LIFE IN
Runoff
URBAN RAIN IS A HIDDEN TREASURE

PROJECT ACTIVITIES AND PROJECT RESULTS 2021–2026

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URBAN RAIN IS WORTH ITS WEIGHT IN GOLD

"Rainwater is constantly changing its shape; if you try to catch it, it has already slipped away. Its incredible force can break through dams and sweep away houses, yet it may also patiently carve dripstones underground for millions of years, flood the burrows of groundhogs, drive earthworms from the soil and snails from the grass, or simply drizzle gently onto our faces, scattering stray drops across our windshields. We wipe them away and move on."

(János Lackfi)

URBAN RAIN IS WORTH ITS WEIGHT IN GOLD

The climate is changing, and so is the weather. Budapest is increasingly facing meteorological extremes that were once considered rare: sudden downpours, flash floods, and increasingly long periods of drought. Although the total annual amount of precipitation has not decreased dramatically, the distribution of rainfall has fundamentally changed: large quantities now fall within short periods and at high intensity, while the number of rain-free days continues to increase.

The densely built urban environment, with its asphalt, concrete and other sealed surfaces, prevents water from infiltrating into the soil, while drainage systems become overloaded. The consequences are unpleasant: flooded streets, water entering basements, traffic disruption and significant financial damage—while only a few days later the city's green spaces may already be suffering from water shortages.

For many decades, the guiding principle of urban water management was that stormwater should disappear as quickly as possible. Under the new conditions created by climate change, however, this approach is becoming increasingly ineffective: it does not significantly reduce flood risk, while further worsening urban drought and the urban heat island effect.

LIFE in Runoff project represents a new approach: it views rainwater not as a problem but as a valuable resource. The objective is not merely drainage, but rather the local retention, slowing, infiltration and beneficial use of rainwater.

To achieve this goal, the project examined and tested in real-life environments the coordinated application of green infrastructure (such as rain gardens, green roofs and tree planting), blue infrastructure (water bodies, retention facilities and infiltration systems) and traditional grey infrastructure (drainage networks, technical systems and permeable pavements).

Through demonstration projects implemented in several districts of Budapest, Urban Rain demonstrates that integrated, nature-based solutions can simultaneously reduce flooding, improve the urban microclimate, increase the resilience of green spaces and prepare the city for the impacts of climate change.

Project Facts

Project **LIFE in Runoff**
Location **Budapest, Magyarország**
Budget **EUR 3,053,810 (EU contribution: 55%)**
Duration **1 July 2021 – 30 June 2025**

OBJECTIVES

The overall objective of the project is to make Budapest more resilient to the impacts of climate change by demonstrating and practically testing an urban stormwater management approach that coordinates green, blue and grey infrastructure and treats rainfall not as a problem but as a valuable natural resource.

The project focused on the following themes:

Local utilisation of stormwater

Our demonstration sites show how rainwater can be used locally. A good example is the rainwater collected from the roof of the Klauzál Square Market Hall into an underground cistern, which is then used by District VII for irrigation purposes.

Reducing the risk of urban flooding and flash floods

To prevent flooding caused by sudden heavy rainfalls, the project tested solutions that slow down runoff, temporarily store water and gradually release it back into the environment. One example is Kolbányi Street in District XVIII, where rain gardens and underground infiltration systems were installed.

Integrating green-blue-grey infrastructure

The project demonstrated that nature-based solutions such as rain gardens, green roofs and permeable pavements can work together effectively with conventional technical systems such as drainage networks, cisterns and infiltration facilities to address the challenges posed by climate change.

Improving the urban microclimate

By retaining rainwater locally, evaporation and vegetation water supply can be increased, helping to cool the environment, reduce the urban heat island effect and create more liveable public spaces. A good example is the complex rain garden system created along Pagony Street in District XII.

Public participation

In addition to technical solutions, the project raised awareness through consultations, public forums and dozens of articles, emphasising that stormwater management is not solely the responsibility of municipalities. It requires cooperation among all actors in the city, including residents, institutions and businesses.

STARTING POINT–
TRADITIONAL URBAN STORMWATER MANAGEMENT METHODS ARE NO LONGER SUFFICIENTLY EFFECTIVE

For a long time, stormwater management in modern cities was based on a simple principle: rainwater should be removed from streets and buildings as quickly as possible. The purpose of drainage systems was to transport rainfall into receiving water bodies within a short period of time, thereby protecting cities from flooding.

As long as cities contained fewer sealed surfaces and more natural areas, and rainfall occurred in a relatively even distribution rather than in sudden, intense downpours, this approach worked well. However, conditions have changed.

Too many impermeable surfaces

Over recent decades, the built-up area of Budapest has continuously expanded, while the proportion of natural surfaces has decreased. As a result, less rainwater can infiltrate into the soil, and a much larger proportion enters the drainage network.

Heavy rainfall overloads drainage systems

The capacity of drainage networks is often insufficient to accommodate the enormous volumes of water arriving within a short period of time. When this occurs, the system fills up and flooding results.

Extreme weather events are becoming more frequent

In recent years, climate change has increased the frequency of sudden extreme rainfall events, flash floods, hailstorms and severe local windstorms in Hungary. Intense rainfall events cause considerable damage to urban infrastructure.

In summary, traditional systems based primarily on drainage can no longer adequately address the extreme precipitation conditions caused by climate change. This is why a new urban approach based on water retention has become necessary.

SOLUTIONS APPLIED IN THE PROJECT

Rain Gardens

A rain garden is a shallow landscaped area planted with vegetation that can collect and absorb stormwater. Instead of immediately running off asphalt or concrete surfaces, water infiltrates gradually into the soil. This reduces pressure on drainage systems and lowers flood risk. Rain gardens also enable local reuse of rainfall by replenishing groundwater resources and supporting vegetation.

Cisterns and Rainwater Harvesting Systems

The use of cisterns and rainwater collection systems is particularly important in urban environments where extensive paved surfaces limit natural infiltration. Rainwater collected from roofs can be stored and later used for irrigation, cleaning or even toilet flushing.

Permeable Pavements

Permeable pavements, such as grass-gravel parking areas, green roofs or special porous surfaces, allow rainfall to infiltrate naturally into the ground. These solutions help recharge local water resources while reducing the burden on drainage systems. Slower runoff reduces flood risk and can also decrease water pollution.

Green Roofs

A green roof is a roof surface covered with vegetation. Beneath the vegetation is a layered system that provides suitable growing conditions while also retaining water. In addition to their aesthetic and environmental benefits, such as cooling buildings, green roofs play a key role in stormwater management. In some districts, including District XII, green roofs are now mandatory for new flat-roof developments.

PLANNING AND PILOT INTERVENTIONS

The objective of the project was not merely to demonstrate individual technical solutions, but to investigate how these interventions perform in densely built urban environments.

For each demonstration site, project experts assessed local technical and environmental conditions, including topography, soil characteristics, utility networks and the proportion of surrounding impermeable surfaces.

Based on these analyses, they selected the most suitable combination of rain gardens, cisterns, infiltration facilities, green roofs and permeable pavements.

BUDAPEST DISTRICT XII

Implemented measures

- Rain garden – Pagony Street
- Cistern – Diana Street / Gyöngyvirág Road junction
- Cistern – Öröm Street
- Green roofs – Krisztinaváros Nursery and Svábhegy Nursery
- Residential rainwater harvesting support programme

BUDAPEST DISTRICT XVIII

Implemented measures

- Rain gardens and infiltration blocks – Kolbányi Géza Street
- Permeable pavement electric vehicle parking area – Riesz Frigyes Street
- Residential rainwater harvesting support programme

BUDAPEST DISTRICT VII

Implemented measures

- Underground cistern – Klauzál Square
- Rainwater harvesting system – Kis Diófa Community Garden
- Rainwater harvesting system – Magonc Kindergarten
- Residential rainwater harvesting support programme

IMPLEMENTATION PROCESS

Each pilot intervention was carried out through several interconnected phases:

1. **Problem identification and data collection**
2. **Technical planning**
3. **Public and institutional engagement**
4. **Construction and testing**
5. **Collection and evaluation of experiences and lessons learned**

RESULTS

The nature-based water retention solutions implemented through the project contributed to reducing stormwater runoff, improving green spaces and increasing the climate resilience of urban areas.

Stormwater retention

Based on monitoring equipment installed within the infiltration systems on Kolbányi Street, approximately 140 m^3 of rainwater was captured and infiltrated between April 2024 and December 2025. This volume of water would otherwise have flowed along streets or entered the drainage network.

In District XII the Pagony Street rain garden can retain approximately 65 m^3 of water. The cistern system at Diana Street and Gyöngyvirág Road can store approximately 30 m^3, the Öröm Street cistern can store approximately 20 m^3 and extensive green roofs installed on buildings can retain an additional 16 m^3 of stormwater.

Reduced flooding

According to resident feedback and observations during rainfall events, the volume of water flowing along streets has decreased. In District XII, interventions not only reduce flooding locally but also decrease flood risk in lower parts of the catchment area by retaining water at higher elevations.

For example, in Öröm Street, flooding of neighbouring properties has been reduced, while the water and mud that previously accumulated at the lower end of the Pagony Street dog park have disappeared, as the rain garden allows the water to infiltrate into the ground.

Improved green spaces and increased biodiversity

In Pagony Street, the size of the green area remained unchanged, but its quality improved significantly. Within the 1,582 m^2 rain garden, approximately 4,000 new plants were introduced, including native perennials and shrubs. Deadwood elements were also incorporated, providing habitat for a wide range of species. The rain garden collects stormwater not only from the green space itself but also from adjacent road surfaces, functioning as a complex nature-based stormwater management system.

As part of the project, 500 m^2 of new green roofs were installed on two nursery school buildings. The modular extensive green roof system consists of 6–7 different sedum species and effectively retains rainwater, improves the local microclimate, and contributes to increasing urban biodiversity.

More Liveable Public Spaces and Positive Public Feedback

The reduction of stormwater runoff and the elimination of large accumulations of standing water have resulted in more liveable public spaces. In Pagony Street, for example, the newly planted vegetation improves the local microclimate, while the renovated dog park has become more orderly and more functional. Water collected in the cisterns can also be used for irrigating vegetation, making green spaces more resilient during dry periods.

Public feedback has so far been largely positive. At the same time, the project has also shown that continued public awareness-raising and education remain important in the fields of water retention and climate adaptation.

Two New Publications about green infrastructure

The Municipality of Budapest publication series about green infrastructures has been expanded with two new volumes about sponge cities and green roofs. The publications were prepared by experts in the field and are intended to support planners and decision-makers while also informing residents and promoting awareness of sustainable urban water management practices.

TOWARDS A BUDAPEST STORMWATER STRATEGY

The Municipality of Budapest aims to integrate stormwater management into the complex system of urban public services. The objective is to ensure the effective provision of water supply, drainage, public transport and other services while making greater use of rainwater for irrigation, urban cooling and improving soil water retention, thereby increasing the city's resilience to a changing climate.

The experiences gained through the LIFE in Runoff project, together with the monitoring data and modelling results, provide a solid foundation for the development of Budapest's future Stormwater Strategy.

The strategy contains technical, institutional and regulatory recommendations relating both to new developments and to the existing urban water management system. One of its main objectives is the coordinated operation of stormwater infrastructure, including drainage channels and ditches, in order to ensure the efficient management of water originating both within Budapest and from surrounding areas flowing through the city.

Businesses, shopping centres, office buildings and private property owners also have a significant impact on stormwater management. Due to extensive paved surfaces and roof areas, a large proportion of rainfall currently enters the drainage network almost immediately. Encouraging property owners and operators to delay runoff and, even more importantly, to make use of rainwater locally is essential for reducing pressure on drainage systems and wastewater treatment plants.

By infiltrating rainwater into the ground and reusing it for irrigation, it is possible not only to support the maintenance of urban green spaces, but also to cool local environments through evaporation during hot summer periods. In addition, these measures contribute to improving the water quality of small watercourses and the Danube by reducing the burden on urban drainage infrastructure.

The strategy proposes the preparation of district-level water management and stormwater action plans similar to the three district action plans developed within the Urban Rain project. It also advocates greater consistency in district-level regulations and promotes catchment-based stormwater management as well as stronger cooperation with municipalities in the wider metropolitan area.

Because rainwater primarily originates on privately owned land and local authorities have only limited opportunities to address the issue on public land alone, awareness-raising plays a particularly important role. The rainwater management solutions tested through the Urban Rain project provide an excellent basis for this process.

PARTICIPATION AND COOPERATION

The successful implementation of urban stormwater management is not possible without broad cooperation. One of the key objectives of the LIFE in Runoff was therefore to connect municipalities, professional organisations and local communities, while also promoting knowledge sharing among settlements across Hungary.

The Role of Municipalities

As part of the project, a series of workshops was organised in 2023 involving all districts of Budapest and structured around the city's stormwater catchment areas. These workshops provided an opportunity for districts to exchange experiences, learn from each other's solutions and jointly explore the future of urban water retention.

Through the LIFE in Runoff, six regional centres and a further eight municipalities were reached, significantly contributing to the dissemination of good practices in urban stormwater management.

Public Engagement

Just as municipal commitment is essential, long-term success in urban water retention cannot be achieved without the support of local communities.

In District XVIII, for example, residents have for several years been able to access rainwater harvesting tanks at reduced cost through a municipal support programme. The project's key messages and results were also presented at various public events, including the "Cyclists' Breakfast" initiative.

LIFE in Runoff also participated in several public programmes, including the green-themed lecture series organised within the UPSURGE project, where participants learned about the relationship between urban green infrastructure and stormwater management. The objective was not only to familiarise residents with rain gardens and other nature-based solutions, but also to encourage their active involvement in maintaining and caring for these interventions.

Public participation was further supported by the fact that all demonstration projects were implemented through consultation processes. Plans were presented to residents, site visits were organised and continuous dialogue was maintained throughout the construction phase.

As one of the project outcomes, a practical toolkit was developed for residents, providing guidance on retaining and making use of rainwater locally.

As a creative communication initiative, the project also linked stormwater management with literature through a short-story competition, which resulted in the publication of the volume Urban Rain, Urban Stories.

Professional cooperation

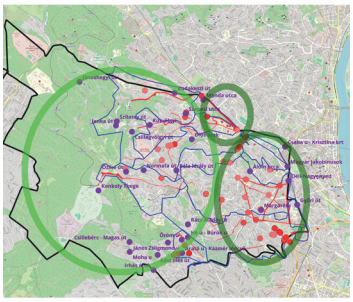
Throughout the project, municipalities worked closely with numerous professional partners. Cooperation included the Budapest University of Technology and Economics, Budapest Sewage Works, HungaroMet, the Hungarian Association of Landscape Contractors and Maintenance Companies, as well as green roof designers, landscape architects and municipal technical departments.

SCIENTIFIC BACKGROUND AND DECISION-SUPPORT TOOLS

The LIFE in Runoff project not only implemented demonstration investments but also developed analyses and tools that will support the climate adaptation efforts of Budapest and other municipalities in the long term.

Climate Models and Rainfall Analysis

Detailed climate models were prepared for Budapest, examining the expected development of heatwaves, extreme rainfall events, tropical nights and drought periods over the coming decades. These analyses were supported by a radar-based rainfall database covering the period from 2004 to 2022 and providing rainfall information for Budapest at fifteen-minute intervals.

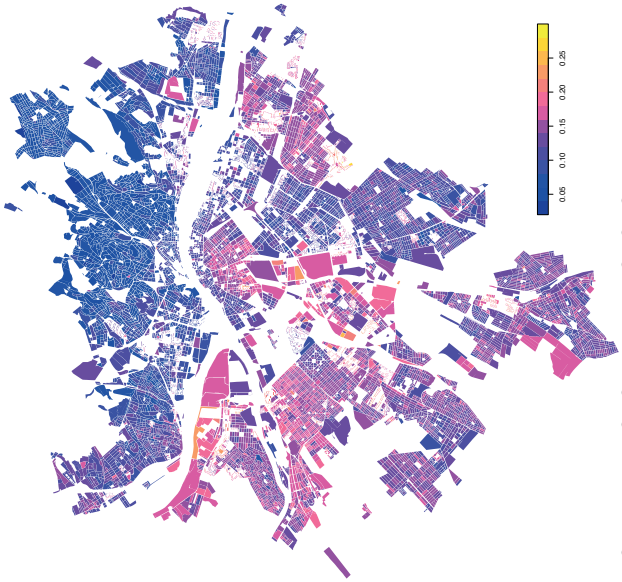


Climate Vulnerability Assessment

A GIS-based climate vulnerability assessment was prepared for the entire territory of Budapest. The assessment identified the districts, buildings, public spaces and green areas most exposed to flash floods, heatwaves and drought conditions. The results support the planning of targeted and cost-effective climate adaptation measures.

During the assessment, we considered the factors that describe:

- extreme weather events, such as the amount of rainfall received within a single day, temperature levels, and similar indicators;
- the sensitivity of those affected by these events; for example, heatwaves pose a greater risk to older age groups, while older buildings are more vulnerable to damage during periods of intense rainfall;
- the adaptive capacity of those affected by extreme weather events; for example, wealthier households are generally better able to protect themselves against extreme heat because they can more easily equip their homes with insulation, cooling systems and other protective measures.



During the project, six different vulnerability assessments were carried out.

Impacts of flash floods:

- urban blocks containing residential buildings
- roads serving motor vehicle traffic
- pedestrian public spaces

Impacts of heatwaves:

- urban blocks containing residential buildings
- pedestrian public spaces

Impacts of drought:

- urban green spaces

The assessment enables the Municipality of Budapest and the district municipalities to identify those parts of the city with the highest vulnerability scores. The underlying data and indicators then help determine the types of interventions that are needed.

For example, if a district's high vulnerability to heatwaves is primarily driven by a large proportion of sealed surfaces, the municipality can examine opportunities for removing pavement and expanding green spaces. At the same time, local residents may undertake similar improvements themselves, for example by greening the courtyards of apartment buildings.

Urban service providers also play an important role in adaptation, for instance by installing shaded bus stops, drinking fountains and misting stations, or by carrying out targeted irrigation of public spaces.

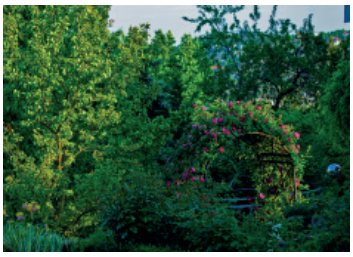
Did you know?

During heatwaves, a south-facing urban block that is completely surrounded by paved surfaces, contains poorly insulated buildings and is inhabited predominantly by elderly residents is far more vulnerable than a suburban-style block with well-insulated buildings, large gardens and a younger population.

Opportunities for Mitigating the Urban Heat Island Effect

As part of the project, sensitivity assessments were carried out to identify the types of interventions that could reduce urban warming. Among other factors, the models examined the effects of increasing green space, using lighter-coloured paving materials and different irrigation practices. The results show that nature-based solutions play an important role not only in retaining rainwater locally, but also in improving the urban microclimate and mitigating the urban heat island effect.

Knowledge Sharing and Replication



Building on the results of the project, toolkits were developed for both residents and municipalities. These provide practical guidance on rainwater retention, rain gardens, green roofs, biodiverse green spaces and other nature-based solutions.

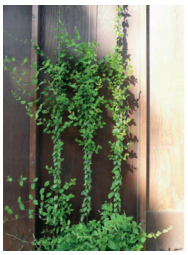
The purpose of the toolkits is to ensure that the experience gained through the Urban Rain project can benefit not only Budapest, but also other municipalities, professionals and residents by providing practical support for climate adaptation. These knowledge resources help ensure that the project's results continue to have an impact beyond the project's completion and become more widely adopted.

TOOLKITS FOR RESIDENTS AND MUNICIPALITIES

One of the project's key outputs is an online, user-friendly toolkit that provides practical guidance on retaining and making use of rainwater locally.

The residents' toolkit demonstrates what can be done around homes, gardens and apartment buildings. It explains how rainwater can be collected and reused, highlights the benefits of rain gardens, garden ponds, infiltration systems and permeable pavements, and shows how biodiverse gardens, tree planting, green roofs and green façades can contribute to creating cooler and more liveable urban environments. The toolkit not only provides ideas but also helps users assess the advantages, limitations and maintenance requirements of different solutions.

The residents' toolkit is available at:
https://zold.hegyvidek.hu/tudastar/lakossagnak/eszkoztar-megfelelo



The toolkit developed for municipalities and professionals presents opportunities for stormwater retention at a broader, settlement-wide scale. Unlike the traditional approach, it treats rainwater not as a problem to be drained away but as a valuable local resource.

The collection brings together both nature-based and technical solutions, including the creation of nature-friendly green spaces, reduced mowing practices, pollinator meadows, tree planting, green roofs and green façades, rainwater storage systems, rain gardens, stormwater retention basins, infiltration systems and permeable pavements.

The purpose of the toolkit is to help decision-makers, planners and urban operators identify solutions that simultaneously reduce flood risk, improve the urban microclimate, support biodiversity and make urban environments more resilient in the long term.

The municipal and professional toolkit is available at:
https://zold.hegyvidek.hu/tudastar/szakembereknek/csapadekvizmegtartasi

LESSONS LEARNED

LIFE in Runoff provided numerous valuable lessons for the participating municipalities in the field of urban stormwater management.

One of the most important outcomes is that stormwater management has gradually become part of the day-to-day operation of local governments. The project contributed to closer cooperation between different municipal departments and public authorities, while also bringing the topic into public communication. Experience shows that residents are becoming increasingly aware of the challenges posed by extreme rainfall events and urban flooding, providing an important foundation for future action. The project also led to the establishment of expert partnerships and the development of concrete action plans that will support future investments and initiatives. Cooperation at the metropolitan level has also strengthened, and the project's results are already being utilised in other initiatives.

At the same time, implementation presented a number of challenges. In densely built urban environments, opportunities for large-scale interventions are limited, while existing infrastructure—such as ageing combined sewer systems—often complicates the application of new solutions. Investments are frequently slowed by complex ownership arrangements, permitting procedures and the need to involve multiple authorities. The project also demonstrated that some measures, such as the green roof grant scheme offered to apartment buildings, attracted less interest than expected, partly because of costs and the technical condition of buildings.

The assessments also highlighted that flooding cannot be effectively addressed at individual locations alone; the entire catchment area must be taken into consideration. In many cases, water retention measures should begin in the upper parts of the catchment. Experience suggests that in densely built urban environments, several smaller, complementary interventions may be more effective than a single large investment.

The project also demonstrated that stormwater management is a long-term process. Planning, data collection and implementation often require several years. Nevertheless, the knowledge, partnerships and methodologies developed through the project provide a solid foundation for future progress.

The participating partners will continue this work through related initiatives, including the Interreg HU-SK #mountgreenfra project and the Horizon CLIMAAX project.

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