RIVER BASIN WATER RETENTION CAPACITY COUPLING WITH NBS FOR HYDRO-METEOROLOGICAL DISASTER RISK REDUCTION

Branislava Matic[1]
[1] Educons University, Faculty of Security Studies, Vojvode Putnika 87, Sremska Kamenica, Republic of Serbia, branislava.matic@educons.edu.rs

Received: 5th August 2023
Accepted: 10th August 2023

Review paper

Abstract: *Sufficient water retention capacity contributes to hydro-meteorological risk reduction at the river basin level in many ways. The function and significance of the river basin water retention capacity for water management and DRR are manifold and documented in the literature. Accordingly, in the last few decades the interest to maintain or improve it is increasing, given the complexity of hydro-meteorological hazards and resulting risks. This paper presents an overview of two similar concepts based on improved ecosystem services: natural water retention measures and nature-based solutions from water management and disaster risk reduction perspectives. The similarities between the two concepts as hydrological ecosystem services are underlined, and indisputable benefits of the two concepts coupling for selected international river basin. Some open issues for better acceptance by practitioners are mentioned.*

Key words: *River basin water retention capacity, Nature-based Solutions, hydrological ecosystem services, river basin management, hydro-meteorological disaster risk reductions*

1. INTRODUCTION

Hydro-meteorological hazards are generated by natural processes and can not be prevented. They are complex events with diverse occurrences (frequency), time and spatial scale. In addition to devastating earthquakes, we are witnessing disasters resulting from hydrological, meteorological and climatological hazards globally. Comparison between the two periods (1980-1999 and 2000-2019) indicated disasters generated by natural hazards at the global level increased according to a report developed by (Centre for Research on the Epidemiology of Disasters- CRED &UN Office for Disaster Risk Reduction UNDRR, CRED&UNDRR, 2020).

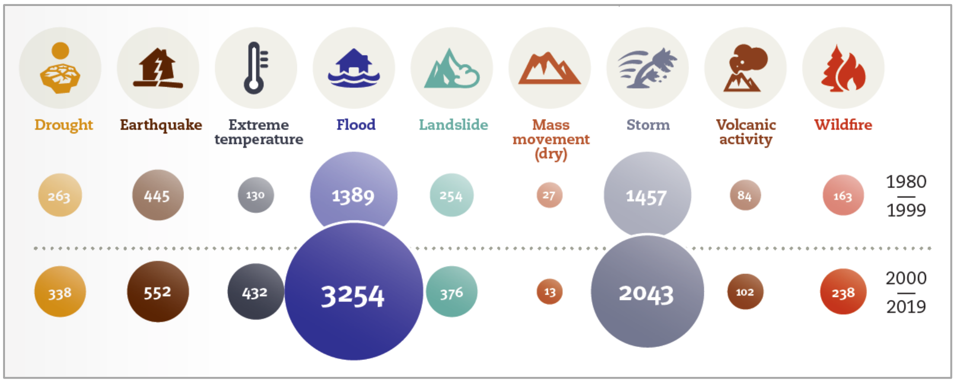

Figure 1. Total disaster events by natural hazard type: 1980-1999 vs. 2000-2019
Source: CRED & UNDRR, 2019

Except for dry mass movement, significant expand in occurrence of disasters generated by natural hazards are evident in the second period as emphasized by Figure 1. For water-related events, the highest increase (74%) is observed for floods, followed by landslides (48%), storms (40%) and droughts (28%). Based on the report results, disaster impact increased in the latter period with respect to total death, affected people, reported total disaster number (75%) and economic losses (US$) approximately 83%.

During the last few decades, there is growing interest in ecosystem services (ESS) and their contribution to hydro-meteorological hazard risk reduction. This generated number of concepts, approaches and definitions with respect to their ESS benefits while evidence-based capabilities from the perspective of natural features of the area and hydrology are sometimes neglected.

In recent years, Nature Based Solutions (NbS) concept is the most advocated as an all-inclusive innovative solution for the majority of issues that humanity is facing. Due to international policy processes and large amounts of funding pledged by both public and private entities, the number of NbS interventions is increasing exponentially (U. Nehren et al., 2023), 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.

Instead of detailed deliberation of the NbS concept advantages and disadvantages, this paper presents similarities with other ecosystem-based approaches the role of the river basin water retention capacity and its contribution to hydro-meteorological hazards Disaster Risk Reduction (DRR).

2. HYDRO-METEOROLOGICAL HAZARDS

Hydro-meteorological risks due to natural hazards such as severe floods, storm surges, landslides and droughts are causing impacts on different sectors of society (Ruangpan et al. 2020). They are unavoidable, with uncertainties regarding frequency and intensity, especially extremes (flood, drought, heavy rainfall) that are of particular interest for disaster risk reduction. The first step in their risk assessment is hydrologic (water) cycle components analysis.

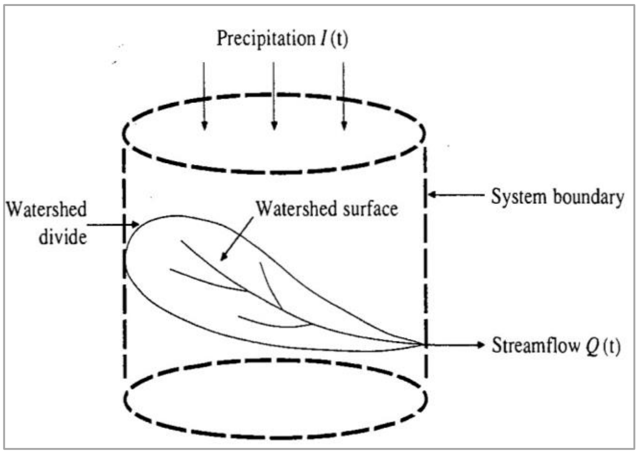

Figure 2. Simplified hydrological cycle terrestrial phase
Source: Chow et.al., 1986

Either simplified water balance (Figure 2) or more complex depends on natural features and capacities of the hydrological unit (from small catchment to large river basins) to retain water. Runoff generation primarily depends on the intensity of precipitation and its time distribution. Due to the capacity of the river basin/ watershed/ catchment/ drainage area to retain precipitation the difference between the discontinuity of precipitation and the continuity of runoff is increasing (Jevdjevic, 1956) and a more uniform surface water runoff regime (quantity and speed) is generated. When the rainfall intensity exceeds the basin/catchment/drainage area water retention capacity, a series of events follows that lead to surface runoff (Srebrenovic, 1986).

Hydro-meteorological hazards are integrated into water management planning documents. Alike DRR planning and management, water management is complex. To combat increasing pressures on water resources (water scarcity, pollution, climate changes, extreme hydrological events, land use changes, etc.) a new doctrine - Integrated Water Resources Management (IWRM) depicted in Figure 3 is incorporated in policy and legal frameworks at the national, transboundary, and global levels.

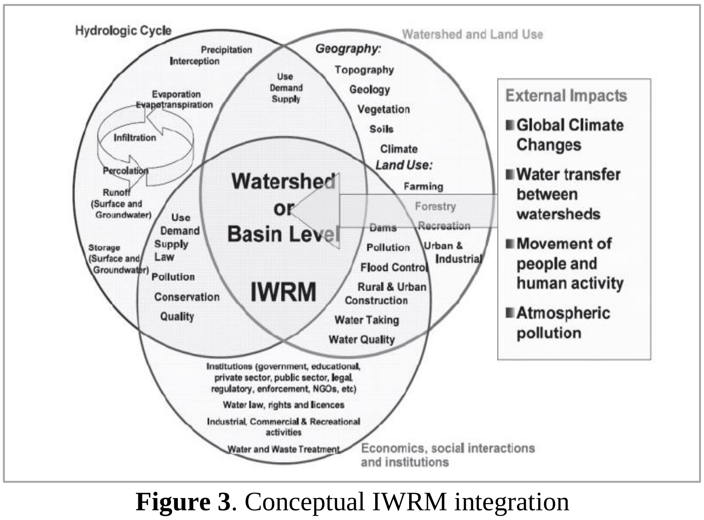

Figure 3. Conceptual IWRM integration
Source: Mayfield et al., 2004

IWRM attempts to integrate prospects and processes of the hydrologic cycle, watershed features and economics, social interactions, and policies (Mayfield et al., 2004) considering external impact with the main goal to address development, social equity, and environmental sustainability.

Natural hazards such as floods or storms can initiate events which challenge the safety and operation of hazardous facilities. Accidents triggered by such events are known as 'Natech' - Natural Hazards Triggering Technological Accidents. These impacts can also have a transboundary dimension (e.g., accidental pollution). The prerequisite for any DRR is to understand the risk which is not simple for hydro-meteorological hazards due to misunderstanding of drivers (frequency, intensity, land use and cover, and other boundary conditions).

EM-DAT classifies disasters based on hazards that generate them as presented in Figure 4 for hydro-meteorological and climatological events.

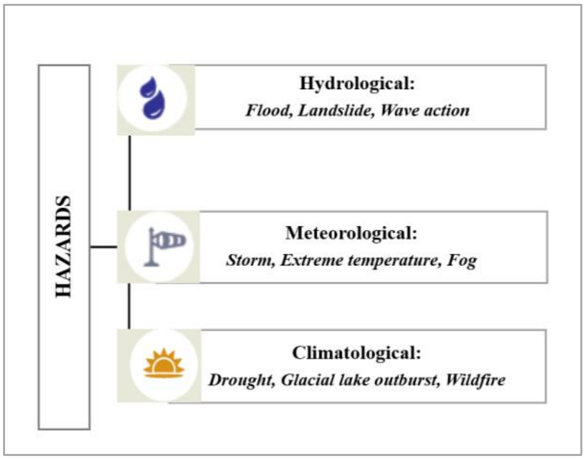

Figure 4. Selected disasters based on natural hazards type
Source: Developed by authors based on EM-DAT Guidline

To be included in EM -DAT disasters database an event must meet at least one criterion (ten or more people were reported killed, 100 or more people reported affected, declaration of a state of emergency, call for international assistance). At present, this is the most comprehensive database available worldwide.

3. HYDROLOGICAL ECOSYSTEM SERVICES AND WATER RETENTION FOR RISK REDUCTION: NWRM, NBS AND ECO-DRR

Hydrological ESS are water related and all ecosystems (terrestrial and aquatic) with a good level of service (not devastated) contribute more or less to hydro-meteorological and climatological hazards risks reduction by regulating runoff, infiltration, evapotranspiration, percolation, groundwater recharge, erosion processes, slope stability, etc. (Brauman et al.,2007). Water retention capacity is a hydrologic service that combines various ecosystems and their services. The most effective approach for water management is at the level of the river basin, sub-basin, and river district - the natural geographical and hydrological unit - instead of administrative or political boundaries. River basin district means the area of land and sea, made up of one or more neighbouring river basins together with their associated groundwaters and coastal waters, which is identified under EU Water Framework Directive Article 3(1) as the main unit for river basin management.

At the United Nations Environment Assembly (UNEA, 2022), governments formally agreed on a definition of nature-based solutions (**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.” Ecosystem Disaster Risk Reduction (**Eco-DRR**) is the sustainable management, conservation and restoration of ecosystems to reduce disaster risk, with the aim to achieve sustainable and resilient development (Estrella and Saalismaa 2013). Natural Water Retention Measures (**NWRM**) are multi-functional measures that aim to protect water resources and address water-related challenges by restoring or maintaining ecosystems as well as natural features and characteristics of water bodies using natural means and processes. The main focus of applying NWRM is to enhance the retention capacity of aquifers, soil, and aquatic and water-dependent ecosystems, 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 (EC DG ENV, 2016). Based on definitions for NbS, Eco-DRR and NWRM the difference is the terminology used to address ecosystem-based concepts with respect to water-related natural hazards. While NWRM efficiency and applicability have to be supported by hydrologic assessment and analyses, for NbS and Eco-DRR is not clear how the statement “measure (s) reduce risk” and contribute to DRR can be justified without request- hydrologic analyses. For spatial scale different terminology is used, landscape, area and natural geographical and hydrological unit for NbS, Eco DRR and NWRM.

Application of the NWRM at the transboundary Tisza River Basin supports environmental and flood risk management objectives synergy and integrated management (Matic et al., 2021). Both integrated river basin and DRR management planning are multidisciplinary, based on effective cross-sectoral cooperation, diverse stakeholders’ interactions, participatory approach, and update of plans. Different spatial dimensions for plans might be reconsidered to allow better maps, data and information overlapping for more effective DRR management, due to water-driven natural hazards nature – they don’t recognize administrative borders (Matic and Karleusa, 2022).

4. CONCLUSION

There is increasing interest among scientists and practitioners in ecosystem services' contribution to hydro-meteorological disaster risk reduction. Various measures that increase water retention capacity based on the ecosystem concept are win-win and no-regret measures. Given the increase in disasters generated by hydrometeorological events and uncertainties with respect to future events (floods, storms, heavy rainfall, drought, etc.) frequency and intensity there is a need for an increase in water retention capacity, from small-scale catchments to large river basins. Since they are site-specific due to the natural features of the drainage area, assessment of their application and efficiency has to be hydrology-based and not bureaucracy and administrative boundaries based. on administrative decisions. Any of ESS approach should not be advocated as an innovative or new approach, since some of the measures are applied for centuries. Deliberating on sectorial terminology and ignoring essence very likely will decrease their acceptance by practitioners in all sectors included in disaster risk reduction. They are all hydrological ecosystem services, site-specific and with respect to low-frequency and high-intensity hydro-meteorological hazards have to be considered only as a support of grey infrastructure, not a wizard stick. Ecosystem services concepts and practical assessment should be more integrated in high-schools and universities curricula.

REFERENCES

Brauman, A.K., Daily C.G., Duarte T., K.T,.and Mooney A.H. (2007). The Nature and Value of Ecosystem Services: An Overview Highlighting Hydrologic Services, The Annual Review of Environment and Resources, 32:67–98, doi:10.1146/annurev.energy.32.031306.102758

Centre for Research on the Epidemiology of Disasters and UN office for Disaster Risk Reduction. (2020). Human Cost of Disasters: an Overview of the Last 20 Years. Available from: https://doi.org/10.18356/79b92774-en Accessed:2022-03-05.

Chow V. T., Maidment R. D., Mays W. L. (1986). Applied Hydrology

(International Edition). McGraw – Hill Series in Water Resources and Environmental Engineering, Book Company, New York, United States of America.

EM-DAT Guidelines-The international disaster database, Centre for Research on the Epidemiology of Disasters. Available from: https://public.emdat.be/about/ Accessed:2022-07-15

Estrella, M. and Saalismaa, N. (2013). Ecosystem-based disaster risk reduction (Eco-DRR): An overview. In The role of ecosystems in disaster risk reduction. Renaud.F.G., Sudmeier-Rieux, K., Estrella, M. (eds.), UNU Press, ISBN 978-92-808-1221-3, e-ISBN 978-92-808-7190-6 Tokyo, 513 pages.

European Commission, Directorate-General for Environment (EC DG ENV), Jaritt, N., Williams, H., Hanus, A., et al. (2016). A guide to support the selection, design and implementation of natural water retention measures in Europe: capturing the multiple benefits of nature-based solutions. Publications Office. Available from: https://data.europa.eu/doi/10.2779/761211 Accessed:2019-02-09.

Jevdjevic V. (1956). Hidrologija I Deo. special ed, book 4, Hidrotehnicki institut "Ing. Jaroslav Cerni", Beograd

Matic, B., Perovic, M., Vulic, D. (2021). Natural water retention measures contribution to integrated transboundary Tisza River Basin Management - Environmental and Flood risk management objectives synergy. In Proceeding of the International Symposium: Water Resources Management: New Perspectives and Innovative Practices, Novi Sad, Serbia, 23-24 September 2021, pp 113-117.

Matic B. B. and Karleusa, B. (2022). Ecosystem-Based Disaster Risk Reduction Framework as a Tool for Improved River Basin Natural Water Retention Capacity and Environmental Hazard Resilience. Environmental Sciences Proceedings 21(1): 40. https://doi.org/10.3390/environsciproc2022021040

Mayfield, C.I., Grover, V.I. and Daley, R.J. (2004). The United Nations Water Virtual Learning Centre: a flexible distance learning Programme for integrated water resources management. Global Environmental Change – Part A, 13(4): 331-318.

Ruangpan, L., Vojinovic, Z., Di Sabatino, S., Leo, L. S., Capobianco, V., Oen, A. M. P., McClain, M. E., and Lopez-Gunn, E. (2020). Nature-based solutions for hydro-meteorological risk reduction: a state-of-the-art review of the research area, Nat. Hazards Earth Syst. Sci., 20, 243–270. doi.org/10.5194/nhess-20-243-2020, 2020. Available at: https://nhess.copernicus.org/articles/20/243/2020/

Srebrenovic D. (1986). Primjenjena hidrologija. Tehnicka knjiga, Zagreb

The fifth season of the United Nations Environment Assembly. (2022). The UNEA-5 resolution. Available from: https://www.naturebasedsolutionsinitiative.org/news/united-nations-environment-assembly-nature-based-solutions-definition#:~:text=The%20UNEA%2D5%20resolution%20formally,effectively%20and%20adaptively%2C%20while%20simultaneously Accessed:2023-07-06.

U. Nehren, T. Arce-Mojica, A. Cara Barrett, J. Cueto, N. Doswald, S. Janzen, W. Lange, A. Ortiz Vargas, L. Pirazan-Palomar, F.G. Renaud, S. Sandholz, Z. Sebesvari, K. Sudmeier-Rieux, Y. Walz. (2023). Towards a typology of nature-based solutions for disaster risk reduction. Nature-Based Solutions, Volume 3, 100057, ISSN 2772-4115, https://doi.org/10.1016/j.nbsj.2023.100057(https://www.sciencedirect.com/science/article/pii/S2772411523000095)