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Mitigating urban flood risks through Nature-based Solutions

Urban sustainability cannot be achieved without water resilience. Many cities are looking beyond traditional infrastructure to address the pressures from expanding urban areas and the increased risks associated with a changing climate. **Low-energy, low emissivity solutions such as nature-based solutions (NbS)** have gained in popularity in recent decades with applications in large and smaller cities aiming to adopt a more holistic approach to managing water. Various NbS, as stand-alone measures or in combination with traditional infrastructure, have proven to significantly **reduce flood damage while fostering community resilience**[1]. Studies have shown that several measures are effective at reducing surface runoff, alleviating urban flooding, enhancing ground water recharge and improving water quality[2].

The need to become more resilient to climate change has prompted cities to better understand the relationships between water systems -within their natural boundaries and catchment areas- and other urban systems as well as their related stakeholders. **From comprehensive planning to piloting innovations and engaging communities, resilience principles and NbS are influencing important transformations** in the urban landscape that aim to deliver multi-faceted benefits. We highlight two leading initiatives that use NbS to mitigate urban flooding caused by stormwater, surface run-off and severe rainfall which advance the expertise and understanding of how to integrate NbS in city plans.

The EU defines Nature-based Solutions (NbS) as *"solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such* ***solutions bring more, and more diverse, nature and natural features and processes into cities,*** *landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions".*

EU policies such as the European Green Deal, the **Biodiversity Strategy 2030**, and the **Strategy on Adaptation to Climate Change** promote the application of NbS, while EU funded programmes such as Horizon Europe bolster research, innovation and piloting NbS , with projects such as NetworkNature.

Several EU policies and initiatives as the New European Bauhaus also encourage the voluntary use of NbS: the EU Adaptation Strategy, the **EU Green Infrastructure Strategy** and the EU Urban Agenda.
https://research-and-innovation.ec.europa.eu/research-area/environment/nature-based-solutions

Resilient Houston: An engineering city embracing a holistic approach with a comprehensive plan

The extensive man-made drainage infrastructure, flood control measures and the expansion of freeways have enabled Houstonians to live in a coastal plain environment surrounded by bayous and bolstered Houston's growth from a small port town to a **667-square-mile city of 2.3 million people**[3]. The historic approach to flood control has been to push water downstream through channelized bayous and to build large single-purpose detention basins to store water. Flood events that were believed to have less than 2% chance of occurring have occurred annually in recent years and have drastically changed the city's outlook and priorities.

Houston's response to Hurricane Harvey in 2017 and six flood disasters in five years has been bold, ambitious and comprehensive to address flooding and other threats. With the appointment of a Chief Resilience Officer in 2019 and their **Resilient Houston Plan (with 62 actions across 18 goals)** that connects and integrates the role of all partners and citizens in building resilience, Houston joined the **100 Resilient Cities (100RC) Network.** A Resilience Executive Order further directed all city Department Directors to use the Plan as a tool in the strategic planning and priorization of programs. While the scope of the Plan developed with hundreds of diverse stakeholders exceeds what can be achieved by the city government alone, it is a blueprint for leveraging the necessary partnerships to address a wide range of stressors in order to improve Houstonian's quality of life and protect them from future disasters. **Their holistic approach integrates NbS to address various goals, but specifically as components of an integrated system to reduce flooding**. Here is a brief outline of key components addressing the management of water risks.

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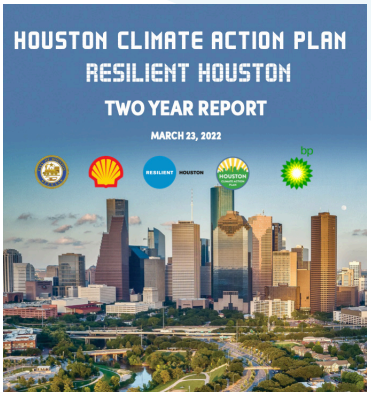
> *"We learned from recent flood events that retention, restoration, and nature-based solutions are of highest priority because not only is flood protection covered, but they also develop multi- benefits with respect to environmental goals, recreation, and biodiversity."*
>
> **Resilient Houston report (Feb 2020)**

1. **Green stormwater infrastructure (GSI)** on private property plays an integral part in the City's complex stormwater system. In 2024, City Council adopted tax abatement guidelines for developers and lowered project threshold for eligible projects to developments worth at least USD735,000 with a minimum of USD35,000 associated green stormwater infrastructure.
2. **Expand the detention capacity of bayou corridors.** Working with partner organizations, the city is looking at possibilities to incorporate large-scale GSI and NBS approaches, such as detention basins with permanent pools of water and wetland vegetation, natural stable channel design, riparian restoration, wetlands, and prairie restoration and preservation to improve the effectiveness of such basins. A combination of these features along expanded bayou corridors will slow down flow and store water to reduce peak flows and flood extents.
3. **Hold water where it falls.** This strategy focuses on the use of innovative on-site water capture such as green roofs, permeable pavement, and rainwater harvesting to mimic the natural flow of water while improving rainwater infiltration and reducing runoff. These retention strategies will provide relief to the overburdened stormwater system and will reduce downstream watershed impacts and costly conveyance requirements.
4. **Natural infiltration and treatment of stormwater**. The city will integrate natural stormwater infiltration and treatment through wetlands and prairies to improve water quality in the bayous and their diverse ecosystems. It will also continue to promote low-impact development and green stormwater infrastructure (GS)I techniques that mimic natural processes to enhance the water treatment across various watersheds.
5. **BAYOU GREENWAYS** 2020 is transforming 150 miles of bayou adjacent trails and 3,000 acres of greenspace through a $220 million public-private partnership. These improvements create parks and greenways that weave throughout Houston's urban fabric to improve equitable access to natural resources.
6. **Research and demonstration projects to improve water management,** including how to use new technology and research to monitor real-time operations, identify choke points, and integrate smart city concepts into water management practices across the city's bayous. The city will partner with local academic institutions and other stakeholders to advance research, piloting and evaluating NbS, specifically tailored to Houston.
7. **Ecosystem toolkit and partnerships for bayou and floodplain restoration.** In collaboration with several local, state, and national partners, as well as environmental non-profits, the city will create a Toolkit of Nature-based approaches for restoring bayou corridors and improving holistic ecosystem health, including flood mitigation projects, such as riparian, urban forest, wetland, and prairie restoration and conservation, and hybrid projects that marry channel stabilization with green techniques to amplify ecological and aesthetic value. The Toolkit will also serve to guide restoration or preservation efforts for sites acquired or managed by various organizations.

So many aspects to this relatively recent strategy should be followed to understand how well NbS measures are being integrated with the existing infrastructure and new developments, their effectiveness and ancillary benefits. The **2022 Two Year Report** identified future reporting specifically on green stormwater infrastructure and urban prairie planting.



The City Blues: finding state-of-the-art solutions for Baltic Sea Region cities

The City Blues project as part of the Interreg Baltic Sea Region programme is a forerunner in developing best practices for planning, design, operation, monitoring and maintenance of green infrastructure in an urban catchment area. There is evidence that the implementation of NbS has increased since the 2000s, particularly in Sweden and Denmark, where

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hybrid solutions like urban wetlands are widely used. Despite this progress, challenges remain in the more widespread adoption of NbS in urban areas, including limited resources, a shortage of expertise, complex institutional arrangements, and difficulties in collaborative governance. To address these challenges, the City Blues project is building on the NbS experience in five cities – Aarhus (Denmark), Malmo (Sweden), Stavanger (Norway), Tampere (Finland) and Tartu (Estonia) – to create a baseline, benchmark practices and develop tools to support a more widespread and systemic adoption of NbS, particularly in urban settings.

The project –running from 2023 to 2026–adopted the objective of developing a joint operational model for planning, design and implementing NbS in the Baltic Sea Region (BSR). Existing practices, regulatory conditions and capacities vary among cities, as the experiences in implementing basin-scale water management and NbS differs significantly. Accordingly, "the expected joint operational model developed in City Blues, will not be a standardized norm, but rather a set of validated best practices developed, tested and transferred across the consortium via mutual learning and experience exchange".

Baseline scenarios considering different possible solutions and outcomes have been developed for the cities' pilot sites and are then subject to discussion with stakeholders. A wealth of information has already been generated by the project and can be accessed at **https://interreg-baltic.eu/project/city-blues/.** Recent milestone reports were published in 2024, summarizing the modelling activities carried out for the pilots to estimate the understanding of the potential impact of the NbS options for managing stormwater and key performance indicators.

Aarhus, Denmark has implemented many significant projects showcasing NbS in the city. One of the landmark projects is Gellerup Park. It has been designed to provide multiple benefits to the community offering a variety of functions – from playgrounds, a football field, and outdoor fitness, to fruit groves and greenhouses. At the same time, the site operates as a stormwater retention basin and treatment system. The city has implemented river restoration projects that serve as examples for river basin management in urban and peri-urban settings, successful deculverting projects, as well as ecological restoration of the river by re-meandering and naturalizing riverbanks[4].

The project has already contributed to a deeper understanding of the potential and limitations of NbS, as well as considerations for their implementation. To break down the barriers between different stakeholders in the seven municipalities participating in the "City Blues" project, it will be necessary to develop more information on life-cycle costs, as well as an easy-to-follow operational model for integrated urban water management planning that considers water-related risks at all stages of urban development.

Other projects to watch and resources

Green Infrastructure Ontario (GIO)

Asset Management Roadmap
The asset management approach to managing ecological systems still faces numerous challenges, especially where the services may not be fully understood, or the nature of the assets may generate unexpected outcomes compared to traditional infrastructure. GIO is currently developing a roadmap for achieving green infrastructure asset management in Ontario, Canada.

https://greeninfrastructureontario.org/asset-management/

From vision to action: A collaborative approach and commitment

Eight cities are taking part in **Commit 2 to Green**, a new EU-funded project that is changing the way cities design, implement and scale-up NbS through participatory greening and renaturing strategies at the community level.

Vejle, Denmark, is transforming a flood-prone former industrial area by integrating blue-green corridors and resilient urban regeneration. It combines climate adaptation with social inclusion, aiming to improve the resilience and quality of life of local communities.

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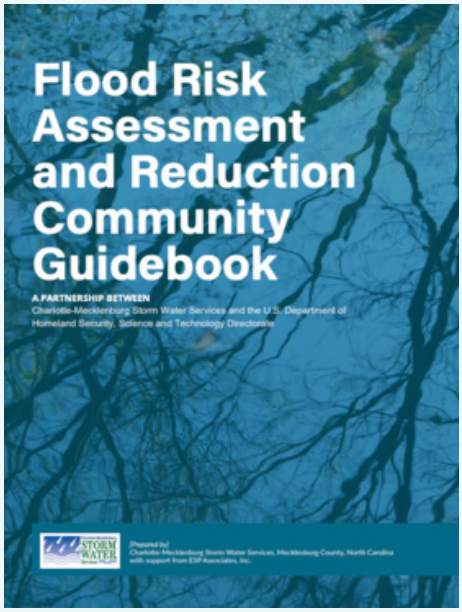

Resources:

https://research-and-innovation.ec.europa.eu/research-area/environment/nature-based-solutions_

Connecting Nature Connecting Nature Resource Centre | Connecting Nature and Connecting Nature Enterprise Platform – https://naturebasedenterprise.com

Network Nature – is a resource for the Nature-based Solutions community
OPPLA - EU Repository of Nature-Based Solutions. https://oppla.eu/
Green infrastructure - European Commission

Sources:

1.Nature-Based Solutions for Flood Mitigation and Coastal Resilience - Analysis of EU-funded Projects. European Commission, Brussels, 2020

2.Anahita Azadgar et al., Optimizing nature-based solutions for urban flood risk mitigation: A multi-objective genetic algorithm approach in Gdańsk, Poland, in Science of The Total Environment, February 2025, Elsevier.

3.Resilient Houston

4.https://interreg-baltic.eu/wp-content/uploads/2024/05/D1.1-Benchmarking-report_final.pdf

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