URBAN GREEN INFRASTRUCTURE

GREEN ROOFS

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ADDRESSED HAZARDS

PROTECTED CRITICAL INFRASTRUCTURE

Pictures of a Green roof at Grünstattgrau, Vienna;
[Weiss-Tessbach, GRÜNSTATTGRAU], [2014]. Used with permission;

What is it?

Green roofs are vegetated roofing systems that integrate layers of soil, plants, drainage, and often irrigation, to deliver a wide range of environmental and infrastructural benefits (Bianchini & Hewage 2012; Ndayambaje et al., 2024). By capturing and retaining rainwater, they help manage stormwater runoff and mitigate urban flooding (Mentens et al., 2006; Shafique et al., 2018). Their insulating and evaporative properties reduce heat stress and combat the urban heat island effect (Berardi, 2016; Santamouris, 2014). In addition, green roofs support urban biodiversity, improve air quality, and extend the lifespan of the underlying roof structure by protecting it from weather extremes (Bianchini & Hewage, 2012; Ndayambaje et al., 2024). Widely applicable in dense urban settings, they serve as multifunctional solutions that enhance climate resilience, ecological value, and urban livability.

Primary functions and key services

(Bianchini & Hewage, 2012; Santamouris, 2014; Mentes et al., 2006)

- **Rainfall runoff management:** stormwater retention and avoided stormwater in the drainage system: controls runoff, reducing flooding risks (Bianchini & Hewage, 2012).
- **Heat island effect reduction:** providing insulation and evaporative cooling. Green roofs applied on a city scale were found to reduce the ambient air temperature by 0.3–3 °C. (Santamouris, 2014)
- **Energy efficiency improvement:** acts as an insulating layer, reducing heating and cooling energy demands.
- **Air quality improvement:** filters airborne pollutants and enhances urban air quality.
- **Green roof vegetation** also allows evapotranspiration which, can help in reducing the runoff water volume.
- **Infrastructure protected:** green roofs protect **building structures**, **insulation layers**, and **drainage systems** from extreme weather events, while improving energy efficiency and extending roof lifespan.

Challenges this NbS addresses

- **Floods –** reduction,
- **Heatwaves –** reduction,
- **Drought –** reduction,
- **Air pollution -** reduction.

Ecosystem services

(Bianchini & Hewage, 2012; Berardi, 2016; Ndayambaje et al., 2024)

- **Carbon sequestration:** moderate carbon capture in herbaceous vegetation.
- **Water purification:** filtration of pollutants from rainwater runoff.
- **Microclimate regulation:** temperature stabilisation and humidity control (Berardi, 2016).
- **Aesthetic and recreational benefits:** improved visual appeal and access to green spaces.
- **Noise reduction:** absorption of sound waves.

Site suitability, scale and coverage

Green roofs are most suitable in urban and peri-urban areas with flat or low-sloped roofs, particularly where impermeable surfaces dominate and runoff poses risks to drainage infrastructure. Implementation is feasible at building scale but can contribute to neighbourhood or city-wide resilience when installed collectively. Key factors for suitability include building load capacity, roof accessibility, and local climate. They are especially relevant in areas vulnerable to heat stress, heavy rainfall, or air quality issues.

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

Green roofs vary in initial costs depending on their type, scale, and complexity. **Extensive green roofs**, which use shallow substrates and hardy vegetation, typically cost between **€120/ m2 and €150/m²**, while **intensive green roofs**, designed to support a greater diversity of plants and soil depth, can range from **€150/m2 to €500/m2** (Bianchini & Hewage, 2012; Vijayaraghavan, 2016). Maintenance costs are variable but generally fall between **€0.75/m2 and €10/m2** annually, depending on vegetation type and access requirements (Bianchini & Hewage, 2012).

Green roofs typically last **40–55 years**, compared to **20 years** for conventional roofs. With conventional re-roofing costs around **€150/m²**, building owners incur this expense every two decades. The longer lifespan of green roofs reduces the frequency and cost of roof replacement, representing a significant long-term financial benefit. (Bianchini & Hewage, 2012).

Despite higher upfront costs compared to conventional roofing, green roofs offer **long-term economic benefits** through energy savings, extended roof lifespan, reduced stormwater management costs, and lower urban heat island effects. They can retain 50–80% **of runoff water** (the percentage of runoff retention is usually defined as the percentage of the total rainfall control by a green roof following a rain event), significantly easing pressure on urban drainage systems (Shafique et al., 2018). A probabilistic lifecycle assessment by Bianchini and Hewage (2012) found that green roofs in Canadian urban areas could yield **positive net present value over a 40-year horizon**, particularly when environmental and social co-benefits are included in the valuation.

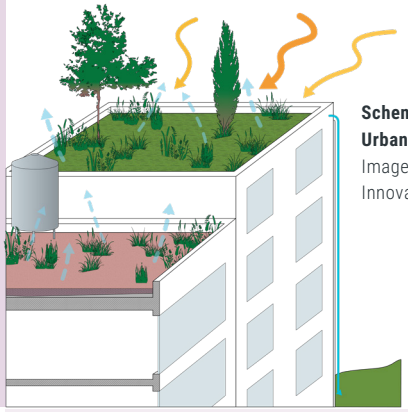
Main components

There are two main types of green roofs:

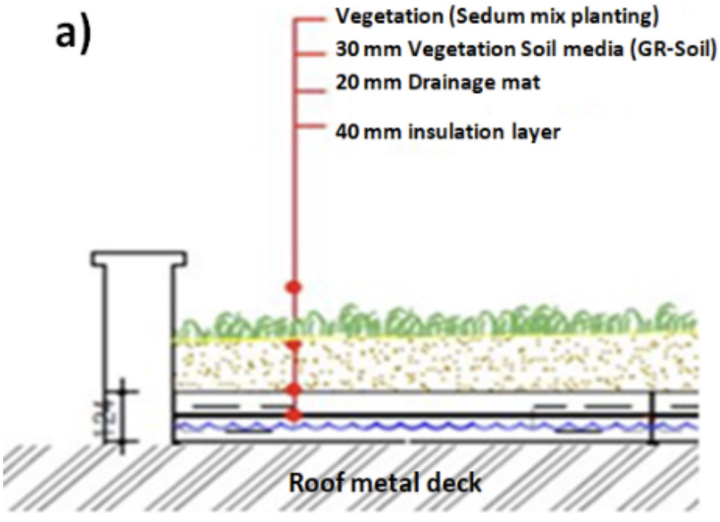
- **Extensive roofs** which are light and are covered by a thin layer of vegetation (substrate depth <150 mm).
- **Intensive roofs** which are heavier and can support small trees and shrubs (Santamouris, 2014).

Typically, a green roof consists of three layers: vegetation, substrate and drain (Shafique et al., 20118).

- **Vegetation layer:** plants, e.g. grasses, sedums, or shrubs.
- **Growing medium:** supports plant growth and retains water.
- **Drainage layer:** prevents waterlogging.
- **Waterproof membrane:** shields structure from moisture.
- **Root barrier:** blocks roots from damaging structures.



Schematic of Green Roof, NbS Typology for Urban Green Infrastructure
Image Credit: [Alchemia-Nova Research and Innovation], [2025].



Schematic (a) and picture (b) of an extensive green roof, in Seoul
Image Credit: [Shafique et al.], [2018], Creative Commons Attribution License

GREEN ROOFS

Example of installation

1. Favoritenstraße 50 (GRÜNSTATTGRAU, n.d.)

Implemented by: GRÜNSTATTGRAU in collaboration with Steinbauer Development

Location: Vienna, Austria

Description and results:
As part of a roof renovation in the 1990s, the pitched roof of a historic Gründerzeit building in Vienna's 4th district was successfully transformed into an intensively greened rooftop landscape. The design applied the damming method and followed substrate standards (ÖNORM L1131), using soil depths of 30 to 100 cm to support a structurally diverse planting scheme. The green roof hosts over 80 plant species, including perennials, shrubs, trees, and bulbous plants, providing a long-standing habitat for urban biodiversity. Research by the University of Natural Resources and Life Sciences (BOKU) has recorded the presence of more than 30 wild bee species. A small pond provides cooling during summer months and serves as a watering place for birds. With Wi-Fi access and flexible shading, the roof continues to function as a green leisure and work space in the heart of the city. (GRÜNSTATTGRAU, n.d.)

The green roof consists of two components:

- **Intensive green roof** (built in 1998): Includes lawn areas, flowering plants, shrubs, trees, a biotope, and an automatic irrigation system. It requires regular maintenance.
- **Extensive green roof** (built in 1989): Planted with drought-tolerant Sedum species, it operates without irrigation and requires only annual maintenance. (GRÜNSTATTGRAU, n.d.)

This long-standing project demonstrates how green roofs can be successfully retrofitted onto existing buildings, delivering sustained benefits in microclimate regulation, stormwater management, biodiversity, and urban quality of life.

Green Roof (Example of installation 1) Favoritenstraße 50, Vienna.
Image Credit: [Weiss-Tessbach, GRÜNSTATTGRAU], [2014]. Used with permission;

Green roof with green pergola over it
Image Credit: [IRIDRA], [2022], Used with permission

2. Green roofs Ex Caserma, Costa San Giorgio (IRIDRA, 2024)

Implemented by: Client was Ponte Vecchio Srl

Location: Vienna, Austria

Description and results:
Intensive green roof with terrace. Pergola for rooftop shading. Cost of the project was €200,000. Year of definitive design: 2022.

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