



RAIN GARDENS

ADDRESSED
HAZARDSPROTECTED CRITICAL
INFRASTRUCTURE

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Some of the rain gardens that can be found in the city of Utrecht, the Netherlands.

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Primary functions and key services

(Bağ, J., & Barjenbruch, 2022; Kasprzyk et al., 2022; Osheen, & Singh 2019)

- **Localised stormwater management and flood control:** surface runoff from nearby impervious surfaces is captured, stored, and infiltrated, thus reducing peak flows in the sewer system, reducing runoff volume from the catchment area, reducing the probability of rainwater/combined sewage system overload, and reducing the risk of flooding. This all allows protecting critical infrastructure such as **conventional sewer and drainage piping systems, housing stock, and local roads**.
- **Improves water quality by filtering out pollutants:** removal of up to 90% of nutrients and chemicals, as well as up to 80% of sediments from stormwater through vegetation and soil before the water reaches groundwater and local waterways. Thanks to these functionalities, **water infrastructure** is prevented from increased sediment pollutant discharge during rainfall events.

Ecosystem services

(Bağ, J., & Barjenbruch 2022; Kasprzyk et al., 2022; Sharma, R., & Malaviya, 2021)

- ▶ **Supporting biodiversity (habitat provision):** by providing shelter and food sources for pollinators, birds, and beneficial insects, enhancing urban ecological networks.
- ▶ **Air quality improvement:** by capturing airborne pollutants and particulate matter, reducing urban air pollution.
- ▶ **Reduce urban heat island effect:** by increasing green cover and facilitating evapotranspiration to cool surrounding areas and moderate local temperatures.
- ▶ **Aesthetic value to urban landscapes:** enhancing visual appeal through diverse plantings and naturalistic design.
- ▶ **Promote formation of nutrient-rich soils:** by accumulating organic matter and stimulating microbial activity to improve soil fertility and plant resilience.
- ▶ **Improves water quality:** filtering runoff by trapping sediments and contaminants before they enter stormwater systems or natural water bodies. (Sharma, R., & Malaviya 2021)
- ▶ **Carbon Sequestration:** plants capture CO₂ and contribute to carbon storage in soil and biomass as they grow and expand

What is it?

Rain gardens are vegetated depression basins designed and strategically implemented close to impervious surfaces (e.g., roads, sidewalks, driveways, etc.) to collect, store, infiltrate, and filter/treat stormwater runoff from these areas. These systems consist of a mixture of native plants that can tolerate moisture regimes, from flooded to dry, and are capable of phytoremediation. To optimise their functionalities, the system must include a porous soil mixture that facilitates drainage and supports plant growth. In a sense, this system serves for the runoff rainwater harvesting, by collection and storage, and potential for reuse, reducing surface runoff and mitigating flood risks. This practice aids in water conservation, provides an alternative water supply, and reduces urban flooding by controlling excessive water flow.

Challenges this NbS addresses

- **Floods** – prevention/reduction.
- **Drought** – prevention/reduction (improves groundwater recharge and increases water availability during dry periods).
- **Erosion** – prevention/reduction; heatwaves – reduction (Provides shade and cooler microclimates, reducing heat stress on infrastructure and surrounding areas).
- **Water resource management** – efficient utilisation of harvested rainwater for non-potable applications.
- **Soil erosion** – reduction.
- **Extreme heat** – reduction.

Site suitability, scale and coverage

Rural, peri-urban or urban regions characterised by minor flooding challenges and suitable for implementation of decentralised NbS systems for water runoff retention/ storage and potential reuse. Its suitability is enhanced by the following reasons:

- **Flexible system:** adaptable design allows customisation to fit various site conditions, sizes, and purposes, including shape, depth, and planting schemes to accommodate different landscapes and needs.
- **Tailored to local characteristics:** the system can be designed and implemented based on local environmental conditions, such as soil type, climate, and hydrology, ensuring effective stormwater management while supporting local biodiversity and meeting community needs.
- **Minimal land take:** requires relatively small areas, allowing them to be integrated into existing landscapes without significant land use changes, especially for urban settings where space is limited.

Environmental impacts (EU taxonomy)

- ✓ Climate change mitigation
 - ✓ Climate change adaptation
 - ✓ Sustainable use and protection of water and marine resources
 - ✓ Transition to a circular economy
 - ✓ Pollution prevention and control
- Protection and restoration of biodiversity and ecosystems.



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▼ Cost-benefit profile

Rain gardens, also known as bioretention cells, are cost-effective green infrastructure solutions for managing stormwater runoff in urban areas. Installation costs vary based on design complexity, site conditions, and scale. For simple residential designs installed by homeowners, costs range from **€29.71 to €39.61 per m²** (EPA, 2015). In contrast, commercial installations by professionals can range from **€99.03 to €396.12 per m²**, reflecting the need for additional features like control structures and piped conveyance systems (EPA, 2015). Maintenance costs are generally moderate, involving routine tasks such as mulching, weeding, and soil testing, with annual maintenance estimated at **€39.61 per m²** (MIT Terrascope, 2024). Over their life cycle, rain gardens can be more economical than traditional stormwater management methods; a study in Cincinnati, Ohio, found that rain gardens cost **42% less** and reduced environmental impacts by **62–98%** compared to conventional infrastructure (Landscape Performance Series, n.d.). These findings highlight the financial viability and environmental benefits of implementing rain gardens in urban settings.

A 2022 evaluation of rain gardens in Thessaloniki (Zeller, 2022) reported construction costs (CAPEX) of € 155,243 (€ 34 per m²) and annual maintenance costs (OPEX) of 7,561 per year. The estimated annual benefits from reduced flooding and wastewater treatment amounted to € 63,242 per year.

Another source (NRC solutions, n.d) reports that annual maintenance (weeding, mulch replacement, sediment removal) ranges from 5–10% of installation costs. Community or volunteer-based maintenance can reduce expenses.

Note: The units in the EPA2015 are given in dollars per square foot. They are converted in Euro per square meter in this factsheet.



Rain garden to recover rainwater from the roof of the adjacent school.

Image Credit: [IRIDRA], [2024], Used with permission

▼ Main components

(Bąk, J., & Barjenbruch, 2022; Kasprzyk et al., 2022)

- **Vegetation:** integrates a variety of native plants that support one to two days of soil moisture.
- **Filtering layers of substrate:** multiple layers of soil and substrate to facilitate rainfall reception, runoff retention, infiltration, drainage, and pollutant removal.

As complementary components in the case of hybrid design with cisterns, rooftop water collection and potential reuse of the stored water:

- **Collection mechanisms:** captured water from rooftops and pavements.
- **Storage components:** water is stored in tanks, reservoirs, or underground cisterns.
- **Filtration and purification:** sedimentation tanks, sand filters, and biofilters to improve water quality.
- **Distribution and utilisation:** irrigation, groundwater recharge.

Example of installation

▶ 1. Newcastle Blue-Green Initiative

▶ **Location:** Newcastle upon Tyne, United Kingdom

▶ **Implemented by:** Newcastle City Council, in collaboration with the Blue-Green Cities Research Consortium (O'Donnell et al., 2017).

▶ **Description and results:** In response to severe flooding in 2012, Newcastle implemented the Blue-Green Initiative to enhance urban flood resilience and sustainability. A key component was the integration of rain gardens, designed to manage stormwater, reduce surface runoff, and improve water quality. These rain gardens also enhance urban biodiversity and aesthetic value. The initiative has successfully reduced flood risk, improved water management, and increased community engagement in sustainable urban planning (O'Donnell et al., 2017).

▶ 2. Veredo (MB) (IRIDRA, 2024)

▶ **Location:** Municipality of Veredo (MB), Region Lombardy, Italy

▶ **Implemented by:** Client was Municipality of Veredo

▶ **Description and results:** Bioretention areas along Kennedy Street and rain garden to recover rainwater from the roof of the adjacent school. The water filtered by the raingarden is collected in a storage tank so that it can be reused both for irrigation and for possible use in the gymnasium (ACS or toilet flushing).

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