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Abbreviations and Acronyms

AC	Associated Country
BANOS	Baltic and North Sea
CSA	Coordination and Support Action
DG MARE	Directorate-General for Maritime Affairs and Fisheries
DRBMP	Danube River Basin Management Plan
EC	European Commission
EEA	European Environmental Agency
EG	Expert Group
EIB	European Investment Bank
ERDF	European Regional Development Fund
ES	Ecosystem Services
ETPS	Economical, Technical, Political and Social
EU	European Union
GES	Good Ecological Status
HE	Horizon Europe
HSM	Habitat Suitability Model
IA	Innovation Action
ICPDR	International Commission for the Protection of the Danube River
IUCN	International Union for Conservation of Nature
KER	Key Exploitable Results
KPI	Key Performance Indicator
M&E	Monitoring and Evaluation
MAG	Mission Action Group
MPA	Marine Protected Areas
MS	Member State
NBS	Nature-based solutions
NGO	Non-governmental Organisation
NGP	Austrian National Water Management Plan
NRR	Nature Restoration Regulation
OECD	Organisation for Economic Co-operation and Development
PESTEL	Political, Economical, Social, Technical, Ecological and Legal
R&I	Research and Innovation
RRF	Recovery and Resilience Facility
SDG	Sustainable Development Goal
SMART	Specific, Measurable, Attributable, Realistic and Time-bound
ToC	Theory of Change
UN	United Nations
UNDAF	United Nations Development Assistance Framework
UNEA	United Nations Environment Assembly
WebGIS	Web-based Geographic Information System
WFD	Water Framework Directive
WISE	Water Information System for Europe
WP	Work Package

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Executive Summary

This deliverable presents the monitoring framework developed by the EcoDaLLi project to support the implementation of the EU Mission *"Restore our Ocean and Waters by 2030"* within the Danube River Basin Lighthouse. As the Mission seeks to drive systemic transformation across Europe's aquatic environments, a robust monitoring system is essential to ensure that Mission-funded activities deliver measurable progress toward ecological restoration, pollution reduction, and the advancement of a sustainable blue economy.

The report outlines the conceptual foundations of the framework, drawing on established approaches in Monitoring and Evaluation (M&E), adaptive governance, and systems thinking. Central to this foundation is the Theory of Change (ToC), which is used to map the causal pathways from project activities to expected outcomes and long-term impacts.

To provide a comprehensive assessment of both external drivers and internal transformational processes, the deliverable applies two complementary analytical frameworks:

- the PESTEL analysis, which examines political, economic, social, technological, environmental, and legal factors influencing project implementation and Mission progress; and
- the Pillars framework proposed by the European Commission Expert Group, which evaluates whether the internal enabling conditions for systemic transformation are being met.

The monitoring framework developed in EcoDaLLi is explicitly positioned within the broader ecosystem of Mission monitoring initiatives. It complements the EEA/DG MARE official Mission Monitoring Framework, which provides the centralised, indicator-based system at EU level, as well as the Danube Lighthouse Baseline Study (2023), which establishes regional reference conditions and identifies data gaps. EcoDaLLi's KPI system strengthens this architecture by offering project-level, innovation-oriented indicators that can be integrated into these existing EU structures.

A Task Force, comprising EcoDaLLi, Innovation Action projects, and other Mission Coordination and Support Actions, ensured harmonisation of KPI requirements and facilitated collaboration across the Danube Lighthouse and other Mission initiatives. The methodology included desktop review, consultations, KPI mapping, and thematic grouping, resulting in a structured KPI dataset to assess project contributions.

The methodological approach followed four phases: a desktop review; Task Force coordination and consultations; KPI mapping to PESTEL dimensions; and the grouping of KPIs into thematic Pillars aligned with the ToC. The resulting KPI set provides a structured and comparable dataset that enables transparent assessment of project contributions to Mission objectives.

The analysis reveals strong indicator coverage in ecological and technological domains, while highlighting gaps in governance, socio-economic, and stakeholder engagement dimensions. These findings emphasise the need for continued alignment among Mission actors, enhanced integration of citizen and stakeholder-generated data, and increased support for monitoring capacities across regions.

Overall, Deliverable D7.2 provides a comprehensive and theoretically grounded monitoring framework for the Danube Lighthouse. By integrating project-level KPIs, cross-basin coordination, and structured Task Force collaboration, EcoDaLLi contributes significantly to the Mission's ability to assess progress, learn from implementation, and support the action toward restoring Europe's ocean and waters by 2030.

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1. Introduction

1.1. The EU Missions

The concept of the European Union's (EU) Missions emerged as a response to the growing recognition that traditional research and innovation programmes were not sufficient to address the complex, interlinked challenges facing society. Rather than focusing just on generating scientific knowledge or technological progress, the Missions were conceived as instruments for achieving measurable societal transformation. They represent a shift in European policy from supporting isolated projects toward mobilising collective efforts across disciplines, sectors, and governance levels. The underlying motive is to direct research and innovation toward concrete goals that respond to pressing global issues - such as climate change, health, sustainable cities, and environmental resilience - while fostering citizen engagement and social inclusion (European Commission. Directorate General for Research and Innovation., 2023).

One main objective of the Missions is to bridge the gap between research policy and societal needs. Traditional R&I frameworks often produce excellent scientific results but struggle to translate these into large-scale societal impact. The Missions seek to overcome this by setting clear, time-bound objectives that connect research outputs to real-world outcomes. Each Mission is framed around a transformative goal, such as making cities climate neutral or improving soil health by 2030. These objectives serve as rallying points for a wide array of actors, such as scientists, policymakers, businesses, local governments, and citizens and encouraging them to work together toward a shared vision. The ambition is not merely to generate new knowledge, but to orchestrate systemic change in how Europe approaches sustainability, health, and innovation (European Commission. Directorate General for Research and Innovation., 2023).

A key motivation behind the Missions is to foster integration across policy domains. Many societal challenges cut across the boundaries of traditional sectors, requiring coordinated solutions that combine technological innovation, policy reform, behavioural change, and institutional adaptation. The Missions therefore aim to act as connectors, linking different areas of public policy - such as research, environment, industry, agriculture, and digitalisation - under a common purpose. This cross-sectoral approach is designed to maximise the coherence and impact of European investments, ensuring that innovation contributes directly to public goods and long-term sustainability objectives (European Commission. Directorate General for Research and Innovation., 2023).

The Missions are also driven by the recognition that transformative change requires action at multiple levels of governance. Global challenges often manifest locally, and local solutions can feed back into European and global progress. For this reason, the Missions are structured to involve actors at the EU, national, regional, and local levels, creating a dynamic governance ecosystem. This multi-level collaboration is intended to strengthen the alignment of European strategies with national and regional priorities, thereby improving the effectiveness and legitimacy of public action. It also ensures that citizens and local communities play an active role in shaping and implementing solutions, reinforcing the democratic dimension of European innovation policies (European Commission. Directorate General for Research and Innovation., 2023).

Another motivating factor is the desire to extend the reach of European research and innovation beyond the boundaries of the Horizon Europe framework. The Missions are not confined to a single funding programme; rather, they are conceived as broad, policy-driven initiatives capable of mobilising resources from diverse sources - other EU programmes,

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national budgets, regional funds, and private investment. This “beyond Horizon Europe” approach reflects the understanding that addressing major societal challenges requires leveraging all available capacities and aligning them toward common goals. It also reflects a transition from considering research funding as an end in itself to employing it as an instrument for broader policy and societal transformation (European Commission. Directorate General for Research and Innovation., 2023).

The Missions embody an experimental spirit, recognising that transformative change cannot be planned in a linear way. Instead of prescribing fixed solutions, they promote learning, adaptation, and feedback throughout the policy cycle. This approach acknowledges that progress toward ambitious goals such as climate neutrality or healthy oceans will involve uncertainty, iteration, and continuous coordination among diverse stakeholders. By integrating adaptive governance into their design, the Missions aim to remain responsive to evolving knowledge, technological developments, and societal expectations (European Commission. Directorate General for Research and Innovation., 2023).

A further underlying motive is to reorient innovation policy toward inclusivity and citizen engagement. The Missions recognise that lasting change depends on public trust and participation. By involving citizens not only as beneficiaries but as co-creators of solutions, they aim to democratise innovation and make European policies more responsive to everyday needs. This participatory approach reinforces the social legitimacy of the Missions, helping to ensure that technological advances translate into socially accepted and equitable outcomes.

Ultimately, the EU Missions were created as instruments to make research and innovation more purposeful, coherent, and impactful. They express a political and scientific commitment to use Europe’s collective knowledge and resources to achieve visible improvements in people’s lives and in the sustainability of the planet. The motive is not only to fund excellent science but to mobilise it in the service of shared societal goals—turning the abstract idea of “innovation for the public good” into a tangible and measurable reality (European Commission. Directorate General for Research and Innovation., 2023).

1.2. EU Mission “Restore our Ocean and Waters 2030”

The health of our ocean and freshwater ecosystems is deteriorating due to pollution, overexploitation, habitat destruction, and climate change. Recognizing the urgent need for action, the EU launched the Mission "Restore Our Ocean and Waters by 2030" as part of the Horizon Europe framework. The Mission "Restore Our Ocean and Waters by 2030" is an ambitious initiative to protect and restore marine and freshwater ecosystems, prevent pollution, and support sustainable blue economies. Given the complexity of environmental challenges, co-creation and co-governance are essential to achieving the mission’s targets (European Commission. Directorate General for Research and Innovation., 2023).

The Mission "Restore Our Ocean and Waters by 2030" exemplifies a novel governance approach that embraces co-creation and co-governance. To maximize its impact, policymakers should:

1. Institutionalize participatory governance mechanisms at all levels.
2. Increase financial and technical support for stakeholder-driven projects.
3. Enhance data accessibility and knowledge-sharing platforms.
4. Foster cross-sectoral synergies to bridge science, policy, and practice.

By embedding co-creation and co-governance at the heart of the mission, the EU wants to catalyse transformative change and ensure the long-term resilience of its aquatic ecosystems.

The Mission's objectives and targets (European Commission. Directorate General for Research and Innovation., 2023)

The Mission is structured around three core objectives:

1. Protect and Restore Marine and Freshwater Ecosystems: Improve biodiversity, restore degraded habitats, and enhance ecosystem resilience.
2. Prevent and Eliminate Pollution: Reduce plastic waste, chemical pollution, and nutrient runoff to achieve good environmental status for aquatic ecosystems.
3. Support a Sustainable Blue Economy: Foster innovative and sustainable business models that balance economic growth with environmental conservation.

The Mission is implemented through lighthouse initiatives in key European sea and river basins, leveraging cutting-edge science, data-driven decision-making, and cross-sectoral collaboration.

Co-creation refers to the active involvement of stakeholders in designing, implementing, and evaluating solutions. In the context of the mission, co-creation ensures that:

- Solutions are grounded in local knowledge and practices.
- Stakeholders have shared ownership over the outcomes.
- Innovations address real-world challenges and are scalable.

Examples of co-creation within the mission include citizen science initiatives, public-private partnerships, and collaborative policy design.

Co-governance is critical for managing complex socio-ecological systems. It involves:

- Multi-Level Governance: Aligning policies across local, national, and EU levels.
- Stakeholder Networks: Engaging NGOs, indigenous communities, academia, and industry.
- Adaptive Management: Using real-time data and feedback loops to adjust strategies dynamically.

By distributing responsibilities among actors, co-governance fosters more resilient and effective policy frameworks.

While co-creation and co-governance provide a pathway to systemic transformation, they also present challenges:

- Coordination Complexity: Balancing diverse interests and governance structures.
- Data Integration: Ensuring interoperability of environmental monitoring systems.
- Long-Term Commitment: Maintaining stakeholder engagement beyond project cycles.

Overall, the Mission aims to create a shared vision that integrates the management, restoration, and sustainable use of water resources—including flood management and other related needs—into a coordinated and future-oriented strategy (Haapasaari et al., 2024). This vision seeks to define clear sector-specific objectives and actionable measures to bring it to life.

Collaboration is a central element, promoting active and innovative approaches to water governance and encouraging private actors to engage in planning and take shared responsibility for implementing management measures and investments. A holistic, integrated perspective is seen as essential to achieving the goals of the Water Framework Directive (WFD).

However, the Mission's ambition to generate social, political, and intellectual benefits for the environment is fraught with uncertainty. Watershed issues are inherently complex, shaped by diverse factors, and the environmental outcomes, particularly long-term impacts, often remain distant and difficult to evaluate. This uncertainty can undermine the mission's credibility and societal legitimacy, reduce funding opportunities, and weaken stakeholder motivation and engagement.

A more robust understanding of the causal pathways linking the Mission to its intended impacts, as well as how observed outcomes can inform the refinement of the Mission, is essential.

This deliverable aims to address this need through the following components:

- **Theoretical foundation:** An overview of key theories related to the governance of common-pool resources, with a focus on water systems.
- **Framework development:** Construction of a theoretical framework that shows the pathway to impact, grounded in a Theory of Change (ToC) approach; application of monitoring concepts to assess activities, outputs, outcomes, and long-term impacts.
- **Indicator methodology:** Definition of a methodology for the selection and collection of indicators aligned with the Mission's objectives.
- **Practical illustrations:** Presentation of exemplary indicators derived from EcoDaLLi and the Innovation Action (IA) projects. These are projects that develops and applies new technologies, methods, or approaches in real settings to address societal, environmental, or economic challenges.
- **Comparative analysis:** Examination of existing monitoring frameworks implemented in other Coordination and Support Actions (CSAs) and related initiatives.
- **Challenges and considerations:** Discussion of methodological challenges, including the selection, number, and comparability of indicators across contexts.

1.3. EcoDaLLi Project

The 2030 and 2050 Green Deal goals drive the EU towards developing integrated, forward-looking solutions and setting clear, measurable targets for environmental sustainability. Within this context, EcoDaLLi, as part of the EU Mission "Restore our Ocean and Waters by 2030", plays a pivotal role in supporting the achievement of the freshwater-related objectives of the European Green Deal. The initiative embraces a systemic and holistic approach to the restoration, protection, and long-term preservation of the entire Danube Basin. This is pursued through a framework of coordinated actions that link environmental, social, and economic dimensions in an integrated governance structure.

EcoDaLLi is Coordination and Support Action (CSA) type and is designed to deliver a series of tools, guidelines, methodologies and recommendations tested through pilot activities, which will interlink, leverage and optimize activities among the projects funded under the Mission Ocean & Waters (Bjørkan, et al., 2023). The main objective of EcoDaLLi as a CSA

(Coordination and Support Action) is to centralise and strengthen governance structures across the Danube region, focusing on innovative, science-based solutions that enhance ecological restoration, safeguard biodiversity, and ensure the sustainable management of the Danube Basin and its Delta. To achieve this, EcoDaLLi aims to foster a dynamic and interconnected innovation ecosystem through the establishment of a comprehensive Practices Living Lab System, promoting collaboration among stakeholders, researchers, and policymakers. This system will be supported by a dedicated digital Portal, fully integrated with the Mission Implementation Platform and aligned with the principles of the Mission Charter, ensuring coherence, accessibility, and long-term impact.

Task 7.2 of WP 7 focuses on the development and implementation of a comprehensive Monitoring Framework to assess progress toward the objectives of the EU Mission “Restore our Ocean and Waters by 2030”. This task is dedicated to designing a structured system of Key Performance Indicators (KPIs) and assessment methodologies that allow for systematic monitoring of the project’s impacts across environmental, social, and innovation dimensions. It ensures that EcoDaLLi’s activities - ranging from ecological restoration and biodiversity protection to innovation ecosystem building - are effectively contributing to the overall goals of the European Green Deal and the Mission Charter. Through Task 7.2, EcoDaLLi establishes a transparent, evidence-based approach to performance measurement, enabling continuous feedback, adaptive management, and knowledge exchange among stakeholders. Furthermore, the outcomes of this monitoring framework feed directly into the project’s governance and decision-making processes, providing policy-relevant insights and ensuring that all restoration and innovation actions within the Danube Basin remain aligned with the Mission Implementation Platform.

1.4. Overview of the Deliverables Purpose and Audience

This deliverable first outlines the theoretical framework and the importance of monitoring, before presenting the various monitoring frameworks developed to support the effective implementation of the Mission “Restore our Ocean and Waters by 2030”. It then details the methodology used to collect and analyse Key Performance Indicators (KPIs) provided by the Innovation Action projects within the Danube lighthouse.

The main purpose of this deliverable is to provide both an overview of existing monitoring approaches and a practical system for collecting, analysing, and sharing information on Mission progress. The collected KPIs are intended to track results, inform decision-making, and ensure that the Mission remains on course over time. By employing a consistent set of KPIs, progress can be assessed in a transparent and comparable manner. Regular collection and review of this information allows the Mission to identify areas of success, as well as areas where additional efforts or adjustments may be needed. Where relevant, these indicators can also be integrated into existing monitoring frameworks developed by the EC Expert Group or EEA/DG MARE (see chapter 3).

This monitoring and evaluation framework is designed to be accessible to educated non-experts and to all actors engaged in the EU Mission *“Restore our Ocean and Waters by 2030,”* with a particular focus on those involved in the design, implementation, and assessment of Mission activities within the Danube Lighthouse. Because Mission implementation spans multiple domains—including ecology, hydrology, innovation, governance, socio-economics, and citizen engagement—no single stakeholder group possesses expertise across all areas. This framework therefore provides clear guidance on the purpose of monitoring, the development of Mission-aligned M&E plans, the selection and application of KPIs, and effective data management practices.

The framework serves as a practical tool for planning, coordinating, and evaluating Mission-related actions. It aims to foster a shared understanding of monitoring requirements and support consistent reporting across the Danube Basin. Key user groups include:

- **Public authorities, river basin managers, and policy-makers** involved in water management, restoration planning, and the implementation of regional and national strategies. The framework supports the development of coherent monitoring plans, tracks progress toward Mission targets, and informs evidence-based decision-making.
- **Innovation Action projects and the scientific community** contributing to research, restoration, and innovation activities. This group benefits from harmonised KPI structures, methodological guidance, and insights into best practices for data collection, analysis, and reporting.
- **Businesses, SMEs, and nature-based or technology-oriented enterprises** engaged in the development or deployment of Mission-relevant solutions. The framework clarifies how innovation outcomes can be monitored and communicated, supporting alignment with EU sustainability objectives and investor expectations.
- **Non-governmental organisations, local stakeholders, and civil society**, including citizen science groups. The framework offers accessible guidance for understanding Mission impacts, contributing data, and participating in collaborative monitoring processes.

2. Theoretical Background

The theoretical roots of environmental monitoring frameworks are deeply intertwined with the concept of collective resource management and the challenges inherent to it. The “tragedy of the commons,” as articulated by Hardin (1968), remains one of the most influential frameworks for understanding why environmental degradation occurs when shared resources lack collective oversight. When a resource is held in common, individuals acting rationally in their own interest may overexploit it, leading to its depletion—a pattern already observed by Aristotle, who noted that what belongs to the greatest number receives the least care. This conceptual foundation underscores the necessity of developing effective monitoring systems: to provide structure, accountability, and shared metrics that transform diffuse responsibility into collective stewardship.

Within the context of the EU Missions—particularly those focused on environmental restoration, ocean health, and climate resilience - the monitoring framework acts as both a coordination mechanism and a safeguard against this tragedy. It allows stakeholders to define common goals, measure progress, and evaluate the effectiveness of interventions in a transparent and harmonised way. In the absence of robust monitoring, even well-intentioned initiatives risk fragmentation, inefficiency, and ultimately, a failure to deliver systemic change.

2.1. Importance of Monitoring and Evaluation (M&E)

Monitoring and evaluation (M&E) systems serve as foundational tools for evidence-based policymaking and adaptive governance. They allow for the translation of complex, multidimensional interventions into measurable indicators that inform decision-making and accountability. However, designing a monitoring framework for EU Missions—characterised by their cross-sectoral, multi-level, and transnational nature—introduces unique theoretical and operational challenges.

Unlike traditional project-based monitoring, the EU Missions approach aims for transformative, system-wide impact. This requires a framework capable of integrating scientific, socio-economic, and policy dimensions; harmonising data across scales; and accommodating long-term trajectories of change. The theoretical challenge lies in reconciling two key tensions: (i) the need for comparability and standardisation across regions, and (ii) the recognition of local specificity and diversity in implementation (Reid et al., 2023).

Thus, the theoretical underpinning of the EU Monitoring Framework is rooted in the concept of *adaptive governance*—a governance mode that values learning, iteration, and feedback loops. It also aligns with the principles of *systems thinking*, acknowledging that interventions operate within complex and interdependent ecological and socio-economic systems (Reid et al., 2023).

Monitoring constitutes a fundamental component of environmental governance and policy implementation within the European Union. It provides an essential basis for environmental protection, strategic decision-making, compliance assurance, and adaptive management across a broad range of sectors—from complex ecological restoration initiatives to industrial operations, such as port management and maritime transport.

Monitoring enables systematic observation, measurement, and evaluation of progress towards defined objectives and facilitates the evidence-based adaptation of actions and policies. Its importance can be structured into three interrelated areas: **(I)** Environmental Protection and

Mitigation (Bilgram et al., 2025), **(II)** Strategic Management and Accountability (Tadaki, 2024), and **(III)** Adaptive Management and Project Validation (Puig & Darbra, 2024).

I. Environmental Protection and Mitigation

In sectors associated with significant environmental impacts, such as ports and coastal industries, monitoring and assessment play a critical role in mitigating adverse effects on ecosystems and local communities. Continuous and systematic monitoring supports the EU's broader environmental and sustainability objectives, including pollution prevention, biodiversity conservation, and climate action.

Key functions and benefits of environmental monitoring include the mitigation and quantification of environmental pressures, protection of public health, and support for sustainable resource management. Monitoring enables the identification and reduction of pollution, habitat degradation, and other human impacts, contributing to the sustainable development of ports and coastal areas. It supports air quality and noise control, helping reduce emissions from maritime activities and safeguard both aquatic life and nearby communities.

Regular monitoring of water, sediment, and biodiversity ensures the protection of aquatic ecosystems, alignment with the EU Water Framework Directive, and early detection of invasive species. It also underpins climate action and energy efficiency by tracking emissions and resource use, contributing to the EU's climate neutrality goals. Finally, long-term and continuous monitoring enhances understanding of environmental change, providing essential data on ecosystem health and supporting evidence-based management of aquatic and coastal environments.

II. Strategic Management and Accountability

Monitoring is an essential tool for the effective management, implementation, and oversight of policies, programmes, and projects. It ensures that strategic objectives are translated into measurable outcomes and provides the necessary data to support transparency and accountability.

Key functions of the monitoring framework include tracking progress, supporting data-driven decision-making, establishing baselines, and ensuring system compliance.

Monitoring uses Key Performance Indicators (KPIs) to quantify progress towards strategic goals, identify areas for improvement, and guide resource allocation. It ensures that decision-making is based on reliable data, providing actionable insights into environmental and economic trends. In line with the European Green Deal's call for "knowledge for action," the framework delivers the evidence needed to support sustainable policy transitions.

By establishing baselines, the framework defines reference conditions against which progress can be measured, particularly in the context of the blue economy and sustainable development. Finally, systematic monitoring supports good administrative practice, ensuring compliance through regular reviews, risk assessments, and transparent oversight of project implementation.

III. Adaptive Management and Project Validation

For complex and long-term projects, monitoring provides the feedback mechanism necessary for adaptive management, validation of underlying assumptions, and iterative improvement.

Many ecological and social outcomes require extended time horizons to become evident; hence, continuous monitoring ensures that projects remain responsive and effective throughout their lifecycle.

Core elements of the monitoring framework include adaptive management, validation of assumptions, structured evaluation, and long-term continuity. Monitoring enables timely adjustments to respond to emerging developments, ensuring flexibility and resilience. It provides evidence to test and refine assumptions within frameworks such as the Theory of Change, thereby strengthening the credibility of interventions. Through measurable indicators, it supports systematic evaluation of outcomes against objectives. Finally, integrating long-term monitoring from the outset ensures continuity of data collection, captures delayed impacts, and promotes institutional learning for future planning.

2.2. Challenges in Implementing M&E

Despite the conceptual clarity of these principles, the implementation of a coherent and functional monitoring system is fraught with multiple layers of difficulty. These challenges can be grouped into four main categories: (I) data and information constraints, (II) conceptual and definitional hurdles, (III) systemic and institutional limitations, and (IV) methodological difficulties (Bilgram et al., 2025; European Commission. Directorate General for Research and Innovation., 2021; Hasler-Sheetal & Moguedet, 2024; McQuaid et al., 2021; Tadaki, 2024).

I. Data and Information Challenges

At the core of any monitoring framework lies the availability, quality, and accessibility of data. Yet, across the blue economy and environmental domains, data-related barriers are both persistent and pervasive.

- Data Scarcity and Accessibility: Many relevant datasets are either incomplete, proprietary, or inaccessible for automated use. Even when open data exist, they often require manual evaluation or interpretation (e.g., maritime spatial plans).
- Lack of Standardisation: Data are collected using inconsistent methodologies across Member States and regions, leading to fragmentation that undermines comparability.
- Reliability and Consistency: Variability in data collection practices raises concerns about the credibility of certain indicators, affecting the robustness of long-term assessments.
- Long-Term Data Gaps: Environmental and restoration outcomes often manifest over decades, yet sustained monitoring funding is rare, resulting in discontinuous datasets and an incomplete evidence base.

II. Conceptual and Definitional Hurdles

Beyond data, theoretical clarity is required in defining *what* is to be measured and *how* success is to be interpreted.

- Absence of Clear Targets: Many Mission-related projects lack specific, quantifiable goals, impeding the evaluation of outcomes and overall Mission success.
- Ambiguity of KPIs: Indicators often remain too broad or qualitative to be operationalised. For instance, measuring nutrient uptake in aquatic systems or biodiversity enhancement in restoration projects requires agreed methodological protocols.
- Lack of Consensus: The conceptual ambiguity around terms such as “Nature-based Solutions” or “circularity” leads to divergent interpretations across projects.
- Missing Policy Linkages: Some thematic areas—particularly freshwater ecosystems and circular economy dimensions—remain underrepresented in current indicator systems, limiting holistic assessments.

These conceptual limitations reveal a fundamental tension between scientific precision and policy pragmatism: monitoring frameworks must be rigorous enough to be credible yet flexible enough to remain policy-relevant.

III. Systemic, Institutional, and Resource Constraints

Monitoring operates within administrative and governance ecosystems that shape what can be achieved in practice.

- **Financial and Institutional Barriers:** Limited long-term funding and institutional fragmentation often interrupt monitoring continuity. This is particularly problematic for ecological restoration, where impacts unfold over long time horizons.
- **Coordination and Integration:** Effective monitoring requires integrating environmental, social, and economic data—yet regional actors often work in isolation. Cross-sectoral coordination remains a structural weakness.
- **Attribution of Results:** In complex systems, it is difficult to directly attribute observed changes to specific actions or interventions. This complicates both accountability and learning.
- **Varying Readiness Levels:** Different sectors, regions, and stakeholders exhibit uneven capacities for monitoring, affecting comparability and data quality.

These challenges highlight that a monitoring framework is not only a technical tool but also a governance instrument, requiring sustained institutional commitment and multi-level coordination (for more details, see EcoDaLLi's D2.1 report on "Methodology for Mission Relevant NBS Assessment" by Martinov et al. (2024) as well as Digest of "Engaging Citizens with Mission Ocean and Waters: A toolbox of approaches" by Martinov et al. (2024)).

IV. Methodological Difficulties in Framework Development

Even the process of developing a monitoring framework presents its own methodological obstacles.

- Inconsistent Stakeholder Engagement: Expert participation varies in quality and representativeness, leading to imbalances in sectoral perspectives.
- Low Participation Rates: Limited feedback during validation phases can undermine confidence in the proposed indicators.
- Lack of Clarity on Purpose: Stakeholders often express uncertainty about the end-use of KPIs—whether they serve accountability, learning, or funding justification purposes.

Such methodological issues underscore the importance of transparent communication, co-creation, and iterative testing in framework design. Monitoring must be understood as a *living process*, continually refined through use and learning rather than a static system defined ex ante (Pott et al., 2025).

Importance of Monitoring

Monitoring is very important for EU Missions because it helps guide their progress, show results, and learn from what works and what doesn't. EU Missions aim to tackle big, complex challenges, and success depends not only on funding projects but on changing how policies work, involving the right people, and coordinating efforts across EU, national and regional levels. Monitoring helps track these changes, spot problems early, and adjust actions so that the Missions stay on track. It also builds trust by showing stakeholders and citizens that the work is making a difference and that resources are being used well.

Monitoring frameworks are needed to make this process organized and clear. They provide a structure for collecting and analysing information consistently, so progress can be compared across different Missions and countries. Frameworks include both numbers and stories, looking at results as well as how projects are carried out, how stakeholders are involved and how policies are aligned. They also make sure monitoring connects with existing systems but adds a focus on bigger-picture changes. Flexible frameworks can adapt as the Missions develop, helping ensure monitoring isn't just a formality but a useful tool for guiding, improving and showing the impact of EU Missions.

2.3. The Temporal and Spatial Dimensions of Monitoring

The consideration of temporal and spatial dimensions is fundamental to the design of effective monitoring frameworks. These dimensions shape how progress, change, and impact are observed and interpreted over time and across different geographical contexts. Integrating them requires clear conceptual planning, the application of advanced technologies, and the strategic definition of indicators that align with various time horizons and spatial scales. Both dimensions must be embedded from the conceptual stage - such as within a Theory of Change (ToC) - to the implementation phase, where standardized data collection and multi-level governance are essential (Carvalho et al., 2022).

Temporal Dimensions

Monitoring frameworks for large-scale initiatives, including ecosystem restoration projects and EU Missions, must explicitly distinguish between short-, medium-, and long-term perspectives to capture the non-linear nature of change (Hasler-Sheetal & Moguedet, 2024). Short-term effects, or outputs, refer to the immediate deliverables and direct results of project activities. In the context of freshwater restoration, this period is typically defined as up to five years after implementation, and indicators can often be reported within the first year. Medium-term outcomes describe changes or benefits arising from these outputs and represent the effects on direct participants or sectors (Pott et al., 2025). Depending on the ecosystem, this horizon usually extends to around ten years, though in some river restoration cases it can reach beyond that. Long-term impacts encompass broader societal, environmental, or economic transformations that emerge only after extended periods, often exceeding a decade. These may include tertiary or systemic effects that are difficult to measure within a single project cycle. In Horizon Europe frameworks, data on such impacts are expected to become more complete only after 2030 (European Commission, 2023a).

The ToC provides a structured way to link activities with these time-sensitive effects. By mapping short-, medium, and long-term changes, it ensures that progress is assessed against measurable, time-bound targets consistent with SMART (Specific, Measurable, Attributable, Realistic and Time-Bound) principles (European Commission. Directorate General for Research and Innovation., 2021).

Spatial Dimensions

Monitoring also requires explicit consideration of spatial scale and contextual specificity. The first step is to define the appropriate unit of analysis, which could be an ecosystem, a sector, or a particular governance level. Understanding this scope clarifies the boundaries within which monitoring operates. Environments can be conceptualized as layered systems, ranging from the local or project level through regional and national to global scales (Bilgram et al., 2025). Effective frameworks, therefore, need to account for the interplay between these governance layers, ensuring consistency and comparability.

While globally standardized indicators support cross-country comparison, they may overlook site-specific ecological and socio-economic realities. Local relevance is best ensured through context-sensitive approaches, often using participatory methods such as living labs that engage local stakeholders in co-design and validation (Bilgram et al., 2025). Furthermore, many ecological systems, particularly river basins, extend across administrative or national boundaries. In such transboundary contexts, harmonized data collection is essential to achieve comprehensive regional assessments, as demonstrated in initiatives such as the BANOS (Baltic and North Sea) area collaboration (Hasler-Sheetal & Moguedet, 2024).

Methodological and Technological Approaches

Capturing the temporal and spatial complexity of ecosystems requires a combination of methodological and technological tools. Continuous monitoring systems provide insights that go beyond one-time sampling; for example, tracking pollutants like trace metals or organotin compounds in port areas reveals temporal variations and spatial distribution patterns that static assessments cannot. Advanced systems such as the Parallel Intelligent Monitoring System integrate real-time data and predictive modelling to support dynamic pollution management.

Spatially explicit information is increasingly obtained through satellite imagery, drone surveys, ground sensors, and citizen science applications. Combining these data sources with in situ sampling improves model accuracy and allows for the prediction of variables such as chlorophyll-a concentrations, which are important for assessing aquatic productivity and sustainable aquaculture planning. Georeferenced data systems like WebGIS enable visualisation of spatial patterns, while Habitat Suitability Models (HSMs) help to identify species distributions and potential shifts under multiple stressors. Such predictive modelling extends monitoring from retrospective analysis to future-oriented assessment.

Establishing a clear and multidimensional baseline is also essential. Defining a reference point, such as the mission's start year, allows progress to be measured consistently across different sectors and readiness levels, enabling longitudinal and spatial comparisons (European Commission. Directorate General for Research and Innovation., 2021).

2.4. The Theory of Change approach

Due to the Mission's broad and holistic character, measuring outcomes remains challenging, particularly at the social, political, and intellectual levels. Water-related issues, for example, are influenced by multiple interdependent factors, and the resulting environmental impacts often occur over extended timeframes. Such uncertainty may affect the perceived credibility and legitimacy of the Mission, potentially influencing funding continuity and stakeholder engagement. A clearer understanding of the causal pathways from Mission activities to desired impacts is therefore essential for strengthening both accountability and confidence in outcomes.

The Theory of Change (ToC) provides a conceptual and theoretical framework to explain how and why specific initiatives are expected to achieve their intended outcomes. It establishes a systematic and cumulative approach that links project activities, outputs, and outcomes within their contextual settings. In doing so, the ToC supports a better understanding of causal pathways and the mechanisms that drive change (Thornton et al., 2017).

The ToC approach responds directly to the growing need for reliable information on whether initiatives are achieving their intended results. It also facilitates the generation of new scientific and empirical knowledge that can inform the design and implementation of future actions. In the context of the Mission, the ToC outlines how research and innovation activities contribute

to societal, economic, and environmental transformation, taking into account the relevant actors, contextual factors, and the logical sequence of cause–effect relationships.

The ToC can be conceptually divided into two main components: **(i)** the *Problem Analysis* and **(ii)** the *Impact Pathway*. Together, these elements define the foundation for both project design and subsequent evaluation (Thornton et al., 2017).

(i) Problem Analysis

The first component involves a joint effort to identify *what* problem is being addressed, *whose* problem it is, and *how* the desired change is expected to be achieved through project activities. This phase defines the underlying societal challenges and articulates the desired impacts.

The problem analysis establishes the intended outcomes and corresponding activities necessary to achieve them, while identifying the internal and external factors that may influence implementation success. This process sharpens both the planning and the execution of the initiative by highlighting causal relationships, identifying knowledge gaps, and clarifying the logic behind intervention choices.

(ii) Impact Pathway

The second component of the ToC is the *Impact Pathway*, which visualises the sequence of changes from research activities to their expected impacts. It illustrates how project outputs are expected to contribute to behavioural, institutional, or systemic changes among key stakeholders.

Within this pathway, monitoring and data collection are integrated to support evaluation processes and track progress. It is important to note that the ToC itself is not a stand-alone evaluation method but rather a framework that draws on a variety of established methodologies to test assumptions and assess effectiveness.

In the Mission context, the ToC and the Impact Pathway are closely linked to monitoring, evaluation, and impact assessment strategies. To ensure consistency, these elements must be harmonised across projects so that all activities contribute coherently to the overarching Mission objectives and targets.

The Mission's funding calls already request projects to include both a *Problem Analysis* and an *Impact Pathway* in their proposals and Grant Agreements. Accordingly, the EcoDaLLi project has collected information on activities, outcomes, and corresponding indicators to support the monitoring of progress towards the Mission's goals. Given that the ToC is inherently dynamic, it can be continuously updated and therefore serves as an integral part of the monitoring and evaluation cycle.

This deliverable applies the ToC approach to analyse project activities, outcomes, and outputs - along with available information on impacts - to determine the extent to which the Mission is on track to achieve its objectives.

The implementation of the ToC approach involves the following aspects:

1. Establishing a Basis for Systematic Assessment

The ToC serves as a blueprint against which monitoring and evaluation activities can be designed and assessed.

- Mapping Causal Pathways: The ToC clearly delineates the logical connections between project activities, intermediate outcomes, and long-term goals. This structure enables evaluators to understand how specific actions are expected to drive change.

- Defining Success and Indicators: For each expected outcome, measurable indicators should be defined to assess effectiveness. Establishing clear targets and indicators allows for the evaluation of progress, success, or failure, and supports contextual interpretation of monitoring data.
- Structured Evaluation of Monitoring Programmes: The ToC framework provides a systematic structure for assessing monitoring programmes themselves, ensuring that data collection and evaluation activities contribute to hypothesis testing and long-term learning.

2. Validating Assumptions and Generating Evidence

The ToC explicitly identifies the assumptions underlying how change is expected to occur. Monitoring activities serve to test these assumptions and validate or revise them based on empirical evidence.

- Planning Tool versus Evidence Base: The ToC functions initially as a planning tool, outlining the causal model of expected change. Monitoring provides the empirical foundation to confirm or challenge these causal linkages.
- Supporting Relationships through Data: Data collected through monitoring provide evidence to support or refine the assumed relationships between activities, outcomes, and impacts.
- Addressing Complexity and Timeframes: Many environmental and social outcomes emerge only after long periods. The ToC provides a structured means to track incremental progress towards such long-term effects.

3. Enabling Adaptive Management

Monitoring and evaluation guided by the ToC strengthen a project's capacity to adapt over time and maintain relevance under changing conditions.

- Iterative Refinement: The ToC is designed to evolve. As new insights emerge, it can be revised to incorporate additional factors or new causal relationships.
- Responsiveness to Change: The ToC supports adaptive management by enabling timely adjustments to project strategies when unexpected or delayed outcomes occur.
- Holistic Alignment: The framework ensures coherence between project-level objectives and overarching social, economic, and environmental goals, supporting integrated decision-making and optimal use of resources.

Since the ToC itself is not an evaluation approach, additional analytical frameworks are required. In this context, EcoDaLLi applied two complementary frameworks: (a) the PESTEL approach and (b) the monitoring framework structured around Pillars, as proposed by an EU expert group.

3. Monitoring Frameworks

3.1. The PESTEL Analysis

The PESTEL approach - an acronym for Political, Economic, Social, Technological, Environmental, and Legal - is a well-established analytical framework used to identify and assess the external macro-environmental factors influencing the performance and development of organisations, programmes, and projects. Within the context of EU Missions, PESTEL analysis provides a structured methodology for examining the external drivers of change that may affect project implementation, governance processes, and long-term impact delivery.

The PESTEL framework complements the analysis of the internal or micro-environment by focusing on broader systemic and contextual conditions. It enables decision-makers and project consortia to better understand the landscape in which they operate and to align strategies and interventions with the evolving external environment.

The origins of this approach can be traced back to Aguilar (1967), who introduced the ETPS model—comprising economic, technical, political, and social dimensions—in his seminal work *Scanning the Business Environment*. Over time, the framework evolved into the PESTEL model widely used today for strategic environmental scanning and foresight.

The PESTEL analysis encompasses six key dimensions that together define the macro-environmental context affecting an organisation or project. Each component provides insights into specific external drivers and their implications for strategy, governance, and implementation (Buye, 2021).

Table 1: PESTEL Components and Definitions.

PESTEL Component	Focus of Analysis (Definition)
Political	*Examines the influence of the political environment, including political stability, policy priorities, and governance structures. This dimension identifies potential opportunities or threats stemming from political decisions, institutional support, or public-sector commitments.*
Economic	*Assesses the economic climate, including factors such as taxation, tariffs, interest rates, economic growth, inflation, and recession. Understanding these dynamics helps evaluate risks and opportunities related to funding, investment, and operational viability.*
Social	*Considers social trends, values, beliefs, attitudes, lifestyles, and demographic characteristics of stakeholders and communities. These factors influence public acceptance, stakeholder engagement, and behavioural change related to project activities.*
Technological	*Analyses the influence of technological developments, including innovation trends, digitalisation, and technological accessibility. It identifies opportunities for efficiency gains, improved monitoring capabilities, and enhanced data management, as well as challenges associated with technology adoption.*
Ecological	*Focuses on the natural environment and associated factors such as pollution, resource availability, waste management, and climate-related risks. It also assesses regulatory frameworks for natural resource protection and environmental sustainability.*
Legal	*Evaluates the legal and regulatory environment, encompassing laws, standards, and compliance requirements that shape organisational activities. This includes environmental legislation, health and safety rules, and market regulations that affect project implementation and sustainability.*

The PESTEL framework is a crucial instrument for conducting environmental scans and defining strategic direction. Its structured approach helps organisations and project consortia to anticipate change, prepare for uncertainty, and align their objectives with external realities.

The primary functions and benefits of the PESTEL analysis include:

- Identification of Opportunities and Threats:
  PESTEL helps identify external opportunities and threats arising from political, economic, social, technological, environmental, and legal factors. This understanding enables projects to adapt strategies and mitigate risks effectively (Buye, 2021).
- Strategic Guidance and Alignment:
  The analysis informs strategic direction and goal-setting by linking external dynamics to organisational missions and visions. For EU Missions, it ensures that project activities remain aligned with EU policy priorities and broader societal objectives (European Commission, 2025).
- Enhanced Planning and Foresight:
  By assessing current and emerging trends, PESTEL supports the anticipation of future developments and their potential impact on ongoing or upcoming projects. It is particularly valuable when launching new initiatives or introducing innovative approaches in evolving regulatory or market environments (Buye, 2021).
- Generation of Actionable Information:
  PESTEL produces evidence-based insights that can inform operational planning, resource allocation, and performance appraisal. It supports decision-makers in adapting project strategies to external conditions and improving overall effectiveness (Hasler-Sheetal & Moguedet, 2024).

Within the Mission framework, the PESTEL approach is explicitly integrated with the ToC to ensure that external contextual factors are systematically considered in both project design and evaluation. This integrated approach enhances the understanding of how external dynamics influence internal project mechanisms and outcomes.

Enhanced Monitoring and Decision-Making

The combined PESTEL-ToC framework strengthens monitoring and evaluation by tracking interconnected influences on project outcomes. It identifies key opportunities and constraints, translating analytical insights into actionable recommendations, investment priorities, and governance proposals. This integration enhances alignment with EU policy objectives and supports evidence-based decision-making for Mission implementation.

Scalability and Transferability

The PESTEL-ToC model is **scalable and transferable** across different geographical, political, and institutional contexts. Its flexibility allows for adaptation to diverse ecosystems—from local marine protected areas to transnational governance frameworks—ensuring coherence in evaluating external influences on environmental and innovation initiatives.

Evaluating External Factors Across the ToC – Example by BlueMissionAA

The **BlueMissionAA project**, for instance, applies the PESTEL-ToC integration to align restoration deliverables and inform governance proposals across the Atlantic and Arctic Lighthouses. Through this approach, PESTEL is used to evaluate external factors at each stage of the ToC—from project inputs and activities to outputs, outcomes, and long-term impacts—thus providing a holistic framework for restoration governance and monitoring.

Specific Influences Across Dimensions

The integration highlights how each PESTEL factor shapes project performance and impact:
Political and Economic
Political priorities and economic conditions influence the feasibility, funding, and scalability of restoration activities. Stable governance and sustained investment are essential enablers for long-term success.

Social and Technological
Social engagement and community participation determine local acceptance, while technological innovation enhances monitoring capacity, data collection, and adaptive management.

Environmental and Legal
Environmental conditions, including climate variability and resource constraints, require adaptive management strategies. Legal frameworks—such as the *EU Nature Restoration Law*—illustrate how evolving regulation can transform former barriers into enabling conditions, fostering cross-sectoral progress.

3.2. Pillars Monitoring Framework

The monitoring framework proposed by the expert group (EG) set up by the European Commission's Directorate-General for R&I is a structured tool designed to assess the implementation and systemic impact of EU Missions as a policy approach, specifically focusing on activities that extend beyond Horizon Europe (HE) (European Commission. Directorate General for Research and Innovation., 2024).

Drawing on the conceptualisation and the findings of the review, the EG formulated a general intervention logic model that frames EU Missions as a systemic policy approach (see Figure 1). The model follows the ToC logic of outputs, outcomes, and impact:

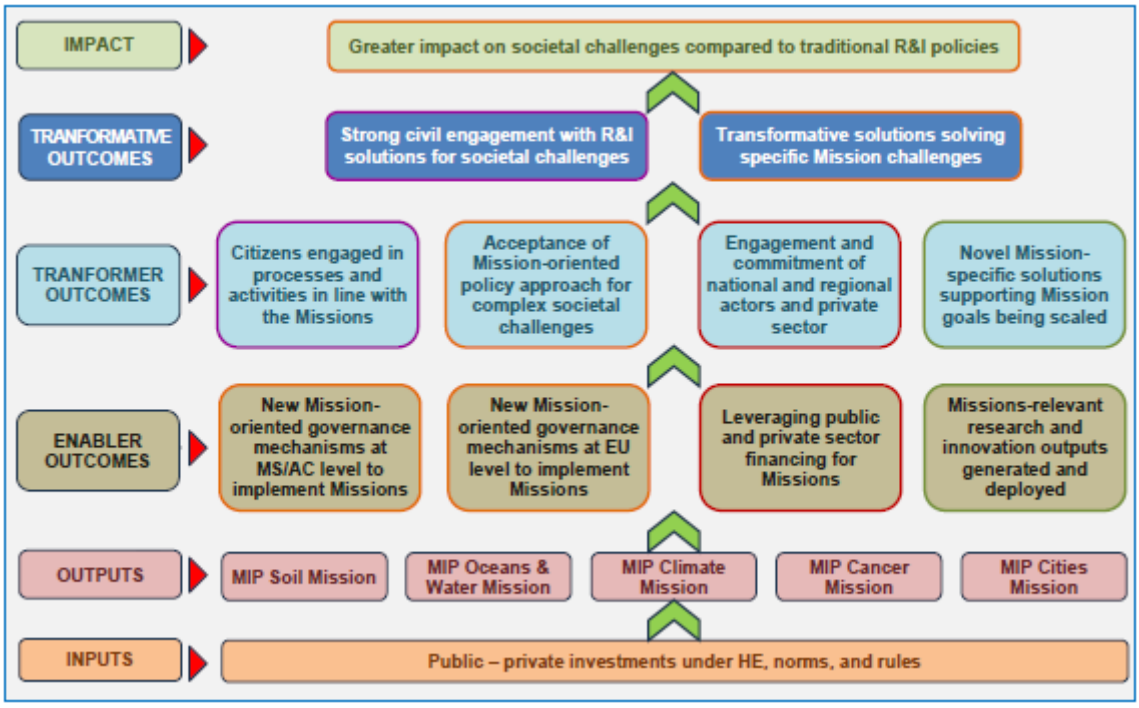

Figure 1: Intervention logic model of the EU Missions as policy approach (European Commission. Directorate General for Research and Innovation., 2024).

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The framework is like a multi-dimensional system built upon four key pillars, supported by indicators that track necessary process transformations over time, which is organized around four key pillars that represent the major areas where systemic change and transformation are required for the Missions to succeed (European Commission. Directorate General for Research and Innovation., 2024):

1. **Knowledge creation and valorisation (Pillar 1):** This pillar monitors the creation and utilization of Mission-relevant knowledge beyond traditional HE research outputs.
    - Indicators focus on measuring new knowledge created in various Mission units (such as living labs, lighthouses, and hubs) and novel solutions further developed and piloted (at lab scale) within these units. This uses both quantitative and qualitative data.
2. **Governance (Pillar 2):** This pillar tracks the development and functionality of governance mechanisms necessary for strategic coordination.
    - It monitors Mission-oriented governance mechanisms at the EU level and at the Member State (MS) and Associated Country (AC) level.
    - Governance is broken down into eight "key building blocks" to be monitored, including strategic orientation and commitment, budgetary processes for aligning funds beyond HE (e.g., ERDF, RRF, EIB), horizontal and vertical policy coordination routines, and novel policy implementation structures.
    - Progress in these building blocks is assessed using a scale ranging from 1 ("Not in place") to 5 ("In place, functioning").
3. **Participatory engagement of citizens and stakeholders (Pillar 3):** This focuses on how Missions successfully trigger broad participation dynamics outside traditional R&I projects.
    - Indicators track the number of actions developed by Mission units where citizens contribute to the co-creation of solutions (extending HE's monitoring efforts) and the formal engagement mechanisms created by these units. It also includes measuring public awareness and acceptance of Missions, often using instruments like Eurobarometer.
4. **Pooling and scaling-up (Pillar 4):** This pillar addresses the crucial requirement for mobilizing additional resources and deploying solutions at scale.
    - Indicators focus on the amount of public and private financial resources pooled/allocated for Mission-relevant activities beyond HE, and the scaling of transformative solutions supported by conducive regulatory and legal environments.

The framework's data gathering is intentionally complementary to the HE Key Impact Pathways (HE KIP) framework. While HE KIP relies on HE projects as the primary information source, the EG's proposed framework begins with non-HE projects/participants' Mission-related activities.

The framework was proposed by the Commission EG to address the unique challenges posed by the systemic and experimental nature of the EU Missions policy approach:

- **Focusing on the "Beyond HE" Context:** The EG's mandate was explicitly to monitor Missions outside of HE funding, specifically looking at the contributions of other funding

programmes (EU, national, regional, local). This monitoring complements the HE KIP, which primarily tracks impacts within the HE domain.

- **Capturing Systemic and Transformative Change:** EU Missions aim for transformative changes within relatively short timelines, requiring coordination across various sectoral policy areas and mobilization of resources far beyond R&I. The monitoring system is designed to capture these system-level revisions and effects, which traditional R&I project monitoring typically misses.
- **Addressing Experimentalism and Lack of Baselines:** Since Missions are a novel policy approach and are still in early, exploratory phases, they lack established "legacy" indicators, common baselines, or best practices. Therefore, the framework focuses on process-level elements—the setting up of governance systems and procedures—which are crucial for enabling the achievement of Mission goals.
- **Supporting Decision-Making and Corrective Measures:** The monitoring framework is intended to be a tool that informs on the progress of EU Missions, identifies emerging practices, and points out potential needs for corrective actions. It provides insights into how the R&I potential delivered by HE is being utilized and valorized in the wider policy context.

Essentially, the framework operates like a coordination compass rather than a simple checklist. If a traditional R&I project monitoring system is like measuring the yield of an individual field (HE KIP), the EG's monitoring framework is like assessing how the entire agricultural ecosystem—including irrigation systems, governance policies, markets, and farmer participation—is transforming to support sustainable regional food production (EU Missions as a policy approach) (European Commission. Directorate General for Research and Innovation., 2024).

3.3. PESTEL vs Pillars Approach

The analysis distinguishes between two complementary frameworks - the PESTEL Analysis Model and the Pillars approach - each serving a distinct function within the Mission context. The PESTEL model is primarily an outward-looking diagnostic tool aimed at understanding the external macro-environment across political, economic, social, technological, environmental, and legal dimensions. It is particularly relevant during the early stages of strategic design, where it supports the Theory of Change by identifying external drivers, risks, and opportunities that could influence the success of the Mission. However, PESTEL provides a static snapshot of contextual conditions and therefore does not serve as an appropriate framework for continuous monitoring or progress tracking. Its main value lies in contextualising implementation and assessing how shifts in the external environment may enable or constrain Mission activities.

In contrast, the Pillars approach offers a structured and dynamic monitoring framework that captures the internal processes and systemic transformations necessary for the effective implementation of the Mission. Built around four interconnected pillars—Knowledge Creation and Valorisation, Governance, Participatory Engagement, and Pooling and Scaling-Up—the framework focuses on measuring progress in establishing governance mechanisms, mobilising resources, fostering stakeholder participation, and valorising knowledge. These dimensions collectively reflect the operational capabilities and policy transformations required to achieve the Mission's long-term objectives.

For the purpose of tracking progress toward Mission objectives, the Pillars approach provides the more appropriate methodological basis. It enables a continuous assessment of how the

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Mission's internal structures, partnerships, and processes evolve, offering process-oriented indicators that directly inform decision-making and corrective actions. PESTEL remains a useful complementary tool for contextual analysis, helping to interpret how external developments may influence internal performance, but it does not replace the need for a systemic monitoring framework.

In summary, PESTEL answers the question of *what external factors may affect the Mission's trajectory*, while the Pillars approach addresses *whether the necessary internal transformations are taking place to achieve the Mission's goals*. Consequently, the Pillars framework is identified as the most suitable approach for tracking progress and assessing the implementation of Mission objectives.

3.4. Monitoring Framework proposed by EEA/DG MARE and EC Baseline Study Report

This baseline study for the EU Mission "Restore our Ocean and Waters by 2030" provides a foundation for developing, piloting, and scaling three Mission lighthouses: the Atlantic and Arctic Sea basin, the Danube River basin, and the Mediterranean Sea basin (European Commission, 2023b). The Atlantic/Arctic and Danube lighthouses focus on Mission Objective 1 - protecting and restoring marine and freshwater ecosystems and biodiversity - while the Mediterranean lighthouse addresses Objective 2 - preventing and eliminating pollution. The study mapped the 2021-22 situation in each lighthouse area, including case studies of EC-supported projects, assessment of ecosystem protection and restoration levels, identification of pollution hotspots, port waste management, and national capacities to address pollution incidents. It also proposed draft indicators for measuring progress toward Mission targets and mapped key stakeholders, networks, past and ongoing projects, and regional strategies to support Mission objectives (European Commission, 2023b).

The study further examined governance structures, including regional, national, and macro-regional plans, and alignment with Mission goals, as well as citizen engagement activities and socio-economic and demographic characteristics of each basin. Regional disparities in socio-economic performance and research and innovation ecosystems were analyzed, alongside synergies with Smart Specialisation Strategies (S3s) and recommendations for alignment with the S4+ framework, an enhanced form of Smart Specialisation that embeds sustainability, digitalisation, social inclusion, and mission-oriented governance, while adding cross-sectoral coordination and strengthened innovation ecosystems to support coherent, place-based transformation. Methodologies included desk research, database analyses, case studies, surveys, and stakeholder interviews. The findings inform the future implementation of the Mission, feeding into the Mission Implementation Platform, Coordination and Support Actions, and strategic planning for the three lighthouse areas (European Commission, 2023b).

The report establishes the baseline for the Danube River Basin in relation to the EU Mission "Restore our Ocean and Waters by 2030." Its main purpose is to consolidate existing data on key indicators linked to the Mission's targets and to highlight the measures—including their funding—that have contributed to enhancing the ecological integrity of the Danube waters and river basin. The report assesses the status of free-flowing rivers, biodiversity, and the potential of restoration measures to achieve the two Danube-related overarching Mission targets (European Commission, 2023b).

The report is structured around the Danube-specific Mission targets:

1. **Target 1** – Restore at least 25,000 km of free-flowing rivers: Presents indicators that measure river connectivity, morphology, and habitat quality.
2. **Target 2** – Restore coastal and freshwater ecosystems and habitats (Art. 4 of the proposed Nature Restoration Regulation): Covers indicators on ecosystem restoration and biodiversity improvements.
3. **Good Ecological Status (GES) indicators:** Evaluates progress of Danube projects in restoring freshwater ecosystem quality under the Water Framework Directive.
4. **Freshwater protected areas:** Provides insights into the status of protected areas and their contribution to Mission objectives and targets.

Additionally, five case studies of completed river restoration projects (Annex E) illustrate the practical impact and potential of restoration measures.

Throughout the report, references are made to relevant EU-level policies, situating local projects within the broader framework of European environmental objectives. Figures and maps highlight regional and Member State-specific data on past and planned restoration efforts.

The Danube River Basin is an ideal Lighthouse Mission area due to its ongoing restoration activities and transboundary significance. This baseline captures the current ecological status while outlining pathways for future development, emphasizing the need for a more integrated approach to achieve a healthy and resilient Danube ecosystem (European Commission, 2023b).

The official monitoring framework for the EU Mission “Restore our Ocean and Waters by 2030”, presented on the European Environment Agency (EEA) and Directorate-General for Maritime Affairs and Fisheries (DG MARE) websites (https://water.europa.eu/marine/europe-seas/eu-mission-restore-our-oceans-and-water) (WISE Marine/Science-Policy Interface), is a dynamic, near real-time, indicator-based system designed to track and assess the implementation and progress of Mission activities. Its primary purpose is to evaluate how these activities contribute to achieving the objectives and targets of relevant EU policies, including the EU Biodiversity Strategy 2030, the EU Action Plan Towards Zero Pollution, and the European Climate Law. The framework covers all aspects of the Mission, which aims to protect and restore Europe’s aquatic systems through research and innovation, citizen engagement, and sustainable blue investments.

The framework is structured around a defined set of quantitative and qualitative indicators, tracking progress toward 10 targets across the three core Mission objectives. Indicator data are drawn from the expected outcomes of Mission-funded projects, based on technical annexes submitted during the proposal phase, and are complemented by existing EEA environmental indicators where available. While the Mission provides an “innovation push” to accelerate EU policy implementation, the overall achievement of the broader EU objectives is influenced by factors beyond the Mission’s projects and funding.

Monitoring outputs are made public through a dedicated Science-Policy Interface on WISE Marine, which includes assessments, infographics, and indicator fact sheets. The methodology and guiding principles are detailed in Policy Brief 1/2025: Monitoring of the EU Mission “Restore our Ocean and Waters by 2030” (May 2025). The first Monitoring Assessment Report is soon to be uploaded, with yearly updates thereafter. The platform also links to other relevant dashboards, such as those for Marine Protected Areas (MPAs), the EU Biodiversity Strategy, the Marine Water Information System for Europe (WISE Marine), and the EU Blue Economy Observatory, providing a comprehensive view of environmental and socio-economic progress.

In summary, the EEA/DG MARE monitoring framework serves as the official, centralized system for measuring the societal and environmental effects of the Mission, connecting the results of Horizon Europe-funded research and innovation projects to tangible progress toward the European Green Deal targets.

Table 2: Comparison of Baseline Study and EEA/DG MARE.

Feature	**EEA/DG MARE Monitoring Framework (https://water.europa.eu/marine/europe-seas/eu-mission-restore-our-oceans-and-water)**	**Baseline Study Report – Danube Indicators (European Commission, 2023b)**
Primary Function / Goal	Provides a dynamic, near real-time tool for qualitative and quantitative assessment of the impact of Mission activities across the EU.	Maps the baseline status of the Danube area (2021–2022) relative to Mission objectives, identifies data gaps, and proposes a draft set of indicators for future monitoring.
Scope of Coverage	Monitors all Mission activities across 10 targets under 3 overarching objectives: Ecosystems, Pollution, and Sustainable Blue Economy.	Focuses specifically on two Mission targets for the Danube River Basin: 1) Restoration of at least 25,000 km of free-flowing rivers; 2) Contribution to nature restoration targets.
Indicator Classification	Indicators are categorized as Output, Outcome, and Impact, following EU Better Regulation Guidelines.	Indicators are organized into three blocks aligned with Danube Mission targets and existing EU policy: 1) Free-flowing river targets; 2) Nature restoration targets; 3) Good Ecological Status under the WFD, supporting both targets.
Baseline Data Source	Draws on expected outcomes of Mission-funded projects (technical annexes) and existing EEA environmental status indicators as baselines.	Primarily relies on regional datasets from the International Commission for the Protection of the Danube River (ICPDR), including the 2021 Danube River Basin Management Plan (DRBMP).
Key Challenge Identified	Ensuring consistency with EU policies and harmonization across existing monitoring frameworks.	Lack of a standardized definition for free-flowing rivers at EU or basin level; variations in river morphology categorization across Member States make data comparison difficult.

4. Methodology

The following section outlines the methodology applied by EcoDaLLi to collect KPIs. After collecting the KPIs, the individual indicators were analysed using two complementary approaches: (a) the PESTEL analysis and (b) the pillar-based framework proposed by the EG. Since there are already various monitoring frameworks established by different actors/institutions, this deliverable serves as a collection of project-scaled indicators to measure the progress in achieving the Mission's objectives.

4.1. Phase 1: Desktop Review

The development of the monitoring and evaluation framework started with a desktop review to gather relevant theoretical background on monitoring and evaluation methodologies, complemented by an assessment of EcoDaLLi's prior work within the EU Mission. This initial phase provided a foundation for understanding the current state of practice and identifying key concepts, approaches, and gaps in monitoring frameworks relevant to the Mission objectives.

Following the desktop review, engagement was established with other CSA projects operating under the Mission, including *Prep4Blue*, *BlueMissionBANOS*, *BlueMissionAA*, and *BlueMissionMED*. These interactions facilitated the exchange of experiences, insights, and best practices regarding monitoring frameworks. Furthermore, collaboration with these projects enabled the planning and coordination of a dedicated workshop during the Mission Ocean Days 2025, fostering dialogue and knowledge-sharing on monitoring strategies across the Mission's portfolio (see the CSA Workshop info box below for details). Furthermore, contact to the Austrian National Contact Point and ERINN was established to synergize with their work (see Austrian Action Plan info box below for details).

CSA Workshop on Harmonising KPIs and Monitoring Approaches

European Ocean Days 2025 – March 3, 2025

As part of the European Ocean Days 2025, the five Coordination and Support Actions (CSAs) supporting the first phase of the EU *Mission "Restore our Ocean and Waters"* co-organised a joint interactive workshop titled *"Harmonising KPIs and Approaches to Support the Development of a Joint Mission Ocean and Waters Monitoring Framework."* The workshop, held on March 3, 2025, marked an important first step toward building alignment across Mission monitoring activities.

The session brought together representatives from the European Commission and each of the Mission's CSAs: Jacques Delsalle (European Commission), Caecilia Managò (ERINN, PREP4BLUE – overarching CSA), Harald Hasler-Sheetal (ICES, BlueMissionAA – Atlantic and Arctic Lighthouse), Lotta Purkamo (GTK, BlueMissionBANOS – Baltic and North Sea Lighthouse), Nikos Streftaris (HCMR, BlueMissionMED – Mediterranean Lighthouse), and Lisa Waldenberger (BOKU, EcoDaLLi – Danube River Basin Lighthouse).

Two panel discussions engaged representatives from Mission Projects—including Alexander Ziemba (Ultfarms), Sophie Jensen (BIOPROTECT), Marton Pesel (DALIA), Lorenzo Proia (SEACURE), and Uroš Novak (REMEDIES)—to explore the key challenges related to *KPI identification, implementation, scalability,* and *integration into Mission Projects*. Participants emphasized the need to consider *local contexts* and *community knowledge* as overlooked yet essential dimensions in future monitoring frameworks.

The workshop combined presentations on current approaches to driving and monitoring impact toward Mission Objectives with interactive sessions, including real-time polls designed to capture diverse stakeholder perspectives from the outset. This participatory design ensured that both strategic and practical insights were collected to inform future coordination efforts.

Overall, the workshop successfully initiated a process of alignment and knowledge exchange among CSAs, Mission Projects, and the European Commission. It laid the groundwork for the second, implementation phase of the Mission by identifying common principles, shared needs, and opportunities for synergy in KPI development and monitoring approaches. The discussions and outcomes—summarized in the joint presentation on Monitoring Approaches and supported by interactive poll results—will serve as a foundation for building a joint Mission Monitoring Framework, reducing duplication of efforts and strengthening coherence across all Mission basins.

Austrian Action Plan for the EU Mission "Restore our Ocean and Waters" (February 2025)

Developed by: *Mission Action Group Waters (MAG Waters)* – experts from science, research, administration, and industry
Purpose: National strategy for implementing the EU's objectives on water and marine health.

Core Goals: Coordinated and sustainable implementation of the EU Mission's objectives at the national level; visible and measurable cross-sectoral progress within Austria; implementation based on the *ToC* with three Impact Pathways.

EU Mission Objectives (by 2030):
(i) Protect and restore marine and freshwater ecosystems and biodiversity
(ii) Prevent and eliminate pollution and restore aquatic habitats
(iii) Promote a sustainable, carbon-neutral, and circular blue economy

Impact Pathway I – Knowledge and Awareness: Strengthening public understanding and addressing scientific scepticism.
Problem: Citizens often underestimate their water use and lack awareness of key water-related issues.
Goals: Improve knowledge of water management, biodiversity, and climate impacts.
Key Measures: Coordination of educational materials (e.g., *gen blue*); expansion of citizen and youth science initiatives (*ABOL-BioBlitze*, *Plastic Pirates*); training of *Water Ambassadors (Wasserbotschafter:innen)* for science communication.

Impact Pathway II – Knowledge Transfer: Overcoming institutional and sectoral divisions to enable evidence-based decision-making.
Problem: Increasing conflicts over water use (energy, tourism, agriculture) driven by climate change.
Key Measures: Expansion of dialogue formats (e.g., *Flussdialoge*) and establishment of an annual *Dialogforum*; strengthening of expert advisory roles; launch of a *Digitalization Offensive* for harmonized data management and a central access platform (based on *WISA*).

Impact Pathway III – Technical Priorities: Implementing measures to counter environmental degradation and secure water resources.
Priority Areas: River basin management, wetland restoration, water resource security, and water quality improvement.
Key Measures: Implementation of *Wasserschatz Österreich* recommendations and creation of an *Extraction Register*; enhanced monitoring of trace substances (pharmaceuticals, microplastics) and expansion of the fourth purification stage in wastewater treatment; alignment of the National Water Management Plan (NGP) with the Flood Risk Management Plan.

Governance and Monitoring: Embedded within existing European and national structures under the Federal Ministries *BMLUK and BMB*. National coordination is led by *Allianz Biodiversität & Wasser (BioDiWa)*. Monitoring and Evaluation (M&E) are carried out by the *Mission Facility* (*ZSI, Joanneum Research, AIT, Fraunhofer ISI*), which develops indicators and an evaluation framework to support policy learning and adaptive management.

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4.2. Phase 2: Task Force Online Kick-off Meeting

The task force kick-off meeting, held on September 22, 2025, introduced the overall objectives of the task force and served as a forum for discussion among participants. The following IAs were part of the task force: Danube4all, DALIA, Restore4Life, DaWetRest, iNNO SED and SUNDANCE. During the session, the Theory of Change (ToC) and PESTEL analysis frameworks were presented, along with an emphasis on the importance of establishing a robust monitoring framework. In the week following the workshop, KPIs from each participating IA project were collected and consolidated to inform subsequent analytical steps.

4.3. Phase 3: KPIs and PESTEL Dimension Mapping

In the following phase, each indicator was analyzed to determine its corresponding PESTEL dimension(s). Task force representatives from each IA were then asked to assign the relevant PESTEL dimension(s) to their respective project KPIs, ensuring consistency and alignment across projects.

After the PESTEL Dimension mapping, it was difficult to analyse the different dimensions for each KPI, since a lot of KPIs were covering various dimensions and similar KPIs from multiple projects. Difficult to evaluate and shortlisting. Therefore, pillars approach was preferred doe different to other CSA approaches.

4.4. Phase 4: KPI Grouping in Pillars

The collected KPIs were organised according to the defined pillars and further clustered into thematic subgroups based on areas of similarity. The final pillar-based KPI list is presented in the Annex, while the outcomes of each methodological phase are described in the following chapter.

5. Results

5.1. Results from Phase 2: KPI Mapping

KPI lists from all six IAs were received, with the number of KPIs per project ranging from 6 to 40. The distribution is as follows:

- **D4all:** 18 KPIs
- **DALIA:** 6 KPIs
- **DaWetRest:** 37 KPIs
- **Restore4Life:** 17 KPIs
- **Sundance:** 8 KPIs
- **iNNO SED:** 40 KPIs

Each set of KPIs was further analyzed using the **PESTEL framework** to assess their relevance across Political, Economic, Social, Technological, Environmental, and Legal dimensions**.** Figure 2 illustrates an example of the Excel template that was provided to each IA project for this analysis, and Figure 3 gives an example from Restore4Life.

OVERVIEW	
IA project:	
Name:	

** PESTEL*
Political
Economical
Social/Societal
Technical
Ecological/Environmental
Legal

IA project	Indicator	PESTEL Dimension						Comment
		P	E	S	T	E	L	
Restore4Life								

Figure 2: Excel file sheet example for KPI collection and PESTEL Dimension.

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OVERVIEW	
IA project:	Restore4Life
Name:	[redacted]

* PESTEL
Political
Economical
Social/Societal
Technical
Ecological/Environmental
Legal

IA project	Indicator	PESTEL Dimension						Project results
		P	E	S	T	E	L	
Restore4Life	Restore4Life Wetland Restoration Decision Support System (long-term online platform)	X	X	X	X	X	X	R4L wetland restoration decision support system; R4L wetland reconstruction accelerator; Long term online wetland restoration service
	Wetland managers and scientists have access to low-cost, easily transferable wetland monitoring tools		X	X		X		Suite of optimised, and transferable low-cost wetland assessment indicators; Suite of Citizen science protocols for wetland assessments
	Re-connection of side arm system (4 km2) and restoration of bank lines in IS1					X		
	Re-connection of side arm system in IS2 (6 km, 560 ha)					X		
	>3000 ha restoration of transitional mire habitats at IS3					X		
	>2000 ha wetlands restored at IS4					X		
	>10,000 people reached through the R4L communication activities and informed about the benefits of wetland restoration			X		X		Physical and online game 'Blue-green Space4all', 5 videos, >5 podcasts
	At least 15 schools have adopted the R4L educational program			X		X		Wetland restoration educational program
	At least 30 stakeholders have been informed about the Wetland4Life web app for citizens and the Solution4Life app for stakeholders			X		X		Wetland4Life and Solution4Life apps
	At least 9 schools have installed a treatment wetland model			X		X		Treatment wetland model for teaching and experimental purposes
	At least 6 scientific papers published in OA journals			X		X		
	Framework for road maps and plans for wetland restoration	X				X		"Cookbook" to develop road maps for wetland restoration in 5 associated regions
	Roadmaps and plans for wetland restoration in 5 associated regions	X				X		
	Capacity building for 50 stakeholders incl. entrepreneurs plus 15 wetland educators per demo sites and associated regions							
	PESTLE analyses conducted with all implementation and associated region site stakeholders (9 sites)	X	X	X	X	X	X	Report available
	SWOT assessment interviews conducted in person with restoration site businesses (21)	X	X	X	X	X	X	Report available
	Review of biodiversity evaluation schemes and regulations conducted	X	X	X	X	X	X	Methodologies for measuring and valuing biodiversity; General matrix of benefits generated by wetland NbS
	NbS business development advice provided to local entrepreneurs (5 cases)		X		X	X		Covers reed harvesting, fish production and ecotourism; confidential

Figure 3: Excel file sheet example filled out for Restore4Life.

5.2. Results from Phase 3: PESTEL and Pillar Analysis

Since a single KPI could relate to multiple PESTEL dimensions, the items for each dimension were organized into separate sublists for further validation. Due to the limited number of KPIs in the legal and political dimensions, these were combined. In total, the KPIs were distributed as follows: 41 in Political-Legal, 30 in Economic, 51 in Societal, 72 in Technical, and 94 in Environmental. The results of the PESTEL analysis are not clearly significant since a lot of KPIs apply to multiple dimensions.

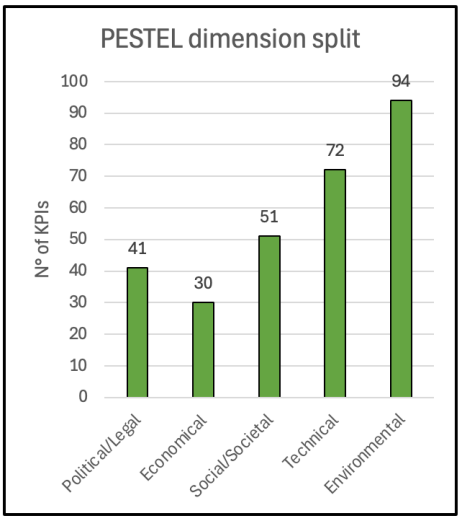

Figure 4: KPI distribution for each PESTEL dimension.

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There is a pronounced predominance of environmental and ecological indicators, followed by technical indicators, whereas social and societal indicators - and particularly political and legal indicators - are markedly underrepresented. This imbalance may be attributed to the limited availability of established monitoring frameworks and assessment methodologies in the social, political, economic and legal domains, in contrast to the environmental and technical fields, where standardized, well-established, and readily measurable indicators are more abundant and widely applied.

After the PESTEL analysis, the KPIs were categorized into the pillars approach proposed by the EG:

Table 3: KPI categorization into pillars.

Pillar	*Sub-pillar*	*Pillar designation*	*KPI Count*
1	1.1	*Knowledge valorisation at local and regional level for transformative Mission-oriented solutions*	35
2	2.1	*Mission-oriented governance mechanisms*	18
	2.2	*Acceptance of Mission-oriented innovation policy*	5
3	3.1	*Co-creation of Mission solutions with citizens in programs beyond Horizon Europe*	4
	3.2	*Citizens engaged in processes and activities in line with the Missions*	21
4	4.1	*Pooling and leveraging public and private funds*	5
	4.2	*Scaling of transformative solutions and supportive measures*	37

Each KPI was assigned to a single sub-pillar, resulting in a clearer and more consistent classification. Within each sub-pillar, KPIs were further clustered into thematic groups based on their functional relationships, supporting clearer presentation and interpretation of results. The distribution of KPIs across the main sub-pillars is as follows:

Sub-pillar 1.1

- Monitoring and Evaluation: 9 KPIs
- Data and Knowledge: 10 KPIs
- Publications and Scientific Outputs: 4 KPIs
- Modelling: 3 KPIs
- Management Tools and Guidelines: 4 KPIs

Sub-pillar 2.1

- Policies and Frameworks: 7 KPIs
- Roadmaps and Action Plans: 7 KPIs
- Cooperation: 2 KPIs

Sub-pillar 3.2

- Education, Training and Awareness: 9 KPIs
- Citizen Science Tools and Involvement: 5 KPIs
- Workshops and Seminars: 3 KPIs

Sub-pillar 4.2

- NbS Solutions & Measures: 9 KPIs
- DEMO / Pilot Site: 10 KPIs
- Restoration / Conservation Measures: 13 KPIs
- Monitoring and Evaluation: 2 KPIs

The remaining sub-pillars contained fewer KPIs or were sufficiently clear without further thematic grouping. The complete overview of all pillars, sub-pillars, and associated KPIs is provided in the Annex.

It can be observed that Pillars 1 and 4 contain a substantially higher number of KPIs - nearly twice as many as the remaining two pillars. In contrast, there is a notable scarcity of KPIs within sub-pillars 2.2, 3.1, and 4.1, which, for example, address the co-creation of solutions and funding mechanisms, whether public or private. Conversely, Pillar 1 and sub-pillar 4.2 encompass a broad range of more commonly applied domains, such as education, data availability, monitoring, and restoration measures. These areas are generally easier to assess quantitatively and are therefore more extensively represented. This uneven distribution of KPIs across the pillars reflects similar domain-specific patterns identified in the PESTEL analysis.

6. Discussion

Monitoring plays a central role in governance, environmental protection, and adaptive management. It provides the empirical basis to identify problems, inform decisions, ensure accountability, and guide interventions across complex socio-ecological systems. As evidenced by the sources, monitoring is indispensable; however, it is not sufficient in isolation to guarantee successful outcomes. Environmental degradation often persists not due to a lack of data, but because the information collected is not consistently translated into action, whether due to institutional, political, or resource constraints.

6.1. The Necessity of Monitoring

Monitoring is critical for assessing current conditions, providing accountability, and enabling evidence-based action in complex, dynamic environments. In sectors such as port operations and ecosystem management, monitoring is essential to understand and address pressures on both ecosystems and public health. It allows for the identification, quantification, and mitigation of environmental pressures, including pollution, habitat degradation, and ecosystem stress. Continuous improvements in monitoring methodologies have enhanced the ability to prevent or reduce negative impacts and to track ecological and social outcomes over time (Bilgram et al., 2025; Tadaki, 2024).

Environmental monitoring plays a particularly vital role in controlling pollution (Puig & Darbra, 2024). For instance, water quality monitoring, widely implemented across European ports, safeguards marine life and prevents contamination, while air quality and sediment monitoring protect human health and maintain ecosystem integrity. Monitoring of port and ship waste ensures compliance with environmental regulations and promotes effective waste management (Puig & Darbra, 2024). At the same time, biodiversity monitoring, including tracking invasive species, provides essential insight into the ecological impacts of industrial activities and shipping. Continuous and long-term monitoring further allows the identification of temporal variability and pollutant distribution patterns, offering a comprehensive understanding of environmental health (Puig & Darbra, 2024).

Monitoring also underpins governance and accountability. It constitutes a core element of Environmental Management Systems and enables the state to understand and manage its environmental resources effectively. Public reporting of monitoring data allows civil society to scrutinize environmental claims, reinforcing transparency and political accountability. Furthermore, monitoring establishes baselines, measures progress towards defined targets, and provides evidence to validate or challenge the assumptions underlying management frameworks, including Theories of Change. By enabling evidence-based decision-making, monitoring supports adaptive management and ensures that projects remain responsive to evolving circumstances (Puig & Darbra, 2024).

6.2. Limitations of Monitoring

Despite their critical role in ensuring accountability, transparency, and learning, M&E frameworks can also impose structural constraints on innovation and transformative change. These limitations primarily emerge through the reallocation of resources toward measurement activities, an overemphasis on empirically measurable forms of knowledge, and a focus on short-term project outputs rather than systemic or long-term impacts. As a result, M&E systems—while indispensable to evidence-based governance—can unintentionally shape organizational behaviour toward conservatism and risk avoidance (Tadaki, 2024).

A key limitation lies in the epistemological narrowing produced by conventional M&E approaches. By privileging what can be empirically measured, such systems tend to marginalize alternative knowledge sources, including modelling, theoretical reasoning, and indigenous or local knowledge. This bias toward quantifiable indicators can restrict the epistemic diversity required for addressing complex socio-environmental challenges. For instance, while empirical monitoring offers a retrospective account of environmental conditions, modelling and qualitative assessment are often better suited to anticipating future change or tracing causal dynamics. Similarly, the use of external scanning frameworks such as PESTEL may reinforce a deterministic understanding of external trends, leading organizations to adopt reactive rather than proactive postures in strategic decision-making, thereby reducing their capacity for innovation (Buye, 2021).

Furthermore, M&E frameworks can inhibit risk-taking and systemic transformation by embedding a governance culture that prioritizes accountability and compliance over experimentation. Innovation—particularly within large-scale research and innovation programs such as the EU Missions—depends on tolerance for uncertainty and the capacity to test unconventional ideas (Manago & Cheallachain, 2023). However, when assessment systems concentrate on predefined indicators or project-level deliverables, they may obscure whether collective efforts are contributing to broader transformative objectives. In addition, the resource-intensive nature of comprehensive monitoring regimes can divert financial and human capacity away from experimental or implementation-oriented activities (Bilgram et al., 2025). Evidence from environmental governance suggests that the costs associated with meeting monitoring obligations can lead to the reallocation of limited public resources, thereby constraining investment in alternative, potentially more effective interventions (Tadaki, 2024).

Challenges in Temporal and Spatial Monitoring

Despite technological advances, several challenges persist. Significant time lags often occur between interventions and observable impacts, complicating the attribution of outcomes to specific actions (Bilgram et al., 2025). Data resolution and frequency can also be limiting, particularly for socio-economic indicators that are typically collected at lower spatial granularity and with less temporal consistency than biophysical data. Additionally, even when measurement methods are standardized, data may carry ontological ambiguity—that is, identical numerical indicators may not reflect the same ecological processes across sites. This limits comparability and can obscure what is most relevant to understanding environmental change (Bilgram et al., 2025).

In sum, integrating temporal and spatial dimensions within monitoring frameworks enhances their capacity to capture dynamic, multi-scalar processes of change. Doing so requires conceptual coherence, technical sophistication, and methodological flexibility to ensure that monitoring outputs remain both meaningful and actionable across different contexts and timeframes.

6.3. Balancing Necessity and Limitations

Monitoring is, therefore, both necessary and inherently limited. It is indispensable for understanding environmental and social conditions, tracking progress, and providing the foundation for adaptive management. At the same time, its value depends on complementary mechanisms: political and institutional commitment to act on the data, adequate financial and human resources for sustained monitoring, and integration with frameworks such as the Theory of Change to ensure that evidence informs decision-making.

In conclusion, monitoring is a necessary but not sufficient condition for achieving environmental and societal objectives. Its ultimate value lies not only in producing data but in enabling action, guiding adaptive strategies, and supporting governance that can translate information into meaningful and lasting change.

Governance of Impact: Who Decides What Counts

(European Commission, 2023a, 2023b; Reid et al., 2023; Tadaki, 2024)

The question of *who determines impact*—and how—reveals a complex interplay of authority among formal institutions, technical experts, and engaged stakeholders. Decisions about defining, measuring, and validating impact are shaped through institutional frameworks, expert assessments, and co-creation processes that operate within inherently political contexts.

1. Institutional Authority and Framework Definition

At the formal governance level, the definition of *what counts as impact* is largely determined by established institutional frameworks and funding mechanisms. Within the European Union, the European Commission (EC) provides overarching structures such as the KIPs under Horizon Europe, which define programmatic success across scientific, societal, and economic dimensions. Mission Boards and Managers further translate these frameworks into concrete objectives and targets, setting the direction for transformative change. Similarly, regulatory measures often align with existing policy and legislative categories, emphasizing indicators that are measurable and consistent with prior datasets. In initiatives like the Nature Restoration Regulation (NRR), legally binding targets necessitate systematic links between planned actions and desired outcomes.

2. Expert and Stakeholder Roles in Defining Criteria and Metrics

Determining *how* impact is measured—what indicators and evidence are deemed valid—relies heavily on technical expertise and stakeholder input. Experts play a central role in developing and the KPIs to ensure clarity, measurability, and alignment with strategic objectives. In projects such as BlueMissionBANOS, indicator selection and monitoring needs were co-developed with expert groups and stakeholders to enhance legitimacy and transparency. Likewise, the ToC approach, commonly used in mission-oriented initiatives, maps causal pathways between activities and long-term goals through participatory processes. These frameworks are grounded in hypothesized, rather than empirically proven, relationships, reflecting collective expert judgment. Further, knowledge assessment panels, as in PREP4BLUE, determine which outputs—such as Key Exploitable Results (KERs)—are prioritized for scaling, thereby influencing which forms of knowledge are recognized as most impactful. Even strategic analytical tools such as PESTEL depend on transparent prioritization criteria and actor involvement, underscoring that impact assessment is never entirely objective but contingent on process design and participation.

3. Political Dynamics and the Contestation of Measurement

The determination of “what impact counts” is ultimately political. Measurement operates as a mode of governance, shaping how reality is perceived and managed by directing institutional attention, funding, and accountability. What is measured—and thus rendered visible—reflects implicit value judgments and decisions about whose knowledge matters. This selectivity risks epistemological narrowing, where the primacy of empirical data marginalizes modelling, theoretical insight, and local or Indigenous knowledge crucial for addressing complex environmental challenges. Moreover, the existence of robust monitoring systems does not guarantee political action: data alone cannot substitute for political will. Even when scientific evidence clearly identifies required interventions, decision-makers may disregard findings if

the implications are politically or economically costly. Consequently, while M&E frameworks are central to accountability, their effectiveness in driving transformative impact ultimately depends on governance choices and the political commitment to act upon what is measured.

7. Conclusion and Outlook

This deliverable has demonstrated that monitoring is an indispensable component of the EU Mission “Restore our Ocean and Waters by 2030,” particularly within a complex, transboundary basin such as the Danube. The analysis of existing approaches—PESTEL, the Pillars framework, and the EEA/DG MARE indicator system—shows that while important conceptual and operational foundations exist, they remain fragmented across projects, sectors, governance levels, and funding streams. EcoDaLLi’s contribution lies in identifying common patterns among Innovation Action KPIs and highlighting the need for greater coherence and long-term alignment across monitoring practices.

A central insight emerging from this work is the necessity of harmonising monitoring frameworks across the Mission. Divergent indicator definitions, differing methodological standards, and inconsistent data collection practices currently limit comparability and weaken the potential for large-scale assessment. Harmonisation does not imply uniformity; rather, it requires developing a shared backbone of concepts, definitions, and minimum data standards that allow basin-wide synthesis while respecting project-specific objectives. The Pillars framework already provides a structure for this alignment, but future Mission phases will require more explicit guidance, shared templates, and coordinated validation processes across CSAs and IA projects.

Closely related to this is the need for cost-effective monitoring systems. Resource-intensive or overly complex indicator sets risk diverting funding and personnel away from implementation activities. Cost-effectiveness can be improved by (i) using indicators that serve multiple governance needs, (ii) integrating existing national or EU datasets rather than duplicating them, and (iii) enhancing interoperability between monitoring platforms. Additionally, the strategic use of technology—remote sensing, automated sensors, interoperable databases, and citizen science—can reduce long-term costs while improving data coverage and quality. A leaner but harmonised monitoring architecture, drawing on indicators that are meaningful, measurable, and scalable, will be essential during the Mission’s second implementation phase.

A further key finding is the importance of institutionalising monitoring beyond individual projects. Current monitoring structures remain heavily dependent on short-term project cycles. Such fragmentation creates discontinuities in data series, limits the ability to observe long-term environmental effects, and complicates Mission-level assessments. Sustainable monitoring must therefore be anchored within stable institutions—such as river basin commissions, national environmental agencies, or long-standing research infrastructures—who can steward data collection, validation, and reporting over decades. Project-based contributions should complement, not replace, these institutional monitoring responsibilities. Establishing such long-term arrangements will be crucial for detecting delayed ecological responses, evaluating system-wide behavioural change, and supporting adaptive governance well beyond 2030.

As the Mission advances, evaluation will play a key role in determining whether monitored outputs translate into meaningful outcomes for the Danube Basin. While this deliverable establishes the foundations for consistent monitoring, future work must strengthen the evaluation dimension by assessing causal links, testing assumptions from the Theory of Change, and identifying which approaches generate the greatest impact. As more data become available, evaluation will support evidence-based adjustments, improve accountability, and ensure that Mission activities contribute effectively to long-term restoration goals.

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The validation of the proposed KPI set with European governance structures, such as the Mission Secretariat, should be further strengthened. The selected KPIs should be embedded within a broader Mission monitoring framework and implemented by long-term institutions (e.g. the European Environment Agency or the International Commission for the Protection of the Danube River), as well as by relevant local communities and public authorities. This is particularly important given the limited project duration of EcoDaLLi, which runs until mid-2026. Continued alignment with other Mission monitoring frameworks, as discussed during the CSA workshop in Brussels in 2025, will be essential to ensure consistency, continuity, and long-term impact.

At the same time, the report underscores that monitoring must operate across multiple levels and perspectives, as different actors monitor different aspects of the Mission. Local communities and practitioners capture context-specific social and ecological change; national authorities focus on regulatory compliance and policy implementation; basin-level organisations analyse transboundary dynamics; and EU institutions evaluate progress toward overarching Mission objectives. Designing a monitoring system that reflects these different vantage points—and that makes their outputs interoperable—is essential for a comprehensive understanding of progress. A differentiated monitoring architecture, aligned through shared principles and core indicators, allows all levels to contribute effectively while preserving the richness of their unique perspectives.

Looking ahead, the continued development of a joint Mission-wide monitoring framework will require strengthened coordination between CSAs, Innovation Actions, the European Commission, and institutional actors such as the EEA. The next phase of Mission implementation should prioritise:

- Establishing a harmonised, Mission-wide indicator catalogue aligned with both Pillars and EEA/DG MARE frameworks.
- Developing clear guidance for cost-effective data collection, ensuring that monitoring obligations remain feasible for projects and institutions alike.
- Embedding monitoring responsibilities within long-term institutional structures, supported by stable funding mechanisms.
- Facilitating cross-basin learning, ensuring that experiences and solutions from the Danube can be shared with other lighthouse regions.
- Integrating stakeholder and citizen-generated data more systematically to improve spatial resolution and societal relevance.

In conclusion, this deliverable highlights both the progress made and the gaps remaining in establishing a coherent monitoring approach for the Mission. A harmonised, cost-effective, and institutionally anchored monitoring system—capable of capturing multi-level perspectives—will be essential to ensure that Mission actions translate into measurable, credible, and lasting change for Europe's freshwater and marine ecosystems. The insights gathered through EcoDaLLi provide a foundation for this evolution and offer concrete guidance for strengthening monitoring practices as the Mission advances into its next phase.

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Annex I

Proj. Nr.	KPI	PESTEL
1	Connectivity of at least 3 DRB technical solutions (DPS + Pilots of the 2nd stage)	Econ
1	Sediment transport optimalisation: minimum 2 DPS and 2 pilots in the 2nd stage	Econ
1	Warning system planned on at least 3 pilots (DPS + pilots of the 2nd stage)	Econ
1	Experimental implementations of at least 20 DALIA tools on the different pilots (DPS + pilots of the 2nd stage)	Econ
1	Connectivity of at least 3 DRB technical solutions (DPS + Pilots of the 2nd stage)	Env
1	Sediment transport optimalisation: minimum 2 DPS and 2 pilots in the 2nd stage	Env
1	Warning system planned on at least 3 pilots (DPS + pilots of the 2nd stage)	Env
1	Experimental implementations of at least 20 DALIA tools on the different pilots (DPS + pilots of the 2nd stage)	Env
1	Warning system planned on at least 3 pilots (DPS + pilots of the 2nd stage)	L
1	Guidelines distributed to at least 200 stakeholders	P
1	Warning system planned on at least 3 pilots (DPS + pilots of the 2nd stage)	P
1	At least 15 Policy makers and Water Authorities linked to the DALIA (LoI / MoU signed)	P
1	Connectivity of at least 3 DRB technical solutions (DPS + Pilots of the 2nd stage)	S
1	Sediment transport optimalisation: minimum 2 DPS and 2 pilots in the 2nd stage	S
1	Warning system planned on at least 3 pilots (DPS + pilots of the 2nd stage)	S
1	Experimental implementations of at least 20 DALIA tools on the different pilots (DPS + pilots of the 2nd stage)	S
1	Connectivity of at least 3 DRB technical solutions (DPS + Pilots of the 2nd stage)	T
1	Sediment transport optimalisation: minimum 2 DPS and 2 pilots in the 2nd stage	T
1	Warning system planned on at least 3 pilots (DPS + pilots of the 2nd stage)	T
1	Experimental implementations of at least 20 DALIA tools on the different pilots (DPS + pilots of the 2nd stage)	T
2	3 detailed business cases at the 3 Demonstration Sites	Econ
2	ESS gains due to Win2 NBS measures demonstrated for 10 floodplains	Econ
2	1 million citizens reached by the DANUBE4all communication activities (including TV spots) and informed about biodiversity loss and measures to improve the situation	Econ
2	Basin wide maps of distribution of protected species and invasive species for at least 15 species	Env
2	1 transboundary monitoring demonstration to assess fish community status covering approx. 800 km of river stretches	Env
2	Demonstration Site 1: Increase of rheophilic juvenile fish abundances along the shorelines of restored river banks by 50% after implementation Demonstration Site 2: Increase of rheophilic fish biomass in optimized groyne sections compared to the situation before Demonstration Site 3: Technical solution to improve the connectivity with the Black Sea showing the multiple ecologic, social and economic benefits agreed with the key stakeholders	Env
2	Win2 NBS restoration measures defined for 100 longitudinal barriers and 3,000 km of river	Env
2	Win2 NBS applied in 3 Demonstration Sites to demonstrate the positive impact on reducing flood and drought risks	Env
2	Win2 NBS restoration measures defined for 50 floodplains, wetlands and the lagoon system	Env
2	Win2 NBS restoration measures applied in the 3 Demonstration Sites in the Upper, Middle Danube and Delta	Env
2	ESS gains due to Win2 NBS measures demonstrated for 10 floodplains	Env
2	5,000 citizens and 100 stakeholders mobilized or involved to participate in the implementation of Demonstration Sites, Synergy Sites and Associated Regions	Env
2	1 million citizens reached by the DANUBE4all communication activities (including TV spots) and informed about biodiversity loss and measures to improve the situation	Env
2	1,000 stakeholders participating and/or informed by 3 Multi-actor fora, 3 International Seminars, 2 Policy Briefs, 1 online training course, as well as complementary educational events – museum visits, boat trips	Env
2	1 integrative Restoration Action Plan for the whole DRB	Env
2	5 replication roadmaps (1 for each Associated Region), 1 online replication toolkit, 1 online pan-European replication workshop	Env
2	3 training workshops in each Associated Region for knowledge transfer, exchange and capacity building	Env
2	1,000 stakeholders participating and/or informed by 3 Multi-actor fora, 3 International Seminars, 2 Policy Briefs, 1 online training course, as well as complementary educational events – museum visits, boat trips	P
2	1 integrative Restoration Action Plan for the whole DRB	P

41	2	DANUBE4all Citizen Science tools transferred, knowledge exchange done for 10 Synergy Sites	S
42	2	ESS gains due to Win2 NBS measures demonstrated for 10 floodplains	S
43	2	5,000 citizens and 100 stakeholders mobilized or involved to participate in the implementation of Demonstration Sites, Synergy Sites and Associated Regions	S
44	2	1 million citizens reached by the DANUBE4all communication activities (including TV spots) and informed about biodiversity loss and measures to improve the situation	S
45	2	1,000 citizens mobilized and equipped with new citizen science tools	S
46	2	1,000 stakeholders participating and/or informed by 3 Multi-actor fora, 3 International Seminars, 2 Policy Briefs, 1 online training course, as well as complementary educational events – museum visits, boat trips	S
47	2	3 training workshops in each Associated Region for knowledge transfer, exchange and capacity building	S
48	2	Demonstration Site 1: Increase of rheophilic juvenile fish abundances along the shorelines of restored river banks by 50% after implementation Demonstration Site 2: Increase of rheophilic fish biomass in optimized groyne sections compared to the situation before Demonstration Site 3: Technical solution to improve the connectivity with the Black Sea showing the multiple ecologic, social and economic benefits agreed with the key stakeholders	T
49	2	Win2 NBS restoration measures defined for 100 longitudinal barriers and 3,000 km of river	T
50	2	1 connectivity restoration toolbox (longitudinal, lateral and vertical dimensions)	T
51	2	Win2 NBS applied in 3 Demonstration Sites to demonstrate the positive impact on reducing flood and drought risks	T
52	2	Win2 NBS restoration measures defined for 50 floodplains, wetlands and the lagoon system	T
53	2	Win2 NBS restoration measures applied in the 3 Demonstration Sites in the Upper, Middle Danube and Delta	T
54	2	3 detailed business cases at the 3 Demonstration Sites	T
55	2	1,000 citizens mobilized and equipped with new citizen science tools	T
56	2	5 replication roadmaps (1 for each Associated Region), 1 online replication toolkit, 1 online pan-European replication workshop	T
57	3	22 stakeholders involved in the field of water management and nature protection	Econ
58	3	12 scientific papers (Open Access) published during the project implementation	Econ
59	3	minimum 70 organisations involved in the Mission charter	Econ
60	3	6 active measures implemented in DaWetRest	Econ
61	3	hydro-technical works conducted within DEMO sites	Econ
62	3	15 local and regional authorities and municipalities involved in trainings	Econ
63	3	3 business models to strengthen economic potentials from wetlands, floodplains, coastal wetlands and salt marshes	Econ
64	3	22 stakeholders involved in the field of water management and nature protection	Env
65	3	6 decision supporting tools made by DaWetRest	Env
66	3	12 scientific papers (Open Access) published during the project implementation	Env
67	3	minimum 70 organisations involved in the Mission charter	Env
68	3	186 field observations conducted	Env
69	3	3 ecosystem service assessments conducted	Env
70	3	1 monitoring activity per each site for the assessment of NBS implementation	Env
71	3	1 conservation work (intervention) provided by DaWetRest	Env
72	3	6 active measures implemented in DaWetRest	Env
73	3	10 passive measures used in the DaWetRest implementation	Env
74	3	8 NBS identified, tested and implemented	Env
75	3	8 NBS ready for replication	Env
76	3	minimum 4 areas under Ramsar Convention covered by DaWetRest	Env
77	3	minimum 9 areas protected by other documents and legislations covered by DaWetRest	Env
78	3	hydro-technical works conducted within DEMO sites	Env
79	3	15 local and regional authorities and municipalities involved in trainings	Env

80	3	4 resilience measures designed to sustain the reduction of local impact for floodplains, draught and storms; resilience measures to be involved in the restoration plans	Env
81	3	ca. 20.372 ha of reed involved in carbon sequestration	Env
82	3	1 km of the area preconditioned for the fast willow growth	Env
83	3	ca. 22.015 ha of wetlands that have received sustainable land management practice	Env
84	3	1 improved methodology for carbon sequestration implemented	Env
85	3	1 new strategy for the improvement of carbon sequestration capacity developed - decision support tool (DTS)	Env
86	3	At least 6 associated regions suitable for replication and applying the Action Plan	Env
87	3	At least 5 strategies incorporated in Action Plans for wetlands, floodplains, coastal wetlands and salt marshes ready for implementation	Env
88	3	300 citizens involved in the monitoring and dissemination activities via the portal	Env
89	3	data from 15 sources gathered in the portal and analysed	Env
90	3	At least 10 best practice examples, tools, actions and measures presented on Digital Portal in form of know-how and methodologies	Env
91	3	Transpose at least 7 EU policies, strategies and other relevant documents that concern freshwater ecosystem protection to the local level	L
92	3	7 national policies and strategies on freshwater ecosystem protection, restoration and management addressed by DaWetRest	L
93	3	Minimum 1 local community per demonstration area involved in the planning phase	L
94	3	15 local and regional authorities and municipalities involved in trainings	L
95	3	Transpose at least 7 EU policies, strategies and other relevant documents that concern freshwater ecosystem protection to the local level	P
96	3	22 stakeholders involved in the field of water management and nature protection	P
97	3	6 decision supporting tools made by DaWetRest	P
98	3	1 green paper released by DaWetRest	P
99	3	minimum 70 organisations involved in the Mission charter	P
100	3	15 local and regional authorities and municipalities involved in trainings	P
101	3	At least 6 associated regions suitable for replication and applying the Action Plan	P
102	3	300 citizens involved in the monitoring and dissemination activities via the portal	P
103	3	10 passive measures used in the DaWetRest implementation	S
104	3	Minimum 1 local community per demonstration area involved in the planning phase	S
105	3	10 events organised by DaWetRest to engage the impacted communities	S
106	3	reaching 5 isolated communities	S
107	3	15 local and regional authorities and municipalities involved in trainings	S
108	3	At least 5 strategies incorporated in Action Plans for wetlands, floodplains, coastal wetlands and salt marshes ready for implementation	S
109	3	5 local community training materials developed, held by the local representatives	S
110	3	1 digital Portal for data storage and communication activities established	S
111	3	2 open-source tools for citizen science activities integrated in the Portal	S
112	3	300 citizens involved in the monitoring and dissemination activities via the portal	S
113	3	data from 15 sources gathered in the portal and analysed	S
114	3	22 stakeholders involved in the field of water management and nature protection	T
115	3	186 field observations conducted	T
116	3	3 ecosystem service assessments conducted	T
117	3	6 active measures implemented in DaWetRest	T
118	3	10 passive measures used in the DaWetRest implementation	T
119	3	8 NBS identified, tested and implemented	T
120	3	8 NBS ready for replication	T
121	3	hydro-technical works conducted within DEMO sites	T
122	3	4 resilience measures designed to sustain the reduction of local impact for floodplains, draught and storms; resilience measures to be involved in the restoration plans	T
123	3	1 improved methodology for carbon sequestration implemented	T

124	3	1 new strategy for the improvement of carbon sequestration capacity developed - decision support tool (DTS)	T
125	3	1 digital Portal for data storage and communication activities established	T
126	3	2 open-source tools for citizen science activities integrated in the Portal	T
127	3	At least 10 best practice examples, tools, actions and measures presented on Digital Portal in form of know-how and methodologies	T
128	4	Implemented sediment measures impact assessed at a minimum of 3 Demonstration Sites	Econ
129	4	Demonstrated improvement of sediment continuity at 3 Demonstration Sites	Econ
130	4	Demonstrated improvement of riverbed erosion at a minimum of 2 DS	Econ
131	4	Exploration of cost-benefit aspects of sediment management alternatives for river stretches and the feasibility of creating green jobs in the maintenance activities of sustainable sediment management at least for 1 demo site.	Econ
132	4	1 online event to share lessons learnt of scenario analysis	Econ
133	4	1 Sediment Action Plan for DRB	Econ
134	4	5 replication roadmaps (1 for each Associated Region), 1 international replication workshop	Econ
135	4	10 Nature-based sediment solutions to stop sedimentation and reduce sediment quality risks	Env
136	4	Evaluated efficiency of the existing structures on 500 km of Danube and tributaries	Env
137	4	Sediment measures defined for at least 50 sedimentation hotspots and/or 500 river-km	Env
138	4	Implemented sediment measures impact assessed at a minimum of 3 Demonstration Sites	Env
139	4	Demonstrated improvement of sediment continuity at 3 Demonstration Sites	Env
140	4	10 Nature-based sediment solutions to stop riverbed erosion	Env
141	4	Sediment measures defined for 1000 km of incised river sections	Env
142	4	Sediment measures to stop riverbed erosion implemented at minimum 2 DS	Env
143	4	Demonstrated improvement of riverbed erosion at a minimum of 2 DS	Env
144	4	Sediment quality risk assessment demonstrated at 3 sites in cascade	Env
145	4	Quantified sedimentation rates at the three most important sediment trapping hotspots in Danube (Aschach, Gabcikovo, Iron Gates) by direct measurements and/or modelling approaches.	Env
146	4	>10 field measurement campaigns performed at sediment quality hotspots.	Env
147	4	At least 2 integrated sediment quantity and quality monitoring set up at sediment quality hotpots in the DRB.	Env
148	4	Quantified assessment of measures to decrease plastic pollution for at least 3 demonstration sites.	Env
149	4	2 Digital Twins for sediments (Iron Gates, Danube Delta)	Env
150	4	>10 sediment management scenarios analyzed by Digital Twins to quantify impacts of proposed sediment management measures.	Env
151	4	At least 2 scenarios developed based on proposed and potential sediment management measures	Env
152	4	Exploration of cost-benefit aspects of sediment management alternatives for river stretches and the feasibility of creating green jobs in the maintenance activities of sustainable sediment management at least for 1 demo site.	Env
153	4	At least 50 stakeholders involved to evaluate the feasibility of scenarios	Env
154	4	1 online event to share lessons learnt of scenario analysis	Env
155	4	>100 citizens educated through public laboratory tours	Env
156	4	>1000 people seeing and learning about sediment transport in a 1:1 scale model	Env
157	4	>500 citizens mobilized with Citizen Science tools	Env
158	4	>50 sediment experts from DRB and beyond trained through on-site trainings and webinars	Env
159	4	>80 science teachers trained for sediment monitoring under the 'train-the-trainer' principle	Env
160	4	>100 students participated in the iNNO SED Summer Schools & Webinars	Env
161	4	1 Sediment Atlas for DRB	Env
162	4	1 Sediment Management Toolbox	Env
163	4	1 Sediment Action Plan for DRB	Env
164	4	5 replication roadmaps (1 for each Associated Region), 1 international replication workshop	Env
165	4	1 Relocatable digital twin framework for Associated Regions	Env
166	4	Sediment quality risk assessment demonstrated at 3 sites in cascade	L
167	4	1 Sediment Action Plan for DRB	L

168	4	Exploration of cost-benefit aspects of sediment management alternatives for river stretches and the feasibility of creating green jobs in the maintenance activities of sustainable sediment management at least for 1 demo site.	P
169	4	At least 50 stakeholders involved to evaluate the feasibility of scenarios	P
170	4	1 online event to share lessons learnt of scenario analysis	P
171	4	>100 citizens educated through public laboratory tours	P
172	4	1 Sediment Atlas for DRB	P
173	4	1 Sediment Management Toolbox	P
174	4	1 Sediment Action Plan for DRB	P
175	4	5 replication roadmaps (1 for each Associated Region), 1 international replication workshop	P
176	4	Implemented sediment measures impact assessed at a minimum of 3 Demonstration Sites	S
177	4	Demonstrated improvement of sediment continuity at 3 Demonstration Sites	S
178	4	Demonstrated improvement of riverbed erosion at a minimum of 2 DS	S
179	4	Exploration of cost-benefit aspects of sediment management alternatives for river stretches and the feasibility of creating green jobs in the maintenance activities of sustainable sediment management at least for 1 demo site.	S
180	4	At least 50 stakeholders involved to evaluate the feasibility of scenarios	S
181	4	1 online event to share lessons learnt of scenario analysis	S
182	4	>100 citizens educated through public laboratory tours	S
183	4	>1000 people seeing and learning about sediment transport in a 1:1 scale model	S
184	4	>500 citizens mobilized with Citizen Science tools	S
185	4	>50 sediment experts from DRB and beyond trained through on-site trainings and webinars	S
186	4	>80 science teachers trained for sediment monitoring under the 'train-the-trainer' principle	S
187	4	>100 students participated in the iNNO SED Summer Schools & Webinars	S
188	4	1 Sediment Atlas for DRB	S
189	4	1 Sediment Management Toolbox	S
190	4	1 Sediment Action Plan for DRB	S
191	4	5 replication roadmaps (1 for each Associated Region), 1 international replication workshop	S
192	4	1 Relocatable digital twin framework for Associated Regions	S
193	4	Reviewed 100 journal papers presenting sediment quality and quantity monitoring and modelling approaches	T
194	4	Combined sediment quantity and quality measurement platform tested at minimum 2 sites in DRB	T
195	4	Surrogate bedload measurement tool tested at minimum 3 sites in DRB	T
196	4	New sediment transport formula for numerical models, based on 1:1 scale model and field data	T
197	4	AI based sediment quality and macroplastic monitoring method tested at 3 sites	T
198	4	EO-based sediment assessment method developed and tested for the Danube Delta region	T
199	4	1 basin scale flow, sediment, and pollutant transport numerical model	T
200	4	1 Engineering handbook and guidelines for sediment analysis methods system in the Danube River Basin covering at least 1000 river km	T
201	4	>20 scientific papers published in international journals and international conferences	T
202	4	10 Nature-based sediment solutions to stop sedimentation and reduce sediment quality risks	T
203	4	Evaluated efficiency of the existing structures on 500 km of Danube and tributaries	T
204	4	Sediment measures defined for at least 50 sedimentation hotspots and/or 500 river-km	T
205	4	Implemented sediment measures impact assessed at a minimum of 3 Demonstration Sites	T
206	4	Demonstrated improvement of sediment continuity at 3 Demonstration Sites	T
207	4	10 Nature-based sediment solutions to stop riverbed erosion	T
208	4	Sediment measures defined for 1000 km of incised river sections	T
209	4	Sediment measures to stop riverbed erosion implemented at minimum 2 DS	T
210	4	Demonstrated improvement of riverbed erosion at a minimum of 2 DS	T
211	4	Sediment quality risk assessment demonstrated at 3 sites in cascade	T
212	4	Quantified sedimentation rates at the three most important sediment trapping hotspots in Danube (Aschach, Gabcikovo, Iron Gates) by direct measurements and/or modelling approaches.	T

213	4	>10 field measurement campaigns performed at sediment quality hotspots.	T
214	4	Quantified assessment of measures to decrease plastic pollution for at least 3 demonstration sites.	T
215	4	2 Digital Twins for sediments (Iron Gates, Danube Delta)	T
216	4	>10 sediment management scenarios analyzed by Digital Twins to quantify impacts of proposed sediment management measures.	T
217	4	At least 2 scenarios developed based on proposed and potential sediment management measures	T
218	4	Exploration of cost-benefit aspects of sediment management alternatives for river stretches and the feasibility of creating green jobs in the maintenance activities of sustainable sediment management at least for 1 demo site.	T
219	4	At least 50 stakeholders involved to evaluate the feasibility of scenarios	T
220	4	1 online event to share lessons learnt of scenario analysis	T
221	4	>100 citizens educated through public laboratory tours	T
222	4	>1000 people seeing and learning about sediment transport in a 1:1 scale model	T
223	4	>500 citizens mobilized with Citizen Science tools	T
224	4	>50 sediment experts from DRB and beyond trained through on-site trainings and webinars	T
225	4	>80 science teachers trained for sediment monitoring under the 'train-the-trainer' principle	T
226	4	>100 students participated in the iNNO SED Summer Schools & Webinars	T
227	4	1 Sediment Atlas for DRB	T
228	4	1 Sediment Management Toolbox	T
229	4	1 Sediment Action Plan for DRB	T
230	4	5 replication roadmaps (1 for each Associated Region), 1 international replication workshop	T
231	4	1 Relocatable digital twin framework for Associated Regions	T
232	5	Wetland managers and scientists have access to low-cost, easily transferable wetland monitoring tools	Econ
233	5	Capacity building for 50 stakeholders incl. entrepreneurs plus 15 wetland educators per demo sites and associated regions	Econ
234	5	PESTLE analyses conducted with all implementation and associated region site stakeholders (9 sites)	Econ
235	5	SWOT assessment interviews conducted in person with restoration site businesses (21)	Econ
236	5	Review of biodiversity evaluation schemes and regulations conducted	Econ
237	5	NbS business development advice provided to local entrepreneurs (5 cases)	Econ
238	5	Wetland managers and scientists have access to low-cost, easily transferable wetland monitoring tools	Env
239	5	Re-connection of side arm system (4 km2) and restoration of bank lines in IS1	Env
240	5	Re-connection of side arm system in IS2 (6 km, 560 ha)	Env
241	5	>3000 ha restoration of transitional mire habitats at IS3	Env
242	5	>2000 ha wetlands restored at IS4	Env
243	5	>10,000 people reached through the R4L communication activities and informed about the benefits of wetland restoration	Env
244	5	At least 15 schools have adopted the R4L educational program	Env
245	5	At least 30 stakeholders have been informed about the Wetland4Life web app for citizens and the Solution4Life app for stakeholders	Env
246	5	At least 9 schools have installed a treatment wetland model	Env
247	5	At least 6 scientific papers published in OA journals	Env
248	5	Framework for road maps and plans for wetland restoration	Env
249	5	Roadmaps and plans for wetland restoration in 5 associated regions	Env
250	5	PESTLE analyses conducted with all implementation and associated region site stakeholders (9 sites)	Env
251	5	SWOT assessment interviews conducted in person with restoration site businesses (21)	Env
252	5	Review of biodiversity evaluation schemes and regulations conducted	Env
253	5	NbS business development advice provided to local entrepreneurs (5 cases)	Env
254	5	PESTLE analyses conducted with all implementation and associated region site stakeholders (9 sites)	L
255	5	SWOT assessment interviews conducted in person with restoration site businesses (21)	L
256	5	Review of biodiversity evaluation schemes and regulations conducted	L
257	5	Framework for road maps and plans for wetland restoration	P

258	5	Roadmaps and plans for wetland restoration in 5 associated regions	P
259	5	PESTLE analyses conducted with all implementation and associated region site stakeholders (9 sites)	P
260	5	SWOT assessment interviews conducted in person with restoration site businesses (21)	P
261	5	Review of biodiversity evaluation schemes and regulations conducted	P
262	5	Wetland managers and scientists have access to low-cost, easily transferable wetland monitoring tools	S
263	5	>10,000 people reached through the R4L communication activities and informed about the benefits of wetland restoration	S
264	5	At least 15 schools have adopted the R4L educational program	S
265	5	At least 30 stakeholders have been informed about the Wetland4Life web app for citizens and the Solution4Life app for stakeholders	S
266	5	At least 9 schools have installed a treatment wetland model	S
267	5	At least 6 scientific papers published in OA journals	S
268	5	Capacity building for 50 stakeholders incl. entrepreneurs plus 15 wetland educators per demo sites and associated regions	S
269	5	PESTLE analyses conducted with all implementation and associated region site stakeholders (9 sites)	S
270	5	SWOT assessment interviews conducted in person with restoration site businesses (21)	S
271	5	Review of biodiversity evaluation schemes and regulations conducted	S
272	5	PESTLE analyses conducted with all implementation and associated region site stakeholders (9 sites)	T
273	5	SWOT assessment interviews conducted in person with restoration site businesses (21)	T
274	5	Review of biodiversity evaluation schemes and regulations conducted	T
275	5	NbS business development advice provided to local entrepreneurs (5 cases)	T
276	6	Industry actors adopts the monitoring and remediation technology (>=50).	Econ
277	6	European industry adopts effective remediation technology by scaling up of innovative solutions and onsite (3 industries)	Econ
278	6	Reduction in infrastructure management time and costs with increased cooperation (15%)	Econ
279	6	Number of associated regions replicating demonstrators with number of local support organisations during 2 open calls. (>=4; >=8)	Env
280	6	Reduction in pollutants in the Danube River Basin where technology is adopted.80%	Env
281	6	Policy Recommendations and Adaptations: number of policy recommendations anda daptations made to the Water Framework Directive and other relevant EU policies based on the project (2+).	L
282	6	Increased Cooperation Index between Danube River national authorises (20%)	L
283	6	Policy Recommendations and Adaptations: number of policy recommendations anda daptations made to the Water Framework Directive and other relevant EU policies based on the project (2+).	P
284	6	Number of stakeholders actively involved in policy discussions and implementation 50+	P
285	6	Increased Cooperation Index between Danube River national authorises (20%)	P
286	6	Number of stakeholders actively involved in policy discussions and implementation 50+	S
287	6	Number of associated regions replicating demonstrators with number of local support organisations during 2 open calls. (>=4; >=8)	S
288	6	Industry actors adopts the monitoring and remediation technology (>=50).	T
289	6	European industry adopts effective remediation technology by scaling up of innovative solutions and onsite (3 industries)	T

Annex II

	Pillar 1 - Knowledge Creation and Valorisation	
	1.1 Knowledge valorisation at regional and local levels for transformative Mission-oriented solutions	
1	Wetland managers and scientists have access to low-cost, easily transferable wetland monitoring tools	Monitoring and Assessment Tools
2	Review of biodiversity evaluation schemes and regulations conducted	
3	AI based sediment quality and macroplastic monitoring method tested at 3 sites	
4	3 ecosystem service assessments conducted	
5	Combined sediment quantity and quality measurement platform tested at minimum 2 sites in DRB	
6	Surrogate bedload measurement tool tested at minimum 3 sites in DRB	
7	EO-based sediment assessment method developed and tested for the Danube Delta region	
8	Sediment quality risk assessment demonstrated at 3 sites in cascade	
9	1 improved methodology for carbon sequestration implemented	
10	1 monitoring activity per each site for the assessment of NBS implementation	Data and Knowledge
11	At least 2 integrated sediment quantity and quality monitoring set up at sediment quality hotpots in the DRB.	
12	Quantified sedimentation rates at the three most important sediment trapping hotspots in Danube (Aschach, Gabcikovo, Iron Gates) by direct measurements approaches.	
13	>10 field measurement campaigns performed at sediment quality hotspots.	
14	Quantified assessment of measures to decrease plastic pollution for at least 3 demonstration sites.	
15	1 Sediment Atlas for DRB	
16	data from 15 sources gathered in the portal and analysed	
17	Basin wide maps of distribution of protected species and invasive species for at least 15 species	
18	186 field observations conducted	
19	1 digital Portal for data storage and communication activities established	
20	12 scientific papers (Open Access) published during the project implementation	Publication/Scientific
21	At least 6 scientific papers published in OA journals	
22	Reviewed 100 journal papers presenting sediment quality and quantity monitoring and modelling approaches	
23	>20 scientific papers published in international journals and international conferences	
24	New sediment transport formula for numerical models, based on 1:1 scale model and field data	Modelling
25	Quantified sedimentation rates at the three most important sediment trapping hotspots in Danube (Aschach, Gabcikovo, Iron Gates) by direct modelling approaches.	
26	1 basin scale flow, sediment, and pollutant transport numerical model	
27	Guidelines distributed to at least 200 stakeholders	Management Tools and Guidelines
28	1 Engineering handbook and guidelines for sediment analysis methods system in the Danube River Basin covering at least 1000 river km	
29	1 Sediment Management Toolbox	
30	At least 10 best practice examples, tools, actions and measures presented on Digital Portal in form of know-how and methodologies	
31	1 Relocatable digital twin framework for Associated Regions	
32	Capacity building for 50 stakeholders incl. entrepreneurs plus 15 wetland educators per demo sites and associated regions	
33	2 open-source tools for citizen science activities integrated in the Portal	
34	1 online event to share lessons learnt of scenario analysis	
35	1,000 stakeholders participating and/or informed by 3 International Seminars and 1 online training course (Separated KPI (1.1.35, 2.1.18 and 3.2.19 originally merged))	

	Pillar 2 - Governance	
	2.1 Mission-oriented governance mechanisms	
1	At least 15 Policy makers and Water Authorities linked to the project (LoI / MoU signed)	Policy and Frameworks
2	Framework for road maps and plans for wetland restoration	
3	Policy Recommendations and Adaptations: number of policy recommendations anda daptations made to the Water Framework Directive and other relevant EU policies based on the project (2+).	
4	Transpose at least 7 EU policies, strategies and other relevant documents that concern freshwater ecosystem protection to the local level	
5	7 national policies and strategies on freshwater ecosystem protection, restoration and management addressed by the project	
6	1 green paper released by the project	
7	1,000 stakeholders informed by 2 Policy Briefs (Separated KPI (1.1.35, 2.1.18 and 3.2.19 originally merged))	
8	Roadmaps and plans for wetland restoration in 5 associated regions	Roadmaps and Action Plans
9	1 integrative Restoration Action Plan for the whole DRB	
10	At least 6 associated regions suitable for replication and applying the Action Plan	
11	At least 5 strategies incorporated in Action Plans for wetlands, floodplains, coastal wetlands and salt marshes ready for implementation	
12	5 replication roadmaps (1 for each Associated Region), 1 online replication toolkit, 1 online pan-European replication workshop	
13	5 replication roadmaps (1 for each Associated Region), 1 international replication workshop	
14	1 Sediment Action Plan for DRB	
15	Increased Cooperation Index between Danube River national authorises (20%)	Cooperation
16	Reduction in infrastructure management time and costs with increased cooperation (15%)	
17	1 new strategy for the improvement of carbon sequestration capacity developed - decision support tool (DTS)	
18	6 decision supporting tools made by the project	

	2.2 Acceptance of Mission-oriented innovation policy
1	Industry actors adopts the monitoring and remediation technology (>=50).
2	European industry adopts effective remediation technology by scaling up of innovative solutions and onsite (3 industries)
3	4 resilience measures designed to sustain the reduction of local impact for floodplains, draught and storms; resilience measures to be involved in the restoration plans
4	Number of stakeholders actively involved in policy discussions and implementation 50+
5	At least 50 stakeholders involved to evaluate the feasibility of scenarios

	Pillar 3 - Participatory engagement of stakeholders/citizens
	3.1 Co-creation of Mission solutions with citizens in programs beyond Horizon Europe
1	At least 30 stakeholders have been informed about the project's web app for citizens and the project's app for stakeholders
2	Minimum 1 local community per demonstration area involved in the planning phase
3	reaching 5 isolated communities
4	15 local and regional authorities and municipalities involved in trainings

	3.2 Citizens engaged in processes and activities in Mission units (lighthouses, living labs, hubs…) + R&I solutions for societal challenges achieved	
1	At least 15 schools have adopted the project's educational program	Education, Training and Awareness
2	At least 9 schools have installed a treatment wetland model	
3	5 local community training materials developed, held by the local representatives	
4	1 million citizens reached by the project's communication activities (including TV spots) and informed about biodiversity loss and measures to improve the situation	
5	>10,000 people reached through the project's communication activities and informed about the benefits of wetland restoration	
6	>100 citizens educated through public laboratory tours	
7	>1000 people seeing and learning about sediment transport in a 1:1 scale model	
8	>80 science teachers trained for sediment monitoring under the 'train-the-trainer' principle	
9	10 events organised by the project to engage the impacted communities	
10	Citizen Science tools transferred, knowledge exchange done for 10 Synergy Sites	Citizen Science Tools and Involvement
11	300 citizens involved in the monitoring and dissemination activities via the portal	
12	1,000 citizens mobilized and equipped with new citizen science tools	
13	>500 citizens mobilized with Citizen Science tools	
14	5,000 citizens and 100 stakeholders mobilized or involved to participate in the implementation of Demonstration Sites, Synergy Sites and Associated Regions	
15	>50 sediment experts from DRB and beyond trained through on-site trainings and webinars	Workshops and Seminars
16	>100 students participated in the project's Summer Schools & Webinars	
17	1,000 stakeholders participating and/or informed by 3 Multi-actor fora, as well as complementary educational events – museum visits, boat trips (Separated KPI (1.1.35, 2.1.18 and 3.2.19 originally merged))	
18	minimum 70 organisations involved in the Mission charter	
19	22 stakeholders involved in the field of water management and nature protection	
20	Number of associated regions replicating demonstrators with number of local support organisations during 2 open calls. (>=4; >=8)	
21	PESTLE analyses conducted with all implementation and associated region site stakeholders (9 sites)	

	Pillar 4 - Pooling and scaling-up
	4.1 Pooling and leveraging of public and private funds
1	3 training workshops in each Associated Region for knowledge transfer, exchange and capacity building
2	3 business models to strengthen economic potentials from wetlands, floodplains, coastal wetlands and salt marshes
3	3 detailed business cases at the 3 Demonstration Sites
4	NbS business development advice provided to local entrepreneurs (5 cases)
5	SWOT assessment interviews conducted in person with restoration site businesses (21)

	4.2 Scaling of transformative solutions and supportive measures (regulatory, technological, standards, educational...)	
1	8 NBS identified, tested and implemented	NbS solutions + measures
2	8 NBS ready for replication	
3	Win2 NBS restoration measures defined for 100 longitudinal barriers and 3,000 km of river	
4	Win2 NBS applied in 3 Demonstration Sites to demonstrate the positive impact on reducing flood and drought risks	
5	Win2 NBS restoration measures defined for 50 floodplains, wetlands and the lagoon system	
6	Win2 NBS restoration measures applied in the 3 Demonstration Sites in the Upper, Middle Danube and Delta	
7	ESS gains due to Win2 NBS measures demonstrated for 10 floodplains	
8	10 Nature-based sediment solutions to stop riverbed erosion	
9	10 Nature-based sediment solutions to stop sedimentation and reduce sediment quality risks	
10	Connectivity of at least 3 DRB technical solutions (DPS + Pilots of the 2nd stage)	Demo / Pilot Site
11	Sediment transport optimalisation: minimum 2 DPS and 2 pilots in the 2nd stage	
12	Warning system planned on at least 3 pilots (DPS + pilots of the 2nd stage)	
13	Experimental implementations of at least 20 project tools on the different pilots (DPS + pilots of the 2nd stage)	
14	hydro-technical works conducted within DEMO sites	
15	Demonstration Site 1: Increase of rheophilic juvenile fish abundances along the shorelines of restored river banks by 50% after implementation Demonstration Site 2: Increase of rheophilic fish biomass in optimized groyne sections compared to the situation before Demonstration Site 3: Technical solution to improve the connectivity with the Black Sea showing the multiple ecologic, social and economic benefits agreed with the key stakeholders	
16	Implemented sediment measures impact assessed at a minimum of 3 Demonstration Sites	
17	Demonstrated improvement of sediment continuity at 3 Demonstration Sites	
18	Sediment measures to stop riverbed erosion implemented at minimum 2 DS	
19	Demonstrated improvement of riverbed erosion at a minimum of 2 DS	
20	Re-connection of side arm system (4 km2) and restoration of bank lines in IS1	Restoration/Conservation measures
21	Re-connection of side arm system in IS2 (6 km, 560 ha)	
22	>3000 ha restoration of transitional mire habitats at IS3	
23	>2000 ha wetlands restored at IS4	
24	1 conservation work (intervention) provided by the project	
25	6 active measures implemented in the project	
26	10 passive measures used in the project's implementation	
27	1 connectivity restoration toolbox (longitudinal, lateral and vertical dimensions)	
28	Sediment measures defined for at least 50 sedimentation hotspots and/or 500 river-km	
29	Sediment measures defined for 1000 km of incised river sections	
30	ca. 20.372 ha of reed involved in carbon sequestration	
31	1 km of the area preconditioned for the fast willow growth	
32	ca. 22.015 ha of wetlands that have received sustainable land management practice	
33	1 transboundary monitoring demonstration to assess fish community status covering approx. 800 km of river stretches	Monitoring and Evaluation
34	Evaluated efficiency of the existing structures on 500 km of Danube and tributaries	
35	Reduction in pollutants in the Danube River Basin where technology is adopted.80%	
36	minimum 4 areas under Ramsar Convention covered by the project	
37	minimum 9 areas protected by other documents and legislations covered by the project	

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