NBS aquatic interventions

This section presents **4 fact sheets** delving into **NBS aquatic Interventions,** elucidating approaches employed for **River Management Techniques**, **riverbank measures, rehabilitation of aquatic systems.**

RIVERBANK MEASURES

CARDIMED	RIPARIAN BUFFER
Picture not available. **Synonyms:** Riparian buffer strip; Vegetative filter strips; Buffer strips, Riparian area, riparian forest. **Description:** A riparian buffer involves the purposeful establishment and management of a vegetated or naturally preserved strip of land along the banks of rivers, streams, or other water bodies. Riparian buffers reduce surface runoff and detain sediments and sediment-bound pollutants, primarily from agricultural areas. Situated between agricultural catchments and streams/rivers, they act as filters for pollutants and sediment transportation into the river, slowing down the flow.	
Main challenges targeted	Biodiversity & renaturalization, Freshwater and groundwater supply and quality, Rainwater management & flood protection
Regulation and Maintenance Services	Improve quality of surface water, Improve quality of groundwater, Avoid / reduce salinity in groundwater, Efficient water treatment (effluent of WWTP), Efficient water treatment (agricultural runoff), Efficient water treatment (urban runoff), Efficient water treatment (rainwater), Reduce flood risk, Reduce sediment flow into drainage systems, River flood protection, Reduce landslides, Reduce urban runoff, Reduce agricultural runoff, Coastal flood protection, Stormwater source control, Permeability restoration, Create or restore habitat, Restore degraded areas, Mitigate desertification, Create or restore fauna, Create or restore flora, Support pollination, Connect blue and green spaces, Develop resilience of green spaces, Support free movement of species, Provide nesting and breeding habitat, Refuge for farm and wild animals, Increase green areas around urban rivers, Restore natural forest fire regime, Coastal restoration & protection/ Promote resilience against natural disasters, Re-establish hydrologic connection, Improvement of the hydromorphological functioning, Restore aquatic habitats, Reduce sediment flow in the river, Reduce sediments deposition in river beds, Reduce changes on soil characteristics, Stabilize soil / substrate, Improve soil fertility / biodiversity, Enhance and stabilize water retention, Improve carbon sequestration, Provide thermal regulation / cooling, Reduce risk of pest and diseases
Cultural Services	Facilitate education, Health and Well-Being improvement, Increase recreational and socialisation value, Increase aesthetic and patrimonial or cultural value, Ensure accessibility to green spaces, Reduce undesired behaviours, activities and vandalism, Support social cohesion and justice, Support environmental awareness, Increase stakeholder engagement, Increase physical health, Promote mental health, Reconnect people with nature, Promote health habits

Provisioning Services	Promote natural aquifer recharge / preserve groundwater supply, Promote natural surface water recharge / preserve surface water supply, Provide nutrition sources for birds and insects, Production of biomass, Nutrient recovery
Other Services	Contribute to local employment, Increase land/property monetary value Increase tourism, Contribute to new or existing business, Reduced costs in comparison with other solutions, Favor green economy (reuse of local by-products)
Replicability	★★☆
Design & planning	The design consists of a **three-zone system**: **Zone 1:** This zone begins at the top of the bank and **plants** will contain trees and shrubs needed to provide aquatic shade, bank stability, detritus, large woody debris, and retain nutrients bound to soils. Large woody debris and tree roots in the water create habitat complexity and niches for invertebrates and aquatic organisms. Detritus such as leaves, twigs and fruit seeds entering the water and held by woody debris provide a base to the aquatic food chain. The minimum **width** for this zone is 4.5 m from the top of the bank. **Zone 2**: This zone is landward of Zone 1 and **plants** will contain the trees and shrubs and other vegetation needed to filter runoff and provide uptake of nutrients and pollutants. Together, Zone 1 and 2 will provide a travel corridor and habitat for wildlife in addition to providing shade and a source of woody debris. The minimum **width** for this zone for all purposes is 6 m. **Zone 3:** This zone, the **plants** are a strip of grass or herbaceous cover to spread, slow and filter runoff which may be transporting sediment, nutrients, and pesticides off cropland or other erosive areas. The minimum **width** for this zone is 4.5 m. Factors that improve effectiveness include: **Slopes** less than 5 percent, groundwater close to the surface. **Planting** during the growing season. **Buffer widths** greater than 7.5 m, entry **stormwater velocity** less than 0.5 m/s.
Operation and maintenance	Monitoring vegetation to ensure survival, removing invasive species, replanting areas with low vegetation survival may be necessary. Others: Training to staff and volunteers responsible for the operation and maintenance. Regular documentation of maintenance activities, operational issues, and measurements.Safety protocols and training (to prevent accidents and ensure compliance with safety regulations).Track legal and regulatory compliance.Be prepared to adapt your operation and maintenance practices over time in response to changing environmental conditions, market dynamics, and other factor
Combinations with other NBS	**Restoring native vegetation** and **Techniques for fauna refuge and nesting** (for providing habitats for local wildlife, stabilising soils, reducing erosion, and improving water quality), **Invasive alien species control** (for preventing competition with native plants, preserving biodiversity and functions of the riparian ecosystem), **Mulching**

	application (for promoting healthy vegetation growth, stabilising soils, reducing erosion, suppressing weed growth and facilitating establishment of native plants). **Green corridor, Urban micro forest, Bioretention cells (rain gardens), Bioswales, Terracing** and **Filter drains** (for an integrated rainwater management). terracing, green corridor and urban micro
Supportive units & smart tech	**Remote sensing** (to evaluate riparian form, function, and change over time, as it allows for the continuous collection of geospatial data over large areas); **GIS Mapping** (geographical Information Systems (GIS) can be used for detailed mapping of riparian zones, analysing spatial relationships and changes over time to help in planning and conservation efforts; **Unmanned Aerial Vehicles (UAVs) or drones** (equipped with cameras and sensors can provide high-resolution imagery and are useful for monitoring changes in vegetation, erosion, and other ecological factors in riparian areas); **Water quality sensors** (automated sensors placed in streams or rivers can continuously monitor water quality parameters such as pH, temperature, turbidity, and contaminant levels, providing real-time data critical for assessing the effectiveness of riparian buffers in filtering runoff); **Automated weather stations** (can collect data on local climate conditions (e.g., rainfall, humidity, temperature) for understanding weather-related impacts and planning adaptive management strategies); **Soil moisture sensors** (can help monitor soil moisture levels, providing data that can be used to assess the health of the vegetation and its effectiveness in stabilising the soil and filtering pollutants).
Treatment efficiency	**TN: 25-97%; TP: 55-94%; TSS: 75-97%**
CAPEX	100 - 2000 €/ha. Main type of costs: Equipment and materials (seeds, shrubs, trees and tree shelters) Labour (planting and tree shelters installation).
OPEX	20-500 €/ha y. Main type of costs: Labour (maintenance and mowing)
By-product(s)	Woody biomass (for biofuel) and organic biomass from trimming, pruning, clippings and fallen leaves (for mulching, soil amendments, composting, organic fertilisers, energy production and biofuel).

RIVER MANAGEMENT TECHNIQUES

CARDIMED	DIVERSION CHANNELS

Picture not available. **Synonyms:** Redirecting channels, Canal diversions, Channelling conduits, Diversion conduits, , Flow redirection channels. **Description:** Diversion channels are primarily artificial waterways crafted to redirect water flow, serving to mitigate flooding, erosion, and landslides, while also facilitating water recharge and supply to other areas or bodies of water. These channels can be constructed or utilised to divert either all or a portion of river flow away from the base of slopes or landslide-prone areas. Typically, diversion channels are stabilised with a covering of vegetation, predominantly comprising grasses. Their lifespan may vary, ranging from temporary to permanent, depending on project goals. Importantly, the design of diversion channels should prioritise biodiversity

benefits and strive to have a positive impact on nature in both the short and long term, contributing not only to water management but also to biodiversity conservation and protection efforts.	
Main challenges targeted	Freshwater and groundwater supply and quality, Rainwater management & flood protection, Biodiversity & renaturalization
Regulation and Maintenance Services	Water regulation, Efficient water treatment (effluent of WWTP), Efficient water treatment (agricultural runoff), Efficient water treatment (urban runoff), Efficient water treatment (rainwater), Reduce flood risk, River flood protection, Reduce urban runoff, Reduce agricultural runoff, Coastal flood protection, Stormwater source control, Create or restore habitat, Mitigate desertification, Create or restore fauna, Create or restore flora, Support pollination, Reduce harmful impacts to fauna & flora, Connect green spaces, Connect blue and green spaces, Develop resilience of green spaces, Support free movement of species, Provide nesting and breeding habitat, Refuge for farm and wild animals, Increase green areas around urban rivers, Restore natural forest fire regime, Coastal restoration & protection/ Promote resilience against natural disasters, Re-establish hydrologic connection, Improvement of the hydromorphological functioning, Restore aquatic habitats, Enhance and stabilize water flow (Sustain river flow), Enhance and stabilize water retention, Provide thermal regulation / cooling
Cultural Services	Increase aesthetic and patrimonial or cultural value, Ensure accessibility to green spaces, Reconnect people with nature
Provisioning Services	Promote natural aquifer recharge / preserve groundwater supply, Promote natural surface water recharge / preserve surface water supply, Water reuse, Provide nutrition sources for birds and insects, Nutrient recovery
Other Services	Contribute to local employment, Increase land/property monetary value Increase tourism, Contribute to new or existing business, Reduced costs in comparison with other solutions, Favour green economy (reuse of local by-products), Reduced water footprint
Replicability	★★☆
Design & planning	The main **plants** are grass or herbaceous species, to stabilise their banks and reduce erosion. A minimum **depth** of 3 m, these channels effectively manage water flow and hydraulic forces. To prevent overtopping, a **freeboard** equal to 10% of the channel depth is recommended, ensuring safety during high-flow periods. Embankments should feature a **crest width** of at least 600 mm and a down-slope bank gradient of 2:1 for stability and accessibility. A minimum **berm width** of 1.5 m along the channel enhances stability and supports vegetation.
Operation and maintenance	**Operational activities:** Inspect weekly inspections of the diversion

	channel and inspect after any increase in flow within the channel. Verify that fill material or sediment is not obstructing the channel in any way **Maintenance activities:** Repair any slumps or loss of freeboard promptly.. Properly dispose of any collected sediment or fill to prevent erosion or pollution hazards. **Others:** Training to staff and volunteers responsible for the operation and maintenance. Regular documentation of maintenance activities, operational issues, and measurements.Safety protocols and training (to prevent accidents and ensure compliance with safety regulations).Track legal and regulatory compliance.Be prepared to adapt your operation and maintenance practices over time in response to changing environmental conditions, market dynamics, and other factor
Combinations with other NBS	**Dams, Bioswale** and **Riparian buffer** (for flood prevention, erosion control and landslide mitigation)
Supportive units & smartech	**Retaining walls** (structural support along channel edges, for resisting lateral soil pressure and minimising erosion risks). **Smart sensors** (to monitor water flow, level, water quality and T for assessing the impact of environmental conditions, detecting anomalies, and optimising maintenance).
CAPEX	*not available*. Main type of costs: Permits, Fees and administrative (engineer fees and land acquisition); Equipment and materials (concrete, stone or other material, monitoring systems); Labour (excavation, levelling, construction of the channel, gates or flow control structures).
OPEX	*not available*. Main type of costs: Labour (inspection, cleaning, and repairing damaged equipment).
By-product(s):	*Not applicable*

CARDIMED	**DAMS**
Picture not available. **Synonyms:** Stone weirs; Sand dams; Embankment; Earth dams; Subsurface dam; Riverbank erosion control and water harvesting structures. **Description:** Dams are a sustainable, low-cost rainwater harvesting technique and highly effective. A dam is a reinforced stone masonry wall built across a seasonal river. They raise groundwater levels, enabling vegetation regrowth, reducing soil erosion, reversing land degradation and increasing the productivity of the land. Also, they reduce runoff, increase infiltration and prevent the formation of gullies (such as earth dams).	
Main challenges targeted	Rainwater management & flood protection, Biodiversity & renaturalization, Societal Benefits
Regulation and Maintenance Services	Improve quality of groundwater, Avoid / reduce salinity in groundwater, Reduce flood risk, River flood protection, Mitigate desertification, Create or restore fauna, Create or restore flora, Provide nesting and breeding habitat, Coastal restoration & protection/ Promote resilience against natural disasters, Improvement of the hydromorphological functioning, Reduce sediment flow in the river, Enhance and stabilize water flow (Sustain river flow)

Cultural Services	Health and Well-Being improvement, Increase recreational and socialisation value, Increase aesthetic and patrimonial or cultural value, Preserve cultural and historic heritage, Facilitate education, Support social cohesion and justice, Support environmental awareness, Increase stakeholder engagement, Reconnect people with nature
Provisioning Services	Promote natural aquifer recharge / preserve groundwater supply, Promote natural surface water recharge / preserve surface water supply, Water reuse , Provide nutrition sources for birds and insects, Material reuse, Sustainable food production
Other Services	Contribute to local employment, Reduced costs in comparison with other solutions, Reduced water footprint
Replicability	★★☆
Design & planning	**Materials** are blocks or stones, alluvial soil, coarse sand, reinforced concrete wall. Typical **heights** ranging from 2.5 to 5 m and lengths varying based on river width. To prevent overtopping, a freeboard equal to 10% of the channel depth is recommended, ensuring safety during high-flow periods. A **freeboard**, the vertical distance between the water level and the top of the dam structure, should always be maintained at a minimum of 0.5 m. However, for optimal safety and effectiveness, it is recommended to aim for a range between 0.75-1.0 m. The embankment **crest width** should be designed to allow the safe passage of plant and equipment to be used in the dam construction and should be no less than 2 m wide. The **embankment** constitutes the core structure of the dam, and adherence to specific design and construction guidelines is imperative. Side slopes should not exceed a ratio of 1:2 on the upstream side and 1:1.75 on the downstream side.
Operation and maintenance	Inspections and repairs to ensure structural integrity and effectiveness in water management and erosion control. Others: Training to staff and volunteers responsible for the operation and maintenance. Regular documentation of maintenance activities, operational issues, and measurements.Safety protocols and training (to prevent accidents and ensure compliance with safety regulations).Track legal and regulatory compliance.Be prepared to adapt your operation and maintenance practices over time in response to changing environmental conditions, market dynamics, and other factor
Combinations with other NBS	**Bioswale**, **Diversion channels** (for flood prevention, erosion control and landslide mitigation)
Supportive units & smartech	**Remote sensing** and **GIS** (for identifying suitable dam sites, monitoring environmental impacts, and optimising dam functionality. They enable effective water resource management, erosion control, and flood risk assessment).
CAPEX	*not available*. Main type of costs: Permits, fees and administrative (engineer fees);

	Equipment and materials; Labour (clearing site, excavating cutoff, backfilling, embankment work, spillway construction and trimming/tidying); Research and development
OPEX	*not available*. Main type of costs: Labour (inspection, cleaning, replacement and repairing of infrastructure).
By-product(s):	*Not applicable*

REHABILITATION OF AQUATIC ECOSYSTEMS

CARDIMED	LAGOON RESTORATION
Picture not available. **Synonyms:** Restoring coastal lagoon; Restore coastal lagoons; Coastal wetlands restoration. **Description:** Lagoon restoration involves restoring the ecological status of degraded lagoon ecosystems due to human activities or natural factors. Main threats include changes in water conditions, pollution, fishing, habitat destruction from infrastructure development, dredging, and hydrodynamic regulation. Measures to address these threats include hydrological modifications, Invasive alien species control, infrastructure removal, habitat creation, and native vegetation replanting. The overarching goal is to enhance ecological resilience, promote biodiversity, and improve the ecological status of lagoon ecosystems.	
Main challenges targeted	Biodiversity & renaturalization, Societal benefits, Local Development & Economic Enhancement
Regulation and Maintenance Services	Efficient water treatment (rainwater), Reduce flood risk, Reduce urban runoff, Reduce agricultural runoff, Coastal flood protection, Stormwater source control, Create or restore habitat, Restore degraded areas, Mitigate desertification, Create or restore fauna, Create or restore flora, Reduce harmful impacts to fauna & flora, Connect blue and green spaces, Develop resilience of green spaces, Support free movement of species, Provide nesting and breeding habitat, Refuge for farm and wild animals, Coastal restoration & protection/ Promote resilience against natural disasters, Improvement of the hydromorphological functioning, Restore aquatic habitats, Improve carbon sequestration, Reduction of greenhouses gases emissions, Provide thermal regulation / cooling, Reduce risk of pest and diseases
Cultural Services	Recreation and ecotourism, Health and Well-Being improvement, Increase recreational and socialisation value, Increase aesthetic and patrimonial or cultural value, Ensure accessibility to green spaces, Preserve cultural and historic heritage, Reduce undesired behaviours, activities and vandalism, Support social cohesion and justice, Support environmental awareness, Increase stakeholder engagement, Increase physical health, Promote mental health, Reconnect people with nature, Promote health habits
Provisioning Services	Promote natural surface water recharge / preserve surface water supply, Water reuse , Provide nutrition sources for birds and insects, Production of biomass, Nutrient recovery, Produce energy / Reduce

	energy demand, Material reuse, Sustainable food production
Other Services	Contribute to local employment, Increase land/property monetary value Increase tourism, Contribute to new or existing business, Reduced costs in comparison with other solutions, Favour green economy (reuse of local by-products), Reduced carbon footprint, Reduced water footprint
Replicability	★☆☆
Design & planning	**Environmental context** is information and data collected through monitoring activities prior to project implementation establish the baseline condition of the site at the onset of the restoration process. The information on biotic and abiotic elements of the site, along with the assessment of pressures, threats, and impacts, forms an initial step in determining the desired and feasible restoration targets. **Desired state to be achieved:** identification of a reference state involves referencing sites that are comparable in structure and function to the proposed restoration site before it was degraded. Restoration projects require clearly defined goals and objectives to achieve success. Directly implementing these goals and objectives establishes standards for measuring success; they must be tied to anticipated outcomes that are measurable through specific indicators. **Policies and socio-economic context:** Recognizing the expectations and interests of stakeholders, involving them directly to identify provisions for site maintenance after project completion, is crucial for ensuring that both nature and society benefit mutually, thus ensuring the long-term viability of a restored area by minimising the need for continuous maintenance. **Typology and actions** involved in the recovery and/or improvement of habitats and ecosystems. **Methods for monitoring** the impact of the project.
Operation and maintenance	**Operational activities:** Monitoring and evaluation involves quarterly site visits to assess habitat health, the presence or lack of invasive weeds, and documenting wildlife within the habitat, etc. These assessments are used to inform maintenance needs. **Maintenance activities:** Additional plantings, weed control, erosion control, trash removal, etc. **Others:** Training to staff and volunteers responsible for the operation and maintenance. Regular documentation of maintenance activities, operational issues, and measurements.Safety protocols and training (to prevent accidents and ensure compliance with safety regulations).Track legal and regulatory compliance.Be prepared to adapt your operation and maintenance practices over time in response to changing environmental conditions, market dynamics, and other factor
Combinations with other NBS	**Invasive alien species control, Restoring native vegetation; Reintroduction of native fauna, Riparian buffer** (for reducing competition between invasive species and newly native plants planted, enabling native species to establish and adapt to their

	environment, improving structure, composition and function of the ecosystem).
Supportive units & smart tech	**Remote sensing** (satellite imagery and aerial drones) and **computer vision** (to monitor lagoon conditions, identify areas of degradation, and track changes in water quality and habitat composition over time). **GIS** (to assess habitat connectivity, and identify suitable locations for restoration).
CAPEX	*not available.* Main type of costs: Equipment and materials (levees, berms, monitoring system and drainage systems); Permits, fees and administrative (environmental assessments, regulatory compliance and engineering fees); Research and development (design restoration plans, feasibility studies, data analysis and technical expertise); Labour (planting vegetation, creating marshes, and constructing fish habitats, removing invasive species, reintroducing native fauna, drainage system installation, levees and berms construction).
OPEX	*not available.* Main type of costs: Labour (monitoring, habitat maintenance, replacement and repairing of infrastructure, invasive alien species control, vegetation maintenance, replanting efforts, water quality testing and nutrient management); Permits, fees and administrative (insurance coverage).
By-product(s):	Mulch and woody biomass (for energy production, biofuel, soil amendments, composting and organic fertiliser). Potential generation for carbon credits.