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# Deliverable 7.1

# Action Agenda for Freshwater Ecosystem Protection and Restoration in the Danube Lighthouse

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## Abbreviations and Acronyms

EcoDaLLi: ECOsystem-based governance with DAnube lighthouse Living Lab for sustainable Innovation processes.

EU: European Union.

WP: Work Package.

PAP / PAPs: Priority Action Package / Priority Action Packages.

CGIS: Crowdsourced Geographic Information Systems.

CSA: Coordination and Support Action.

ICPDR: International Commission for the Protection of the Danube River.

NGO / NGOs: Non-governmental organisation / organisations.

VGI: Volunteered geographic information.

UNDP: United Nations Development Programme.

# Executive Summary

This Action Agenda presents a strategic and highly operational framework for the protection and restoration of freshwater ecosystems and biodiversity across the Danube River basin. Developed within the Horizon Europe EcoDaLLi project, the document serves as a critical bridge between high-level European policy objectives—such as the EU Mission "Restore our Ocean and Waters by 2030", the Water Framework Directive, and the EU Biodiversity Strategy—and practical, on-the-ground implementation. Functioning as a Coordination and Support Action (CSA), EcoDaLLi moves beyond isolated interventions by fostering knowledge sharing, stakeholder engagement, and the scale-up of innovative solutions through a network of regional Living Labs.

A defining feature of this Agenda is its methodological shift from a generic policy document to a project-based synthesis. The priorities outlined herein are directly derived from empirical findings, stakeholder validation workshops, and spatial policy co-creation sessions conducted across the Upper, Middle, and Lower Danube, as well as the Danube Delta. By integrating real-world case studies and bottom-up feedback, the Agenda addresses concrete barriers such as fragmented governance, "participation fatigue", and insufficient funding models for Nature-Based Solutions (NBS).

To operationalize these strategic goals, the Action Agenda introduces five interconnected Priority Action Packages (PAPs), designed to work systemically rather than in isolation:

- **PAP 1: Integrated freshwater ecosystem restoration** – Focuses on rehabilitating floodplains, wetlands, and river connectivity using cost-effective, nature-based solutions tailored to local contexts.
- **PAP 2: Biodiversity protection and recovery** – Targets the recovery of priority habitats and species by mitigating pressures from invasive species, migration barriers, and human activities, ensuring ecological continuity.
- **PAP 3: Data, monitoring, and CGIS** – Emphasizes the use of Crowdsourced Geographic Information Systems (CGIS) and citizen science to bridge data gaps, providing actionable, localized evidence for decision-makers.
- **PAP 4: Governance, participation, and capacity building** – Aims to overcome institutional fragmentation by fostering cross-border coordination and active community involvement in multi-level governance frameworks.
- **PAP 5: Innovation uptake and scaling** – Acts as the scaling mechanism to transition innovative solutions from pilot sites to basin-wide application, aligning them with regional funding and policy tools.

Implementation is structured across a three-phase roadmap: Consolidation, Piloting, and Long-Term Scaling. To guarantee measurable progress and avoid vague adaptive statements, the framework introduces specific Key Performance Indicators (KPIs) spanning ecological, governance, and innovation metrics. Crucially, it addresses systemic risks and identifies diverse financing mechanisms—including EU funds (Horizon Europe, LIFE, ERDF), blended finance, and public-private partnerships—to secure long-term viability for local developers.

Finally, the Agenda sets out a clear post-project sustainability framework. By institutionalizing the Living Labs into permanent regional innovation hubs under frameworks like the ICPDR or EUSDR, and maintaining the EcoDaLLi digital portal as a centralized knowledge hub, the project ensures that the dynamic governance culture and coordination activities initiated here will sustain well beyond 2026.

# 1. Introduction and scope

Freshwater ecosystems are among the most vulnerable ecosystems globally and are undergoing accelerated degradation, despite their critical role in sustaining biodiversity, human well-being, and socio-economic development (Dudgeon et al., 2006; IPBES, 2019). Rivers, floodplains, wetlands and delta systems provide critical ecosystem services, such as water supply, nutrient cycling, flood and climate regulation, as well as habitats for a wide diversity of species (Millennium Ecosystem Assessment, 2005). However, these systems are subject to increasing cumulative pressures, generated by hydromorphological changes, pollution, land-use changes, invasive species and the effects of climate change (Reid et al., 2019).

In the Danube River basin, these pressures are particularly pronounced due to its vast scale, high ecological diversity, and complex socio-economic context. The Danube crosses and connects numerous states, governance systems, and land use regimes, making the protection and restoration of freshwater ecosystems a transboundary challenge that requires coordinated action across the basin. The fragmentation of river continuity, the degradation of floodplains and wetlands, the deterioration of water quality, and the loss of biodiversity continue to affect the ecological status and resilience of freshwater ecosystems in the region (ICPDR, 2021).

At European level, the urgency of addressing these challenges is reflected in several key policy frameworks, including the EU Water Framework Directive (2000/60/EC), the EU Biodiversity Strategy for 2030 and the EU Mission "Restoring our Ocean and Waters by 2030" (European Commission, 2020; European Commission, 2021).

It is important to clarify the geographic and strategic scope of this Action Agenda. Originally, the EU Mission established the "Danube River basin lighthouse". Over time, this concept evolved to encompass the connected marine environment, becoming the "Danube and Black Sea Lighthouse". However, this Action Agenda maintains its targeted focus exclusively on the Danube River basin freshwater ecosystems, reflecting the specific mandate and geographic scope established at the outset of the EcoDaLLi project.

Together, these initiatives underline the need to overcome isolated interventions and transition to integrated, systemic and participatory approaches that combine ecological restoration with social engagement, innovation and adaptive governance. In this context, the EcoDaLLi project contributes to the EU Mission's Danube Lighthouse, acting as a coordination and support action. Instead of directly implementing restoration measures, EcoDaLLi facilitates knowledge sharing, stakeholder engagement and innovation uptake through a network of Living Labs distributed throughout the Danube basin. These Living Labs provide spaces dedicated to co-creation, experimentation and dialogue between researchers, policymakers, practitioners, civil society and innovation actors, helping to strengthen the collective capacity for action.

This Action Agenda is developed to support and structure these efforts. Its aim is to provide a coherent and action-oriented framework for the protection and restoration of freshwater ecosystems and biodiversity within the Danube Lighthouse. The document does not aim to duplicate existing river basin management plans, conservation strategies or technical guides. Instead, it complements these tools by translating the strategic objectives and experiences generated within the Living Labs into a set of priority actions, aimed at supporting the coordination, implementation and scale-up of solutions.

The Action Agenda focuses on freshwater ecosystems and biodiversity, with a particular focus on restoration, protection, monitoring, governance and uptake of innovations. It addresses multiple spatial scales, from local and regional interventions to basin-level coordination, and recognises the need to align ecological objectives with socio-economic realities. The document is aimed at a wide audience, including public authorities, river basin management organisations, research and innovation actors, non-governmental organisations and other stakeholders involved in freshwater management.

The Action Agenda is designed as a dynamic and adaptable framework. The proposed actions and priorities are indicative After an initial validation through EcoDaLLi's Living Labs, the Agenda is meant to be taken up and extended by other actors in the future. In this way, the Action Agenda aims to support a collaborative and long-term trajectory for the protection and restoration of freshwater ecosystems and biodiversity in the Danube basin.

## 2. Methodological approach

This Action Agenda has been developed based on a synthesis-oriented and expertly supported methodological approach, in line with the role of the EcoDaLLi project as a Coordination and Support Action (CSA) within the Danube Lighthouse of the EU Mission. The aim of this outcome is not to generate new empirical evidence or to assess the ecological status through standardised analytical methods, but to structure, articulate and operationalise strategic directions of action for the protection and restoration of freshwater ecosystems and biodiversity, building on existing knowledge and frameworks (European Commission, 2021).

In this sense, the methodological approach is qualitative, integrative and future-oriented. It is based on the consolidation of the literature, European policy objectives and experiences gained in relevant projects, which are translated into a coherent framework of priority actions. Such an approach is specific to Action Agendas,


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designed to support decision-making, coordination, and implementation, rather than reporting experimental results or monitoring data (Reed et al., 2018).

A central methodological pillar of this Action Agenda are the EcoDaLLi Living Labs. Living Labs are recognized in the literature as participatory environments that facilitate co-creation, experimentation and collective learning among diverse categories of stakeholders, including policymakers, researchers, practitioners, civil society organizations and innovation actors (Bergvall-Kåreborn et al., 2009; Leminen et al., 2012). Through these spaces, EcoDaLLi supports the exchange of perspectives, the identification of common challenges and the exploration of potential solutions related to the restoration of freshwater ecosystems and the protection of biodiversity. The information resulting from these interactions contributes to the strategic orientation of the Agenda, even when it is not formalised in the form of quantitative data sets.

In addition, the Action Agenda is aligned with the general objectives and principles of the main relevant European policy frameworks. These include the EU Water Framework Directive, which promotes integrated river basin management and the achievement of good environmental status; The EU Biodiversity Strategy for 2030, which calls for the large-scale restoration of degraded ecosystems; and the EU Mission "Restoring our Ocean and Waters by 2030", which focuses on systemic approaches, innovation and citizen engagement (European Commission, 2020; European Commission, 2021). Instead of doubling these frameworks, the Action Agenda aims to operationalise them by identifying concrete areas of action relevant to the scale of the Danube basin.

The elaboration process also recognises the multi-level and cross-border nature of freshwater governance in the Danube region. Consequently, the methodology aligns governance levels of governance and between different spatial scales, from local and regional interventions to coordination at basin level, in line with recommendations on adaptive governance of water resources (Huitema et al., 2009). The proposed actions are formulated in such a way that they are adaptable to diverse institutional and environmental contexts, recognising that implementation modalities may vary between countries and regions.

The Action Agenda is designed as a dynamic and adaptable document. The methodological choice to avoid rigid prescriptions or fixed targets reflects the need for flexibility in a context marked by environmental changes, policy developments and changing stakeholder priorities. The actions and priorities presented are intended to be refined, validated and subsequently operationalized through the ongoing activities of the Living Labs, the involvement of stakeholders and the subsequent results of the EcoDaLLi project. Ultimately, they are intended to be taken up, adapted, and operationalized by regional stakeholders and other actors to ensure long-term sustainability in monitoring and governance. By adopting this methodological approach, the Action Agenda provides a structured yet flexible framework that supports coordinated actions, encourages the uptake of innovation and contributes to the long-term protection and restoration of freshwater ecosystems and biodiversity within the Danube Lighthouse.

A central methodological pillar of this Action Agenda is the direct integration of empirical findings, stakeholder consultations, and validation processes conducted across the EcoDaLLi Work Packages (WPs). Specifically, this Agenda synthesizes the outcomes of the Nature-Based Solutions (NBS) validation workshops documented in Deliverable 2.4, the spatial policy and stakeholder-tailored co-creation sessions from Deliverable 3.2, and the extensive consortium contributions to the four regional Living Labs detailed in Deliverable 4.2. By systematically mapping stakeholder inputs across the Upper, Middle, Lower Danube, and the Danube Delta, the methodology ensures that the proposed actions directly address on-the-ground realities, such as governance fragmentation, funding barriers, and the need for localized NBS adaptation. To operationalize these findings, the methodology introduces the concept of **Priority Action Packages (PAPs)** early in the planning process. The PAPs serve as thematic clusters, ranging from ecological restoration to digital monitoring and governance, that translate EcoDaLLi's theoretical models and Living Lab feedback into structured, actionable implementation steps. This approach ensures a shift from a generic policy document to a project-based synthesis, explicitly demonstrating EcoDaLLi’s added value in co-creating solutions directly with basin stakeholders.

# 3. Strategic objectives

The Action Agenda is structured around a set of interconnected strategic objectives, which collectively address the protection and restoration of freshwater ecosystems and biodiversity in the Danube basin. These targets reflect the systemic and interdependent nature of freshwater challenges and recognise the need for integrated, coordinated and long-term responses, as highlighted in the literature and relevant European policies (IPBES, 2019; European Commission, 2021). Rather than focusing on isolated interventions, the objectives are designed to support complementary actions in the areas of environmental, governance, data and innovation, recognizing that sustainable outcomes in freshwater ecosystem restoration require multi-sectoral and multi-level approaches (Huitema et al., 2009). The interconnected nature of these strategic pillars and their focus areas are illustrated in Figure 1.


**Figure 1 : Strategic Objectives Framework of the Action Agenda**

## 3.1 Enhancing the ecological status and resilience of freshwater ecosystems

A central objective of this Action Agenda is to improve the ecological status and long-term resilience of freshwater ecosystems in the Danube basin. Freshwater ecosystems


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are dynamic systems, the functioning of which depends on maintaining hydrological and morphological connectivity, habitat diversity and adequate water quality. The degradation of one or more components of these systems may reduce their ability to absorb disturbances and increase vulnerability to external pressures, including climate change (Dudgeon et al., 2006; Reid et al., 2019).

In this context, the objective prioritizes restoration approaches that work with natural processes, such as restoring river-floodplain connectivity, rehabilitating wetlands, and improving hydromorphological conditions. Nature-based solutions are particularly relevant as they can generate multiple benefits simultaneously, including biodiversity conservation, flood risk reduction, and climate change adaptation (European Commission, 2020; IPBES, 2019). Aligning restoration efforts with basin planning tools, such as river basin management plans under the EU Water Framework Directive, is essential to ensure coherence of interventions and maximise cumulative impact (European Commission, 2000).

The focus on resilience reflects the recognition that the restoration of freshwater ecosystems is not a one-off intervention, but an ongoing process that must take into account future pressures and uncertainties. Adaptive management approaches, supported by monitoring systems and feedback mechanisms, are considered essential components of this objective (Huitema et al., 2009).

## 3.2 Halting biodiversity loss and supporting recovery of freshwater species and habitats

The biodiversity of freshwater ecosystems in the Danube basin continues to be under significant pressure, manifested by population decline, habitat fragmentation and loss of ecological integrity. A second strategic objective of this Action Agenda is to halt biodiversity loss and support the recovery of priority species and habitats associated with freshwater ecosystems, in line with trends and recommendations identified at global and European level (Dudgeon et al., 2006; IPBES, 2019).

This objective focuses on integrating biodiversity into restoration and management actions, rather than treating species conservation as a separate activity. Protecting and restoring habitats, improving ecological connectivity, and reducing pressures from

pollution, hydromorphological changes, and invasive species are key pathways to sustain biodiversity recovery (Reid et al., 2019). Particular attention is paid to habitats and species of high conservation value, as well as areas where restoration interventions can generate disproportionate benefits for biodiversity.

This target is aligned with the EU's 2030 Biodiversity Strategy, which calls for the large-scale restoration of degraded ecosystems, including freshwater ecosystems. Within the Danube Lighthouse, biodiversity recovery is understood as a collective responsibility, requiring coordination across sectors and levels of governance, as well as the involvement of local communities and other relevant stakeholders (European Commission, 2020; Reed et al., 2018).

## 3.3 Strengthening data-driven and participatory freshwater governance

The effective protection and restoration of freshwater ecosystems depends on robust governance frameworks based on reliable data and inclusive decision-making. A third strategic objective of this Action Agenda is to strengthen data-driven and participatory freshwater governance in the Danube basin, in line with recommendations in the literature and European policies on adaptive water resources management (Huitema et al., 2009; European Commission, 2021).

This objective starts from the recognition that formal monitoring systems, while essential, may not fully capture the complexity of freshwater ecosystem dynamics or the spatial and temporal variability of pressures and impacts. Complementary approaches, including the use of digital tools, geographic information systems, and participatory data collection initiatives, can help increase transparency, improve spatial coverage of information, and actively involve stakeholders in monitoring and evaluation processes (Buytaert et al., 2014; Fritz et al., 2019). When properly designed and governed, these tools can provide relevant information for planning, monitoring and adaptive management.

Participatory governance is an essential complementary component of this objective. Stakeholder involvement in decision-making processes helps to increase legitimacy, strengthen shared ownership for restoration actions, and improve implementation

outcomes (Reed et al., 2018). In this context, the Living Labs offer a key mechanism for operationalizing participatory governance, providing structured frameworks for dialogue, co-creation and learning between policymakers, researchers, practitioners, civil society and other relevant actors.

## 3.4 Enabling innovation uptake and scaling across the Danube basin

Innovation plays a key role in addressing the complex challenges associated with freshwater ecosystems, but innovative solutions often remain fragmented or limited to pilot contexts. A fourth strategic objective of this Action Agenda is to facilitate the uptake, transfer and scale-up of innovative solutions to protect and restore freshwater ecosystems in the Danube basin, in line with the objectives of the EU Mission "Restoring our ocean and waters by 2030" (European Commission, 2021).

This objective focuses on bridging the gap between the development and implementation of innovation, emphasizing the need to connect innovators with end-users, decision-makers and practitioners in the field of water management. It also highlights the importance of aligning innovation processes with existing regulatory, financial and institutional frameworks in order to ensure the feasibility and long-term sustainability of the proposed solutions (OECD, 2015). Innovation is approached in a broad sense, including technological, social, governance and nature-based solutions, recognizing their complementarity in generating systemic change.

By facilitating knowledge sharing, supporting experimentation through Living Labs and connecting innovative solutions to existing support services and governance structures, the Action Agenda aims to create the necessary conditions for their replication and scale-up beyond individual projects or sites. In this respect, the objective contributes directly to the ambitions of the EU Mission, which identifies innovation and citizen engagement as key factors for accelerating the transitions needed to restore freshwater ecosystems on a large scale (European Commission, 2021).

# 4. Priority Action Packages (PAPs)

## 4.1 Concept and Definition of Priority Action Packages (PAPs)

The Priority Action Packages (PAPs) represent the operational core of this Action Agenda, designed to translate strategic objectives into a coherent set of coordinated directions for the Danube Lighthouse. Rather than prescribing rigid technical measures, a PAP serves as a flexible framework for prioritisation and coordination. This approach allows interventions to be adapted to diverse local ecological and socio-economic contexts while ensuring they contribute to the goals of the EU Mission "Restoring our Ocean and Waters by 2030".

The PAP framework is built upon three functional pillars:

- Systemic Integration: PAPs are designed to move from isolated interventions toward a basin-level perspective that considers hydrological processes and habitat connectivity as a whole.
- Functional Interdependence: The packages are not standalone; they form an interconnected system where governance (PAP 4) and data (PAP 3) provide the necessary foundation for ecological restoration (PAP 1), biodiversity recovery (PAP 2), and the scaling of innovation (PAP 5).
- Operational Agility: Each package is structured to support a phased implementation, from consolidation and alignment to piloting and long-term scaling, allowing for continuous refinement based on real-world feedback.

To ensure effective implementation, the PAPs are structured with a clear prioritization logic. **PAP 1 (Ecosystem Restoration)** and **PAP 2 (Biodiversity Recovery)** form the ecological foundation; they must be prioritized geographically where degradation poses immediate risks to basin-wide connectivity. **PAP 3 (Data & Monitoring)** and **PAP 4 (Governance)** are enabling packages, they must be implemented concurrently with PAPs 1 and 2 to provide the necessary data, public awareness, and institutional support. Finally, **PAP 5 (Innovation Uptake)** acts as the scaling mechanism, applying outputs from previous EcoDaLLi Work Packages to replicate the successes of the preceding packages (Table 1).

**Table 1: Matrix of PAP Interlinkages and Operational Details**

| Priority Action Package | Lead Actors | Timeline | Linkages & Operational Role |
|---|---|---|---|
| **PAP 1: Ecosystem Restoration** | River basin authorities, NGOs | Phase I-II | Supported by data (PAP 3) and governance frameworks (PAP 4). |
| **PAP 2: Biodiversity Protection** | Conservation agencies, Researchers | Phase I-III | Relies on restored habitats from PAP 1. |
| **PAP 3: Data, Monitoring & CGIS** | Tech providers, Citizen Scientists | Phase I-II | Feeds actionable data to PAP 1 & 2; drives digital innovation scaling in PAP 5. |
| **PAP 4: Governance & Participation** | Local/National authorities | Phase I-III | Provides the institutional basis and stakeholder alignment for all other PAPs. |
| **PAP 5: Innovation Uptake** | Innovators, Private Sector | Phase II-III | Scales the solutions developed across PAPs 1-4 to basin-wide application. |

## 4.1 PAP 1 – Integrated freshwater ecosystem restoration

a) **Objective and rationale**

The first Priority Action Package (PAP 1) focuses on the integrated restoration of freshwater ecosystems in the Danube basin. This PAP responds to the need to overcome fragmented interventions, limited to individual sites, and to promote coordinated actions that take into account hydrological processes, habitat connectivity

and ecological functionality at multiple spatial scales, in line with the principles of integrated river basin management (European Commission, 2000; Huitema et al., 2009).

The degradation of freshwater ecosystems in the Danube basin is closely linked to hydromorphological changes, regulation of watercourses, disconnection of floodplains and cumulative pressures generated by land-use changes. These processes have led to simplification of habitat structure, reduced ecological connectivity, and decreased resilience of ecosystems to disturbances, including those induced by climate change (Dudgeon et al., 2006; Reid et al., 2019). In this context, PAP 1 promotes restoration approaches that work with natural processes and aim to restore ecosystem dynamics, rather than strictly structural or technical interventions, in line with the EU Water Framework Directive and the EU Biodiversity Strategy for 2030 (European Commission, 2000; European Commission, 2020).

The rationale for this PAP is based on the fact that integrated restoration can generate multiple co-benefits, including improved biodiversity status, increased resilience to climate change, reduced flood risk, and the provision of essential ecosystem services for local communities (IPBES, 2019; European Commission, 2021). Such benefits can only be fully realised when restoration actions are designed from a basin-level perspective and coordinated across different levels of governance.

b) **Scope and focus**

PAP 1 covers rivers, floodplains, wetlands and associated freshwater habitats in the Danube basin. It targets both heavily modified and semi-natural systems, recognising that restoration objectives and feasible types of interventions may vary depending on the existing ecological status, land use and local socio-economic context (European Commission, 2000).

The scope includes, but is not limited to:

- restoration of river-floodplain connectivity;
- rehabilitation of degraded wetlands and side channels;
- improvement of hydromorphological conditions;
- reducing pressures that limit ecological recovery, such as altered flow regimes and physical barriers.

Instead of prescribing a uniform set of measures, PAP 1 provides a framework for prioritisation and coordination, which allows actions to be adapted to local conditions, while contributing to the achievement of strategic objectives at basin level.

c) **Key action areas**

A first area of action under this PAP is to identify and prioritize restoration opportunities. This process involves mapping degraded freshwater ecosystems and identifying areas where restoration interventions can generate the greatest ecological and socio-economic benefits. Prioritisation criteria include environmental status, biodiversity value, potential for restoring green connectivity and alignment with existing planning and management tools (European Commission, 2000; IPBES, 2019).

A second area of action focuses on the implementation of nature-based solutions and process-oriented restoration measures. These include reconnecting floodplains, restoring natural variability of flow regimes where possible, and rehabilitating wetlands to improve water retention and habitat diversity. Nature-based solutions are prioritised due to their ability to deliver multiple benefits and their alignment with climate change adaptation and natural risk reduction objectives (European Commission, 2020; IPBES, 2019).

A third area of action concerns coordination with existing river basin management and spatial planning frameworks. Restoration actions should be aligned with river basin management plans, flood risk management plans and relevant conservation strategies in order to avoid conflicts between objectives and maximise the cumulative impact of interventions. This alignment is essential to ensure the long-term sustainability of restoration efforts (European Commission, 2000; Huitema et al., 2009).

d) **Integration of Project Outputs & Case Studies**

The necessity of these actions is heavily supported by the EcoDaLLi validation workshops (WP2) and spatial policy sessions (WP3). Concrete examples identified by local stakeholders include the successful floodplain reconnection at Lonjsko Polje Nature Park (Croatia) and the wetland restoration at Zasavica Special Nature Reserve (Serbia), which effectively combine biodiversity conservation with local ecotourism. Furthermore, constructed wetlands, such as the Palić-Ludaš Lake System and

Begečka Jama (Serbia), were highlighted by stakeholders as highly replicable, cost-effective nature-based solutions for wastewater treatment in small settlements.

e) **Role of Living Labs**

Living Labs plays a central role in the operationalization of this PAP, providing dedicated platforms for co-creation, dialogue and collective learning. Through them, stakeholders can jointly identify restoration priorities, explore alternative solutions, and assess trade-offs associated with different intervention options, in a structured and participatory framework (Bergvall-Kåreborn et al., 2009; Leminen et al., 2012).

Within the Living Labs, restoration concepts and options are discussed and refined in direct dialogue with local communities, public authorities and practitioners, which contributes to increasing the social acceptability and practical feasibility of the proposed interventions. This approach is recognized as essential for reducing conflicts, increasing the legitimacy of decision-making processes, and improving implementation outcomes in ecological restoration projects (Reed et al., 2018).

The Living Labs also support transversal learning and knowledge sharing by connecting experiences and lessons learned from different parts of the Danube basin. This process facilitates the dissemination of good practices and helps to identify the conditions under which certain restoration approaches are most effective, recognizing that solutions need to be adapted to local ecological and socio-economic contexts (Leminen et al., 2012).

f) **Governance and stakeholder involvement**

Integrated restoration of freshwater ecosystems requires coordination between a wide range of actors, including river basin management authorities, environmental agencies, land managers, municipalities, non-governmental organisations and local communities. This PAP promotes inclusive governance arrangements that facilitate collaboration across sectors and across administrative borders, in line with the principles of adaptive water governance (Huitema et al., 2009).

Stakeholder engagement is not conceived as a process limited to consultation, but as an active participation in the planning, implementation and, where possible, monitoring

stages. Such involvement contributes to increased ownership of restoration efforts and supports the long-term stewardship of restored ecosystems, aspects recognized as critical to the success of ecological restoration interventions (Reed et al., 2018).

g) **Expected outcomes**

The expected results of this PAP include improving the ecological status and resilience of freshwater ecosystems, increasing the connectivity of habitats and strengthening the capacity to plan and implement coordinated restoration actions at the level of the Danube basin. Although the Action Agenda does not set specific quantitative targets, this PAP provides a clear strategic basis for operationalisation, monitoring and subsequent evaluation of progress through EcoDaLLi activities and partner initiatives, in line with adaptive and learning-oriented approaches.

## 4.3 PAP 2 – Biodiversity protection and recovery in freshwater ecosystems

a) **Objective and rationale**

The second Priority Action Package (PAP 2) focuses on protecting and restoring the biodiversity of freshwater ecosystems in the Danube basin. Although freshwater ecosystems occupy a relatively small area globally, they support a disproportionately large proportion of biodiversity, while also being affected by some of the fastest rates of species decline (Dudgeon et al., 2006; Reid et al., 2019). In the Danube basin, pressures such as habitat degradation and fragmentation, pollution, invasive alien species and changes in hydrological regimes continue to affect the conservation status of freshwater species and habitats (ICPDR, 2021).

The justification for this PAP starts from the recognition that the restoration of ecosystems does not automatically lead to the recovery of biodiversity. While restoration interventions can create favourable conditions, the effective recovery of sensitive species and habitats often requires specific, biodiversity-oriented actions tailored to the ecological requirements of the taxa concerned (Palmer et al., 2014; Reid et al., 2019). In this regard, PAP 2 complements the integrated ecosystem restoration promoted by PAP 1 by explicitly addressing biodiversity objectives and ensuring that species and habitat conservation considerations are integrated into broader freshwater management and restoration efforts.

This approach is aligned with the EU Biodiversity Strategy for 2030, which aims to halt biodiversity loss, restore degraded ecosystems and improve the conservation status of species and habitats of European importance (European Commission, 2020). Within the Danube Lighthouse, biodiversity recovery is understood as a cross-cutting priority, which requires coordinated actions in the ecological, governance and social dimensions.

b) **Scope and focus**

PAP 2 covers freshwater-dependent species and habitats, including fish, aquatic invertebrates, amphibians, aquatic plants, as well as riparian habitats and associated wetlands. This applies to both protected and unprotected areas, recognising that the success of biodiversity conservation depends on landscape-scale processes and ecological connectivity rather than the management of isolated sites (Opdam et al., 2006).

The scope includes, but is not limited to:

- identifying and protecting priority areas for biodiversity and ecological corridors;
- recovery of degraded habitats essential for different stages of the life cycle of freshwater species;
- reducing pressures that directly affect biodiversity, such as migration barriers and invasive alien species;
- integrating biodiversity objectives into restoration, water management and spatial planning processes.

PAP 2 recognises that biodiversity conservation priorities may vary between different regions and ecological contexts in the Danube basin. It therefore promotes flexible implementation pathways that can be adapted to local conditions and existing governance frameworks.

c) **Key action areas**

A first area of action within this PAP is the identification and prioritization of biodiversity values in freshwater ecosystems. This involves the recognition of areas of high importance for biodiversity, such as breeding habitats, ecological refuges and areas supporting rare, endemic or threatened species. The prioritization process must take into account the ecological relevance, the degree of vulnerability to pressures and the recovery potential of habitats (Dudgeon et al., 2006; IPBES, 2019).

A second area of action focuses on the explicit integration of biodiversity requirements into restoration and management actions. This implies that restoration measures are designed to meet the ecological needs of the target species and support ecological connectivity at appropriate spatial scales. For example, the reconnection of floodplains or side channels can be planned to increase habitat diversity and improve conditions for a wide range of taxa (Palmer et al., 2014).

A third area of action addresses the management of pressures that limit biodiversity recovery, including physical barriers that restrict the movement of species, invasive alien species that alter the structure and functioning of ecosystems, and water quality pressures that reduce habitat suitability. Actions in this area aim to reduce or mitigate these pressures in coordination with competent authorities and relevant stakeholders (Reid et al., 2019).

A fourth area of action concerns adaptive biodiversity management, supported by monitoring and feedback mechanisms. Biodiversity responses to restoration and management interventions can be complex and context-dependent. Consequently, continuous observation and adaptive learning are essential for adjusting actions over time and maximizing conservation outcomes (Huitema et al., 2009; IPBES, 2019).

Discussions from the Danube Delta Living Lab (WP4) and spatial policy workshops (WP3) explicitly linked biodiversity recovery to the management of human activities. For instance, stakeholders pointed out that traditional activities, such as sturgeon fishing, require carefully balanced conservation measures and subsidies to protect populations while supporting local livelihoods. Similarly, the workshops highlighted the urgent need to address invasive species, such as bark beetles in Montenegro's national parks, demonstrating the critical need to integrate biodiversity targets into broader forest and water management practices.

d) **Role of Living Labs**

Living Labs provide a key platform for the operationalisation of biodiversity-focused actions under this Priority Action Package. They facilitate collaboration between ecologists, practitioners, local communities and decision-makers, allowing the identification of conservation priorities and the co-design of interventions adapted to


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local ecological and socio-economic contexts (Bergvall-Kåreborn et al., 2009; Leminen et al., 2012). Through Living Labs, scientific knowledge on biodiversity can be integrated with local experience and societal perspectives, increasing the relevance, acceptability and feasibility of conservation actions.

In addition, Living Labs play an important role in communicating and raising awareness about biodiversity values and conservation needs. The direct involvement of local stakeholders in biodiversity-related discussions, activities and learning processes helps to strengthen local stewardship and long-term commitment to protecting freshwater ecosystems, which is recognised as essential for conservation success (Reed et al., 2018).

e) **Governance and stakeholder involvement**

Protecting and restoring biodiversity requires coordinated governance that transcends sectoral and administrative boundaries. This PAP promotes cooperation between environmental authorities, watershed management organisations, conservation agencies, research institutions, non-governmental organisations and users of land and water resources, in line with the principles of adaptive and participatory governance (Huitema et al., 2009).

Stakeholder involvement is particularly important in situations where biodiversity conservation objectives intersect with socio-economic activities such as fisheries, agriculture or water use. Transparent dialogue and participatory decision-making processes can help identify socially acceptable solutions, reduce conflicts, and strengthen shared responsibility for conservation outcomes, without compromising ecological goals (Reed et al., 2018; IPBES, 2019).

f) **Expected outcomes**

The expected results of this PAP include improving the conservation status of freshwater species and habitats, increasing ecological connectivity, and a stronger integration of biodiversity considerations into freshwater management and restoration practices. Although the Action Agenda does not set specific quantitative targets at this stage, this PAP provides a clear strategic framework to guide coordinated actions in

the field of biodiversity and to support the long-term recovery of freshwater ecosystems in the Danube basin.

## 4.4 PAP 3 – Data, monitoring, and Crowdsourced Geographic Information Systems (CGIS)

### a) Objective and rationale

The third Priority Action Package addresses the role of data, monitoring and participatory digital tools in supporting the protection and restoration of freshwater ecosystems and biodiversity in the Danube basin. Effective freshwater governance and restoration interventions depend on reliable, up-to-date and explicitly spatial information on ecological status, anthropogenic pressures and ecosystem responses to management measures (Huitema et al., 2009).

In the Danube basin, however, monitoring capacities are spatially uneven, and data gaps persist especially at local and regional scales. Conventional monitoring systems, while essential for reporting and compliance with European policies, may not fully capture the spatial and temporal variability of freshwater ecosystems or the rapid emergence of local pressures (Buytaert et al., 2014).

The rationale for this PAP is that complementary approaches, which leverage digital technologies and stakeholder participation, can help improve data availability, increase transparency and strengthen responsiveness. In this context, crowdsourced Geographic Information Systems (CGIS) provide a valuable opportunity to support monitoring, awareness, and decision-making, provided that they are adequately designed and governed (Goodchild, 2007; See et al., 2016).
This PAP is aligned with the EU Mission 'Restoring our Ocean and Waters by 2030', which highlights the importance of digital tools, citizen engagement and the use of data to drive systemic change. It also supports the principles of integrated river basin management promoted by the EU Water Framework Directive.

### b) Scope and focus

PAP 3 focuses on the collection, management and use of data relevant to freshwater ecosystems in the Danube basin, with a particular focus on digital and participatory

approaches. It covers ecological, hydromorphological and anthropogenic pressure information, which is essential for assessing the state of ecosystems and associated biodiversity.

The scope includes:

- complementary monitoring of freshwater ecosystems through CGIS and other participatory tools;
- integrating citizen-generated data with formal monitoring systems, where possible and relevant;
- data standardisation, interoperability and quality assurance mechanisms;
- Use of data for planning, implementation and adaptive management.

The PAP does not aim to replace existing monitoring frameworks, but to complement them by increasing spatial coverage, granularity of information and stakeholder involvement.

c) **Key action areas**

A first area of action is the development and implementation of CGIS tools tailored to freshwater ecosystems. These tools can allow local communities, practitioners and citizens involved to contribute observations on water quality, habitat conditions, species presence or emerging pressures. Such contributions can expand the spatial coverage of monitoring and provide early warning signals for localized problems (Dickinson et al., 2012).

A second area of action concerns data quality, validation and information governance. For CGIS data to be credible and usable in decision-making processes, clear protocols for collection, validation and use are needed. This includes defining responsibilities, setting minimum quality standards and ensuring transparency in the processing and interpretation of data. Ethical aspects, such as data privacy and informed participation, are essential in this context (Haklay, 2013).

A third area of action concerns interoperability and integration with existing platforms and services. CGIS data should be compatible with existing river basin management information systems, biodiversity platforms and spatial data infrastructures. Interoperability increases the potential for data reuse, supports cross-sectoral

analyses, and increases the relevance of participatory data for decision-making and innovation.

A fourth area of action concerns the use of data for learning, communication and adaptive management. Data collected through formal and participatory mechanisms should inform restoration planning, support the evaluation of interventions, and feed feedback loops. Accessible visualization tools and communication formats can facilitate common understanding among stakeholders and strengthen long-term engagement.

d) **Role of Living Labs**

Living Labs provide a suitable framework for testing, adapting, and refining CGIS approaches in real-world contexts. Within them, digital tools can be co-designed together with end-users, ensuring that the solutions developed respond to local needs, capacities and constraints (Bergvall-Kåreborn et al., 2009; Leminen et al., 2012). This participatory approach contributes to increasing the relevance and usability of CGIS tools in freshwater monitoring and management practices.

The Living Labs also provide valuable opportunities to explore how participatory data can be integrated into decision-making processes and to build trust and legitimacy around the information generated through CGIS. Through iterative experimentation and learning processes, they can support the identification of good practices for the implementation of CGIS in diverse ecological and governance contexts in the Danube basin, which is essential for transferability and scaling (Voytenko et al., 2016).

e) **Governance and stakeholder involvement**

Governance arrangements are critical for the effective implementation of this PAP. Clear institutional responsibilities are required for managing data flows, ensuring quality control, and defining how CGIS results are used in planning and management. Collaboration between public authorities, research institutions, civil society organisations and technology providers is essential to ensure the credibility and sustainability of CGIS systems (Huitema et al., 2009).

Stakeholder engagement is both a means and an objective of this PAP. By facilitating participation in the collection, interpretation and use of data, CGIS can contribute to raising awareness of environmental issues, empowering local actors and strengthening the social legitimacy of freshwater governance processes. Such participatory processes are recognized as key factors for the long-term acceptance and effectiveness of management decisions (Reed et al., 2018).

f) **Expected outcomes**

The expected results of this PAP include improved availability and accessibility of data on freshwater ecosystems, increased stakeholder involvement in monitoring and governance activities, and stronger links between data generation and decision-making. By complementing formal monitoring systems, CGIS can contribute to a more responsive, transparent and adaptive management of freshwater in the Danube basin, supporting long-term restoration and conservation objectives.

## 4.5 PAP 4 – Governance, participation, and capacity building

a) **Objective and rationale**

The fourth Priority Action Package addresses governance, participation and capacity building as key enablers for the effective protection and restoration of freshwater ecosystems and biodiversity in the Danube basin. While environmental knowledge and technical solutions are indispensable, their impact is often limited by fragmented governance structures, insufficient coordination between sectors and administrative levels, and unequally distributed institutional and human capacity (Huitema et al., 2009).

The justification for this PAP is based on the fact that freshwater restoration and biodiversity conservation are inherently multiscale and cross-border challenges. In the Danube basin, responsibilities related to water management, nature conservation, spatial planning, agriculture and infrastructure development are distributed among numerous institutions and levels of governance. In the absence of effective coordination mechanisms and inclusive decision-making processes, restoration efforts risk remaining isolated, temporary or producing limited results (OECD, 2015).

This PAP is aligned with the EU Mission 'Restoring our Ocean and Waters by 2030', which underlines the central role of new forms of governance, stakeholder engagement and citizen participation in achieving systemic transformation. It also reflects the principles enshrined in the EU Water Framework Directive, which promote integrated river basin management and public participation as key elements of effective water governance.

b) **Scope and focus**

PAP 4 focuses on governance arrangements and processes that support the protection and restoration of freshwater ecosystems in the Danube basin. It addresses both formal institutional structures and informal mechanisms for coordination, cooperation and participation.

The scope includes:

- multi-level governance arrangements connecting local, national, basin and EU actors;
- cross-sectoral coordination between the fields of water, biodiversity, climate, agriculture and spatial planning;
- stakeholder participation and co-creation processes;
- strengthening the capacities of institutions, practitioners and communities involved in freshwater management and restoration.

Instead of prescribing uniform governance models, the PAP provides a flexible framework, capable of adapting to the diversity of institutional, administrative and socio-economic contexts in the Danube basin.

c) **Key action areas**

A first area of action aims to strengthen multi-level and cross-border coordination. It includes promoting dialogue and cooperation between river basin management organisations, national authorities, regional and local administrations and other relevant actors. Mechanisms for information exchange, joint planning and target alignment are key to addressing cumulative pressures and ensuring coherence of actions across the basin (OECD, 2015).

A second area of action focuses on stepping up stakeholder participation and co-creation processes. Meaningful participation goes beyond mere consultation and

involves relevant actors in defining issues, prioritising actions and evaluating results. Living Labs play a central role in operationalizing participatory governance, providing structured spaces for dialogue, experimentation, and collective learning (Reed et al., 2018; Leminen et al., 2012).

A third area of action addresses institutional and human capacity building. The effective implementation of restoration and biodiversity actions requires adequate skills, knowledge and resources within institutions and stakeholder groups. Capacity-building activities may include training on restoration approaches, governance processes, the use of digital tools and the facilitation of participatory methods. In parallel, clarifying roles and responsibilities and improving institutional coordination mechanisms are key to long-term efficiency (UNDP, 2018).

A fourth area of action is communication, trust building and conflict management. Freshwater restoration often involves divergent interests and trade-offs, especially where ecological objectives interact with economic activities. Transparent communication, access to information, and inclusive dialogue are key elements for building trust and constructive conflict management, contributing to social acceptance and sustainability of restoration measures (Reed et al., 2018).

Findings from the EcoDaLLi validation workshops (WP2) revealed that fragmented governance structures and a lack of cross-border collaboration represent severe barriers to ecosystem restoration. For example, stakeholders noted that conservation measures taken in the Romanian Danube Delta are often undermined by differing regulations in neighbouring countries sharing the same delta. To address this, the Action Agenda builds on the Living Lab models developed in WP4 to foster multi-level dialogue and ensure that local communities are actively engaged in decision-making processes, thereby reducing "participation fatigue" and building trust.

d) **Role of Living Labs**

Living Labs are a central component of this Priority Action Package. They function as innovation spaces in governance, where new forms of collaboration, participation and coordination between actors can be tested, adapted and refined. Through Living Labs, stakeholders can jointly explore existing governance arrangements, identify

institutional barriers, and co-develop solutions which are tailored to local contexts and socially acceptable (Bergvall-Kåreborn et al., 2009; Voytenko et al., 2016).

In addition, the Living Labs facilitate collective learning and exchange of experience between regions, providing opportunities for knowledge transfer and adaptation of good governance practices to different ecological and institutional contexts in the Danube basin. This peer learning process is recognized as a key mechanism for strengthening adaptive governance and increasing the capacity to respond to complex and dynamic challenges (Huitema et al., 2009).

e) **Expected outcomes**

The expected results of this PAP include improved coordination between levels of governance, greater involvement and ownership by stakeholders, as well as strengthened institutional capacity for the protection and restoration of freshwater ecosystems. By strengthening participatory governance and collaborative mechanisms, this PAP contributes to the long-term sustainability and effectiveness of the actions proposed under the Action Agenda.

## 4.6 PAP 5 – Innovation uptake and scaling for freshwater ecosystem restoration

a) **Objective and rationale**

The fifth PAP focuses on facilitating the uptake, transfer and scale-up of innovative solutions to protect and restore freshwater ecosystems and biodiversity in the Danube basin. Although a wide range of innovative approaches (technological, social, governance and nature-based) are developed and tested in research projects and pilot initiatives, the transition from experimentation to large-scale deployment often remains limited. Common barriers include regulatory constraints, institutional fragmentation, insufficient access to support services, and reduced visibility of existing solutions (OECD, 2016).

The rationale for this PAP is that innovation requires active support and integration into governance and implementation frameworks to produce systemic impact. In the context of the EU Mission 'Restoring our ocean and waters by 2030', innovation is not

an end in itself, but a means to accelerate progress towards restoration goals. EcoDaLLi, as a Coordination and Support Action, plays a key role in connecting innovators with end-users, decision-makers and support structures, creating favourable conditions for the adoption and scale-up of innovative solutions (Leminen et al., 2012; Voytenko et al., 2016).

b) **Scope and focus**

PAP 5 addresses innovation processes relevant to the protection and restoration of freshwater ecosystems in the Danube basin. Innovation is broadly understood and includes:

- technological solutions (e.g. monitoring tools, restoration techniques);
- social and governance innovations (e.g. participatory approaches, new models of collaboration);
- nature-based solutions.

The scope includes:

- supporting the transfer of innovative solutions from pilot to deployment contexts;
- connecting innovators with public authorities, practitioners and local communities;
- aligning innovation processes with regulatory, financial and institutional frameworks;
- facilitating the replication and scaling up of solutions in different regions and countries in the Danube basin.

Instead of promoting specific technologies or solutions, this PAP focuses on creating the enabling conditions for the uptake, diffusion and scaling of innovation.

c) **Key action areas**

A first area of action aims to strengthen the links between innovators and end-users. This includes facilitating dialogue between innovative solution developers, water managers, conservation practitioners and policymakers to ensure that innovations respond to real needs and practical constraints. Living Labs provide an effective mechanism for testing solutions in real-world contexts and collecting feedback that can inform their adaptation and refinement (Bergvall-Kåreborn et al., 2009).

A second area of action focuses on improving access to innovation support services. Innovators often need support that goes beyond technical development, including guidance on regulatory compliance, access to finance, business model development, and impact assessment. By connecting innovation actors to existing support services and platforms – including those developed under WP5 and WP6 – this PAP contributes to reducing barriers to implementation (OECD, 2016).

A third area of action addresses ways to scale and replicate innovative solutions. Scaling up innovation requires a clear understanding of the environmental, institutional and socio-economic conditions that influence the transferability and impact of solutions. Knowledge sharing, documentation of good practices and mutual learning between regions are key mechanisms to support scaling processes in the Danube basin.

A fourth policy area concerns the alignment of innovation with policy and investment frameworks. Widespread uptake of innovative solutions is more likely when they are supported by coherent policies and appropriate funding mechanisms. This area promotes dialogue between innovators and policymakers to identify opportunities for policy support, regulatory flexibility and integration of innovative approaches into public and private planning and investment processes.

d) **Role of Living Labs**

Living Labs are essential for the adoption and expansion of innovation in the field of freshwater ecosystem restoration. They provide controlled but reality-anchored environments where innovative solutions can be tested, adapted and demonstrated in direct collaboration with stakeholders. Through the Living Labs, EcoDaLLi supports processes of experimentation, learning and confidence building, elements recognized as critical for overcoming resistance to change and for increasing the acceptance of new approaches in diverse institutional and social contexts (Bergvall-Kåreborn et al., 2009).

In addition, the Living Labs facilitate the interregional exchange of knowledge and experience, allowing innovators and practitioners to learn from implementations carried out in different parts of the Danube basin. This mutual learning process supports the

replication and adaptation of innovative solutions to new contexts and is considered a key mechanism for sustainable scaling of innovation (Voytenko et al., 2016; Leminen et al., 2012).

e) **Expected outcomes**

The expected results of this PAP include an increase in the uptake of innovative solutions for the protection and restoration of freshwater ecosystems, stronger connections between innovation actors and end-users, and an increased capacity to replicate and scale up effective approaches in the Danube basin. By supporting the diffusion of innovation beyond pilot contexts, this PAP contributes to long-term sustainability and amplifies the impact of restoration efforts, both within and beyond the lifetime of the EcoDaLLi project.

# 5. Implementation roadmap

The Implementation Roadmap describes how the PAP proposed in this Action Agenda can be progressively operationalised, coordinated and scaled up over time. Given the complexity of restoring freshwater ecosystems and protecting biodiversity in the Danube basin, implementation is conceived as a phased and adaptive process, rather than as a linear succession of actions. Such an approach allows flexibility in relation to changes in environmental conditions, policy changes and the dynamics of stakeholder priorities, being recognized as essential for the management of complex socio-ecological systems (Huitema et al., 2009; Folke et al., 2016).

The roadmap is structured around three complementary phases of implementation: (i) consolidation and alignment, (ii) piloting and refinement, and (iii) long-term scaling and integration. These phases are indicative and may partially overlap in practice, reflecting the dynamic nature of the coordination and implementation processes within the Danube Lighthouse.

## 5.1 Phase I – Consolidation and alignment

The first phase focuses on strengthening priorities and aligning the Action Agenda with existing initiatives, governance frameworks and relevant stakeholder processes. At this stage, the focus is on translating the strategic directions defined in the Priority Action Packages into a common understanding and areas of action agreed between the key actors involved.

The main activities in this phase include the validation of priorities through structured dialogue with stakeholders involved in Living Labs, Innovation Actions and existing governance structures. This process aims to ensure that the proposed actions are relevant, feasible and complementary to the efforts already underway. Alignment with river basin management plans, biodiversity strategies and other relevant planning tools is a key component of this phase, helping to avoid duplication and maximise synergies (OECD, 2015).

Another important element of Phase I is the clarification of roles and responsibilities. While the Action Agenda proposes indicative roles for different categories of actors,


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further adaptation to specific institutional contexts is needed. The early establishment of communication and coordination mechanisms creates a solid basis for effective implementation in the later phases and contributes to strengthening joint responsibility.

## 5.2 Phase II – Piloting and refinement

The second phase focuses on piloting and refining actions through practical implementation and continuous learning processes. Living Labs play a central role at this stage, providing structured environments for testing Priority Action Packages in real-world contexts and collecting feedback from stakeholders (Bergvall-Kåreborn et al., 2009; Voytenko et al., 2016).

In this phase, selected actions from each PAP can be implemented on a pilot scale, allowing different approaches to be explored, feasibility assessment and operational challenges to be identified. For example, restoration measures, biodiversity-oriented interventions, participatory monitoring tools or governance arrangements can be tested and adapted according to local ecological and institutional conditions.

Learning and feedback mechanisms are essential in this phase. The results of monitoring, stakeholder experiences and lessons learned should be systematically documented and shared between Living Labs and the regions. This iterative process supports the refinement of actions and facilitates the identification of factors influencing the success or limitations of interventions, providing a solid foundation for further scaling and integration efforts (Reed et al., 2018; Huitema et al., 2009).

## 5.3 Phase III – Scaling and long-term integration

The third phase focuses on scaling up actions that have proven effective and integrating them into long-term policy, planning and investment frameworks. In this context, scaling does not imply the uniform replication of interventions, but the transfer and adaptation of effective approaches to new ecological, institutional and socio-economic contexts in the Danube basin. This perspective recognizes that successful solutions are context-dependent and require adjustments to remain relevant and effective (OECD, 2016).

Key activities in this phase include identifying opportunities to integrate actions into existing governance and funding mechanisms, such as river basin management

processes, national and regional strategies and relevant investment programmes. Strengthening links between innovators, public authorities and funding bodies is key to supporting the transition from pilot interventions to sustained and long-term implementation (OECD, 2015).

Long-term integration also involves institutionalizing learning and knowledge exchange processes. Good practices, tools and governance approaches developed through EcoDaLLi and in the Living Labs should be documented, systematized and made available to support continued uptake beyond the lifetime of the project. In this way, the Action Agenda contributes not only to short-term coordination, but also to strengthening the sustainable capacity to protect and restore freshwater ecosystems in the Danube basin.

### 5.4 Adaptive implementation and feedback loops

In all phases of the roadmap, adaptive implementation is a guiding principle. Freshwater ecosystems, as well as the governance frameworks associated with them, are subject to continuous change, and implementation pathways must remain responsive to new information, uncertainties and emerging challenges. Therefore, feedback loops connecting monitoring, evaluation, and decision-making are an integral part of the implementation process (Huitema et al., 2009; Folke et al., 2016).

Regularly reflecting on progress and adjusting actions based on results and lessons learned help to maintain the relevance and effectiveness of the Action Agenda in the long term. This adaptive approach is fully in line with the principles of the EU Mission 'Restoring our Ocean and Waters by 2030', which promotes lifelong learning, innovation and flexibility as key elements of systemic transformation. It also supports the long-term resilience of freshwater management and restoration efforts in the Danube basin.

## 6. Governance and roles

The effective implementation of the Action Agenda requires clear governance arrangements as well as well-defined roles between the actors involved, at different

levels and in different sectors. Given the transboundary nature of the Danube basin and the diversity of institutional and socio-economic contexts, governance is understood here not as a rigid structure, but as a flexible, multi-level framework capable of supporting coordination, learning and adaptation over time (Pahl-Wostl, 2009; OECD, 2015).

## 6.1 Multi-level governance framework

The governance of the protection and restoration of freshwater ecosystems in the Danube basin operates at interconnected levels, including the European level, the basin level, the national and regional levels, as well as the local level. The Action Agenda supports a multi-level governance model that promotes policy coherence, coordination of actions and the efficient flow of information between these levels.

At European level, the EU Mission 'Restoring our Ocean and Waters by 2030' provides the overall strategic guidance, while policy frameworks such as the Water Framework Directive and the EU Biodiversity Strategy for 2030 set common objectives and principles. At the Danube basin level, transnational coordination between river basin organisations and cooperation platforms is essential to address cumulative pressures and align cross-border actions (ICPDR, 2021).

National and regional authorities play a key role in translating strategic objectives into regulatory, planning and financing instruments, while local actors are essential for effective implementation and management on the ground. The interaction between these levels is crucial to avoid fragmentation and ensure the long-term impact of actions (Figure 2).

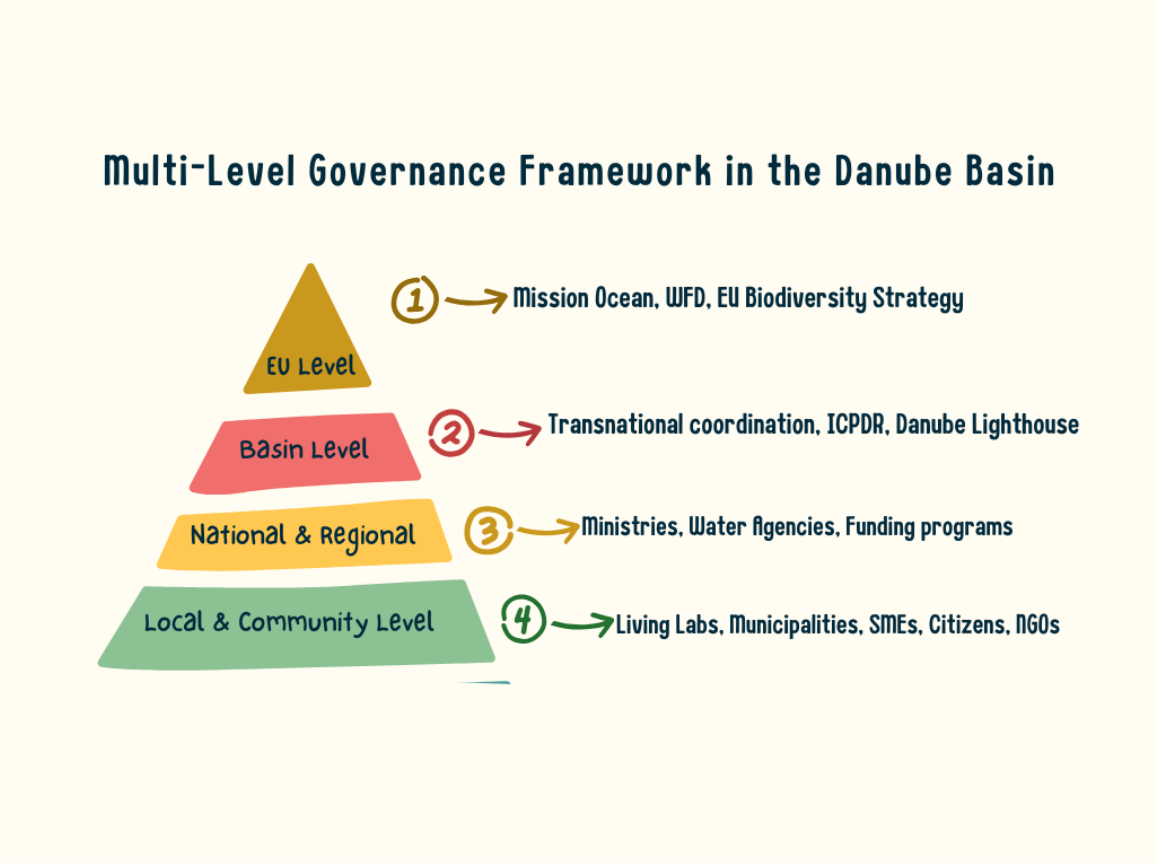


**Figure 2: Multi-Level Governance Framework in the Danube Basin**

## 6.2 Roles of key actor groups

The implementation of the Action Agenda is based on complementary contributions from several stakeholder groups.

Public authorities and river basin organisations are responsible for aligning policies, developing and enforcing regulatory frameworks, and coordinating restoration and management actions. Their role includes integrating the priorities of the Action Agenda into existing planning processes and facilitating cross-sectoral cooperation.

Research and innovation actors contribute scientific knowledge, technical expertise and innovative solutions, supporting the development, testing and refinement of interventions. They also provide evidence supporting informed decision-making and adaptive management of freshwater ecosystems (Cash et al., 2006).

Non-governmental organisations and civil society actors play an important role in advocacy, stakeholder engagement and local implementation. They often act as

intermediaries between authorities, communities and practitioners, facilitating the translation of strategic objectives into relevant actions at local level.

Local communities, land and water users, and practitioners are essential for implementation and long-term sustainability. Their involvement ensures that actions are anchored in local realities and supported by long-term ownership and management.

## 6.3 Role of EcoDaLLi and Living Labs

EcoDaLLi has acted primarily as a facilitative and coordinating mechanism within the governance landscape of the Danube Lighthouse, with a focus on enabling interaction rather than directly influencing decision-making structures. In line with its nature as a Coordination and Support Action, the project did not intervene in formal governance processes, but instead contributed to shaping the conditions under which coordination, knowledge exchange and innovation uptake could occur. This distinction is important, as it also defines the limits of its impact: while EcoDaLLi has strengthened dialogue and alignment, its ability to translate these into concrete governance changes remains indirect and dependent on external actors.

In practice, EcoDaLLi's role has been operationalised through stakeholder engagement processes, including validation workshops and thematic sessions across the Danube basin. These activities have generated a substantial amount of qualitative input, particularly in relation to governance gaps, policy inconsistencies and implementation barriers. The workshops confirmed recurring structural challenges, such as fragmentation between policy domains, limited financial instruments for scaling solutions, and insufficient stakeholder engagement, especially at local level. At the same time, they demonstrated that while stakeholder dialogue can effectively identify problems and refine recommendations, it does not automatically lead to their implementation. This highlights a key limitation of the EcoDaLLi approach: the project has been more effective in problem framing and consensus building than in enabling concrete follow-up actions.

Within this context, the Living Labs have functioned as the main operational interface between stakeholders and the governance framework. Their contribution has been significant in terms of process, providing structured environments for co-creation, experimentation and exchange. Evidence from project activities shows that Living Labs have successfully facilitated interaction across sectors and governance levels, and have supported the integration of scientific and local knowledge. However, their effectiveness has also depended on contextual factors, including stakeholder availability, institutional capacity and the degree of alignment with existing policy processes. In several cases, the Living Labs have remained primarily deliberative spaces, with limited capacity to influence decision-making beyond the project framework. This suggests that while they are valuable tools for participatory governance, their impact is contingent on stronger institutional anchoring and continuity beyond project timelines.

From a governance perspective, EcoDaLLi has therefore contributed most clearly to improving processes of interaction and learning, rather than to structural change. It has helped to clarify priorities, connect actors and articulate shared challenges, but it has not resolved key systemic issues such as fragmented governance, insufficient funding alignment or regulatory barriers. These findings point to a gap between coordination and implementation that remains largely unaddressed.

Looking ahead, the experience of EcoDaLLi indicates that a future Coordination and Support Action will need to move beyond facilitation towards a more implementation-oriented role. While maintaining the strengths of the current approach, particularly in stakeholder engagement and co-creation, the next phase will likely require stronger mechanisms to ensure that identified priorities are translated into concrete actions. This includes a more explicit linkage between coordination activities and funding instruments, as well as closer integration with policy and regulatory frameworks.

In this context, the Living Labs are expected to evolve from experimental and project-based environments into more stable governance components. For this transition to be effective, they will need clearer institutional roles, sustained resources and stronger connections to decision-making processes. Without such integration, there is a risk

that the knowledge and networks developed within the Living Labs remain underutilized once project support ends.

EcoDaLLi can be seen as a necessary but transitional step in the development of the Danube Lighthouse governance framework. It has provided a foundation in terms of stakeholder engagement, shared understanding and tested methodologies, but it has also exposed the limitations of a coordination-focused approach in the absence of stronger implementation mechanisms. A future CSA is therefore expected to build on these lessons by reinforcing the link between coordination, policy and implementation, and by supporting the long-term integration of Living Labs into the governance architecture of the Danube basin.

## 6.4 Flexibility and adaptive governance

Given the diversity of ecological and institutional contexts in the Danube basin, the governance framework promoted by this Action Agenda is intentionally flexible. Roles and responsibilities may vary depending on local capacities and governance arrangements should be adapted accordingly.

This approach supports adaptive governance, which emphasizes learning, adjustment and the ability to respond to change. By maintaining flexibility and integrating feedback from implementation, the Action Agenda supports the long-term resilience and effectiveness of efforts to protect and restore freshwater ecosystems in the Danube basin (Huitema et al., 2009; Folke et al., 2016).

# 7. Monitoring and adaptive management

Adaptive monitoring and management are essential components to ensure the effectiveness, relevance and robustness of the Action Agenda over time. Given the complexity of freshwater ecosystems and associated governance systems, monitoring is not approached exclusively as a technical exercise, but as a continuous learning process, designed to support decision-making and adjustment of interventions under conditions of uncertainty (Walters, 1986; Williams et al., 2007).

## 7.1 Monitoring principles

Monitoring under this Action Agenda should be aligned with existing frameworks, indicators and mechanisms, where possible, in order to avoid duplication of efforts and to ensure coherence with river basin management and biodiversity monitoring processes. Both quantitative and qualitative data are relevant as they allow capturing not only ecological changes, but also results related to governance, participation and institutional capacity.

Complementary monitoring approaches, including participatory methods and CGIS tools, can improve spatial and temporal coverage and provide valuable insights into local conditions and emerging pressures. The integration of these sources with formal monitoring systems contributes to a more comprehensive picture of the dynamics of freshwater ecosystems (Conrad & Hilchey, 2011). Transparency and accessibility of monitoring information are key to building trust and supporting the active involvement of stakeholders.

## 7.2 Adaptive management approach

Adaptive management is a fundamental principle of this Action Agenda. The actions proposed under the Priority Action Packages are not designed as fixed prescriptions, but as flexible interventions, which can be adjusted over time based on the results of monitoring, stakeholder feedback, and environmental and policy developments.

Adaptive management is based on iterative cycles of planning, implementation, observation and adjustment. By systematically linking monitoring results with decision-making processes, stakeholders can identify what works, what doesn't work and what causes them. This learning-oriented approach reduces the risks associated with uncertainty and increases the likelihood of achieving long-term objectives of ecosystem restoration and biodiversity conservation (Holling, 1978; Allen et al., 2011).

## 7.3 Learning and knowledge exchange

Learning and knowledge sharing are intrinsically integrated into adaptive monitoring and management processes. The experiences and lessons learned from Living Labs, pilot actions and stakeholder engagement should be systematically documented and shared across regions and stakeholder groups.

This knowledge exchange supports mutual learning, facilitates the replication of good practices and contributes to scaling up effective approaches in different contexts in the Danube basin. In this sense, monitoring is not only a tool for evaluation, but also a mechanism for building collective capacity and stimulating continuous innovation (Reed et al., 2010).

## 7.4 Long-term perspective

Adaptive monitoring and management go beyond the time horizon of individual projects. By integrating these principles into governance frameworks and implementation processes, the Action Agenda contributes to institutionalizing learning and building long-term capacity to protect and restore freshwater ecosystems in the Danube basin.

This long-term perspective is essential to cope with environmental change, socio-economic pressures and future uncertainties and is fully aligned with the approaches promoted under the EU Mission 'Restoring our Ocean and Waters by 2030'.

# 8. Implementation Enablers and Long-Term Sustainability

## 8.1 Key Performance Indicators (KPIs) and Measurable Progress

To move beyond vague adaptive statements, the implementation of this Action Agenda will be monitored using concrete KPIs derived from the project's Living Lab findings and spatial policy evaluations:

- **Ecological:** Number of floodplain hectares reconnected; number of targeted priority species showing population stabilization in pilot areas.
- **Governance & Participation:** Number of cross-border institutional agreements signed; number of active participants from the quadruple helix (research, governance, business, civil society) in Living Labs and citizen science (CGIS) initiatives.
- **Innovation & Scaling:** Number of innovative Nature-Based Solutions (NBS) successfully transferred from pilot stage (e.g., constructed wetlands) to regional implementation; number of new start-ups or SMEs engaged in restoration activities.

## 8.2 Funding and Financing Mechanisms

The transition from project-based coordination to long-term implementation requires robust financing. As extensively documented in the EcoDaLLi validation workshops (WP2) and spatial policy sessions (WP3), the lack of financial resources and the difficulty in monetizing the benefits of regulatory ecosystem services represent the primary barriers to NBS implementation. To overcome these economic barriers, the implementation of the PAPs will leverage:

- **Public and EU Funding:** Alignment with Horizon Europe, the LIFE Programme, and the European Regional Development Fund (ERDF) targeted at the Danube Region.
- **Private and Blended Finance:** Encouraging public-private partnerships (PPPs) and exploring green bonds and payment for ecosystem services (PES) schemes to finance nature-based solutions identified in PAP 1 and PAP 2.
- **EcoDaLLi Support:** Utilizing the networks built within the project to connect local developers with regional investors, and advocating for short-term financial incentives for landowners.

## 8.3 Risk Analysis and Mitigation Strategies

The EcoDaLLi validation workshops and Living Labs identified several systemic risks that could hinder implementation:

- **Risk: Lack of long-term funding post-EcoDaLLi.**
    - *Mitigation:* Early engagement with managing authorities of EU funds (ERDF, LIFE) to embed PAPs into regional operational programs.
- **Risk: Legal and Institutional Barriers (Property rights and land-use conflicts).**
    - *Mitigation:* Establish interdisciplinary working groups to harmonize sectoral policies at the national and EU levels, advocating for legal reforms that incentivize NBS-friendly land use rather than penalizing it.
- **Risk: Low stakeholder engagement and 'participation fatigue'.**
    - *Mitigation:* Utilizing the established Living Labs to maintain continuous, transparent, and mutually beneficial communication channels, while translating technical concepts into accessible language.
- **Risk: Data fragmentation across borders (PAP 3).**
    - *Mitigation:* Establishing strict data interoperability standards using open-source CGIS frameworks aligned with ICPDR guidelines.

## 8.4 Post-Project Sustainability and Continuation Framework

To ensure applicability post-2026, the governance mechanisms established by EcoDaLLi will be formally handed over to permanent regional bodies. The Living Labs are designed to transition into permanent regional innovation hubs under the umbrella of the ICPDR or macro-regional strategy (EUSDR) frameworks. Furthermore, the digital EcoDaLLi portal will be maintained as a centralized knowledge hub to facilitate ongoing best-practice transfer. This ensures that the dynamic and adaptive processes initiated by EcoDaLLi are institutionalized, transitioning from a temporary coordination action to a permanent basin-wide governance culture.

# 9. Conclusions

This Action Agenda provides a clear and action-oriented framework to support the protection and restoration of freshwater ecosystems and biodiversity within the Danube Lighthouse. It responds to the complexity and urgency of freshwater challenges through an integrated approach, bringing together ecological restoration, biodiversity recovery, data use and monitoring, governance and innovation uptake into a coherent set of Priority Action Packages.

Instead of replicating or replacing existing management strategies and plans, the Action Agenda complements them, transforming high-level objectives into operational directions for coordinated action. It highlights the importance of a basin-level perspective that takes into account ecological processes, governance structures and socio-economic realities, while remaining flexible enough to be adapted to the diverse local contexts in the Danube basin.

A defining element of this Agenda is the focus on participation, innovation and lifelong learning. Living Labs are positioned as central spaces for co-creation, experimentation and knowledge exchange, where stakeholders can explore solutions together, test new approaches and build governance arrangements adapted to the context. At the same time, digital and participatory tools, including Geographic Information Systems based on collective contributions, are recognized as important means for increasing transparency, engagement and adaptive management capacity.

The Action Agenda is conceived as a living document, open to evolution. The proposed actions and priorities are not final, but indicative, to be refined, validated and implemented through the continuous involvement of stakeholders and the future activities of EcoDaLLi. By providing a common strategic framework, the Agenda supports coordination, encourages the uptake of innovation and strengthens the long-term commitment to protecting freshwater ecosystems and restoring biodiversity in the Danube basin and beyond.

# Annex A – Priority Action Package (PAP) template

This annex provides a generic template to support the operationalisation and further development of Priority Action Packages proposed in this Action Agenda. The template is intended to be used and refined during implementation phases, including Living Lab activities and coordination with relevant stakeholders.

**Priority Action Package:**
**title**

**Objective:**
**Brief description of the main objective(s) of the action package.**

**Description and rationale:**
**Short explanation of the problem addressed, the rationale for action, and the relevance to freshwater ecosystem protection and biodiversity restoration.**

**Geographic scope:**
**Indication of spatial scale (local, regional, basin-wide) and geographic focus.**

**Key actions:**
**Overview of proposed actions and interventions.**

**Key stakeholders:**
**Identification of relevant actor groups (e.g. authorities, NGOs, research institutions, local communities, innovation actors).**

**Expected outcomes:**
**Description of anticipated ecological, governance, or socio-economic outcomes.**

**Indicative timeline:**
**Short-term, medium-term, and long-term perspectives.**

**Links to innovation and digital tools:**
**Potential links to innovation support services, CGIS, and other digital or participatory tools.**

**Validation status:**
**Indication of whether the action package is proposed, under validation, or operationalised.**

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