

Towards a Carpathian rivers research and policy agenda: science networks supporting river connectivity and restoration

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Human pressures on mountain rivers

- modification of the fluxes of natural river material & generation of fluxes of xenobiotic substances
- change in the riverine morphology & river-bed characteristics (the aquatic habitats)
- change in the river hydrological & thermal regime
- alteration of water quality
- introduction/invasion of exotic aquatic species
- and a resultant cascade of unwanted, unexpected side effects

But..mountain rivers have been notoriously causing problems

Detrimental effects of (past) river management and pressures in the Carpathian rivers

- **loss of geomorphic dynamic equilibrium** leading to rapid river incision
- **loss of flood water storage** in floodplain areas, leading to higher peak discharges of flood waves in downstream reaches
- **loss of longitudinal and lateral connectivity**
- simplification of channel structure
- **loss of habitats** (reduced morphological and hydraulic complexity of the channels, reflected in the reduced heterogeneity of habitats for river biota)

increased flood hazard downstream, channel instability, danger to infrastructure, decreased biodiversity, decreased recreation potential

Legacy engineering pressures



Consequences for river systems

- Little/ Nonoperational reservoirs
- Embankments
- Channelization
- Rigid bank protection
- Transversal weirs
- Small hydropower barriers
- Underperforming or obsolete fish passes



- Loss of floodplain connectivity
- Sediment discontinuity
- Channel simplification
- Habitat degradation
- Reduced ecosystem services
- Variable & reduced streamflow
- Enhanced erosion
- Diminished sediment yield
- Locally Increased water temperature
- Fish migration obstacles



In river channels, the reaction to change is not limited to the place the change occurred (and it may be delayed)



Emerging and under-addressed issues in the Carpathians

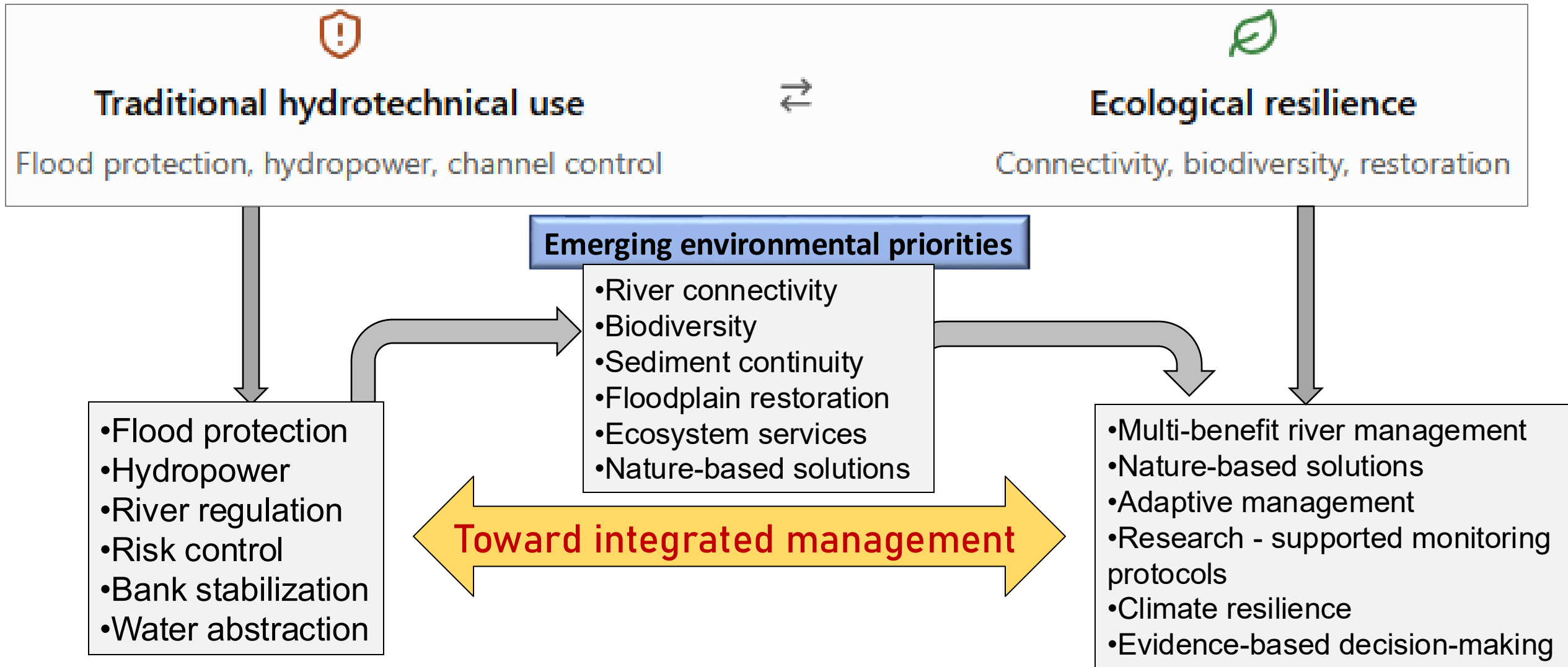
- Sand and gravel mining, sediment budget imbalances
- (Macro)plastics presence: delivery, fragmentation, impacts
- Water and hydromorphological quality
- Flash floods: forecasting, warning systems, adaptation
- Floodplain development: flood risks vs economic and aesthetic incentives
- Hydropower and water diversions, water availability in energy production
- Loss of three-dimensional connectivity
- Beaver (*Castor fiber*) expansion
- Large wood fluxes: vital functions vs. hazards, logging connections
- Riparian forests: use vs. biodiversity
- Modern flood risk management strategies
- River restoration and biodiversity (and long term monitoring of success)

European policy framework applied in EU Carpathian countries

- EU Water Framework Directive
- EU Biodiversity Strategy for 2030
- EU Nature Restoration Law

- **Implementation remains uneven across Carpathian countries**, reflecting differences in institutional capacity, funding priorities, historical river management practices, and national implementation pathways.
- **Different legal and governance frameworks as the Carpathian region encompasses both EU and non-EU countries.** While EU Member States implement common environmental directives through national legislation, non-EU Parties operate under different legislative and institutional frameworks, which may include equivalent national policies or alternative governance approaches.
- **Differences in legislation, monitoring methodologies, ecological assessment, and river management practices can complicate the coordinated management of shared transboundary river basins.** Strengthening dialogue, harmonizing approaches where appropriate, and improving knowledge exchange would support more coherent river basin management across the Carpathian region.

Reconciling engineering and ecological approaches in Carpathian river management



The challenge is not choosing between engineering and ecology, but integrating both through science-based, transboundary river management.

A plethora of opinions – emerging conflicts

- Where river scientists see unique ecosystems or process, others may see flood hazard, wasted resource or missed recreation opportunity
- Scientists understand the word 'river' in a much wider sense – but views and perceptions drive social demands (settlement, infrastructure, management, safety)
- Dynamic or unstable?
- Millenium flood/ Hundred years' flood

Different expectations and social demand

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- Promote participatory action research methodologies

Session: Plastics in the Mountains - session and panel discussion³⁴

- **Support plastics research.** Since plastics is ubiquitous in different forms in mountain environments at all elevations, there is an urgent need for research into plastics delivery routes, fate and potential impacts to the develop accurate short- and long-term management strategies

Session: Historical Ecology and Geography: New Perspectives for Conservation and Management (RPS)³⁵

- Foster collaborations between researchers and public institutions to integrate historical landscape knowledge into conservation planning and rural development strategies (Grabska-Szwagrzyk et al. 2024)³⁶.

Session: Carpathian Waters³⁷

- **Foster research, knowledge exchange, and joint projects on river and wetland protection and restoration in the Carpathians to help** co-develop strategies to mitigate impacts and restore river connectivity and ecosystem services.
- **Support the creation of a Carpathian Hydromorphology and Waters Advisory Group** bringing together researchers and practitioners from all Carpathian countries, as well as experts working in the region, to foster structured communication and collaboration. Its role would include providing expert guidance, sharing best practices, and supporting the alignment of national legislation with common objectives.

Integrated River Basin Management approach

- Integrated River Basin Management (IRBM) is the process of coordinating the conservation, management, and development of water, land, and related resources across different sectors within a given river basin. Instead of managing water according to artificial political or administrative boundaries, IRBM treats the river basin as a single, independent hydrological and ecological unit.

suggested activities from/by S4C

- support for continued discussion on integrated river basin management (IRBM) in the Carpathian region
- *Hydromorphology and Water Advisory group*
- joint, hybrid technical meeting during FC 2027 on issues of climate change adaptation, water, restoration and biodiversity
- scientific support and coordination of available research on natural hazards and risk management (including cascading effects)
- long term: Carpathian water and restoration conference

River truths

Fragmented knowledge can only engender fragmented management

Emerging approaches to integrative river management appraise feedbacks between social and ecological processes, conceiving riverscapes as complex, dynamic, interacting social–ecological systems.

*[...] Framed in this manner, a riverscapes ethos provides **a holistic platform for biodiversity management, flood risk and climate change adaptation programmes***

Brierley and Fryirs, 2022 *Geoscience Letters*