Ecosystem–based disaster risk reduction framework as a tool for improved river basin natural water retention capacity and environmental hazards resilience

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Abstract: Contemporary water and environmental governance have to address diverse common objectives merged to target economic development, social equity, and environmental sustainability. Climate and land use changes coupled with natural environmental hazards generate immense and complex issues and challenges around the globe. Multilateral Environmental Agreements, EU Water Framework and other Directives, national policies and international conventions relevant for water and environmental governance indicate ecosystem approach. With respect to disaster risk reduction all Sendai Framework priorities includes ecosystems. River basin natural water retention capacity (hydrological ecosystem services) benefits from the water/environmental governance and selected environmental hazards disaster risk reduction perspective is elaborated and presented results underline measures that improve river basin management and increase resilience to natural environmental hazards at selected river basins.

Keywords: ecosystem – based disaster risk reduction, river basin management, natural water retention, environmental hazards.

1. Introduction

The term ecosystem services (ESSs) emerged in the early 1980s [1], as a framework to shape and understanding of ecosystem processes benefits for society. Convention on Biological Diversity (CBD) [2] defines ecosystems (ES) as a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit. European Environmental Agency (EEA), agreed on Europe's wide list of ecosystem types feasible for data and information aggregation or disaggregation for Mapping and Assessment of Ecosystems and their Services (MAES) as explained in details in [3]. According to [4] ESS are the benefits for people from ecosystems classified as regulating (hydrological cycle and flow maintenance, flood protection, mass stabilisation and erosion control, etc.), provisioning (surface and groundwater, etc.), and cultural by Common International Classification of Ecosystem Services (CICES) [5].

The ES approach is recommended in the majority of Multilateral Environmental Agreements (MEAs) [6, 7] and EU Directives [8, 9] relevant for integrated river basin management. At the European level, both EU member and non-member countries incorporate EU Water Framework Directive (WFD) and EU Floods Directive (EU FD) objectives and requirements in the national law and are obliged to develop River Basin Management Plans (RBMP) and Flood Risk Management Plans (FRMP) to support sustainable and integrated river basin management.

Based on the weather- and climate-related events information on economic losses and fatalities [10] evaluation of data and information synthesised from two databases, analyses of results from the CATDAT and NatCatSERVICE indicate that disasters from hydrometeorological and climatological events caused nearly 100 000 fatalities, affected more than 11 million people and resulted in total economic losses between 450 - 520 billion euros from 1980 – 2020. Total losses were between 34% and 44%, 22% and 24%, respectively for hydrometeorological and climatological events.

Sendai Framework for Disaster Risk Reduction 2015-2030 (SFDRR) [11] as a global framework advocates for the substantial reduction of disaster risk and losses in lives, livelihoods and health in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and

countries. The ESs functionality and contribution in Disaster Risk Reduction (DRR) is included in all SFDRR and consideration and incorporation of integrated environmental and natural resources management approach is recommended. As elaborated in the following, Natural water retention measures applied in integrated river basin management for the Danube and Tisza river basins support water related natural hazards DRR and Ecosystem-based disaster risk reduction (Eco-DRR) approach. The number of water-related disasters and their consequences entails identifying possible obstacles and issues for better interdependence in the river basin and DRR management and ESS incorporation that would enhance disaster risk reduction.

2. Integrated River Basin and Disaster Risk management and Eco-DRR synergies

2.1 Planning framework

In Europe, development of RBMP and FRMP are elements of integrated river basin (the natural geographical and hydrological unit - instead of according to administrative or political boundaries) management developed in line with EU WFD and EU FD, respectively. Both plans incorporate management visions, objectives and measures for 6 years planning period and updated afterwards. DRR Plans (DRRP) are elements of DR management (DRM) and are developed at the national, regional and local levels for natural hazards of interest (floods, droughts, earthquakes, etc.) for selected spatial scale based on agreed scenarios and risk assessment. DRRP set out the goals and specific objectives for reducing disaster risks together with related actions to accomplish these objectives. They should be guided by the SFDRR and considered and coordinated within relevant development plans, resource allocations and programme activities. "National-level plans need to be specific to each level of administrative responsibility and adapted to the different social and geographical circumstances that are present e.g., disaster scenarios" [12].

In addition to risk assessment and cross-sectoral cooperation with respect to institutions, decision makers and stakeholders, and public participation are required for successful plans implementation as stipulated in the EU WFD, Flood Directive and Sendai Framework. The necessity for transboundary /international cooperation is emphasized for integrated water and disaster risk management.

Common segments in FRM and DRM preparedness, intervention (response), rehabilitation and recovery, prevention are based on risk management cycle (Figure 1) with main goal to reduce the risks and potential adverse consequences – disasters for human health, the environment, cultural heritage and economic activity. Similar approach is applied for river basin management planning DPSIR (Driving forces, Pressures, States, Impacts, Responses) framework with respect to river basin significant water management issues and planning cycle.

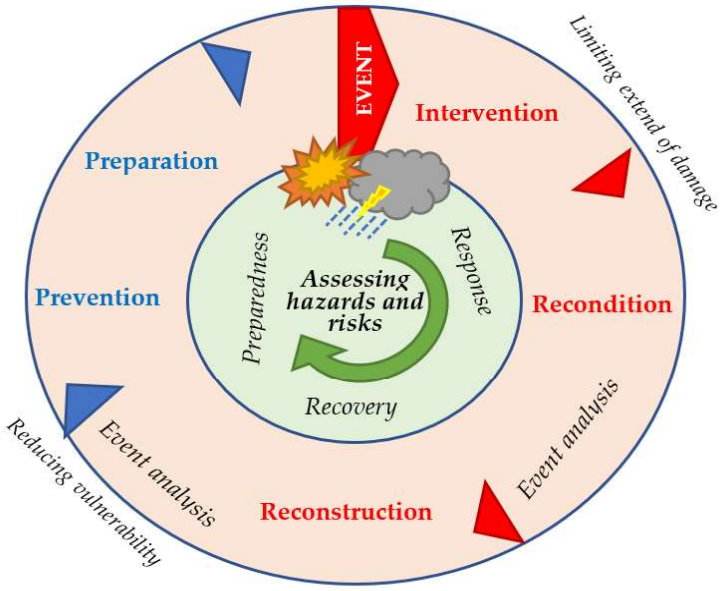

Figure 1. Risk Management Cycle (adapted form Integral Management Cycle, FOCP 2003).

2.2 Spatial scale

The most effective approach for water management is at the level of 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 WFD Article 3(1) as the main unit for river basin management. Danube River Basin (DRB) is the world's most international river basin, shared by 19 countries. Integrated water management concepts within the DRB and cooperation among the Danube countries are implemented within the auspices of the International Commission for the Protection of the Danube River (ICPDR) based on the Convention on Cooperation for the Protection and Sustainable use of the Danube River (Danube River Protection Convention, 1998). Danube River Protection Convention (DRPC) forms the overall legal instrument for co-operation on transboundary water management in the Danube River Basin. As a result, Danube countries developed Danube River Basin Management Plan (DRBMP) [13] and Danube FRMP (DFRMP) [14] plans that are updated every 6 years (planning period) and include measures to address pressures and risks for strategic objectives and visions in line with EU WFD and EU FD. Reported measures (implemented and planed) are based on Danube countries official water management planning documents and have relevance for the whole DRB water management in line with criteria listed in DRBMP and DFRMP.

Planning levels at the spatial scale are divided in A, B and C category for DRB, sub basins –main tributaries (Sava, Tisza, etc.) and river basin districts, respectively.

Figure 2 presents planning level spatial scales applied. At the national and local levels strengthening DRR governance to manage DR requires adaptation and implementation of national and local disaster risk reduction strategies and plans, across different timescales, with targets, indicators and time frames, aimed at preventing the creation of risk, the reduction of existing risk and the strengthening of economic, social, health and environmental resilience [11] among the other tasks proposed in the SFDRR priority area 2. DRRM (Disaster Risk Reduction Management) plans are updated periodically.

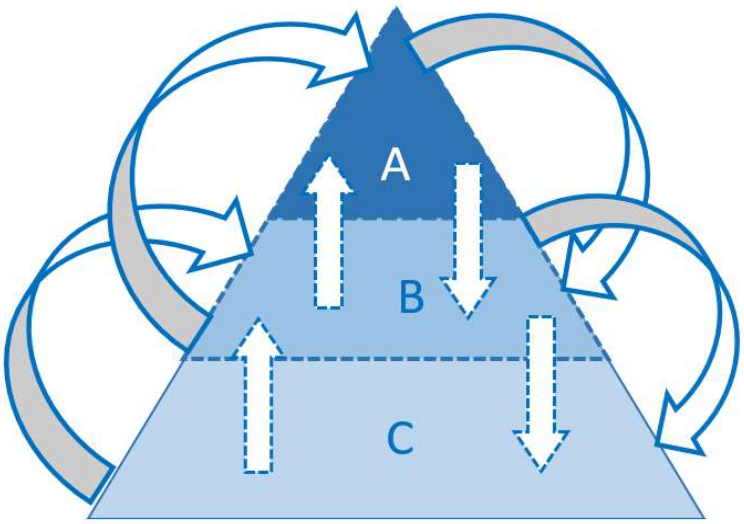

Figure 2. DRB Spatial scale water management planning levels schematics, developed by authors based on [8].

They are developed at the administrative level (local or regional and national). Cooperation and coordination at the international level are defined and organized based on bilateral agreements and international organizations.

2.3 Environmental hazards and solutions inspired by nature

EU Research and Innovation policy agenda on Nature-Based Solutions (NBS) and Re-naturing Cities defines nature-based solutions to societal challenges as "solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience". Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions [15].

Ecosystems preservation, restoration and their services are the key for successful NBS implementation in urban and rural areas. There are a lot of projects at the global and EU level that evaluate, analyse and implement NBS in recent years resulting from the use of nature and natural processes to provide multifunctional and integrated solutions to many of the challenges human society is facing. Many of the existing concepts similar to NBS have multifunctional benefits and are considered as integrated solutions. A significant factor in the reduction of societies and countries' adaptive capacity to reduce disaster risks is environmental degradation as highlighted in last decade policy documents [15].

3. Eco-DRR, Natural Water Retention Measures (NWRM) and floods

For risk management planning generated by water related natural hazards, ecosystem approaches that support DRR and natural water retention capacity are of great importance. Both concepts provide multifunctional benefits, have potential to reduce environmental hazards and can contribute to climate change adaptation. They can increase grey infrastructure efficiency by their integration with existing and foreseen facilities.

Eco-DRR is "sustainable management, conservation and restoration of ecosystems to reduce disaster risk, with the aim of achieving sustainable and resilient development" [16]. They support DRRM for a number of natural hazards, e.g., floods, mass movement, droughts, flash floods, torrents, etc. "Natural Water Retention Measures (NWRM) are multifunctional measures that aim to protect and manage water resources and address water–related challenges by restoring or maintaining ecosystems as well as natural features and processes with main focus to enhance water retention capacity of aquifers, soils and ecosystems" [17]. Their potential to provide multifunctional benefits include floods and drought risk reduction, improvement of water quality, habitat improvement, among the others. Their

implementation supports green infrastructure, preserve or improve water bodies' quantitative status and can positively affect their status, and can contribute to climate change adaptation and mitigation.

3.1 Danube River Basin - NWRM support to ecological hazards resilience

The rationale and support for EU WFD and EU FD integration and importance of two processes coordination and synergy is provided in [13, 14, 18]. Natural phenomena like floods, droughts, heavy rainfalls are uncertain and can't be prevented. The risks of natural hazards are managed by measures to avoid disasters during the emergency situations. Natural water retention capacity from the hydrologic response unit to basin level scale support both EU WFD and EU FD objectives. With respect to latter, NWRM reported by Danube countries are included in DFRMP 2021 (Annex 2). These measures support EU WFD environmental objectives, require multidisciplinary approach and horizontal and vertical coordination, among sectors and stakeholders and from local to national level. High probability floods have environmental benefits (groundwater recharge) and NWRM contribution to holistic drought management should be underlined.

3.2 Integrated Tisza River Basin Management Plan (ITRBMP) - NWRM for environmental and flood risk objectives synergy

Tisza River Basin (TRB) is largest DRB sub-basin, shared by 5 Tisza countries. In comparison to DRBM there is additional water management identified by ICPDR Tisza group issue relevant for TRB– water quantity and water quality inter-linkage and key water quantity management issues floods and excess water, droughts and water scarcity, and climate change. Secondly, ITRBMP integrates FRMP objectives and measures. Data and information included in the plan provided by Tisza countries following ICPDR procedures and Memorandum of Understanding for TRB. In addition to FRM measures, ITRBMP Update 2019 incorporates "win-win" measures that support EU WFD environmental objectives for flood risk management within the TRB. Identified "win-win" measures in ITRBMP Update 2019 are elaborated with respect to field of action and category to emphasize NWRM concept within the TRB [18]. All 38 NWRMs are in prevention field of action, for some of them urban or rural area for implementation is indicated, while other are applicable at the catchment level scale or basin level scale to improve retention capacity by increasing the safety of existing large dams - attenuation of reservoirs capacity towards projected one.

4. Discussion

Solution based on ESS concept for water related natural hazards mitigation decrease risks, vulnerability and exposure by regulating natural phenomena extremes. By providing benefits for human society these services also prevent environmental degradation. This approach is not new, application of measures for improved ESS is well documented through centuries around the globe. They are characterized by multi- benefits, multidisciplinary approach and require political support at the national level to be implemented at the local/regional level. For both concepts (RBM and DRM) with respect to planning processes coordinated activities by various sectors, stakeholders and vertical and horizontal cooperation is required. With respect to Eco-DRR and NWRM for flood risk management they are more suitable for high probability events and both concepts should be integrated with existing and planned grey infrastructure to increase their level of service for medium and low probability events. Based on [19] out of 6 case studies mitigated hazards by measures categorized as NWRM and elaborated in [14 and 18], e.g., deforestation, polders, etc. The lack of political support and scepticism by practitioners haven't been involved in implementation is identified for some case studies.

On the other hand, for flood risk management NWRM are based on national official data and address basin level scale risks. Eco-DRR efficiency is still uncertain and design criteria is not well documented while for NWRM these data and information are better structured and supported. Based on [14] NWRM support flood risk management objectives with respect to avoidance of new risks, reducing new risks, and solidarity principles for the prevention and protection aspects of FRM.

Comparison of RBFRM and DRR plans indicate development of maps, use of tools and various software. Plans are developed based on risks, vulnerability and exposure and resulting measures are based on this assessment. It is not possible to conclude to which extent measures based on ecosystem

services, i.e., Eco-DRR approach is integrated in DRRM plans that are developed based on the administrative boundaries.

It is very likely that better overlapping of the existing plans will generate increased security of the society and environment.

Participatory approach, involvement of local population in ecosystem-based planning processes could generate better results and efficiency. There are number of concepts with different names and similar targets that support ecosystem approach, this might generate confusion among practitioners and general public. Water related natural hazards are addressed by both ecosystem concepts addressed in this paper. Given the nature and spatial distribution of water related natural hazards, DRRM plans development should be based on the natural geographical and hydrological unit - instead to administrative or political boundaries, at least for high risks areas prone to disasters. FRM awareness rising measures might disseminate to general public information on ecosystem services benefits and constrains (with respect to probability, maintenance, downstream influence) for natural hazards management and disasters risk reduction. With no intention to favour any concept or definition based on ecosystems services, data and information presented indicate Eco-DRR and NWRM synergies and same goals. There are better documented data and information available for NWRM benefits (e.g., hydrology based), so Eco-DRR based on this concept very likely increase natural hazard resilience within the natural geographical and hydrological units.

5. Conclusions

Interaction between two concepts and objectives to support increase in resilience to water related natural hazards is indicated for selected river basin management. 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 dimension 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. Different definitions and concepts (Eco-DRR, NWRM, Nature-based Solutions - NbS, Ecosystem-based Adaptation - EbA, etc.) based on ecosystems, their services and benefits might result in low level of acceptance among practitioners and general public, combined with confusing statement that this is a new approach, although majority of measures all implemented for centuries around the world at the local level. In some publications they are advocated as the wizard stick, with no clear message on constrains, with respect to low probabilities events, land ownership, potential space limits in urban areas, etc. That might increase scepticism and rejection among stakeholders and decision makers, despite the great number of benefits that are evident. For DRR Eco-DRR concept and low probability events should be considered as a support for grey infrastructure. More research, better monitoring of already included and applied ecosystem-based approach will increase their integration in policies at the national level.

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