

EU4GREEN

GUIDANCE DOCUMENT ON NATURE-BASED SOLUTIONS: RIPARIAN BUFFER ZONES

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the Green Agenda for the Western Balkans

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of Floodplains in Protected Areas

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ABBREVIATIONS

| | |
|--------------|--|
| CICES | Common International Classification of Ecosystem Services |
| ES | Ecosystem Services |
| EU | European Union |
| GIS | Geographic Information System |
| IUCN | International Union for Conservation of Nature |
| NbS | Nature-based Solutions |
| NGO | Non-governmental Organisation |
| WB6 | Western Balkans Six (Albania, Bosnia and Herzegovina, Kosovo*, Montenegro, North Macedonia and Serbia) |

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SUMMARY

The Western Balkans host diverse riparian ecosystems that are vital for biodiversity and human well-being but are increasingly threatened by climate change, unsustainable land use, and hydrological modifications. Addressing these pressures requires adaptive measures that meet both ecological and societal needs while supporting alignment with EU environmental standards.

Nature-based Solutions (NbS) provide practical and cost-effective measures for achieving many environmental and climate objectives. NbS help to protect, sustainably manage, and restore natural or modified ecosystems while addressing societal challenges and providing benefits for human well-being and biodiversity. In the context of riparian ecosystems such as floodplains, NbS offer promising and cost-effective approaches to the named challenges.

High flood risk is one of the most pressing societal challenges in the floodplains of the Western Balkans. The implementation of riparian buffer zones offers a potent example of how NbS can tackle societal challenges, provide economic revenue, and secure benefits for biodiversity.

This guidance document is meant for practitioners, policy makers and project developers, and provides a comprehensive framework for the effective planning, implementation, and management of riparian buffer zones as a NbS, incorporating the IUCN Global Standards of NbS as backbone. It elaborates on the definition and benefits of NbS in general and riparian buffer zones in particular, covers relevant policies, frameworks and guidelines, lays out data-based options for planning and evaluating riparian buffer zones as NbS, summarises funding options, provides a three-phased implementation plan and highlights potential constraints faced during implementation. By promoting strategic, evidence-based, and participatory approaches, this document supports the integration of NbS into broader policy and planning frameworks to achieve sustainable, resilient, and multifunctional outcomes.

The guidance document developed underlines both the opportunities and the challenges of translating NbS from concept to practice in the Western Balkans. To ensure success, a balanced approach that integrates science, policy, and local participation is required. The key takeaways can be concluded as:

- **High potential of NbS, specifically riparian buffer zones:** NbS offer multiple benefits, from flood risk reduction and water quality improvement to biodiversity conservation and enhanced human well-being.
- **Evidence-based and participatory approach:** Combining scientific data with expert and stakeholder input ensures more robust, context-specific solutions.
- **Key role of indicators:** Monitoring through clear and measurable indicators is essential for evaluating effectiveness, adaptive management, and long-term sustainability as well as the preliminary assessments of the status of the site and the demand of societal challenges.
- **Challenges remain:** Implementation faces barriers such as limited data availability, financial constraints, fragmented governance, and competing land-use priorities.
- **Way forward:** Bridging the gap between policy ambitions and on-the-ground practice requires sustained commitment, cross-sectoral cooperation, and investment in knowledge and capacity building.

1 INTRODUCTION

The Green Agenda for the Western Balkans (GAWB) is setting a strategic framework for the six economies in Southeastern Europe – Albania, Bosnia and Herzegovina, Kosovo*, Montenegro, North Macedonia, and Serbia. It was adopted by the Western Balkan Six (WB6) at the Sofia Summit in 2020, with the aim to guide the economies' transition towards climate neutrality and environmental sustainability in alignment with the European Green Deal.

The GAWB reflects the European Union's commitment to support the WB6 in addressing environmental challenges while promoting economic and social development. It defines five key pillars, covering Decarbonisation, Circular Economy, Depollution of Air, Water and Soil, Sustainable Agriculture and Protection of Biodiversity and Ecosystems. By striving to develop the economies in accordance with the objectives of those pillars, the WB6 work towards the fulfillment of the requirements for EU membership.

The EU4Green project plays a key role in the European Commission's ongoing commitment to supporting the WB6 in their transformative journey towards sustainability. Protecting and safeguarding biodiversity while balancing economic growth and environmental sustainability is one of the core topics of the biodiversity pillar. It tackles a wide range of topics, including Nature-based Solutions (NbS), particular focus is laid on Natura 2000, Invasive Alien Species and Connectivity. Knowledge and expertise are being shared to assist the beneficiaries of the partnered economies. This guidance document is one of its outcomes, dealing in particular with NbS and their implementation in the context of floodplains.



Nature-based Solution in the Western Balkans

Given its rich biodiversity, varied ecosystems, and vulnerability to climate change and environmental degradation, the Western Balkan region presents a compelling case for the implementation and scaling up of NbS. Currently, the region faces several pressing challenges such as land degradation, water scarcity, flooding, and biodiversity loss – often exacerbated by unsustainable land use, limited environmental governance capacity, and underinvestment in green infrastructure. (Schwarz et al. 2018).

Despite these challenges, there is growing recognition of the value and potential of NbS in addressing these issues in a cost-effective and socially inclusive way. Several economies in the region have initiated pilot projects on wetland restoration, forest conservation, and erosion control, which show promising results in terms of enhancing ecosystem services and community resilience. The Western Balkans' alignment with EU environmental standards through the GAWB creates a favourable policy environment for further mainstreaming NbS.

With increased technical support, investment, and cross-border cooperation, the region has substantial potential for scaling up NbS interventions that not only contribute to EU-aligned environmental objectives but also foster sustainable economic development, rural revitalisation, and greater climate resilience.

2 HOW TO USE THE GUIDANCE DOCUMENT

The aim of this guidance document is to lead the readers through the process of designing, implementing and maintaining NbS related to freshwater ecosystems, using riparian buffer zones as an example. Following the eight criteria of the Global Standard for Nature-based Solutions (IUCN, 2020a), the key aspects during the realisation process are elaborated on the example of riparian buffer zones. To underline the importance of NbS, specifically riparian buffer zones, in the context of biodiversity protection, mitigation of climate change effects and, ultimately, serving the society, the arising benefits of NbS in general are presented.

The **identification of suitable indicators** as well as the **general data availability** for planning the measures is a crucial point. Useful data types and examples for available sources are intended to help with the search of suitable information to back up the envisaged NbS project fact-based following a scientific approach. Environmental or biological parameters serve as indicators for defining pressing societal challenges, measuring the desired impact and effectiveness of the actions and monitoring the riparian buffer zone outcome in the long run.

A **robust financial plan** and thus access to reliable and sufficient funding is vital for being successful. Due to its importance, this topic is covered specifically within the respective chapter. Existing funding opportunities from the global to the regional level are presented to the user. Also, an overview of the funding requirements, budget ranges and links to the various programs is given to help with the selection of the right funding scheme.

In order to break down the challenging endeavour of planning and realising suitable NbS like riparian buffer zones in the Western Balkans, this document pursues an **implementation approach** structured in three phases:

1. **Design and assessment**
2. **Implementation**
3. **Maintenance and evaluation**

It enables the user to develop a sound, sustainable and effective implementation of the given NbS, that aims to tackle challenges of society and nature conservation in an inclusive manner. The final project plan should not only describe solutions provided by nature but also be integrated in policy - making processes and gain acceptance among the general public. Analysing and considering potential **constraints and barriers** during different phases of the activities also add to a sound implementation concept.

Overall, this document is intended as a guide for practitioners, planners, and decision-makers involved in environmental restoration and landscape management specifically in the Western Balkans but also beyond. This includes implementing stakeholders, such as administrative bodies of protected areas, governmental entities, NGOs or technical bureaus, with the goal of implementing riparian buffer zones in the floodplains of their economy, region or municipality. The user should be informed about the key aspects and necessary steps that support successful project implementation. They should also understand how to approach and integrate these elements into the process. However, for the purpose of a comprehensive guidance document, not every step is intended to be explained in full detail.

For more specific information and further readings on the several considerations, the guidance document refers to complementary guidelines, handbooks and other relevant sources.

3 NATURE-BASED SOLUTIONS

What are Nature-based Solutions?

Nature-based Solutions (NbS) are interventions that protect, sustainably manage and restore natural or modified ecosystems. They effectively and adaptively address societal challenges while simultaneously providing benefits to human well-being and biodiversity gain (Figure 1). NbS are more than just random environmental interventions; they consider economic, social and environmental conditions prior to the actions. Thus, they are strategic responses to issues such as climate change, disaster risk, food and water security, and human health. These interventions are grounded in the functionality and resilience of nature and natural ecosystems. (Sowińska-Świerkosz & García, 2022; Dumitru & Wendling, 2021; Cohen-Shacham et al., 2016)



“Nature-based solutions are actions to protect, manage and restore natural or modified ecosystems, which address societal challenges, effectively and adaptively, providing human well-being and biodiversity benefits“- IUCN (2016).



Figure 1: NbS addressing societal challenges with the ecosystem-based approach. (IUCN, 2020a)

Other than technology-based solutions relying heavily on engineered infrastructure such as flood barriers, storm basins or concrete drainage systems, NbS use the inherent processes and services of nature.

As concluded by Nesshöver et al. (2017), NbS offer a promising integrative approach to tackle environmental and societal challenges such as climate change, urban resilience, and biodiversity loss. However, realising their full potential requires transdisciplinary collaboration, strong policy frameworks, and a robust evidence base.

Nature-based Solutions for freshwater ecosystems

Freshwater ecosystems play a crucial role in supporting human life and health, for example by supplying drinking water, enabling agriculture and offering recreational opportunities. At the same time, they can be rich in biodiversity. Yet, human activities such as over-extraction, pollution, and alteration of river flows often disrupt these dynamic and sensitive ecosystems, leading to declines in water quality and loss of habitat, thereby affecting both people and biodiversity.

However, NbS in freshwater ecosystems can tackle these challenges, reduce the vulnerability of water management systems and simultaneously generate socio-economic benefit. (European Commission, 2024; van Wesenbeeck et al., 2021)

This includes, for example, restoring wetlands or riparian forests, which can absorb and slow floodwaters naturally. These solutions become more adaptive over time and often offer additional benefits such as the creation of habitats, carbon sequestration, and recreational spaces. In comparison to the technical alternative, floodplain restoration can ensure equal flood security while providing more ecosystem services (ES) and greater benefits for biodiversity. (Turlboom et al., 2021)

As shown in several European countries (e.g. NL & HU), NbS approaches, such as management measures that restore a river's ability to form the landscape in its proximity are a great success. Pressures on floodplains, such as altered hydraulic conditions can affect biodiversity. However, these effects can be counteracted, leading to improvements in biodiversity, landscape diversity and natural dynamics (Schindler et al., 2016). Within EU4Environment (2024) – another EU-funded project, implemented by the Environment Agency Austria – 34 effective NbS that can be applied for water management in river basins were identified, providing a broad overview of the ample options available.

Nature-based Solutions in EU policies and frameworks

NbS in freshwater ecosystems are closely aligned with several key pillars of European environmental policy, particularly those that shape the governance and management of water and biodiversity.

Within the framework of the **EU Water Framework Directive (WFD)**, which aims to achieve good ecological and chemical status of all water bodies, NbS offer a practical and effective means to meet these goals. The restoration of floodplains, the rewetting of peatlands, and the rehabilitation of riverbeds directly improve water quality, regulate hydrological regimes, and enhance the ecological integrity of aquatic systems.

The **EU Nature Restoration Regulation (NRR)** further strengthens the relevance of NbS by proposing legally binding targets for the restoration of degraded ecosystems across member states. This law acknowledges that ecological restoration is not only a means of reversing biodiversity loss but also a key strategy for climate adaptation and resilience. Key restoration activities such as afforestation, wetland regeneration, or coastal habitat recovery are considered as NbS.

The multi-functional character of NbS renders them especially valuable for meeting restoration targets while delivering co-benefits in areas such as climate change mitigation and adaptation, agriculture, water retention, and disaster risk reduction. Art. 9 specifically targets the "Restoration of the natural connectivity of rivers and natural functions of the related floodplains", but also other articles of the EU NRR are closely connected to the studies aim.

The objectives of the **EU Habitats Directive** are also reflected in NbS, as the directive establishes a network of protected areas under Natura 2000 and mandates the conservation of natural habitats and species of European importance. By restoring or enhancing the structure and functioning of ecosystems of the floodplains and beyond, NbS improve the conservation status of habitats and species listed under the directive. They provide a strategic means of supporting habitat connectivity, buffering protected areas, and increasing the resilience of species populations in the face of environmental pressures and climate change.

The **EU Biodiversity Strategy** for 2030 further integrates NbS into the broader European environmental agenda by explicitly calling for the large-scale deployment of NbS as part of its overarching goal to halt and reverse biodiversity loss. The strategy envisions the restoration of at least 20 percent of the EU's land and sea areas, a target that hinges on implementing effective, scalable, and inclusive approaches. The importance of NbS as pivotal instruments for achieving this objective is emphasised, not only through direct nature restoration but also by integrating biodiversity considerations into sectors such as agriculture, forestry, and urban planning.

The **EU Adaptation Strategy** explicitly highlights the potential and promotes the large-scale application of NbS for climate change adaptation and particularly carbon removal. The Commission affirms that financial approaches covering nature-based adaptation will be developed, and that Member States will be assisted in rolling out NbS. Furthermore, the importance of NbS is highlighted in the **EU Climate Law**.

In addition, NbS in the context of freshwater ecosystems can be linked to various other EU policies like the Nitrates Directive, the Groundwater Directive, the Floods Directive, the Common Agricultural Policy or the novel EU Water Resilience Strategy. (Albrecht et al., 2025) In essence, NbS serve as a unifying framework that connects these major EU directives and strategies. NbS embody a paradigm shift towards systemic, ecosystem-based governance, where water management, habitat conservation, climate resilience, and sustainable development are addressed through interconnected, nature-positive actions.

In the case of the WB6, these the concept, planning or implementation of NbS support them in their various stages of the accession process, thus helping to advance in the alignment to these EU directives and strategies.

Guidelines and frameworks on NbS implementation

Before embarking on the conceptualisation of the NbS and its implementation, it is advisable to make use of the various guidelines and frameworks, during and after the planning phase. They offer tools to e.g. develop indicators, choose methods and elaborate an adaptive management and a monitoring plan, optimising the concept for the NbS project.

The [IUCN Global Standard for Nature-based Solutions](#) (IUCN, 2020a, 2020b) is a framework developed by the International Union for Conservation of Nature (IUCN) to guide the design, implementation, and evaluation of NbS. It defines eight criteria and 28 indicators to evaluate the effectiveness and sustainability of NbS, including a guidance on biodiversity monitoring, ecosystem integrity, trade-offs and adaptive management. Ensuring that the NbS effectively address societal challenges – such as climate change, biodiversity loss, and disaster risk – while simultaneously supporting sustainable development and protecting natural ecosystems. The standard promotes solutions that are both scientifically sound and socially inclusive, encouraging collaboration among stakeholders to maximise benefits for people and nature.

Meeting the eight criteria of the IUCN Global Standard for Nature-based Solutions (IUCN, 2020a, 2020b) is particularly helpful in designing and managing NbS to achieve feasible, measurable and sustainable benefits for society and the environment. The Global Standard offers scalable, biodiverse, economically viable and inclusive solutions. Their adaptability and integration into policy frameworks make them central to improving ecosystem health, human well-being and resilience to global challenges.

All criteria are interconnected and fulfilling them is vital for the successful implementation of NbS in a sustainable manner. The eight main aspects can be summarised as follows (IUCN, 2020a, 2020b):

| | |
|--------------------|---|
| Criterion 1 | The NbS effectively addresses the most pressing societal challenges, with a clear understanding of and documentation of these challenges, as well as the outcomes for human well-being. |
| Criterion 2 | The NbS recognises the necessary scale and considers the interaction between ecosystems, the economy and society, as well as possible synergies and risks. |
| Criterion 3 | The NbS leads to an increase in biodiversity and ecosystem integrity that can be monitored periodically. |
| Criterion 4 | The NbS is economically viable, considering several options for resources |
| Criterion 5 | The NbS is based on inclusive, transparent and empowering governance processes, including feedback of local stakeholders. |
| Criterion 6 | The NbS equitably balances trade-offs between achievement of its primary goal(s) and the continued provision of multiple benefits. |
| Criterion 7 | The NbS is managed adaptively, based on evidence. |
| Criterion 8 | The NbS is sustainable and has been integrated into an appropriate jurisdictional context. |

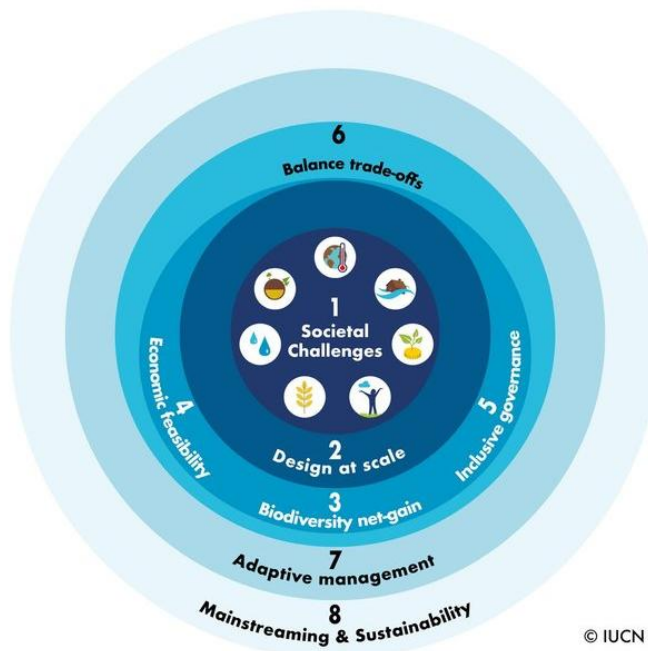


Figure 2: The eight interconnected criteria of the IUCN Global Standards for NbS. (IUCN, 2020a)

The principles of the eight interconnected criteria (Figure 2) form the basis of this document, which tries to cover the most relevant points for the WB6, with the focus on riparian buffer zones.

Further frameworks and concepts also highly relevant for the implementation of NbS are, among others, listed below:

Frameworks of Ecosystem Services

These hierarchical frameworks define ES in a structured manner. Based on the definitions, indicators can be derived, enabling the assessment of ES and their changes over time. Thus, the effect of NbS on monitored systems, such as floodplains, can be evaluated as well. Examples for possible indicators include carbon storage in the soil, purification degree of the water, etc.

This guidance document follows one of the most widely used systems – the [Common International Classification of Ecosystem Services](#) (CICES; Haines-Young, 2023).

EU Mapping and Assessment of Ecosystems and their Services

The so-called [MAES report](#) (Maes et al., 2020), prepared by the Joint Research Centre, the European Environment Agency, DG Environment, and the European Topic Centres, assesses the state of EU terrestrial, freshwater, and marine ecosystems. Using a consistent methodology and the 2010 policy baseline, it analyses ecosystem pressures and conditions to evaluate progress toward the 2020 biodiversity targets and to provide a data foundation for future policy and restoration efforts (2020–2030).

This knowledge can be used for planning green infrastructure and biodiversity by EU member states. It also helps to assess the condition of ecosystems and services provided by implemented NbS.

Catalogue of Nature-based Solutions (EU4Environment)

This [catalogue](#) for the water sector in the Eastern Partnership countries (EU4Environment, 2024) provides 34 NbS specifically for the context of river ecosystems habitats or land use types in proximity to water bodies. Besides the restoration of riparian vegetation and buffer strips, it offers potential measures for the river itself, adjacent forests, agricultural land or grasslands as well as built-up areas.

A one-paged factsheet is dedicated for each measure, consisting of information on scale, pressure efficiency, relevant stakeholders, a short description on how to implement it, including a cost calculation as well as technical references and related case studies.

Guidelines for measuring ES Indicators

The [guidance on measuring ecosystem services](#) (Brown et al., 2014) provides support for selecting suitable environmental, social and economic indicators. These parameters are also highly applicable on NbS. Indicators should follow the SMART concept (meaning they should be specific, measurable, achievable, relevant, time-bound).

OPPLA Knowledge Platform

The purpose of the [OPPLA Knowledge Platform](#) is to provide a collection of tools, guidance on elaborating and monitoring NbS as well as case studies. Examples of such tools are the EKLIPSE Impact Evaluation Framework.

Knowledge Hub of Biodiversa+

Provided and funded by Biodiversa+, the [Knowledge Hub](#) provides a broad selection of handbooks and guides, knowledge synthesis as well as policy briefs for further reading about different implementation aspects of NbS.



The frameworks and guidelines offer a broad overview of the background information, general concepts and approaches on Nature-based Solutions and the closely linked ecosystem services. This guidance document is built on the existing work and aims to synthesise that information while applying it to the Western Balkans.

Additional regional context is available in the project's *Summaries of Pilot Areas*, which document all activities carried out in the pilot sites under the EU4Green project. The summaries present the current situation based on the project's results and findings regarding the thematic pillars NbS, Natura 2000 and Connectivity.



4 RIPARIAN BUFFER ZONES AND THEIR ENVIRONMENTAL AND SOCIETAL BENEFITS

What are riparian buffer zones?



“Riparian buffers [...] are linear bands of permanent natural or semi-natural vegetation adjacent to streams and rivers. A general, multi-purpose, riparian buffer design consists of a strip of grass, shrubs, and trees between the normal bank-full water level and more intensively used land, such as cropland, roads, built-up areas.” – EEA (2016)



Figure 3: Examples of riparian buffer zones in cultural landscapes. (top left: © Katharina Huchler, all others: © Umweltbundesamt Gröger, B.)

A riparian buffer zone typically forms a mosaic of diverse aquatic and terrestrial habitats along rivers that vary in age, structure, moisture levels, soil characteristics, and biological composition as well as productivity (Geilen et al., 2004).

Naturally, these areas are biodiversity hotspots due to their structural and functional complexity, driven primarily by the riverine flow dynamics (Graziano et al., 2022; Ward et al., 1999), supporting a wide range of species – both generalists and specialists – whose survival often depends on the quality, connectivity, and proximity of various habitat patches (Schindler et al., 2016; Romanowski et al., 2005; Scholz et al., 2012). They also play a crucial ecological role as dynamic interfaces between terrestrial and aquatic ecosystems.

Thus, they also serve as transitional areas between the intensive agricultural land and the valuable riparian habitats, providing protection from the effects of land use. They act as natural barriers that

filter pollutants, reduce erosion and maintain water quality (Graziano et al., 2022). This effect occurs via three pathways, filtering agricultural pollutants in solution, attached to soil particles, or is transported via air (Figure 4; EA UK, 2020). Depending on their structural composition (forested/vegetated strips/mixed), the amount of reduction regarding different nutrients (Nitrogen, Phosphorus, sediments) varies. (Hawes & Smith, 2005).

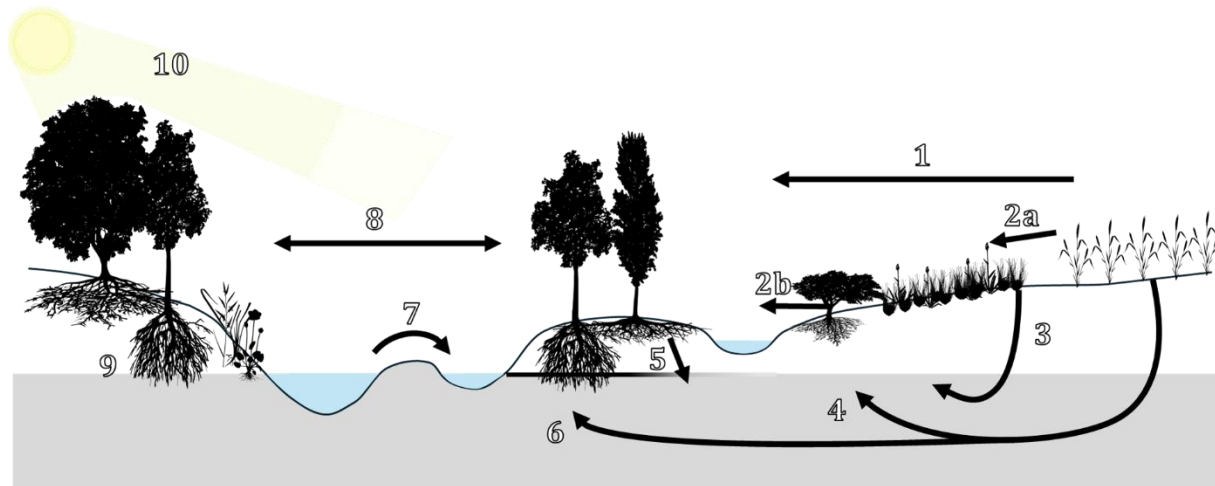


Figure 4: Schematic illustration of a riparian buffer zone between a water course and agricultural land. It can contain of woody, shrubby or grassland elements that provide various buffer functions. Provided processes and functions by the riparian buffer zone include: intercepted airborne agrochemical drift by tree canopy (1), infiltration of surface runoff through vegetation (2a, b), slowed water flow enhances nutrient and contaminant processing by plants and soil (3), vegetation absorbs and stores nutrients (4), higher organic matter in soil improves natural pollutant attenuation (5), halting drain discharges allows margin soils to filter pollutants (6), reshaped banks reconnect channels with floodplains & increase sediment retention and varying soil moistures (7), Land-water interactions strengthen stream ecosystem (8), tree roots stabilising banks against erosion (9), shade from vegetation improves microclimate & reduces stress on riparian life (10). (Figure and content according to Environment Agency UK (2020); attribution & license for used silhouettes on [phylopic.com](https://www.phylopic.com))

Through their ability to improve water quality, support biodiversity, control soil erosion, regulate hydrology, buffer floods and improve land use management, these zones not only play a central role in ecosystem stability but also provide many ecological and hydrological benefits for human well-being (Graziano et al. 2022, Gonz ales et al. 2017, Naiman & Decamps 1997).



“Ecosystem services are defined as the direct and indirect contributions of ecosystems to human well-being, focusing on the outputs of natural processes and attributes that offer provisioning, regulating and cultural benefits to people” – CICES (2023)

In accordance with the CICES nomenclature (Haines-Young 2023), some of the major ecosystem services provided by riparian buffer zones include:

- **Reduction of waste, toxic substances** is a key service of riparian buffer zones. Riparian buffer zones filter pollutants (such as nutrients, pesticides, and other contaminants) out of surface runoff before they reach water bodies. This improves water quality and maintains a healthy aquatic environment. (Mayer et al., 2007; Dosskey et al., 2010)
- **Hydrological cycle and water flow regulation (incl. flood control)** is another key service of riparian buffer zones. Vegetation in riparian buffer zones absorbs excess water during heavy rainfall, reducing the speed and volume of runoff entering water bodies. This significantly reduces the risk of flooding and helps to mitigate flood damage. (Thomas & Nisbet, 2012; Keesstra et al., 2018)

- **Lifecycle maintenance, habitat and gene pool protection:** Riparian buffer zones provide habitat for a wide variety of species, both aquatic and terrestrial. They support diverse ecosystems, providing food, shelter and breeding grounds for birds, fish, mammals and amphibians as well as numerous plant species that are depending on the hydrological dynamics of this ecotone. (Gregory et al., 1991; Naiman et al., 2005).
- **Erosion control:** The vegetation of riparian buffer zones stabilises soil with its roots, reduces riverbank erosion, and prevents sedimentation that can degrade aquatic habitats. (Sweeney & Newbold, 2014; Zaimis & Schultz, 2015)
- **Regulation of atmospheric composition and conditions** is another key service of riparian buffer zones. Riparian vegetation provides shade to water bodies, which is essential for regulating water temperature. This is vital for the health of aquatic species, particularly fish, which are extremely sensitive to temperature fluctuations. Terrestrial species also benefit from microclimate regulation. On a larger scale, riparian buffer zones also serve as carbon sink – independently from vegetation type and soil texture. Evidently, soil organic carbon (SOC) was found to be significantly higher in mature buffer systems in comparison to adjacent agricultural land fields. (Vijayakumar et al., 2020)

Some of the positive effects listed above are not limited to the river section directly adjacent to the riparian buffer zones. For example, water flow regulation provided by the riparian buffer zone can benefit downstream settlements or urban areas.

Another example is the positive impact on water quality by the reduction of agricultural runoffs are sustained downstream and other ecosystems like lakes, estuaries and oceans, improving not only the environmental conditions and lowering pressures for biodiversity, but also benefits society (e.g. through drinking water or leisure activities in the river itself).

Intensification of land use and large-scale modifications of water bodies have profound impact on floodplain ecosystems throughout Europe (Nilsson et al., 2013). Many European floodplains have been hydrologically disconnected from their rivers by dikes and altered for intensive human uses such as farming, infrastructure, and urban development (Hein et al., 2016). The remaining riparian areas often suffer from degraded ecological conditions due to river regulation, damming, pollution, invasive species, and intensive land use (Leyer 2005; Rinaldi et al., 2013). As shown by Schindler et al. (2014), technical interventions that restrain the river in its natural course and dynamics have been proven to decrease the number of supplied ESS. This human impact significantly affects the ecosystem services of regulation, provision and culture.

The approach of restoration, lateral reconnection and renaturation increases the multifunctionality of the ecosystem, including key ES, and tackling the targeted societal challenges. Using the tools of NbS, such as riparian buffer zones, can foster natural floodplain dynamics together with the removal of technical constructions that fix riverbanks and restrict the water body.

Various stakeholders such as municipal authorities as well as authorities of waterway management and forestry, construction companies, landscape architects or ecological restoration experts as well as, landowners and land users (e.g. fisheries, farmers, forest owners), and authorities of existent protected areas can combine a number of these interventions to enable river dynamics and to promote associated benefits.



5 MEASURING POTENTIAL AND PERFORMANCE OF RIPARIAN BUFFER ZONES AS NBS

5.1 Data-based assessment of societal challenges and NbS

The implementation of NbS requires an evidence-based approach during every phase of the project (Figure 5). Using quantifiable indicators for the assessment and evaluation of

- the most pressing societal challenges,
- the initial condition of the site,
- the effectiveness of the implemented measures,
- long-term monitoring
- as well as the general project progress and successful implementation (output and result indicators – see 7.3)

is crucial for the realisation of riparian buffer zones or NbS in general. The development of a concept in meaningful indicators enables the implementer before, during and after the project to effectively track changes, impact and success over time. Through adaptive management the multifunctional benefits are effectively and sustainably maintained while at the same time the community resilience can be monitored. The use of clear and informative indicators also facilitates the project communication and engagement of the stakeholders.

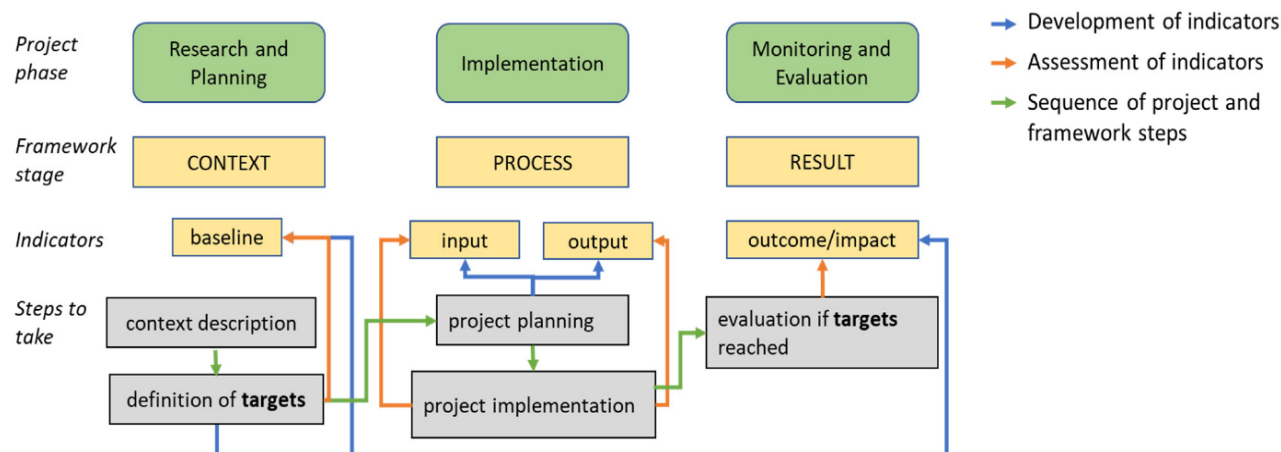


Figure 5: The relations of indicators, project phases and framework stages. (Figure by Hale et al., 2023; © CC BY 4.0)

To measure the implications of the actions taken and the benefits that are starting to materialise, several indicators can be used. Their selection can be adapted according to the available resources, expertise and the pursued goals, whereby a combination of several indicators is favourable.

5.1.1 Ecological indicators

1. Water quality



Riparian buffer zones play an important role in filtering pollutants and improving water quality. The following water quality metrics can be used to assess these functions and enable an evidence-based evaluation of the current ecosystem status as well as NbS benefits:

- 1. Nutrient levels (nitrogen and phosphorus):** Elevated concentrations of nitrogen (N) and phosphorus (P) in surface waters are commonly linked to agricultural runoff. Riparian vegetation helps mitigate these nutrient loads through direct plant uptake and enhanced microbial activity in the soil, both of which contribute to nutrient retention and transformation. A noticeable reduction in nutrient levels downstream of a riparian buffer is a key indicator of its functional effectiveness. According to a meta-analysis by Mayer et al. (2007), wider riparian buffer zones (greater than 50 meters) consistently achieved higher rates of nitrogen removal compared to narrower buffers (0–25 meters). While all vegetation types showed capacity for nitrogen removal, the study found that wider buffers containing either herbaceous vegetation, or a combination of forest and herbaceous cover were particularly effective in enhancing nitrogen retention. A meta-analysis of case studies from the USA and Canada concludes that riparian buffer zones and similar vegetated buffer or filter structures remove on average approximately 51–55% of phosphorus from runoff, with their effectiveness strongly influenced by buffer width in clay soils and by slope in sandy soils, highlighting the need for site-specific design to optimise phosphorus retention. In the specific case studies, phosphorus retention capacity varied widely within and of bare soil, soil saturation and type, or snow coverage could all contribute negatively to the desired effect and add to a higher P runoff and explain the range of P removal. (Tsai, 2022)
- 2. Sediment load:** Elevated sediment levels in water typically indicate soil erosion and are associated with declining water quality. Monitoring suspended sediment concentrations downstream of riparian buffer zones provides a useful measure of their effectiveness in controlling erosion and capturing sediment. Riparian buffer zones are particularly effective in trapping suspended sediment. Wenger (1999) reports that even narrow buffers, around 4.6 m wide, can achieve short-term sediment retention, while widths of approximately 30 m are generally sufficient under most slope conditions. The efficiency of sediment trapping is also influenced by vegetation structure and hydrological flow dynamics (Dunn et al., 2022).
- 3. Turbidity:** Riparian buffer zones improve water clarity by intercepting sediment and organic particulates before they enter aquatic systems. A comprehensive review by Yuan et al. (2009) concluded that riparian and vegetative filter strips can significantly reduce sediment loads, with trapping efficiency increasing with buffer width; effectiveness also depends on slope and vegetation but yields broadly consistent improvements in water clarity.
- 4. Dissolved oxygen (DO):** Healthy riparian buffer zones contribute to enhanced dissolved oxygen levels in adjacent streams by reducing excess nutrient inputs – which can otherwise drive eutrophication and oxygen depletion – and by stabilising stream temperature and flow regimes. A study by Dodds (2016) showed that live roots from riparian vegetation directly affect in-stream DO dynamics via enhanced respiration and nutrient uptake, thereby influencing daily DO fluctuations beyond what is expected from in-stream photosynthesis or shading alone.

Exemplary methods for monitoring water quality

Monitoring water quality in riparian buffer zones involves collecting water samples upstream and downstream and analysing them in laboratories for nutrient levels, sediment load, dissolved oxygen and turbidity. The methods for conducting these can include:

- **In-situ water sensors:** They can provide a continuous monitoring of turbidity, DO, pH and temperature, providing real-time data via remote servers.
- **Secchi-Disc:** A low-cost alternative is to use an opaque, black and white coloured disc – the Secchi disc – to estimate water clarity by lowering it until it ceases to be visible from the water surface. This Secchi depth provides an approximate measure of turbidity and is ideal for monitoring with limited resources. These methods help to track changes in water quality over time.

**2. Biodiversity conservation**

Riparian buffer zones provide essential habitats, food and shelter for terrestrial and aquatic species and promote ecological resilience. Biodiversity metrics reflect the health and functionality of these zones. They also indicate gains in biodiversity and the integrity of the ecosystem as well as how well the riparian buffer is supporting the ecosystems. This functioning and diverse ecosystems also hold benefits for society, providing ES such as recreational or educational value. But also, from an economic point of view through a higher resilience and sustainable resources (raw materials, genetic diversity) or tourism.

1. **Plant species diversity and composition:** A diverse mix of native vegetation in the buffer zone indicates good ecological health and resilience. Experimental research by Allen et al (2016) has demonstrated that increased plant species richness enhances soil stability and erosion resistance, with multispecies mixtures reducing fluvial erosion by up to 23% compared to monocultures – largely because diverse root structures improve soil cohesion and structural complexity. Monitoring plant species can also highlight any invasion of non-native species that may reduce the effectiveness of the buffer or threaten native and endangered species. Monitoring plant diversity and community composition also allows habitats and their quality over time.
2. **Macroinvertebrate diversity:** Aquatic macroinvertebrates (e.g. mayflies, stoneflies) are sensitive to changes in water quality and are good bioindicators of stream health. High diversity and abundance of these species indicate effective riparian buffering. (Bonada et al., 2005; Duehr et al., 2006).
3. **Fish diversity:** Healthy riparian buffer zones create optimal aquatic conditions for fish by regulating water temperature, sediment levels and food availability. Surveys of fish diversity and population size are key indicators of ecosystem health. (Duehr et al., 2006)
4. **Diversity of terrestrial and semi-aquatic species:** Riparian buffer zones provide habitat and corridors for a variety of terrestrial and semi-aquatic wildlife. Monitoring birds, amphibians and small mammals in riparian buffer zones highlights their ecological value as biodiversity hotspots.

Exemplary methods for monitoring biodiversity

Effective monitoring of riparian buffer zones involves diverse methods to evaluate vegetation, habitat quality, and fauna, ensuring a comprehensive assessment of ecological health:

- **Vegetation surveys:** Seasonal transect surveys and quadrat sampling are used to document plant species richness, density and distribution. This approach captures annual vegetation changes and identifies indicative plant species.

- **Biotope mapping:** Regular assessments of habitat types, considering species composition, structural features and human influence, provide insight into the ecological development of the buffer zone.
- **Macroinvertebrate sampling:** Using kick nets or leaf litter packs, macroinvertebrates are collected twice a year to analyse water quality using metrics such as the Biotic Index, which reflects seasonal variability.
- **Fish surveys:** Techniques such as electrofishing or seining, conducted annually or biannually, provide data on species richness and population health, considering life cycle stages.
- **Monitoring of terrestrial/semi-aquatic wildlife:** Camera traps record the presence of mammals, birds and amphibians, while quarterly point-counting bird surveys assess bird diversity and abundance.



3. Hydrological function

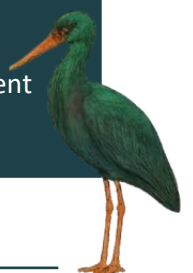
Riparian buffer zones influence the movement of water, helping to moderate hydrological processes such as flooding, groundwater recharge, and the regulation of streamflow. Thus, the frequency of disaster events can be reduced and damages in local communities mitigated or avoided.

1. **Infiltration rates:** The speed at which water infiltrates in a riparian buffer can indicate its effectiveness in reducing surface runoff and supporting groundwater recharge.
2. **Flood attenuation capacity:** Riparian buffer zones help to absorb and slow down floodwater. Monitoring the extent of flooding and changes in flood frequency or intensity can indicate the buffer's ability to mitigate flood impacts.
3. **Water retention:** Riparian buffer zones can store water, reducing the volume and velocity of runoff entering streams. Monitoring water retention in the buffer area can help assess its hydrological function.

Exemplary methods for monitoring hydrological function

To assess the hydrological performance of riparian buffer zones, the following methods are used.

- **Infiltration rate tests:** A double ring infiltrometer measures the rate of infiltration of water into the soil, indicating the buffer's effectiveness to reduce surface runoff and recharge groundwater.
- **Floodplain inundation monitoring:** Water level loggers record the frequency, magnitude and duration of floods, providing insight into the buffer's flood attenuation capacity.
- **Stream flow measurement:** Stream gauges installed upstream and downstream of the buffer track flow changes during rainfall, demonstrating the buffer's role in reducing peak flows and stabilising stream flow.
- **Water retention monitoring:** Soil moisture sensors measure changes in soil water content within the buffer, indicating the effectiveness of the zone in retaining water.



4. Soil protection

Riparian vegetation stabilises the soil, preventing erosion and reducing sediment deposition in water bodies. The following metrics are used to assess and monitor this function:

- 1. Erosion rates:** Quantifying soil loss or deposition within the buffer zone provides a direct measure of its protective role. Low rates of soil erosion indicate that the vegetation and root structures in the riparian buffer zone are effectively stabilising the soil.
- 2. Bank stability:** Riparian buffer zones help to protect stream banks from undercutting and collapse. Measuring streambank erosion or stability over time can provide insight into the buffer's effectiveness to prevent erosion.
- 3. Sediment deposition rates in streams:** By comparing sediment levels upstream and downstream of riparian buffer zones, researchers can assess how effectively the buffer traps sediment. (Graziano et al., 2022; Welsch, 1991)

Exemplary methods for monitoring soil erosion and sediment control

There are several methods to assess the effectiveness of riparian buffer zones in controlling erosion and sedimentation:

- **Erosion pin measurements:** Metal rods (erosion pins) are installed along stream banks to track changes in the ground level over time, allowing erosion or deposition rates to be calculated through regular measurements.
- **Sediment traps:** Sediment traps are placed in water bodies to collect sediment. The mass and particle size of the sediment is periodically analysed to measure deposition rates.
- **Remote sensing and Geographic Information System (GIS) mapping:** Tools such as drone-based LiDAR, aerial photography and satellite imagery are used to map changes in streambank morphology, vegetation and land cover. Comparing historical and current data helps to identify erosion, channel shift and vegetation dynamics.
- **Sediment load monitoring:** Water samples collected during storm events are analysed for suspended sediment concentrations. Comparing data from before and after the implementation of riparian buffer zones highlights their impact on reducing sediment loads



4. Sustainable land use

Human activities and management practices, such as intensive agricultural use accompanied by heavy use of pesticides and fertiliser, can significantly affect the effectiveness of riparian buffer zones and furthermore impacts the water quality, affect communities and biodiversity.

- 1. Land use practices in adjacent areas:** Assessing the agricultural, urban or industrial practices surrounding the buffer zone can help assess potential threats and the buffer's effectiveness to mitigate them.
- 2. Buffer width:** The width of a riparian buffer zone affects its effectiveness to filter pollutants, support biodiversity and prevent erosion. Wider buffers are generally more effective than narrower ones.
- 3. Vegetation structure and health:** Assessing the diversity, structure, age and health of the vegetation in the buffer zone provides information on the resilience of the zone and its ability to fulfil its ecological functions.

Exemplary methods for land use and management indicators

- **Land use surveys or remote sensing:** Conduct land use surveys or remote sensing analysis to monitor changes in land use around the riparian buffer. This can help assess external pressures (e.g. agriculture, urban development) that may affect buffer effectiveness.
- **Monitor buffer width and vegetation structure:** Use GIS and field surveys to monitor changes in riparian buffer width and vegetation structure (height, density, and diversity). Changes over time may indicate encroachment or management success.

5.1.2 Societal indicators

Societal indicators evaluate the social benefits and community impacts of riparian buffer zones (Cohen-Shacham et al., 2016; Keesstra et al., 2018):

- **Community engagement:** Participation in buffer planting, monitoring, and maintenance activities.
- **Public health and recreation:** Improved access to green spaces, better air quality, and recreational opportunities.
- **Environmental education:** Awareness and knowledge gains about river ecosystems and biodiversity.
- **Social equity:** Equitable access to riparian areas and their benefits across communities.
- **Resilience and safety:** Reduced vulnerability to flooding, bank erosion, and water pollution for nearby communities.

5.1.3 Economic indicators

Economic indicators assess the financial and resource-related benefits of implementing riparian buffer zones along rivers or streams:

- **Cost-efficient flood management:** Reduced expenditures on engineered flood defenses due to natural water retention and bank stabilisation.
- **Agricultural productivity:** Impact on crop yields from improved soil quality and reduced erosion.
- **Value of Ecosystem Services:** Monetary benefits from water purification, sediment retention, carbon sequestration, and habitat provision.
- **Job creation:** Employment generated through planting, maintenance, and monitoring of buffer zones.
- **Reduced property damage:** Decreased economic losses from flood or erosion events.

5.2 Data availability

A sound database is the key to evaluating the current situation and identifying negative or positive developments. In the long run, it facilitates the monitoring of the measures implemented in the area and, ideally, demonstrates the positive impact of the NbS. If necessary, appropriate actions can be implemented to improve the status on site, based on ongoing collection of data. Depending on the indicator, several already existing data sources can be used as well. Examples for the Western Balkans include the following.

Land cover data

Data Type: Geospatial data on land cover and land use patterns, which help analyse land cover change in and connectedness of riparian buffer zones.

Source: European Environment Agency (EEA) and CORINE Land Cover.

Accessibility: Freely available for download from the EEA's website.

Link: [CORINE Land Cover+Backbone](#)

Hydrological data

Data Type: Geospatial floodplain data, hydrological flow models, and real-time flood monitoring.

Source: European Space Agency (ESA) and the European Flood Awareness System (EFAS).

Accessibility: Available through the Copernicus Emergency Management Service, though not all models are freely accessible. Some regional environmental ministries also produce floodplain maps, but access can be limited.

Link: [EFAS - Copernicus Emergency Management Service](#)

Biodiversity data

Data Type: Numeric and geospatial data on species distribution, habitat types, and ecosystem services within riparian buffer zones.

Source: Biodiversity databases such as the Global Biodiversity Information Facility (GBIF) and local inventories maintained by environmental agencies or NGOs.

Accessibility: GBIF is publicly accessible. Additional information may be available through regional authorities and institutions, but access may be restricted or limited to aggregated data.

Link: [GBIF](#)

Climate and Meteorological Data

Data Type: Numeric and geospatial data on temperature, precipitation, and other climate variables relevant for hydrological modelling and ecosystem resilience.

Source: National Meteorological Institutes, the World Bank Climate Change Knowledge Portal, and the European Centre for Medium-Range Weather Forecasts (ECMWF).

Accessibility: Publicly accessible through national services or global datasets like ECMWF.

Link: [ECMWF Climate Data](#)

Satellite imagery and remote sensing data

Data Type: High-resolution satellite imagery consisting of several bands providing various information about land cover, moisture, water coverage, plant cover, etc.; suitable for mapping vegetation, land use changes, and analysing riparian buffer zone effectiveness.

Source: Copernicus Sentinel Program and Landsat by the United States Geological Survey (USGS).

Accessibility: Freely available through the Copernicus Open Access Hub and the USGS Earth Explorer.

Link: [Copernicus Open Access Hub](#)

However, in the Western Balkans, data are often difficult to obtain or simply do not exist, which poses a significant challenge for comprehensive evaluation and monitoring.

Therefore, for many cases, it remains necessary to gather data directly on site for assessing and evaluating the most pressing societal challenges, possible NbS and to ensure adequate monitoring and informed decision-making.

6 FUNDING AND RESOURCES

6.1 Financing Nature-based Solutions

Financing NbS can be a complex endeavour. While some of nature's contributions generate commodities that can be traded and reap direct monetary benefits (e.g. agricultural or forestry products), others constitute public goods that do not create a direct financial return and cannot be sold on markets easily (e.g. climate regulation or recreational and educational value).

Direct monetary returns on investment are often small and occur at a later stage of project implementation. The wider, less tangible socio-economic benefits for local communities are often not factored into cost-benefit analyses. That is one reason why NbS remain underfunded and rely mostly on public money for financing. Upscaling NbS through unlocking additional (private) capital requires innovative financing schemes, such as blended finance or public-private partnerships and the accompanying governance architecture. Furthermore, the involvement and efficient management of various stakeholder groups (e.g. landowners, utility companies, municipal authorities, local communities, etc.) is required to ensure the durability of funding streams towards the ecological intervention, and, ideally also for the ongoing monitoring activities beyond the implementation stage.

Other important considerations include the specific characteristics of the ecosystem, and the ecosystem services it provides. As with all other project components, the financing solution should be tailored to the geographical and ecological context. In riverine systems, landowners and communities upstream and downstream of the NbS implementation site must be included in the planning process as well as potential financial agreements on profit-sharing or compensation. The situation is different for projects in forestry or agricultural systems where ownership structures are more clearly defined.

According to a study by the European Investment Bank, the majority of NbS in river and lake ecosystems involve public funding following regulatory drivers such as the EU Water Framework Directive. In many cases, national water authorities lead the projects. Private landowners within riparian buffer zones often must be compensated for the flooding of their land. Private investment is largely absent from these ecosystems as the benefits of implemented NbS accrue primarily to the general public. One possible exemption to this could be investments by private water utilities to fulfil regulatory requirements. (EIB, 2023)

In the face of these challenges, it becomes clear that, in most cases, there will be no simple financial solution for funding NbS. Depending on the context, the best fit for the project at hand might be a funding mechanism or a mix of multiple funding mechanisms (grants, loans or equity; public or private funds). Multilateral development banks (e.g. EIB, EBRD or the World Bank), commercial banks, local municipalities, local landowners and businesses, regional and state authorities, NGOs, philanthropic donors and grass-roots organisations can all play an important role in the financing of NbS. It is essential to identify suitable financing and insurance solutions from the very start of the project's planning process.

6.2 Funding opportunities for NbS on EU-level

Embedded in the [Multiannual financial framework 2021-2027](#), the EU funding landscape offers various avenues to fund NbS including some open for non-EU countries, including the Western Balkan economies. Relevant EU funding options include:

- **[Economic and Investment Plan \(EIP\) for the Western Balkans 2021-2027](#)**: As part of the **[Western Balkan Investment Framework](#)** (WBIF), the EIP prioritising Environment & Climate, is (co)funding projects in the environment sector with the focus on improving infrastructure, adopting climate-smart technologies, modernising water and waste management systems, and enhancing resilience to extreme weather conditions. The latter is also specifically targeting the protection of biodiversity. The WBIF grants for environmental projects equivalent 11% of the total WBIF budget (EUR 274.5 million). The granted budget of funded projects by the WBIF range mostly from EUR 250.000 to EUR 2.000.000.
- **[Programme for the environment and climate action \(LIFE\)](#)**: Subprogrammes 1. Nature and biodiversity and 3. Climate change mitigation and adaptation are best suited for the funding of NbS. The funding mechanism mainly consists of grants and co-financing rates range from 60-95 %. Non-EU countries associated with the LIFE programme, including candidate countries, can apply. Projects funded under the LIFE programme typically range between EUR 1 and 10 million, projects under EUR 500.000 are rarely funded.
- **[Horizon Europe](#)**: one of the four key strategic aims for the programme is “restoring Europe’s ecosystems and biodiversity and sustainably managing natural resources to ensure food security and a clean and healthy environment.” The funding mechanism consists of grants. Non-EU associated countries, which includes all WB economies, can apply for funding. In the period 2021-2023 the average grant size in the Horizon Europe programme was EUR 2.9 million.
- **[InvestEU programme](#)**: an instrument to boost green growth in the EU and to dedicate resources to “the enhancement and restoration of ecosystems and their natural and biodiversity services by means of green and blue infrastructure projects, such as sustainable agriculture, forestry and fishery”. This funding mechanism consists of an EU budgetary guarantee that supports implementing partners in increasing their risk-bearing capacity. The Invest EU programme is also open for (potential) candidate countries.

In addition to environmental and technical requirements, EU funding schemes often emphasise the importance of integrating gender considerations throughout the project cycle. This includes promoting gender equality, ensuring balanced participation, and addressing gender-specific impacts of NbS interventions in project design, implementation, and reporting.

A comprehensive overview of the different EU funding opportunities, their components, requirements and eligibility criteria can be found in the European Commission brochure: [“Find Your EU Funding Programme for the Environment”](#).

6.3 Other funding opportunities and further information

An example for a transboundary conservation trust fund, based on the state-level, is the [Prespa Ohrid Nature Trust \(PONT\)](#). Offering two grant programmes (the Protected Area Programme and Environmental Actor Programme) with a co-financing rate of 25%, PONT ensures long-term, sustainable financing. Its mission is to foster the protection and effective management of key conservation areas as well as the cooperation between NGOs and local people.

Further information on NbS funding, including “The Nature-Based Solutions Opportunity Scan”, can be found on the website of the [Global Program on Nature-Based Solutions for Climate Resilience](#), an initiative of the Global Facility for Disaster Reduction and Recovery together with the World Bank.

A database of case studies and good practice examples for NbS, including information on financing, is available on the website of the [Nature-Based Solutions Initiative](#) of the University of Oxford.

Regarding different ways to leverage private capital for investment in freshwater systems, the [Guidebook](#) “Nature-based Models for Unlocking Private Investment into Water Quality and Availability” published by the Green Finance Institute includes case studies of proven, revenue-generating investment models for freshwater NbS.

6.4 Further reading

To deepen the understanding of the crucial topic of project financing, the following references and links provide a selection of key resources. They include both the sources cited in Chapter 6 and additional materials that offer further insights and guidance for readers interested in exploring the subject in more detail:

Calliari, E., Castellari, S., McKenna, D., Linnerooth-Bayer, J., Martin, J., Mysiak, J., Pastor, T., Ramieri, E., Scolobig, A., Sterk, M., Veerkamp, C., Wendling, L. & Zandersen, M. (2022). **Building climate resilience through nature-based solutions in Europe: A review of enabling knowledge, finance and governance frameworks**. *Climate Risk Management* 37 (2022), 100450.

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Chausson, A., Welden, E.A., Melanidis, M.S., Gray, E., Hirons, M., Seddon N. (2023). **Going beyond market-based mechanisms to finance nature-based solutions and foster sustainable futures**. *PLOS Clim*, 2(4), e0000169.

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EIB (2023). Investing in nature-based solutions – **State-of-play and way forward for public and private financial measures in Europe**.

https://www.eib.org/attachments/lucalli/20230095_investing_in_nature_based_solutions_en.pdf

Thompson, A., Bunds, K., Larson, L., Cutts, B. & Hipp, J.A. (2022). **Paying for nature-based solutions: A review of funding and financing mechanisms for ecosystem services and their impacts on social equity.** Sustainable Development, 2023, 31, 1991-2066.

<https://onlinelibrary.wiley.com/doi/10.1002/sd.2510>

UNEP FI (2024). **Recommendations for Scaling Finance for NbS.**

<https://www.unepfi.org/wordpress/wp-content/uploads/2024/08/Recommendations-for-designing-regulatory-frameworks-to-scale-finance.pdf>

Van Raalte, D. and Ranger, N. (2023). **Financing Nature-Based Solutions for Adaptation at Scale: Learning from Specialised Investment Managers and Nature Funds.** Global Center on Adaptation and Environmental Change Institute, University of Oxford.

https://www.eci.ox.ac.uk/sites/default/files/2023-12/Financing_NbS_for_Adaptation-GCAOxford2023-finalv2.pdf



7 IMPLEMENTATION: FROM IDEA TO REALISATION

This chapter provides a step-by-step guide to designing, implementing and maintaining riparian buffer zones in line with the concepts covered by the IUCN's eight criteria of the Global Standard for Nature-based Solutions (IUCN, 2020a).

The right approach helps to minimise potential errors and risks, and is key for a successful and sustainable realisation. It is advisable that the process follows a phased, cyclical framework. Systematic planning, execution, and monitoring of the NbS, can maximise ecological and socioeconomic benefits. The approach contains three phases (Design and assessment, Implementation, Maintenance and evaluation), described in more detail in the subsequent chapters.

7.1 Phase 1: Design and assessment

The first phase of establishing riparian buffer zones is critical to laying the foundation for a successful, sustainable initiative. This phase focuses on comprehensive site assessments, stakeholder engagement and the integration of buffer zones into broader land-use planning frameworks. A clear, strategic approach will ensure that riparian buffer zones effectively address environmental and societal needs while gaining the support of the community and other stakeholders.

❖ Definition of most pressing societal challenges

As a core step in the implementation process, the assessment and clear identification of the most pressing societal challenges must be done. By specifying at least one societal challenge, the NbS intervention addresses this issue and aims to solve or mitigate it in a sustainable and inclusive way. For this to happen, the societal challenge needs to be addressed and documented clearly, using indicators (see 5.1) as measure for its status, development and successful mitigation.

In the context of Nature-based Solutions (NbS), societal challenges refer to the pressing social, economic, and environmental issues confronting communities and the planet, including climate change, biodiversity decline, threats to food and water security, natural hazards, poverty, inequality, and public health concerns.” – IUCN (2020a, b)

When planning and implementing NbS, it is important to set clear targets that show how the intervention will improve human well-being. The targets should cover both the practical steps of implementation (e.g., hectares restored, number of community members engaged) and the expected outcomes (e.g., improved water quality, reduced flood risk). Even if the full benefits of NbS may only become visible after the project ends, defining interim milestones is useful. These milestones can demonstrate progress, make it easier to monitor results over time, and help attract long-term funding and stakeholder support for maintaining the intervention. (IUCN, 2020b)



The IUCN (2020a) further defines eight major societal challenges that Nature-based Solutions aim to address (Figure 6):

- 1) **Climate change mitigation and adaptation:** reducing greenhouse gas emissions and enhancing resilience to climate impacts.
- 2) **Disaster risk reduction:** minimising vulnerability and exposure to natural hazards such as floods, droughts, storms, and landslides.
- 3) **Economic and social development:** supporting livelihoods, job creation, and inclusive growth.
- 4) **Human health:** improving physical and mental health, reducing disease risks, and providing green spaces.
- 5) **Food security:** ensuring sustainable agricultural production and resilient food systems.
- 6) **Water security:** enhancing water availability, quality, and resilience of hydrological systems.
- 7) **Environmental degradation and biodiversity loss:** conserving, restoring, and sustainably managing ecosystems.
- 8) **Social development:** fostering equity, cultural identity, and community resilience.



Figure 6: The eight major societal challenges according to the IUCN. (2020a)

The example of riparian buffer zones as NbS for floodplains in the WB6 tackles several of those challenges.

In any case, decision-makers as well as local stakeholders and experts need to define the primary objectives and societal challenges in an inclusive process, as this will shape the design of the NbS. For example, a buffer zone designed to mitigate flooding might prioritise flood-tolerant vegetation, whereas a zone designed to enhance biodiversity might include a mix of native plant species.

Independent from the primary target, well-designed NbS such as riparian buffer zones will always play a vital role in enhancing biodiversity. They act as critical corridors for wildlife, providing habitats and connectivity between fragmented ecosystems. During the design phase, the assessment of the existing flora and fauna and selection of native vegetation will support the local ecosystem as well. Incorporating species that provide food and shelter for pollinators and aquatic species will enhance the ecological value of the zone and its resilience.

❖ Conduct comprehensive site assessments

Use scientific research and traditional ecological knowledge to inform the implementation process. The process begins with a thorough assessment of the landscape to identify suitable areas for riparian buffer zones. Besides the site selection, this step provides critical data for the further design of the measures. Piloting small-scale buffers prior to full-scale implementation can help refine approaches and mitigate risks. The assessments include:

- **Definition of the project area:** Defining the project extent is a key step when planning riparian buffer zones and NbS in general. The effectiveness, ecological coherence, and societal acceptance of measures depend heavily on how the boundaries of the study area are drawn. The area should not be limited to the riverbanks but also include floodplains, nearby farmland, forests, or urban areas that are affected by or affect the riparian ecosystem. Because rivers are connected systems, measures taken upstream can have strong impacts downstream – both positive and negative. Therefore, it also must be considered that the implemented measures and desired outcome may not occur in the same location. Additionally, the river’s dynamic and ecology changes along their course from the headwaters to the lowlands. Within each of the river sections’ lateral connections to the surrounding area (e.g. floodplains or agricultural land), impacting in both directions, are influencing the project scope as well.

Finally, it is important to keep the scale in mind. A small buffer strip may only show its benefits when seen across the whole catchment, while larger restoration areas can have local and regional impacts. Defining the project area with these principles ensures that measures are effective, connected, and sustainable.

- **GIS mapping:** Use GIS tools to map the terrain and identify high-priority areas based on factors such as water quality, erosion risk and biodiversity needs. GIS data helps visualise critical zones and assess connectivity with existing ecosystems.
- **Field surveys:** Conduct on-site assessments to analyse soil quality, vegetation and hydrological conditions. These surveys provide the basis for GIS data and highlight site-specific challenges such as invasive alien species or bank instability.
- **Identify priority areas:** Combine GIS analysis and field survey data to select high-priority stretches of a river or stream for initial buffer zone establishment. These areas often include areas at high risk of flooding or adjacent to agricultural land prone to runoff.
- **Regulatory framework:** Besides the already-mentioned site-specific and ecological factors, it is also necessary to investigate the tertiary landscape structure – namely legal requirements and restrictions, relevant laws and land ownerships. This aspect defines what is legally possible and maybe obligatory or required for the WB6 during the accession process and afterwards, regarding the responsibilities according to EU law, such as the Habitats Directive or the Nature Restoration Regulation. Furthermore, it can give provide information on financing options, such as national funding.

❖ Stakeholder involvement and education

Involving stakeholders at every stage – design, implementation and maintenance – is essential to successfully realising the NbS and enhancing the multifunctionality of floodplains. A wide spectrum of stakeholders with different backgrounds and fields of interest need to be involved, as they have diverse expertise and interests. (Schindler et al., 2016)

Scientists provide the ecological and hydrological expertise needed for effective design. Technical experts and engineers provide practical solutions to stabilise banks and manage water flows. NGOs and civil society organisations can mobilise resources, facilitate community engagement and provide

advocacy. Most importantly, local communities are the custodians of these solutions. Their traditional knowledge, cultural values and vested interest in the land make them essential partners in ensuring the success of the riparian buffer.

Equally important is the broader integration of the public. Raising awareness, fostering transparency, and encouraging active participation from the general public not only builds trust but also strengthens the long-term sustainability and acceptance of NbS. Public involvement can help shape context-specific approaches, promote stewardship, and ensure that the benefits of these interventions are widely understood and supported.

Early and transparent stakeholder engagement also builds trust, encourages commitment and fosters collaboration. Integrating the buffer into wider land-use planning ensures that the costs and benefits are shared equitably.

The inclusion of governments, NGOs and private stakeholders in the process is also key for the economic sustainability of the measures. Fostering cooperation with and between them enables and establishes long-term funding mechanisms. Conservation easements and payments for ecosystem services (PES) are examples of this. Government agencies play a particularly important role in policy setting and funding. In the WB, PES initiatives are not abundant yet, and the existing ones are in early stages of implementation, mostly facing legal, institutional and financial obstacles. (Ilieva et al., 2014 & 2017).

Vuletić et al. (2020) examined the level of the implementation of PES concepts, in WB economies, such as Serbia and Bosnia and Herzegovina, concluding that most of the existing schemes are only in the stage of being “PES like”, while only schemes for forest development fit the criteria according to Wunder (2005) for “pure PES” schemes. In the concrete case studies, the strong role of the state in managing natural resources and the lack of transparency with it are seen as a key barrier to developing genuine PES schemes. This highlights the need for greater transparency in how funds are collected, allocated, and monitored.

A sound, transparent and inclusive **communication plan** sets the base for successful and sustainable implementation. It includes three major approaches for stakeholder involvement on different levels:

- **Information campaigns:** Launch educational initiatives to inform stakeholders - including local communities, landowners and policy makers - about the environmental and economic benefits of buffer zones. Emphasise their role in improving water quality, reducing flood risk and enhancing biodiversity. By publishing or posting findings and outcomes regularly, on related occasions (World Biodiversity Day, scientific or public events, etc.), the reach can be increased tremendously. Representatives or influencer from the worlds of politics and science could also advertise the project’s results.
These campaigns should be inclusive, ensuring that people of all genders have equal access to information, training opportunities, and decision-making processes.
- **Community meetings and workshops:** Organise forums where stakeholders can discuss project objectives, review data and voice concerns. Transparent communication builds trust and encourages collaboration. Special attention should be given to promoting gender-balanced participation, creating safe and accessible spaces for women, youth, and other underrepresented groups to share their perspectives.

- **Collaborative goal setting:** Work with stakeholders to co-create a vision for the riparian buffer zone. This should include diverse perspectives and balance conservation objectives with community and cultural values. Integrating gender considerations helps ensure that the initiative reflects the needs, priorities, and roles of all community members – recognising that women and men may be differently affected by environmental changes and may contribute unique knowledge and solutions.

Further guidance on visibility for [recipients of EU funding](#) and for [international partners in general](#) are provided by the European Commission.

❖ Integrate land use planning and policy development

Advocating the project and the NbS concept in general at the municipal or state level is the key for making this initial phase of the implementation process truly inclusive. After communication with the respective representatives, the following steps support sustainable future of the measures. To ensure a long-term success, riparian buffer zones need to be integrated into wider land use planning and policy frameworks, including:

- **Incorporate buffer zones into land-use plans:** Update local and regional land use plans to designate areas for conservation, restoration or limited development. This will ensure that riparian buffer zones are recognised as essential components of sustainable land management.
- **Develop buffer zone regulations:** Establish clear guidelines for permitted activities within buffer zones. These regulations should address issues such as the use of chemicals, livestock access and construction controls, to protect water quality, soil stability and biodiversity.
- **Create incentive schemes:** Encourage landowner participation through financial incentives such as tax breaks, grants or conservation easements. These schemes reward stewardship efforts and share conservation responsibilities between the public and private sectors.

❖ Balancing benefits across sectors

Riparian buffer zones should provide measurable benefits across environmental, economic and social dimensions. For example, a well-maintained buffer can reduce sedimentation and improve water quality (environmental), provide recreational areas for communities (social), and protect downstream agricultural productivity (economic) (Schindler et al., 2014). Guarantee a balance between these dimensions at the planning stage to guarantee widespread support and impact.

❖ Financial planning and sponsorship

Equally important as a well-structured, integrative and participative project idea on the practical and scientific level that is considering the aspects mentioned above, is a sound plan of the required budget. It ensures that the NbS is realistic, impactful, resilient, and sustainable in the long run. A robust financial plan has also many advantages:

- **Feasibility and strategic planning:** A clear and realistic plan helps to demonstrate how resources will be allocated across planning, implementation, monitoring, and maintenance phases. Thus, showing potential funding gaps early, avoiding delays or underperformance. By



linking project activities with their associated costs and expected returns it can also support decision-making.

- **Transparent budgeting:** Keeping the financial plan transparent enhances the confidence among partners and the local communities. But it also makes it easier to attract public and private fundings by showing accountability and readiness, which is often a prerequisite for EU-level fundings such as Interreg, LIFE or Horizon Europe.
- **Adaptive management:** A robust financial concept followed throughout the project also helps to track spending and outcomes which is essential for reacting to unpredicted developments in the project progress and to adjust to it by (re)allocating resources.

Since the question regarding the source or sponsor of the necessary finances is an important and challenging one, the chapter on Funding and resources elaborates the topic of funding NbS further, listing several funding opportunities.

7.2 Phase 2: Implementation

The second phase of riparian buffer implementation focuses on creating, enhancing and maintaining the ecological functionality of the buffer. This phase includes reforestation, vegetation management, infrastructure installation, erosion control and habitat restoration. Each step is essential to ensure that the buffer effectively stabilises soil, filters pollutants and supports biodiversity.

In general, the implementation should ensure long-term sustainability and viability. This requires the inclusion of practices such as staggered planting, soil stabilisation and erosion control into the implementation plan to ensure that the buffer remains functional for decades.

❖ Reforestation and vegetation management

Reforestation and vegetation management are the backbone of a successful riparian buffer. Start by selecting a diverse mix of native trees, shrubs and grasses that are well adapted to local conditions (e.g. soil, hydrology and climate conditions). With the ubiquitous and increasing effects of climate change, also properties such as climate-resilience should be considered. Native plants stabilise the soil, filter runoff and provide important wildlife habitat. For example, planting willows, alders and sedges along watercourses helps to anchor the soil, supporting both aquatic and terrestrial species.

Vegetation management steps:

- Plan the design: Divide the buffer zone into areas. Plant trees and shrubs closest to the water to stabilise the riverbanks, and plant grasses further back to intercept runoff.
- Plant in layers: Use ground cover under larger vegetation to improve soil retention and filter out pollutants. This understorey also prevents invasive alien species from establishing themselves.
- Ensure diversity: Include a range of species to create a resilient ecosystem that can withstand environmental pressures.

❖ Installing infrastructure (e.g. fencing and signage)

Install infrastructure such as fencing and signage to protect the riparian buffer from damage and to raise awareness. Fencing is particularly important in agricultural areas to keep livestock out of sensitive areas, reduce erosion and prevent water pollution. Signage helps educate the public and local stakeholders about the ecological importance of the buffer and to encourage responsible practices.

Steps for installing infrastructure:

- Install protective fencing: Mark buffer boundaries and prevent encroachment, especially in areas prone to livestock grazing.
- Install educational signs: Provide information on the purpose of the buffer, its biodiversity benefits and role in improving water quality. Include boundary markers to ensure visibility.

❖ Soil stabilisation techniques

Effective soil stabilisation ensures that the riparian buffer remains resilient to erosion.

Soil stabilisation steps:

- Use live stakes to reinforce the soil with vegetation.
- Use erosion control blankets or bioengineered solutions to secure unstable areas.

- Consider contour planting or terracing to reduce runoff velocity and increase water infiltration.

❖ Restoring wildlife habitat

Improve the buffer's ability to support local wildlife by restoring and expanding habitats.

Steps to restore habitats:

- Create wide wildlife corridors to connect fragmented habitats.
- Install bird and bat boxes to provide safe nesting areas.
- Add large woody debris to streams to improve aquatic habitats.
- Introduce native flowering plants to attract pollinators and improve food webs.

❖ Management of invasive alien species

Regular monitoring and control of invasive alien species is essential to protect native biodiversity. Invasive alien species easily spread along rivers, particularly if the newly planted vegetation is not yet well-developed.

Steps to manage invasive alien species

- Conduct regular monitoring to identify invasive alien species at an early stage.
- Use manual removal or targeted methods to eliminate invasive alien species.
- Replant cleared areas with competitive native species to prevent regrowth.

❖ Control nutrients and pollutants

Control nutrient and pollutant runoff with targeted practices such as constructed wetlands or grass filter strips.

Nutrient control steps:

- Build constructed wetlands to capture and treat agricultural runoff.
- Establish native grass filter strips to trap pollutants.
- Focus on planting crops that can absorb nutrients efficiently to remove excess nutrients.

❖ Sediment and runoff management

Install structures to slow water flow and trap sediment before it reaches waterways.

Steps to manage sediment:

- Use check dams, berms or sediment basins to reduce sediment flow.
- Plant vegetation along contours or create terraces to slow runoff.
- Encourage infiltration with strategically placed swales and ditches.
- Community involvement and monitoring.
- Involve local stakeholders in ongoing activities to encourage ownership and ensure the longevity of the buffer.

❖ Community engagement

Community engagement is a vital component of implementing and sustaining riparian buffer zones. Local communities are not only beneficiaries of Nature-based Solutions but also essential partners in their long-term success. Inclusive participation ensures that the voices of a diverse range of people, including farmers, landowners, young people, and especially women, are integrated into the planning and decision-making process. Gender equality is particularly important, as women often possess unique knowledge and play key roles in land and water management. Their active involvement contributes to socially just and ecologically resilient outcomes. The involvement of local youth can also increase the sustainability of the solutions, while raising awareness among this stakeholder group for Nature-based Solutions and creating capacity for their further implementation.

Educational activities, such as school programmes, public events, and targeted awareness campaigns, help to increase understanding of the benefits of buffer zones, such as improved water quality, flood mitigation, and enhanced biodiversity. Community workshops and volunteer events provide hands-on opportunities for residents to participate in planting, invasive species removal, and basic maintenance. These activities strengthen local ownership and build capacity.

Citizen science programmes further enhance engagement by involving community members in data collection and monitoring, offering training in simple techniques to observe water quality, vegetation health, and the presence of wildlife. Regular feedback mechanisms, including community meetings and participatory mapping, ensure that the project remains responsive to local needs and knowledge. Emphasising the multiple co-benefits of buffer zones – such as recreational spaces, aesthetic improvements, and reduced disaster risk – helps foster long-term stewardship. Incentives, recognition, and small-scale support for local maintenance efforts can further encourage active community participation and ownership.

7.3 Phase 3: Maintenance and evaluation

The long-term sustainability of riparian buffer zones also depends on ongoing management and maintenance. Without regular monitoring, invasive alien species can outcompete native plants, erosion can weaken banks, and sedimentation can degrade water quality. Maintenance activities, such as replanting, clearing debris and adapting the design to changing environmental conditions, are essential to ensure the resilience of the buffer over time. (EEA, 2016; Majumdar & Avishek, 2025) In addition, adaptive management, informed by ongoing monitoring and stakeholder feedback, allows adjustments to be made to meet new challenges and opportunities.

❖ Monitoring of the implementation success

In order to track and evaluate the progress and success of the implementation and effects of the NbS, it is essential to use output and result indicators. These indicators measure different aspects of the actions taken and the intended specific goals that should be achieved through them.

- **Output indicators** measure the direct results of the implementation, such as the length of shoreline restored, number of people reached through a workshop or excursion, riverine trees planted, meters of built-up banks dismantled, etc.; and thus, monitoring the progress of the measures planned.
- **Result indicators** measure the change achieved through the implementation effort, such as improved water quality, higher-quality habitats and thus greater biodiversity, a buffer effect for water level changes and flood protection in the long term. While some of these indicators can be measured immediately, others can only be detected through long-term monitoring.

Defining these indicators also aids in the planning phase, since the actions and goals need to be estimated realistically and specified according to the implementer's possibilities. A widely used methodology for planning, organising and evaluating the measures or projects is the Logical Framework Approach. LogFrames are structured as a matrix containing an overview of the overall and specific objectives, expected outcomes and the indicators.

For more information and examples on output and result indicators, see:

- [Annex 2 of the Programme Manual of the EU funding programme Interreg CE](#)
- [Results and Monitoring of the OPSYS Portal \(EC\)](#).



❖ Long-term monitoring and maintenance

The first step in maintaining the effectiveness of riparian buffer zones is to establish a comprehensive monitoring plan. This plan should focus on key water quality indicators such as nutrient levels, sediment load and pH. Regular testing of these parameters provides a clear picture of the riparian buffer zone's impact on water quality and identifies areas that may require intervention.

Vegetation management is equally important. Controlling invasive alien species prevents them from outcompeting native plants and promoting a healthy vegetation cover that supports ecosystem stability. Dead or damaged plants should be replaced promptly to maintain the integrity of the buffer zone. In addition, monitoring soil stability and erosion rates helps to identify areas at risk of soil loss.

Proactive measures, such as replanting vegetation or installing erosion control structures, can be implemented to mitigate these risks and maintain the structural and ecological function of the buffer.

❖ **Community involvement and adaptive management**

Involving the local community plays an important role in the ongoing maintenance of riparian buffer zones. Organising activities such as planting events, clean-up days and educational tours fosters a sense of ownership and responsibility among community members. This involvement not only strengthens the community's connection to conservation efforts but also provides valuable labour and resources for maintenance activities.

In parallel, adaptive management ensures that the buffer zones continue to meet environmental and social objectives. Regular assessments of the buffer's impact on water quality, erosion control and biodiversity provide critical information. Community feedback and scientific assessments should inform adjustments to management practices. This iterative approach allows the buffer zone to adapt to changing conditions and needs, ensuring its long-term functionality and effectiveness.

❖ **Securing follow-up funding and long-term sustainability**

Long-term sustainability depends on securing diverse sources of funding, including grants, public funds and support from conservation organisations. These funds should be channelled into a well-structured management protocol that outlines clear responsibilities for maintenance activities, budgeting and stakeholder involvement. This framework not only ensures the financial stability of the buffer zone but also provides a roadmap for its continued success.

❖ **Document and share success stories**

To encourage wider adoption of riparian buffer zones, it is important to document and share success stories. Reporting on quantitative outcomes, such as improvements in water quality and biodiversity, as well as qualitative stories of community engagement, highlights the positive impact of buffers. Sharing these stories through reports, presentations or media campaigns promotes riparian buffer zones as effective and replicable solutions to environmental challenges.

7.4 Transparency and accountability

According to the Kunming-Montreal Global Biodiversity Framework, it is crucial for a project, such as implementing an NbS, to have a sound monitoring of its progress and goals. This encompasses regular evaluations and reporting, conducted in a transparent and responsible manner.

The definition of feasible indicators helps

- to evaluate the effectiveness of implementation
- identify challenges and lessons learned, and
- highlight necessary adjustments and corrections to get the project back on track.

Such transparent monitoring ensures that the implementing organisation or economy is honouring its commitments and can be held accountable if it is not. (CBD, 2022)

If these principles are followed, conservation efforts are less likely to be met with public or stakeholder scepticism. Without the necessary knowledge or scientific background, measures that appear to be quite drastic and destructive might undermine conservation efforts. Setting up a transparent evaluation plan with clear indicators ensures a better communication of the methods, goals and, eventually, conservation outcomes. (Cook et al., 2024)

If it comes to the implementation of any NbS or projects in general, trade-offs are inevitable, especially when balancing the needs of different stakeholders. For example, restricting livestock access to riparian areas may benefit water quality, but may challenge local farmers. Transparency in the form of open discussions, clear communication and participatory decision-making can help identify and manage trade-offs, ensuring that all voices are heard and conflicts are minimised.

8 CONSTRAINTS AND RISK MANAGEMENT

Several barriers could hinder the effective implementation of riparian buffer zones in the Western Balkans. These challenges range from ecological limitations to logistical and technical constraints. The main challenges and risks that need to be considered and possible mitigation strategies to navigate through or prevent them completely are covered below.

8.1 Ecological constraints

Lack of knowledge on riparian restoration

Limited expertise: Riparian restoration requires an understanding of hydrology, soil science and ecology. In some areas, there may be a shortage of professionals experienced in designing and managing riparian buffer zones, particularly when it comes to integrating native vegetation and erosion control structures into diverse environments. Inadequate understanding of effective buffer design, planting and maintenance can result in poorly functioning buffers that fail to provide the desired effects.

To strengthen the knowledge base for riparian restoration, regional capacity-building programs should be established and systematically linked with exchange opportunities involving organisations with demonstrated expertise in both practical and theoretical aspects of ecosystem management. Such programs can provide structured training modules and peer-to-peer learning platforms where participants learn about best practices and innovative approaches. Through this, experts, municipal staff, and protected area managers can be equipped with the technical skills and practical experience needed for planning, implementing, and monitoring riparian restoration measures. These exchanges not only convey technical knowledge but also foster long-term professional networks that support collaboration across institutions and borders, ultimately ensuring that restoration efforts are informed by the latest scientific knowledge and adapted to local conditions.

Another less structured but more inclusive approach may prove particularly effective in the regional context. Rather than relying solely on formal training programs or top-down institutional mechanisms, flexible, community-based networks of practitioners (e.g. informal communities of practice) could serve as a foundation for knowledge exchange and collaboration. These volunteer-based groups can emerge organically around shared interests or ongoing projects, fostering trust, peer learning, and the exchange of practical experience across borders. With time and the right support through funding or integration into regional programs, these informal structures could evolve into more institutionalised platforms for capacity building.

Gender-related knowledge gaps: In addition to the general shortage of technical expertise, restoration efforts often lack the integration of gender-specific knowledge and roles. Women, particularly those in rural communities, often have valuable informal knowledge of local ecosystems, land management practices, and plant species. However, their contributions are often overlooked because they are underrepresented in technical discussions and decision-making processes.

Addressing this imbalance by actively involving women and supporting their participation in training and restoration planning can help fill important knowledge gaps, improve the relevance and sustainability of interventions, and foster more inclusive approaches to ecosystem restoration.

Limited availability of native species for planting

Insufficient plant stock: Many native riparian plant species may be scarce in nurseries or unavailable from commercial sources. Limited seed banks or lack of nursery stock of native trees, shrubs and grasses adapted to local conditions can delay or hinder restoration.

Propagation and growth challenges: Some native plants are slow growing or difficult to propagate, which can increase the time required to establish a functional buffer. High mortality of young plants can further delay results.

To ensure a reliable supply of suitable native plant species for restoration projects, the establishment or strengthening of regional native plant nurseries is recommended. These nurseries can serve as central hubs for propagating and distributing plant material that is adapted to local ecological conditions. In addition, the creation of cross-border seed banks would help secure a broader genetic pool and make species more readily available across national boundaries, particularly for ecosystems and communities that span the economies' borders.

The active involvement of botanical gardens and research institutions can further support this effort by providing technical expertise, maintaining living collections, and facilitating knowledge exchange. Together, these measures would not only improve access to native species but also enhance regional cooperation, build long-term capacity, and strengthen ecological restoration outcomes.

Challenges in invasive alien species management

Resilient invasive alien species: Invasive plants that thrive along riverbanks can outcompete native species and prevent the establishment of native vegetation. Managing these invasive alien species can require regular and resource-intensive interventions, including repeated removal, which can be labour-intensive and expensive.

Potential for re-introduction: Invasive alien species can easily re-establish in areas with seed dispersal from nearby infestations, requiring ongoing monitoring and control, which may be difficult to maintain over large buffer areas.

Effective management of invasive alien species may require overarching coordination along the entire river stream, as many species spread rapidly, especially along ecological corridors like rivers and their associated landscapes, not following administrative boundaries. A first step is to establish joint early detection systems to collect, share, and standardise data on the occurrences of invasive alien species. Based on this information, mechanical removal measures can be coordinated to reduce existing populations in priority sites, while ensuring that removal methods are ecologically appropriate.

At the same time, mechanisms for rapid response should be put in place to quickly address new invasions before they become established. This includes developing common protocols, training staff in participating economies, and securing flexible funding for emergency interventions. Planned on a regional level, these measures could effectively enhance regional resilience, protect biodiversity, and reduce long-term management costs.

Complex site conditions and climate variability

Variability in soils and hydrology: The Western Balkans contain diverse landscapes with highly variable soil and hydrological conditions. Some areas may have compacted or eroded soils with low fertility. This can make it difficult for plants to become established and thrive without soil amendments or intensive management.

Extreme weather events: Climate change is expected to increase the frequency of extreme weather events, including intense rainfall and prolonged droughts, both of which can disrupt riparian buffer zones. These conditions may require adaptation measures that are technically challenging and costly.

Species resilience: Native plants may not be fully resilient to changing climate patterns, which could lead to additional vegetation loss, requiring more adaptive management or the introduction of new species.

To address these challenges, it is recommended to conduct comprehensive site assessments that analyse soil composition, moisture availability, and hydrodynamic processes before selecting restoration measures. Based on these assessments, practitioners can choose site-specific plant communities with species adapted to local conditions.

This can include, for example, species with a higher drought or flood tolerance. In addition, the use of adaptive restoration techniques – such as staged planting or soil management – can help to stabilise soils and regulate water retention. Ongoing monitoring and adaptive management will be essential to evaluate outcomes and adjust practices over time, ensuring that restored ecosystems are resilient to local site conditions and climate extremes.

Water quality issues

High pollutant loads: Agricultural runoff and untreated wastewater are prevalent issues in parts of the Western Balkans, leading to high concentrations of nutrients and pollutants in rivers and streams. Without additional interventions, such as constructed wetlands or sediment basins, riparian buffer zones may struggle to manage these levels.

To reduce the impact of agricultural runoff and industrial discharges on water quality, in addition to the establishment of the riparian buffer zone, other preventive measures can be applied. For example, sustainable agricultural practices (e.g. reduced pesticide use, crop rotation, and organic farming) can significantly decrease diffuse pollution at the source.

On the industrial side, investments in modern facilities for wastewater treatment as well as the enforcement of stricter discharge standards are essential to limit the release of waste waters into riparian systems. These measures should be complemented by regular monitoring programs, capacity-building for farmers and industries, and the introduction of economic incentives, such as subsidies for sustainable practices or penalties for non-compliance, to ensure long-term effectiveness.

8.2 Logistical constraints

High initial cost and maintenance requirements

Material and infrastructure costs: Erosion control materials, fencing and other infrastructure required for riparian buffer zones can be costly. Financial constraints may delay implementation or limit the size of buffer zones. This challenge is particularly relevant in the Western Balkans, where limited public funding, competing development priorities, and under-resourced environmental agencies often hinder large-scale environmental initiatives.

Ongoing maintenance requirements: Riparian buffer zones require regular maintenance, especially in the early years, to control invasive alien species, monitor plant health, and repair damage from floods or human activities. Lack of sustained funding for maintenance can compromise the effectiveness of buffers over time. In the Western Balkans, such maintenance often lacks sustained funding, due in part to institutional weaknesses and budgetary constraints. This can severely compromise the long-term effectiveness and resilience of riparian buffer systems in the region.

To overcome this financial barriers, restoration projects should actively leverage EU pre-accession funds ([IPA III](#)) and align proposals with the Green Agenda for the Western Balkans to maximise eligibility for external financing. In addition, the use of blended financing models, combining public resources with private-sector investment through public-private partnerships (PPPs), can help distribute financial risks and create long-term sustainability.

Municipalities could also establish cost-sharing schemes with local beneficiaries (e.g., water utilities, tourism operators, agricultural associations) who directly profit from improved ecosystem services. By securing diverse funding sources and including maintenance costs into long-term management plans, projects can reduce financial dependency on short-term grants and ensure that the implemented NbS remains functional and effective over time. (For more detail, also see chapter Funding and resources)

Limited data and monitoring capabilities

Baseline data deficiency: Implementing effective riparian buffer zones requires accurate baseline data on current water quality, soil composition, erosion rates, and biodiversity. In some areas, such data may be lacking or inconsistent, making it difficult to measure the impact of buffers.

Monitoring infrastructure: Regular monitoring of water quality, soil stability, and vegetation health is essential but may require specialised equipment and trained personnel, which are sometimes limited. Citizen science can help, but it may not always provide the precision needed for certain indicators.

To address this gap, remote sensing technologies (e.g., satellite imagery, drones) should increasingly be applied, allowing a cost-efficient, large-scale monitoring of land cover changes, hydrology, and vegetation health.

At the same time, involving local communities and schools in citizen science initiatives (e.g. iNaturalist) can broaden the data collection, raise awareness, and reduce costs, while ensuring the involvement and participation of society in the monitoring activities.



To improve comparability and facilitate EU integration, monitoring frameworks should harmonise indicators with EU standards, such as those used for Natura 2000 or the Water Framework Directive. This ensures that collected data supports both reporting on economy level as well as the accession processes. Finally, building regional data-sharing platforms would enable cross-border learning and create synergies between research institutions, municipalities, and protected areas, ultimately improving decision-making and long-term adaptive management.

Poor site accessibility in rural/mountainous terrain

Transport of materials and mobilisation of workforce: Many potential restoration or conservation sites in the Western Balkans and similar regions are located in remote landscapes where roads and transport infrastructure are limited or in poor condition. This makes the transport of materials (e.g., plants, soil, equipment) and mobilisation of specialised workforce logistically challenging and more costly (Cohen-Shacham et al., 2016; Kapović Solomun et al., 2018). In winter and during adverse weather conditions, access can be further restricted, delaying project timelines and reducing the effective working season (Castellari et al., 2021).

Monitoring and maintenance: Limited accessibility also complicates the long-term monitoring and maintenance of NbS interventions, which is essential for their success. For example, regular monitoring of restored riparian buffer zones, wetlands, or erosion-control structures may not be feasible without reliable access routes. Moreover, emergency interventions (e.g., after floods or landslides) are harder to carry out, risking the effectiveness of earlier investments (WWF Adria, 2020; Seddon et al., 2020).

Stakeholder involvement: Finally, poor accessibility can reduce local stakeholder involvement in NbS projects, as communities may be isolated from project sites and less able to participate in decision-making, co-implementation, or benefit-sharing. This limits the social co-benefits of NbS and can undermine community ownership, which is critical for sustainability (Reed et al., 2009; Nesshöver et al., 2017). Addressing this constraint requires careful logistical planning, seasonal scheduling, and, where possible, investments in basic infrastructure or alternative transport methods adapted to remote terrain.

To mitigate these challenges, project planning should include seasonal windows for implementation activities (e.g. fieldwork and construction activities), scheduled during periods of high probability of good weather conditions and accessibility to reduce risks and costs. At the same time, investment in basic transport and logistics infrastructure, such as improving access roads, installing temporary bridges, or ensuring reliable equipment transport, can significantly improve project feasibility.

Where infrastructure development is limited, the use of locally adapted solutions, such as relying on pack animals, small-scale machinery, or community-based maintenance groups, can provide practical alternatives. Integrating these logistical considerations early in project design will help ensure that NbS interventions are not only technically sound but also workable with manageable costs in in challenging landscapes.

8.3 Administrative and social constraints

Low stakeholders' support and awareness

Stakeholder opposition and lack of political commitment: Conflicts of interest or lack of understanding regarding the measures and goals of the implementation can complicate or impede the realisation of a buffer zone. Lacking support of the public, regional players or governmental authorities affects the project severely, e.g. by the unwillingness of landowners to provide land for the necessary measures or the opposition of the local population to the measures taken. This applies equally to the maintenance of the buffer zone after the end of the project. The lack of political will to pursue the efforts and maybe even continue with similar measures is crucial for a sustainable implementation and future actions.

The best way to minimise such issues is to involve and inform stakeholders from the start of the implementation process, ensuring their support and sharing information and knowledge transparently. With the requirements of future legal frameworks (Nature Restoration Law, etc.) in mind, policy makers need to be informed and reminded of their obligations. One method for stakeholder involvement is the organisation of participatory workshops that actively address communities, ensuring their voices and opinions are heard and local knowledge is integrated into project design.

Complementary, education and awareness campaigns that communicate the benefits and value of the riparian buffer zones for nature and society help to build a shared understanding for it. Finally, showcasing pilot projects with visible outcomes (e.g., restored wetlands reducing flood risks) can serve as powerful demonstration sites, inspiring confidence and motivating replication in other areas. Embedding these approaches in long-term outreach strategies strengthens local ownership and ensures that NbS become part of community identity and practice.

Conflict of interests

Conservation vs. socioeconomics: One of the most persistent challenges for NbS in general in the Western Balkans and elsewhere is the tension between conservation goals and development priorities. For example, tourism development and hydropower expansion are often promoted as economic drivers but may directly undermine river restoration, wetland conservation, or forest protection efforts (Schwarz, 2015, 2019). Such conflicts can delay or block NbS implementation, as decision-makers prioritise short-term economic benefits over long-term ecological resilience. Additionally, weak enforcement of environmental regulations can exacerbate these conflicts, especially in regions where governance capacity is limited.

To address these tensions, the NbS should be systematically integrated into local and regional spatial plans, ensuring that restoration and conservation measures are considered, while they are accompanied by development priorities rather than competing with them. Structured mediation and dialogue processes with affected stakeholders, including municipalities, developers, communities, and conservation actors, can help to identify trade-offs and negotiate acceptable solutions.

Demonstrating the economic co-benefits of NbS, such as enhanced tourism potential from restored landscapes, reduced flood risks lowering municipal costs after floods, or increased agricultural productivity from healthier soils, can also shift the perception of NbS from being restrictive to adding value. Embedding these approaches in transparent, participatory planning processes increases the likelihood of finding balanced solutions that align conservation and development objectives.

Weak inter-sectoral coordination among ministries

Communication and mainstreaming: NbS require cross-sectoral collaboration, as they span multiple domains such as water management, forestry, agriculture, energy, and urban development. In the Western Balkans, ministries often work in silos, with little coordination or communication across sectors (Castellari et al., 2021; European Commission, 2020). This fragmentation results in overlapping responsibilities, inefficient allocation of resources, and conflicting policies (e.g., subsidies for intensive agriculture vs. biodiversity conservation). Without institutionalised mechanisms for inter-sectoral coordination, NbS projects face delays, duplication of efforts, and lack of mainstreaming into national strategies.

To address this, governments should establish a national NbS coordination body or task force that brings together relevant ministries, agencies, organisations and stakeholders. The goal should be to streamline the decision-making process and ensure coherence in policy and its implementation. This has been done in other European countries already. A perfect example is the [NbS Italy Hub](#), which was developed and established as part of the NetworkNature project, promoted by the European Commission as one of several national hubs dedicated to NbS.

Aligning national strategies and action plans with the Green Agenda for the Western Balkans and related directives (e.g., Water Framework Directive, Habitats Directive) would further promote consistency, improve the preparatory process for EU accession, and enable access to EU funding. Regular inter-ministerial working groups, joint monitoring systems, and shared performance indicators can also improve cooperation and accountability, ensuring that NbS become a cross-sectoral priority rather than remaining exclusively within environmental agencies.

Limited long-term funding

Decreasing commitments after project closure: Many NbS initiatives in the region are financed through short-term international donor projects or EU pre-accession funding. While these funds can support pilot projects and initial implementation, there is often limited commitment to ensuring financial sustainability beyond the project's lifetime (Cohen-Shacham et al., 2019; Kabisch et al., 2017). This can lead to cases where restoration works or NbS pilots degrade after external support ends, undermining credibility and effectiveness. Without national or local budgetary allocations for maintenance, monitoring, and scaling, NbS risk becoming one-time experiments rather than sustainable and transformative solutions.

To overcome this, it is essential to establish dedicated maintenance funds at municipal, regional, or protected-area levels that secure resources for routine monitoring and management activities beyond the project's lifespan. In parallel, project developers and authorities should actively link ongoing activities to EU funding mechanisms, such as the LIFE Programme or Horizon Europe, which offer opportunities for continuity and scaling-up of successful pilots.

Embedding NbS into national and local budgets, aligning them with broader policy instruments like the Green Agenda for the Western Balkans and overall advocating for them, further increases the likelihood of stable, long-term financing. Additionally, blended financing models with private beneficiaries (e.g., water utilities, tourism operators) can provide complementary budget, ensuring that NbS deliver benefits also in the future.

9 CONCLUSION

Nature-based Solutions hold great potential for addressing the intertwined ecological and societal challenges of the Western Balkans, particularly in flood-prone riparian ecosystems. As demonstrated in this guidance document, riparian buffer zones can provide multiple co-benefits, including flood risk reduction, improved water quality, biodiversity conservation, and enhanced human well-being. The guidance developed for the region offers a structured framework for planning, implementing, and monitoring such measures, grounded in international standards, scientific evidence, and participatory processes.

Nevertheless, the transition from policy recognition to effective on-the-ground implementation remains complex. **Persistent challenges – such as limited data availability, financial and institutional constraints, fragmented governance, and competing land-use priorities – continue to slow progress, potentially during every project phase.** Addressing these barriers requires sustained cross-sectoral collaboration, investment in knowledge and capacity building, and the integration of Nature-based Solutions into wider policy and planning frameworks.

The Western Balkans stand at a pivotal point where adopting evidence-based, participatory, and adaptive Nature-based Solutions can deliver resilient and multifunctional outcomes. The success of future efforts will depend on ensuring robust monitoring systems, strong institutional support, and active stakeholder involvement. By balancing science, policy, and practice, Nature-based Solutions can become a cornerstone of sustainable regional development while aligning with EU environmental objectives.



10 REFERENCES

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