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NbS for flood adaptation

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Javna ustanova Regionalna RAZVOJNA AGENCIJA KARLOVAČKE ŽUPANIJE

REGEA

KARLOVAČKA ŽUPANIJA In medias res

cmcc Centro Euro-Mediterraneo sui Cambiamenti Climatici

CORILA

Ministero delle Infrastrutture e dei Trasporti

Agroforestry

DESCRIPTION

Agroforestry is a land management system that integrates trees and shrubs into agricultural landscapes to enhance biodiversity and sustainability. It combines agricultural and forestry technologies to create more diverse, productive, and sustainable land-use systems. By mimicking natural ecosystems, helps in mitigating climate change and improving resilience against extreme weather conditions, offering in addition economic advantages by diversifying income sources.

TYPE

TIME

ECOSYSTEM SERVICES

- Nutrition
- Material
- Energy
- Mediation of wastes or toxic substances
- Mediation of nuisances of anthropogenic origin
- Regulation of baseline flows and extreme events
- Lifecycle maintenance, habitat and gene pool protection
- Pest and disease control
- Regulation of soil quality
- Atmospheric composition and conditions
- Intellect and education
- Recreation and well-begin
- Landscape experience
- Tourism

SUCCESS AND LIMIT FACTORS

☺ Agroforestry can improve crop productivity by providing shade, reducing wind exposure, and improving soil fertility.

☺ In agroforestry systems trees and shrubs contribute to nutrient cycling by fixing nitrogen, increasing nutrient availability, and reducing the need for external fertilizers.

☺ Agroforestry can foster community engagement and social cohesion by promoting shared management of natural resources, providing employment opportunities, and preserving cultural landscapes and biodiversity.

☹ To establish an agroforestry system can be expensive, requiring investment in planting and maintaining trees and shrubs.

☹ Agroforestry requires careful planning and management to balance the needs of trees, crops, and livestock, and to avoid competition for resources.

☹ Effective implementation requires specialized knowledge in both agriculture and forestry, which may not be readily available to all farmers.

☹ The benefits of agroforestry, such as improved soil health and timber production, often take years to manifest, requiring patience and long-term commitment from farmers.

COSTS CONSIDERATIONS

The costs of agroforestry vary depending on several factors, including the project's scale, the specific practices employed, the types of trees and plants chosen, and the geographical location. Key elements to consider include:

Implementation costs	Manutention costs
- Tools and equipment for planting - Land preparation or soil tests to determine nutrient needs - Seedlings or saplings varies by species - Labor for planting - Infrastructures, such as irrigation systems or the creation of new pathways - Permitting and legal fees	- Maintaining soil fertility through the application of fertilizers - Pest and disease management - Watering and irrigation

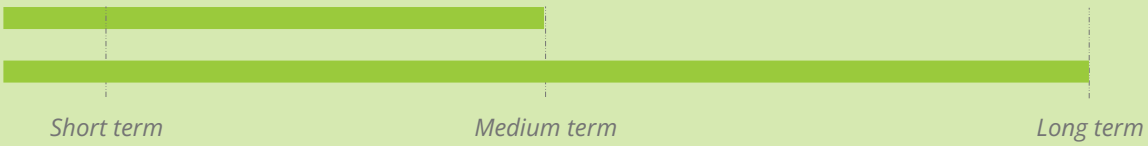
Basins and ponds

DESCRIPTION

Bioretention areas are highly versatile and can be customized to suit a wide range of urban environments. They come in various forms and shapes, each serving different functions and adapting to specific contexts. Examples include bioretention basins, vegetated swales, rain gardens, and retention and detention ponds. These systems can be designed either as dry or wet retention areas, depending on the volume of stormwater they need to manage. When systematically planned and implemented, bioretention systems enhance urban green infrastructure, promote biodiversity, and provide aesthetic, recreational, educational, and quality-of-life benefits to residents.

TYPE

TIME



ECOSYSTEM SERVICES

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- Tourism

SUCCESS AND LIMIT FACTORS

☺ They serve as reservoirs for storing water that can be reused during dry periods, promoting sustainable water management practices and reducing reliance on freshwater sources .

☺ These ponds enhance biodiversity by providing habitats for aquatic and terrestrial species, contributing to ecosystem health and supporting wildlife in various environments.

☺ Retention ponds enhance the aesthetic appeal of public spaces and residential areas, serving as scenic features that improve the overall quality of the environment.

☹ Regular maintenance is necessary to ensure proper functioning of retention ponds, including sediment removal, vegetation management, and infrastructure upkeep, which can be resource intensive.

☹ Initial construction and ongoing maintenance costs can be significant, depending on the size, location, and specific design requirements of the retention pond.

☹ If not properly designed and managed, retention ponds may accumulate pollutants and nutrients, potentially affecting water quality and requiring additional management measures.

COSTS CONSIDERATIONS

The initial implementation costs of basins and ponds as Nature-Based Solutions (NBS) for flood mitigation can vary significantly depending on the scale, location, design, and specific requirements of the project. Below is an analysis of the main cost components involved in the construction of basins and ponds:

Implementation costs	Manutention costs
- Site assessment and planning, including feasibility studies and environmental impact assessments - Permitting and legal fees - Land preparation and clearing - Construction costs as excavation and earthworks - Planting aquatic and riparian vegetation	- Regular monitoring of water quality - Managing vegetation, including mowing, pruning, and controlling invasive species - Sediment removal

Beach nourishment

DESCRIPTION

Beach nourishment or replenishment is the artificial placement of sand on an eroded shore to maintain the amount of sand present in the foundation of the coast, and thereby to compensate for natural erosion and to a greater or lesser extent protect the area against storm surge. Nourishment may also use gravel and small pebbles, applied to the shoreface. The process involves dredging material (sand, gravel, small pebbles) from a source area (offshore, near-land or inland) to feed the beach where erosion is occurring.

TYPE


Inland


Transitional area


Coast

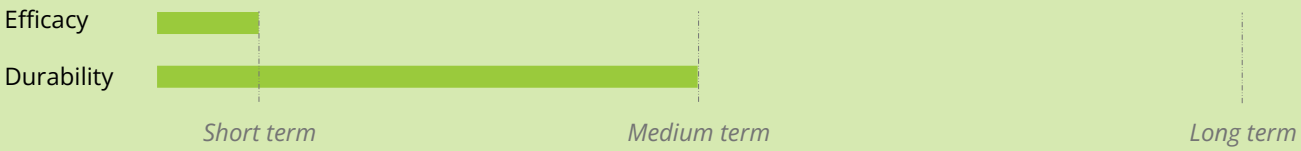

Punctual


Large scale


Supporting


Creating

TIME



ECOSYSTEM SERVICES

- Nutrition
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- **Landscape experience**
- Tourism

SUCCESS AND LIMIT FACTORS

☺ It is a flexible and fast coastal management option, and it is adaptable to changing conditions. If conditions change in a negative way, additional nourishment can be added.

☺ Can use material extracted for another purpose from other lands, allowing it to be productively reused. However, sediment typology and quality need to be properly assessed to avoid any contamination of the destination site.

☺ Beach nourishment has been applied around the world for many years and consequently a broad experience can support its correct design and implementation.

☹ It can potentially negatively affect foreshore ecosystem with the loss of habitats in nearshore sandbars, or the disruption of bird and other animal nesting on the beach.

☹ It is usually a repeated process, which leads to higher costs over time and repeated disturbance of the ecosystem.

☹ It does not end erosion; it only provides additional sediments on which erosion's process will continue.

COSTS CONSIDERATIONS

The costs of beach nourishment projects can vary significantly based on the project's scope, the volume of sediment required, and logistical considerations. These figures highlight the substantial investment required but also underscore the potential benefits of beach nourishment in terms of coastal protection, habitat restoration, and recreational value:

Implementation costs	Manutention costs
- Site assessment and planning, including feasibility studies and environmental impact assessments - Permitting and regulatory compliance - The cost of acquiring suitable sediments the major expense - Transportation and placement of the sediment - Mobilization and demobilization of the equipment and infrastructures needed	- Regular surveys, monitoring and inspections - Remote sensing technologies, such as drones or satellite imagery (not always) - Compiling, analysing, and reporting the collected data is an ongoing requirement

beach nourishment for tourism and coastal defence.

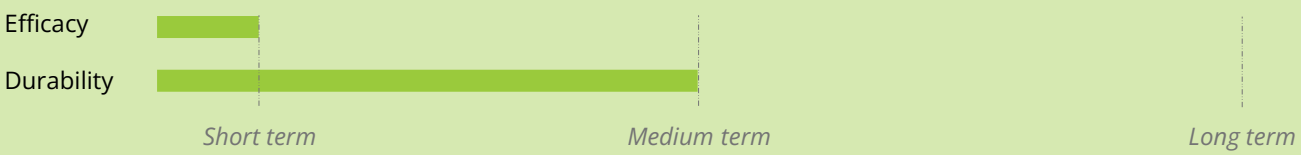
Dune reinforcement and strengthening

DESCRIPTION

Dune reinforcement and strengthening for flooding involve enhancing coastal dunes to act as natural barriers against storm surges and high tides. Techniques include planting vegetation to stabilize sand, installing sand fences to reduce wind erosion, and adding sand to increase dune size. These measures effectively absorb wave energy, reduce coastal erosion, and protect inland areas from flooding. Engaging local communities in these efforts ensures long-term maintenance and increases resilience to climate change impacts.

TYPE

TIME



ECOSYSTEM SERVICES

- Nutrition
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- Tourism

SUCCESS AND LIMIT FACTORS

- Is often more cost-effective and requires lower long-term maintenance costs.
- Well-maintained dunes contribute to better beach conditions, enhancing recreational opportunities for residents and tourists.
- Reinforced dunes maintain the natural landscape, preserving the scenic beauty and ecological integrity of coastal areas, which is beneficial for tourism and local economies.
- Dune projects often align with environmental regulations and coastal management policies, making them easier to implement and maintain.
- Natural dunes grow and evolve over time, offering a sustainable and dynamic solution that adapts to changing environmental conditions.

- Coastal development projects can conflict with dune reinforcement efforts, limiting available land and resources for natural solutions.
- The long-term effectiveness of dune reinforcement in certain areas can be uncertain due to factors like sea-level rise and changing weather patterns.
- While cost-effective in the long term, the initial investment for dune reinforcement, including feasibility studies, design, and implementation, can be significant.

COSTS CONSIDERATIONS

These costs can vary based on the size and location of the dune system, the specific techniques used, and local economic conditions. In addition, continuous maintenance is necessary to ensure the long-term stability and effectiveness of dunes:

Implementation costs	Manutention costs
- Site assessment and planning, including ecological surveys, hydrological studies, and project design - Permitting and regulatory compliance - The cost of materials, such as sand, vegetation, sand fences… - Costs for planting, constructing, and any other manual labour needed - Mobilization and demobilization of the infrastructure needed	- Regular monitoring of dune health and stability - Vegetation management - Fence and pedestrian routes repair and replacement - Adaptive management strategies, which can involve additional costs for implementing new techniques

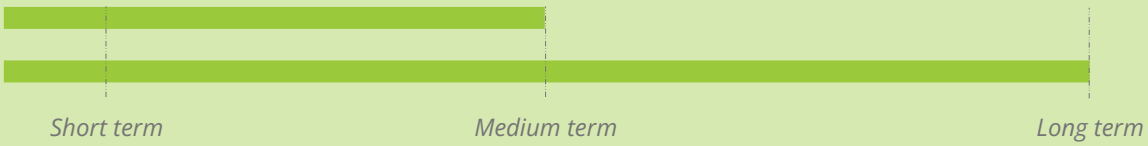
Green corridors

DESCRIPTION

Green corridors are stretches of natural or semi-natural vegetation that connect fragmented habitats across landscapes, facilitating wildlife movement and enhancing biodiversity. These corridors act as pathways for species to migrate, disperse seeds, and find mates, thereby maintaining genetic diversity and ecological resilience. They work by providing safe habitats while offering recreational opportunities for human residents, promoting physical activity and mental well-being. Green corridors contribute to sustainable development goals by enhancing ecosystem services, creating more liveable and resilient cities.

TYPE

TIME



ECOSYSTEM SERVICES

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- Tourism

SUCCESS AND LIMIT FACTORS

☺ Green corridors create interconnected habitats that support wildlife movement, promoting biodiversity and enhancing ecological resilience in various environments.

☺ Green corridors can increase property values and attract businesses, contributing to local economic development and job creation.

☺ Well-designed green corridors attract visitors, boosting local tourism and supporting recreational activities such as hiking, birdwatching, and picnicking.

☺ Green corridors improve pedestrian and cyclist connectivity between neighbourhoods, enhancing accessibility and promoting active transportation.

☹ Maintaining green corridors requires ongoing efforts, including vegetation management, litter control, and infrastructure upkeep.

☹ Regulatory complexities and bureaucratic processes related to land acquisition, zoning, and environmental regulations may delay or complicate green corridor projects, impacting their timely implementation.

COSTS CONSIDERATIONS

Costs of the green corridors' project include the initial investment in restoration or conservation efforts, ongoing expenses for monitoring and maintenance, and long-term economic benefits. Balancing these costs with ecosystem services and community resilience is crucial for sustainable management. Generally, they include:

Implementation costs	Manutention costs
- Site assessment and planning, including feasibility studies and environmental impact assessments - Planting and seedling cost - Hiring labour for planting, site preparation, and maintenance activities is a significant cost component - Mobilization and demobilization of the equipment and infrastructure needed	- Regular monitoring of environmental parameters such as water levels, sediment deposition, vegetation health, and animal biodiversity - Processing and analysing collected data to assess the health and resilience of these ecosystems as flood buffers

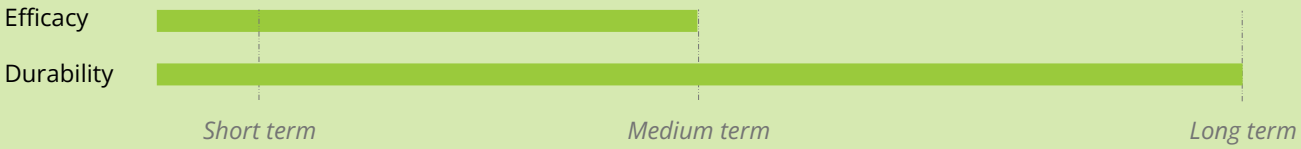
Levees renaturation

DESCRIPTION

By integrating natural features and processes, such as wetlands, riparian vegetation, and aquatic habitats, into levee design and management, this NBS seeks to mimic natural floodplains, protect from flood events, and support biodiversity. This approach not only provides habitat for aquatic species but also enhances water quality, reduces erosion, and increases resilience to flooding by allowing floodwaters to spread out and dissipate energy more naturally. Additionally, restoring aquatic elements within levee systems can contribute to overall ecosystem health and promote sustainable flood risk management practices in urban and rural landscapes alike.

TYPE

TIME



ECOSYSTEM SERVICES

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- Tourism

SUCCESS AND LIMIT FACTORS

☺ Can create visually appealing landscapes and recreational opportunities such as walking trails, birdwatching areas (due to the increase of biodiversity), and green spaces for community enjoyment.

☺ Integrating natural features into levees can enhance nearby property values by creating desirable and attractive living environments.

☺ Enhancing flood management and water quality through renaturation can lead to economic benefits such as reduced insurance premiums, lower flood damage costs, and increased tourism revenue from enhanced natural amenities.

☹ Renaturation efforts must balance ecological goals with engineering standards and safety requirements, which can sometimes be challenging.

☹ Competing land uses and stakeholder interests may pose challenges to implementing renaturation projects, particularly in urban or developed areas.

☹ Obtaining necessary permits and approvals for renaturation activities, particularly in regulated flood zones, can be time-consuming and complex.

☹ Continuous monitoring and adaptive management are essential to ensure the long-term success of renaturation efforts and address unforeseen challenges or impacts.

COSTS CONSIDERATIONS

The costs of re-meandering floodplain for flood mitigation can vary significantly depending on the scale, location, design, and specific requirements of the project. Below is an analysis of the main cost components involved in the construction of basins and ponds:

Implementation costs	Manutention costs
- Site assessment and planning, including ecological surveys, hydrological studies, and project design - The cost of planting native vegetation and creating natural habitats - Engineering tasks like modifying existing levees, creating wetlands, and installing necessary structures	- Vegetation management - Expenses for dredging, sediment removal, and disposal to maintain proper water levels

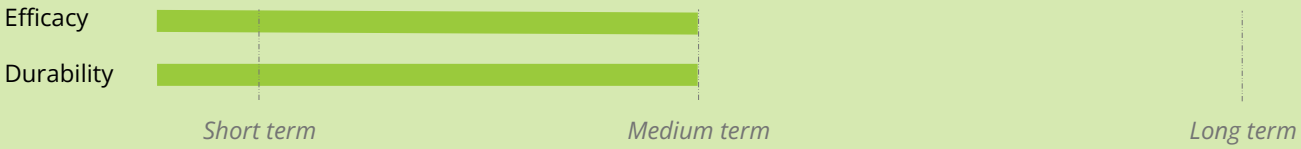
Mangrove forests

DESCRIPTION

Mangrove forests form intricate coastal ecosystems uniquely adapted to brackish water and muddy sediments. These forests densely populate sheltered coastlines, estuaries, and lagoons with their characteristic labyrinthine root systems, creating vital habitats for a wide array of marine and terrestrial species. Beyond their biological diversity, mangroves play pivotal ecological roles by stabilizing shorelines, mitigating coastal erosion, and filtering contaminants from water sources. They serve as indispensable nurseries for fish and other marine life, bolstering local fisheries and enhancing biodiversity within their habitats.

TYPE

TIME



ECOSYSTEM SERVICES

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- Tourism

SUCCESS AND LIMIT FACTORS

☺ Mangrove forests provide, as well as natural, significant economic benefits to local communities through sustainable resource use (such as food or material) and eco-tourism opportunities.

☺ Mangroves support diverse economic activities such as eco-tourism, recreational fishing, and traditional crafts, offering alternative sources of income for local communities.

☹ Coastal areas suitable for mangrove forests are often prime locations for development or agriculture, leading to conflicts over land use and difficulties in securing areas for restoration.

☹ Mangroves are particularly sensitive to pollution from agricultural runoff, industrial waste, and oil spills. Contamination can hinder their growth and diminish their ecological functions.

☹ Establishing and maintaining mangrove forests requires significant financial investment and ongoing resources, which can be a barrier for many communities and organizations.

☹ Mangrove restoration is a complex task and requires detailed planning, including understanding local hydrology, selecting appropriate vegetation species, and ongoing management to ensure success.

COSTS CONSIDERATIONS

Costs of mangrove forests include the initial investment in restoration or conservation efforts, ongoing expenses for monitoring and maintenance, and the long-term economic benefits. Balancing these costs with ecosystem services and community resilience is crucial for sustainable mangrove management. Generally, they include:

Implementation costs	Manutention costs
- Site assessment and planning, including feasibility studies and environmental impact assessments - Hiring labour for planting, site preparation, and maintenance activities is a significant cost component - Planting and seedling cost - Mobilization and demobilization of the equipment and infrastructure needed	- Regular monitoring of environmental parameters such as water levels, sediment deposition, and vegetation health, and biodiversity - Processing and analysing collected data to assess the health and resilience of mangrove ecosystems as flood buffers.

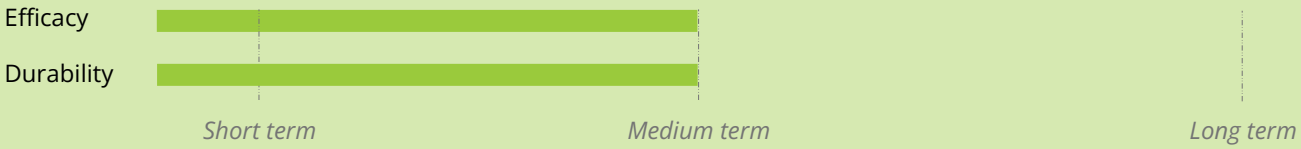
Re-meandering floodplain

DESCRIPTION

Re-meandering a floodplain involves the process of restoring a river or stream to its natural, winding course, which may have been altered through previous straightening or channelization for purposes such as flood control or land development. This ecological restoration technique aims to reestablish the natural dynamics and hydrology of the floodplain, allowing the river to resume a more sinuous path characterized by curves and bends. The approach enhances the river's capacity to slow down water flow, increasing the floodplain's ability to store floodwater and thereby reducing flood risks downstream, and increasing its water purification capability.

TYPE

TIME



ECOSYSTEM SERVICES

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- Tourism

SUCCESS AND LIMIT FACTORS

☺ Re-meandering enhances the connectivity between aquatic and terrestrial habitats, allowing for the movement and migration of species, which is crucial for maintaining healthy populations.

☺ Properties adjacent to restored, aesthetically pleasing floodplains often experience increased real estate values, benefiting local economies.

☺ The restored areas can offer enhanced recreational activities such as fishing, kayaking, hiking, and birdwatching, which can boost local tourism and related businesses.

☺ By reducing the frequency and severity of flooding, re-meandering can lower costs associated with flood damage repairs, emergency response, and insurance premiums.

☹ Re-meandering requires land, which may be in use for agriculture, development, or other purposes. Acquiring and reallocating land can lead to conflicts with landowners and stakeholders.

☹ Designing and implementing re-meandering projects requires specialized knowledge and expertise in hydrology, ecology, and engineering.

☹ It may take years to fully realize the benefits, and the results can sometimes be unpredictable due to natural and climatic changes.

COSTS CONSIDERATIONS

The costs of re-meandering floodplain for flood mitigation can vary significantly depending on the scale, location, design, and specific requirements of the project. Below is an analysis of the main cost components involved in the re-meandering floodplain:

Implementation costs	Manutention costs
- Site assessment and planning, including feasibility studies and environmental impact assessments - Land acquisition and permits - Construction costs, as excavation and earthworks - Planting native vegetation - Water management infrastructure	- Regular monitoring of water quality and biodiversity - Managing vegetation and its growth - Sediment management with periodic removal of its excess

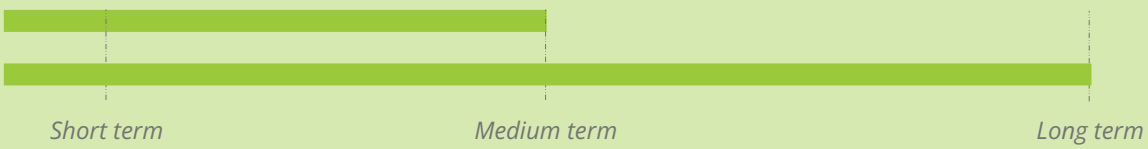
Terraces and slopes

DESCRIPTION

These techniques harness natural processes to mitigate flood risks while providing additional environmental and social benefits. Terracing involves creating stepped levels on a slope, which can effectively slow down and control water runoff. By breaking the length of the slope into a series of flat or gently sloping sections, terraces reduce the velocity of water flowing downhill. This decreased speed allows more water to infiltrate into the soil rather than quickly running off the surface, thus reducing the volume and speed of water reaching the lower areas, which mitigates flood risks. Terraces also help to retain soil and prevent erosion, promoting better soil health.

TYPE

TIME



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SUCCESS AND LIMIT FACTORS

☺ Over time, the economic benefits of enhanced productivity and reduced disaster-related expenses outweigh the initial costs, providing a strong economic incentive for their adoption.

☺ Terracing and slope management create more usable land for agriculture on hilly terrains, leading to higher crop yields and better land utilization.

☺ Enhance agricultural productivity, leading to better food security and higher income for local communities ensure economic stability, improving overall community well-being.

☹ The construction of terraces and swales can be labour-intensive and costly. This initial investment can be a barrier for communities with limited financial resources.

☹ Terraces and slopes require regular maintenance to remain effective. Erosion, vegetation growth, and other environmental factors can necessitate continuous efforts and resources.

☹ Designing and implementing effective terrace and slope management systems require technical knowledge and expertise.

☹ The effectiveness of these techniques can vary depending on the specific topography. What works well in one region may not be as effective in another.

COSTS CONSIDERATIONS

The initial implementation costs of terraces and slopes as NBS for flood mitigation can vary significantly depending on the scale, location, design, and specific requirements of the project. Below is an analysis of the main cost components involved in the creation of terraces and slopes:

Implementation costs	Manutention costs
- Site assessment and planning, including feasibility studies and environmental impact assessments - Land acquisition and permissions - Construction costs, as excavation and earthworks - Cost of materials - Planting native vegetation	- Regular monitoring of water quality and biodiversity - Managing vegetation and its growth - Sediment management with periodic removal its excess

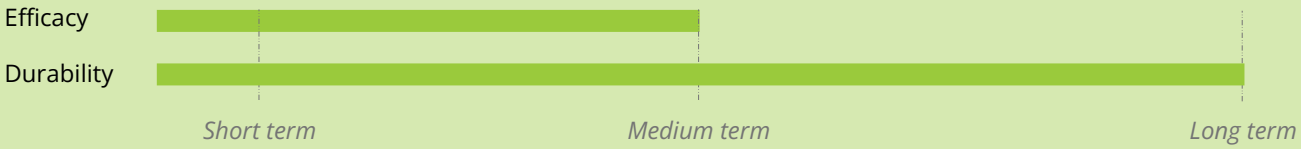
Wetlands

DESCRIPTION

Wetlands act as natural sponges: they absorb large amounts of water during periods of intense rainfall and release it slowly, reducing peak flows that cause flooding. Additionally, wetlands provide crucial habitats for many species of flora and fauna, contributing to biodiversity and ecosystem health. Their creation involves the design and management of retention basins, artificial lakes, and saltmarshes, which not only offer flood protection but also recreational and educational opportunities for local communities. In summary, wetlands represent a natural and multifunctional solution for addressing water risks and promoting a more sustainable environment.

TYPE

TIME



ECOSYSTEM SERVICES

Nutrition

Material

Energy

- Mediation of wastes or toxic substances
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- Landscape experience
- Tourism

SUCCESS AND LIMIT FACTORS

☺ Wetlands provide a solution for climate adaptation and disaster risk reduction in threatened coastal areas, providing ecosystem services (carbon storage, water purification, etc.), while also enhancing biodiversity.

☺ Compared to constructing traditional flood defences such as levees and dams, creating and restoring wetlands can be more cost-effective in the long term, requiring less maintenance and fewer repairs.

☺ Wetlands offer spaces for recreational activities like birdwatching, hiking, and fishing, which can enhance community well-being and provide economic benefits through eco-tourism.

☺ Wetlands can adapt to slow changes in climate conditions, such as increased rainfall or rising sea levels, making them a resilient and sustainable solution for flood management.

☹ The upfront costs of planning, designing, and constructing wetlands can be significant, requiring substantial funding and resources that may be difficult to obtain.

☹ While less costly than traditional infrastructure, wetlands still require periodic management to ensure their functionality, including controlling invasive species and monitoring water quality.

☹ Securing the necessary land for wetland creation or restoration can be challenging, particularly in densely populated, leading to potential conflicts and high costs.

COSTS CONSIDERATIONS

Considerations about the costs of wetlands include initial investment in land acquisition, design, and construction, along with periodic expenses for maintenance, monitoring, and adaptive management. These costs are crucial for ensuring wetlands' effectiveness in flood mitigation, water quality improvement, and biodiversity conservation over the long term:

Implementation costs	Manutention costs
- Costs associated with conducting feasibility studies and environmental assessments - Costs associated with obtaining necessary permits - Expenses for earthworks, excavations, planting native vegetation, and constructing infrastructure	- Vegetation management - Structural maintenance - Wetlands may require periodic adjustments to water levels - Regular dredging or nutrient removal may be necessary to prevent eutrophication and maintain water clarity