, i.e., more sever events their integration with existing grey infrastructure is required. NWRM and other ecosystem-based approaches (NBS, Eco-DRR, etc.) acceptance by practitioners and implementation might be compromised if they continue to be advocated as new approach, solution for all issues and constrains, among the other buzz words and narratives. As presented for Tisza River Basin effective cooperation of the riparian countries technical experts is prerequisite for the integrated water resources management implementation at the level of transboundary river basins. It includes coordinated management of surface and ground water bodies of basin relevance, flood risk management, to support achievement of integrated management of shared river basins. Identification and proposal of the win-win measures to reinforce synergy of the WFD and FD objectives implementation indicated recognition of the NWRM multi-functionality and possibilities for implementation within TRB.

[13] Areas with potentially significant flood risk
[14] Updated ITRBMP 2019, https://www.icpdr.org/sites/default/files/nodes/documents/updated_itrbmp_2019.pdf

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