Call: HORIZON-CL6-2021-ZEROPOLLUTION-01
Project 101060922

Innovative methodology to prevent and mitigate diffuse pollution from urban water runoff

WATERUN

Deliverable D1.3

WATERUN Policy Brief

Work Package 1

WATERUN Policy Brief

Document type	:	DEC – Websites, patent, filings, videos, etc.
Version	:	1.0
Date of issue	:	31/01/2026
Dissemination level	:	PUBLIC
Lead beneficiary	:	WAREG

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or European Research Executive Agency (REA). Neither the European Union nor the granting authority can be held responsible for them.

Funded by the European Union

Executive Summary

Abstract	Urban Water Runoff has become a major challenge for European cities. Accelerated urbanisation, increasing soil sealing, and climate change–driven rainfall extremes are significantly altering the urban water cycle. Rainwater that once infiltrated into soils is now rapidly conveyed across impervious surfaces, generating higher runoff volumes, increasing flood risks, and transporting diffuse chemical and microbiological pollution into receiving water bodies. These pressures undermine water quality objectives, strain urban drainage infrastructure, and threaten ecosystem health and public safety. Urban Water Runoff Management (UWRM) is therefore no longer a marginal technical concern, but a strategic policy issue at the intersection of climate adaptation, environmental protection, urban planning, and public health. Yet, managing UWR effectively remains inherently complex. Responsibilities are typically fragmented across municipalities, water utilities, environmental authorities, urban planners, road agencies, developers, and private property owners. This fragmentation is compounded by limited data availability, constrained financing mechanisms, and regulatory frameworks that have

historically prioritised wastewater management over stormwater and diffuse pollution.

Against this backdrop, the European Union's evolving legal and policy framework is reshaping expectations for UWRM. The recast Urban Wastewater Treatment Directive (UWWTD), alongside the Water Framework Directive (WFD), the Zero Pollution Action Plan, and the European Water Resilience Strategy, collectively embed urban runoff more firmly within EU water and environmental policy. These instruments emphasise pollution prevention at source, integrated planning at agglomeration level, enhanced monitoring, and the prioritisation of nature-based and blue–green solutions over conventional grey infrastructure. While they create new compliance obligations for Member States and local authorities, they also provide a clear strategic direction and an opportunity to rethink how cities manage stormwater in a more sustainable and resilient way.

This policy brief analyses how these EU drivers are likely to influence urban runoff management practices and investment decisions across Europe. It shows that while grey–blue–green solutions—such as Sustainable Urban Drainage Systems (SuDS), green roofs, bioretention systems, permeable pavements, wetlands, and sponge city approaches—are technically mature and increasingly recognised for their multiple co-benefits, their deployment remains uneven. Key barriers include fragmented governance, limited regulatory recognition of UWR as a distinct pollution source, uncertainty around cost allocation and financing, insufficient technical capacity at local level, and a lack of practical tools to support risk-based decision-making.

The WATERUN project directly addresses these challenges by developing an integrated, risk-based methodology for urban runoff management grounded in Water-Sensitive Urban Design principles. Rather than focusing solely on infrastructure, WATERUN combines advanced monitoring solutions, source identification tools, decentralised planning instruments, and a risk-based

Funded by the European Union

Decision Support System (DSS) to guide the selection and prioritisation of appropriate interventions. A central feature of the approach is the early and continuous involvement of stakeholders through structured co-creation processes, ensuring that technical solutions are aligned with institutional realities and user needs.

The project's case studies in Santiago de Compostela (Spain) and Århus (Denmark) illustrate how these tools can be applied in contrasting urban, climatic, and governance contexts. In Santiago de Compostela, the implementation of SuDS and bioretention systems revealed significant institutional and regulatory barriers, including limited awareness of nature-based solutions, non-mandatory planning frameworks, and capacity constraints in design, permitting, and maintenance. In Århus, where stormwater management is more advanced, challenges related to regulatory rigidity, cost-efficiency requirements, and uncertainty around the classification of blue–green infrastructure still constrained innovation. Across both cases, the WATERUN tools proved valuable in supporting evidence-based planning, improving understanding of pollution pathways, and facilitating dialogue between stakeholders.

Building on these practical insights, the policy brief formulates a set of recommendations aimed at enabling more effective, proportionate, and forward-looking UWRM. First, it calls for stronger policy recognition of urban runoff as a distinct and significant source of pollution, deserving explicit consideration within urban water and environmental planning frameworks. Second, it highlights the need for risk-based and proportionate regulatory approaches that reflect the diffuse and variable nature of stormwater, rather than applying wastewater-derived standards by default. Tools such as the WATERUN DSS can support such approaches by linking monitoring data, modelling, and quantitative risk assessment. Third, the brief stresses the importance of aligning UWRM practices with existing EU water legislation,

	providing clearer guidance on how modelling, scenario analysis, and adaptive monitoring can support compliance with WFD and UWWTD objectives. Fourth, it emphasises the need for flexible data and monitoring requirements that lower entry barriers for municipalities with limited resources, while still enabling informed decision-making. Finally, it underscores the importance of clarifying institutional roles and strengthening cross-sector coordination, particularly at municipal level where responsibilities are often most fragmented. Overall, the findings demonstrate that the main obstacles to scaling up sustainable UWRM are not technological, but institutional, regulatory, and financial. While EU policy increasingly promotes integrated, nature-based approaches, their successful implementation depends on coherent governance frameworks, stable and transparent financing mechanisms, and decision-support tools that translate high-level objectives into operational choices. In conclusion, managing UWR effectively is both a regulatory necessity and a strategic investment in urban resilience, environmental protection, and quality of life. By aligning EU policy frameworks, local governance structures, and innovative tools such as those developed within the WATERUN project, European cities can move beyond reactive, infrastructure-centric approaches and transform urban runoff from a growing liability into a lever for sustainable and climate-resilient urban development.
Keywords	Urban water runoff Urban diffuse water pollution Grey-blue-green infrastructure Sponge city EU stormwater policy

Funded by the European Union

Revision history

Version	Date	Status	Author	Description
0.0	11/12/2025	First draft	WAREG	First draft shared with the AR and QCG
0.1	16/12/2025	Draft reviewed by QCG	AIMEN	Minor comments and suggestions
0.2	09/01/2026	Draft reviewed by WP Leader	SEECON	Minor comments and suggestions
0.3	21/01/2026	Draft reviewed by QCG	AIMEN	Suggestions
0.4	26/01/2026	Final version	WAREG	Final version addressing the comments from the QCG and the WP Leader
1.0	27/02/2026	Final Version including validated recommendations	WAREG	Final version including validated recommendations

TABLE OF CONTENTS

Funded by the European Union

Funded by the European Union

1 INTRODUCTION

Urban Water Runoff (UWR) is an increasingly critical challenge for European cities. As urban areas expand and impermeable surfaces multiply, rainwater that once infiltrated the soil now rapidly flows across streets, roofs, and paved areas, contributing to flooding, water pollution, and long-term degradation of aquatic ecosystems. Managing this runoff effectively is essential not only for climate resilience and environmental protection but also for safeguarding public health and ensuring the sustainability of urban infrastructures.

However, Urban Water Runoff Management (UWRM) is inherently complex. It requires the integration of hydrological modelling, urban planning, infrastructure design, environmental protection, and multi-level governance. Responsibilities are often fragmented across municipalities, utilities, environmental authorities, land developers, and private property owners, making coordination and coherent management difficult. This complexity has become even more pressing as climate change intensifies rainfall extremes and pollution loads across Europe.

Several EU legal and policy instruments now embed specific requirements and expectations for managing urban runoff more sustainably. These frameworks call for integrated planning, pollution prevention at the source, enhanced monitoring, and the prioritization of nature-based and blue–green solutions over traditional grey infrastructure. Together, they will significantly influence how Member States, regulators, cities, and utilities plan and finance stormwater management over the coming decades.

These evolving requirements create both obligations and opportunities. Cities will need to invest in new infrastructure and governance models, but they can also reap long-term benefits through reduced flood risks, improved water quality, enhanced biodiversity, and more livable urban environments. A key lever for this transition is the widespread adoption of grey-blue-green solutions, including green roofs, bioretention systems, permeable pavements, wetlands, and smart stormwater management tools. While these solutions are mature and well-documented, their deployment across Europe often remains limited by financial, regulatory, institutional, and cultural barriers.

The WATERUN project contributes to addressing these challenges by developing innovative tools and methodologies to support the identification of pollution sources, planning of stormwater interventions, and selection of appropriate nature-based measures. Its case studies in Santiago de Compostela and Århus offer practical illustrations of how cities can adopt blue-green infrastructure to improve resilience, reduce diffuse pollution, and meet EU requirements.

This policy brief aims to guide policymakers, regulators, and practitioners through the evolving landscape of urban water runoff management. It explains why UWR matters, clarifies the complexity of managing it, outlines the main EU regulatory drivers, assesses their potential impacts, and provides actionable insights on how to accelerate the shift toward integrated grey-blue-green approaches—supported by evidence and solutions emerging from the WATERUN project.

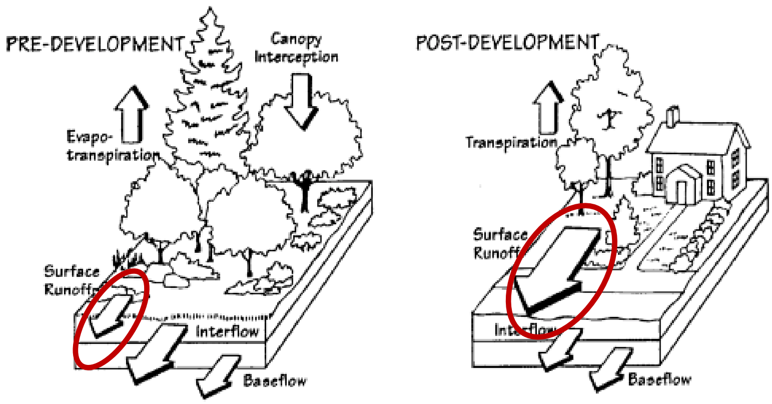
2 URBAN WATER RUNOFF AS A REGULATORY AND ENVIRONMENTAL CHALLENGE

2.1 What is urban water runoff: definition and scope

Definition

UWR refers to precipitation—rain, snow, or meltwater—flowing over urban surfaces such as roofs, pavements, roads, and compacted soils, rather than infiltrating into the ground. According to article 2 of the recast Urban Wastewater Treatment Directive (UWWTD), it is defined as "precipitation in agglomerations collected by combined or separate sewers." This phenomenon is a direct consequence of urbanization, where impervious surfaces prevent natural infiltration, leading to rapid water flow into storm drains and sewer systems, and reduced groundwater recharge (Figure *1*).

Figure 1 Pre and post development surface water runoff



Source: (Maryland Department of the Envionment)

Urban water runoff management steps

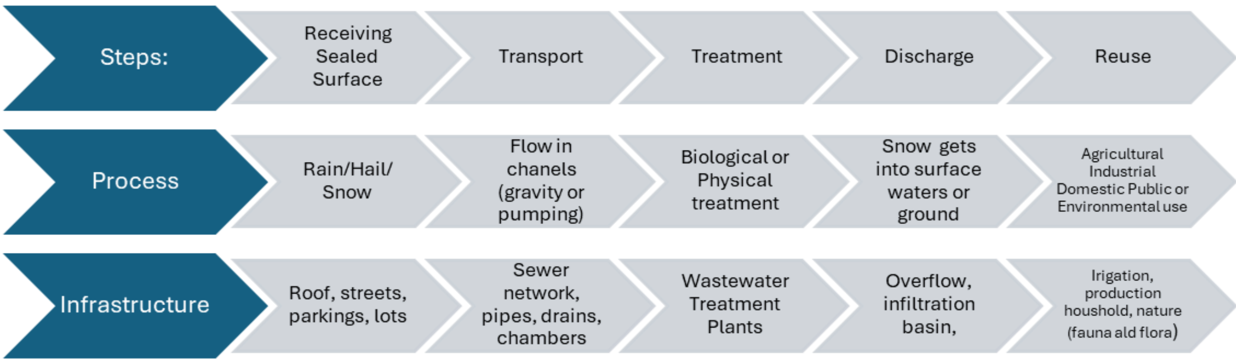
UWRM encompasses five key steps (Figure *2*). It begins with collecting rainfall from impervious surfaces, which are owned by private or public entities. It should be noted that as runoff often crosses multiple properties, determining responsibility for potential damage and pollution can be difficult to distinguish (for example, water may flow from one to other landowners). In this context assigning liability in such cases may be challenging.

The water is then transported through a sewer network, which may also have multiple owners: private companies, housing community, road authorities, municipalities, or wastewater operators. This issue becomes particularly complex in combined sewer systems, where it is difficult to determine which part of infrastructure assigned to collect domestic wastewater and which serves stormwater.

At the next stage, water undergoes pre-treatment or treatment either in facilities dedicated exclusively to stormwater or (in combined systems), at wastewater treatment plants. Stormwater inflows affect capital investment needs (hydraulic and biological capacity of wastewater treatment plant) as well as operational expenditures (e.g., increasing aeration or reagent dosing).

Subsequently, water is discharged into a receiving water body. The managers of these water bodies or surrounding land have limited influence over the treatment process and face challenges in monitoring discharge quantities and quality. When stormwater is intended for reuse, additional stakeholders become involved: industrial users, private consumers, managers of green areas, or operators of urban infrastructure.

Figure 2 The steps, processes and infrastructure of the urban runoff system



Source: (WATERUN Consortium, s.d.)

2.2 Why does urban water runoff matter: environmental, public health and economic relevance of UWR

When urban runoff occurs, it raises two major concerns for local residents and the environment.

Increased risk of flooding

Urban runoff can overwhelm drainage systems, especially during heavy rainfall or rapid snowmelt. If rainwater cannot easily escape down drains or if the volume is too great for the infrastructure to manage, water accumulates on surfaces. This accumulation can lead to localized or widespread flooding, causing damage to buildings, infrastructure, and public spaces. In extreme cases, flooding can result in the loss of homes, personal belongings, and even lives. The course and dynamics of urban floods are strongly influenced by topography, particularly the slope of the terrain, which is a key variable in most mathematical models developed for urban flooding.

Water pollution

In natural environments, rainwater infiltrates the soil, which acts as a filter, removing many pollutants before the water reaches rivers, lakes, or groundwater. However, in urban areas, impervious surfaces prevent this natural filtration. Instead, rainwater flows over these surfaces, collecting a wide range of pollutants—such as organic compounds, solids, nutrients, pathogens, heavy metals, microplastics, and persistent organic pollutants—from buildings, roads, commercial streets, industrial parks, and atmospheric deposition. This contaminated water then enters storm drains and, ultimately, water bodies, leading to urban diffuse water pollution which poses serious environmental issues, despite significant efforts to address it. The magnitude of the problem caused by diffuse pollution is very significant throughout the EU as 38% of European surface waterbodies are affected by diffuse pollution (European Environment Agency, 2020). Urban runoff, alongside agricultural pollution, is a major contributor to these challenges. The European Environment Agency reports that urban development, wastewater discharges, and climate change are putting unprecedented pressure on Europe's water resources, with seasonal variations further complicating the issue.

For instance, wet seasons produce more runoff and pollutants, while dry seasons result in less dilution and higher concentrations of contaminants. Furthermore, the pollutants carried by runoff can have cumulative and far-reaching effects, degrading water quality, harming aquatic ecosystems, and posing risks to human health. For example, nutrients like nitrogen and phosphorus can cause eutrophication, leading to algal blooms that deplete oxygen in water bodies and harm aquatic life. Heavy metals and microplastics can accumulate in the food chain, affecting both wildlife and human populations.

Broader impacts and exacerbating factors

Furthermore, urbanization not only increases the volume of runoff but also alters the hydrological response of urban catchments. The reduction in landscape infiltration capacity means that precipitation is less likely to recharge groundwater and more likely to become surface runoff. This shift is influenced by a variety of factors, including anthropogenic activities (such as construction and industrial processes), geomorphological characteristics (like soil type and topography), and atmospheric conditions (such as rainfall intensity and duration). Climate change exacerbates these issues by altering precipitation patterns, increasing the frequency of extreme rainfall events, and intensifying the flushing and remobilization of contaminated materials into water bodies.

In this context, managing UWR is a critical challenge for modern city planning. The disruption of the natural water cycle by urbanization—characterized by impervious surfaces, rapid runoff, and reduced infiltration—demands innovative and sustainable solutions, and traditional approaches often prove insufficient to address the complex and interconnected issues of flooding, pollution, and ecosystem degradation.

3 UNDERSTANDING THE COMPLEXITY OF URBAN WATER RUNOFF MANAGEMENT

UWRM is a complex topic as it requires understanding and articulating different layers of knowledge such as, for instance, rainfall patterns, city layout, catchment characteristics, to foster sound regulatory decision-making. Furthermore, fragmented institutional responsibilities and multi-level governance is adding complexity to the UWRM.

3.1 Technical, data and modelling challenges for regulatory decision-making

UWR should always be analyzed as a direct side effect of rainfall. Therefore, when developing urban runoff management plans, it is essential to understand the principles and complex issues related to the rainfall-runoff interaction. The rainfall process is inherently unpredictable, which makes its comprehensive description and accurate modelling challenging. The ability to forecast rainfall is limited not only by the intrinsic unpredictability of climate but also by the imperfections of meteorological models. It is important to recognize that the key factors influencing rainfall extend beyond local conditions and are part of the broader hydrological cycle, whose dynamics span far beyond the boundaries of the urban area covered by any specific management plan.

For the design and maintenance of urban drainage systems, it is crucial to determine the so-called design rainfall, defined as “the rainfall amount and its distribution in time and space used to determine a design flood or design peak discharge” (Texas Department for Transportation, s.d.). The value assigned to design rainfall is foundational for all hydraulic calculations and for sizing investments related to stormwater management in cities. This value directly influences both capital expenditures (CAPEX) and operational expenditures (OPEX) associated with stormwater infrastructure. Selecting an appropriate design rainfall requires balancing two critical aspects: safety (where a larger assumed design rainfall improves protection against flooding) and cost-effectiveness (where a smaller assumed design rainfall reduces the required infrastructure and associated costs). This decision is not merely a technical task; it must also reflect the city’s risk management policy, which can vary spatially. For example, municipalities may prioritize higher protection for strategic facilities such as hospitals, schools, and critical infrastructure.

The adoption of a design rainfall intensity can be approached through various methods, but the primary basis remains historical rainfall data for the specific area. However, these data are often burdened with uncertainties due to gaps in long-term records (systematic rainfall measurements have generally only been conducted in recent decades), measurement errors, and the fact that rainfall is typically measured at selected points within the catchment, while its spatial distribution is highly variable, especially in urban environments. In practice, spatial rainfall distribution can differ significantly even within a single city, and the temporal distribution of rainfall intensity is equally crucial, as it determines the load on stormwater drainage systems. Key temporal parameters include the time of concentration—the time required for runoff, after the onset of rainfall, to reach the storm sewer outlet from the most distant point of the catchment—and the duration of rainfall and its peak flow.

Another fundamental factor affecting runoff is the catchment area. While the size of the catchment generally influences runoff volume in a linear manner, the catchment's topography and land cover—particularly the ratio of impervious to pervious surfaces—are also decisive. Soil characteristics, such as structure, permeability, and thickness, are typically incorporated into runoff calculation formulas. Land cover can further influence runoff through its impact on infiltration and the potential delay of surface flow, such as in vegetated areas. It is also essential to consider that land cover may evolve as the city develops. Stormwater management plans should account for both current land cover and anticipated future changes. When creating urban drainage plans, it is necessary to analyze how increases in built-up areas will affect runoff volumes and to define target guidelines for urban planning that limit land sealing.

An important tool for regulating urban runoffs in cities is the establishment of monitoring programs. The choice of measurement methods and locations is critical, given the high variability of inflow characteristics and urban development. Monitoring should encompass physical aspects such as flow, rainfall intensity and duration, as well as water and sediment quality—both physicochemical and biological. Data should be analyzed continuously and integrated into long-term studies to inform adaptive management.

3.2 Fragmented institutional responsibilities and complex multi-level governance

The governance of urban water runoff is often fragmented, with management typically occurring at the local level through municipalities, inter-municipal entities, or metropolitan and water authorities. However, effective management requires a multi-level governance approach, involving coordination between local and national and/or regional stakeholders.

The latter often have responsibilities in terms of strategic policymaking, regulation, monitoring and evaluation standards, while the former are in charge of planning, implementing and operationalizing UWR management.

In Spain, for instance, UWRM responsibilities are shared at local level between municipalities and the Regional Autonomy (when the basin is entirely within the Regional Autonomy). This responsibility can be intertwined with the mandate of wastewater utilities in case of combined sewers. In Denmark, municipalities and utilities are in charge of UWRM, under the regulatory authority of the Danish Environment Protection Agency. In France, municipalities and inter-municipal entities are primarily in charge of UWRM. As in Spain, this responsibility can be intertwined with the mandate of wastewater utilities in case of combined sewers. Furthermore, French Water Agencies provide financial support for UWRM at the river basin scale, while other national institutions provide technical assistance and guidance. In Poland, UWRM falls under the responsibility of municipalities.

Where they exist, water regulators typically do not have a formal mandate to regulate urban water runoff management. This is primarily because UWRM is considered a municipal responsibility rather than a core wastewater utility function, particularly in the case of separate sewer systems. As a result, stormwater management generally lies outside the scope of regulated water and wastewater services, limiting the role of regulators in setting service standards, approving investment plans, or overseeing cost recovery mechanisms related to urban runoff.

Consequently, water regulators do not regulate tariffs or user charges that may be applied by municipalities for urban water runoff management. Even in countries where stormwater fees or runoff-based charges have been introduced, these instruments are usually established at the local level through municipal (intermunicipal) ordinances and remain outside the purview of national or regional economic regulators. This situation leads to heterogeneous practices across municipalities, both in terms of pricing approaches and levels of cost recovery.

In most European countries, urban water runoff is therefore financed through municipal general budgets, funded primarily by local taxes rather than through dedicated tariffs linked to service provision. This financing model often places UWRM in direct competition with other municipal spending priorities and can constrain investment capacity, particularly in smaller or financially stressed municipalities. The absence of ring-fenced funding mechanisms may also reduce transparency regarding the true costs of stormwater management.

Furthermore, even at city level, responsibilities may be further fragmented across various entities such as road authorities, landowners, developers, wastewater utilities, and municipalities. As such, a wide range of stakeholders often have a say in the planning, design, and management of stormwater infrastructure which significantly complicates urban runoff management.

As part of WATERUN project, the complexity of urban runoff management and the important number of stakeholders involved were clearly illustrated as the project identified the most important UWR stakeholders and their responsibilities for the two case studies of Santiago de Compostela and Århus (Table 1). This analysis was carried out during stakeholder workshops.

Table 1 Most important stakeholders and responsibilities for Santiago de Compostela and Århus

Responsibilities	Identified stakeholders	
	Santiago de Compostela	Århus
Policymaking	▪ Municipality at local level ▪ Aguas de Galicia at regional level	▪ Danish EPA ▪ Local government ▪ Utilities
Regulation	▪ Municipality at local level ▪ Aguas de Galicia at regional level	▪ Danish EPA ▪ Local government ▪ Danish Competition and Consumer Authority
Implementation	▪ Aguas de Galicia at regional level ▪ Water utility (VIAQUA) ▪ Santiago de Compostela City Council	▪ Local government ▪ Water utilities
Financing	▪ Municipality and Aguas de Galicia ▪ Water utility (VIAQUA)	▪ National government ▪ Local government ▪ Utilities
Operation & Maintenance	▪ Aguas de Galicia ▪ Water utility (VIAQUA)	▪ Utilities

Monitoring & Evaluation	▪ Municipality and Aguas de Galicia ▪ Water utility (VIAQUA)	▪ Utilities ▪ Danish EPA
Other Stakeholders	▪ Citizens ▪ Industries ▪ NGOs ▪ Irrigation associations ▪ Transport agencies ▪ Association of companies of the industrial park ▪ Fisherman associations ▪ River sport clubs	▪ Citizens ▪ Industries ▪ NGOs

Source: (WATERUN Consortium, s.d.)

4 EU LEGAL AND REGULATORY FRAMEWORK FOR URBAN WATER RUNOFF MANAGEMENT

The European Union (EU) implements a comprehensive climate mitigation and adaptation policy framework. In the context of urban runoff management, this framework encompasses a wide range of regulatory instruments designed to support the development of sustainable and resilient rainwater infrastructure. Given the complexity of EU policy—comprising multiple measures and legal instruments—providing a complete overview of all regulations influencing local policies is challenging. However, four key EU documents were identified as the most relevant and significant legal and policy instruments for UWRM.

4.1 The UWWTD recast: implications for stormwater regulation

The Urban Wastewater Treatment Directive[1] (UWWTD), first adopted in 1991, underwent a significant revision in 2024. While the original directive primarily focused on domestic sewer systems, the revised version explicitly incorporates stormwater management, particularly in combined sewer systems. This update was driven by the recognition that urban runoff contributes substantially to pollution loads, including approximately 19% of the biochemical oxygen demand (BOD) load, 7.2% of nitrogen, 9.5% of phosphorus, 29.7% of E. coli, and 25.7% of micropollutants (European Parliament, 2024). The revised Directive must be transposed into national law by July 2027, a process that will necessarily lead to the modification, alignment, and in some cases strengthening of existing national legal frameworks governing urban water runoff across EU Member States. As a result, current stormwater and urban runoff regulations are expected to evolve significantly in the coming months and years, reflecting a more integrated, harmonised, and pollution-oriented approach to urban water management at the European level.

Clarifying definitions and strategic requirements

[1] The text of the recast Urban Wastewater Directive can be consulted here.

The revised UWWTD provides harmonized definitions to ensure consistency across Member States, many of which previously used varying terminology. Under the directive:

- Urban runoff is defined as "precipitation in agglomerations collected by combined or separate sewers."
- Stormwater overflow refers to the "discharge of untreated urban wastewater into receiving waters from combined sewers caused by precipitation or system failure."

The directive requires agglomerations to adopt a strategic approach to managing and preventing discharges from stormwater overflows and urban runoff. A key milestone is the establishment of integrated urban wastewater management plans for drainage areas in agglomerations of 100,000 population equivalents (p.e.) and above by 31 December 2033. Additionally, Member States must identify agglomerations where stormwater overflows pose risks to the environment or human health, or where they prevent compliance with legal requirements. For these areas, integrated management plans must be developed by 31 December 2039.

Key components of integrated urban wastewater management plans

The integrated urban wastewater management plans are designed to be the primary tool for planning and managing urban runoff. These plans must include measures to:

- Reduce pollution from stormwater overflows.
- Address significant pollution from separately collected urban runoff, such as pollution occurring during the first rains after prolonged dry periods in densely populated areas.
- Prevent pollution at its source, prioritizing nature-based solutions over traditional grey infrastructure.

Specific measures may include:

- Preventive actions to avoid the entry of clean rainwater into sewer systems, such as promoting natural water retention or rainwater harvesting.
- Temporary storage of runoff, including through natural retention methods.
- Treatment of heavily polluted runoff or overflows, particularly during first flush events.

The plans must also incorporate a detailed description of the sewer system, including the characteristics of urban runoff storage, flow-conveyance capacities, and existing wastewater treatment capacities during rainfall events. A dynamic analysis of wastewater flows in combined sewer systems is required, based on hydrological and hydraulic data, water-quality models, and climate projections, including estimated pollutant loads such as microplastics generated during rainfall.

Objectives for stormwater overflow management

The directive sets indicative, non-binding objectives for stormwater overflows:

- Stormwater overflow should represent no more than 2% of the annual collected urban wastewater load (calculated under dry weather conditions) by:
  - 31 December 2039 for agglomerations of 100,000 p.e. and above.
  - 31 December 2045 for agglomerations of 10,000 p.e. and above.
- A progressive reduction of macroplastics in stormwater discharges.

To achieve these objectives, Member States must implement three types of measures:

1. *Preventive measures* - Avoiding the entry of unpolluted rainwater into sewer systems by promoting natural water retention, rainwater harvesting, and increasing green and blue spaces in urban areas to reduce stormwater overflows and limit impermeable surfaces.
2. *Optimization of existing infrastructure* - Enhancing the management of collecting systems, storage volumes, and wastewater treatment plants to minimize the release of untreated urban wastewater or polluted runoff into receiving waters.
3. *Additional mitigation measures* - Adapting infrastructure for the collection, storage, and treatment of urban wastewater, with priority given to green and blue infrastructure such as vegetated ditches, treatment wetlands, and storage ponds designed to support biodiversity.

Monitoring and implementation requirements

According to Article 21, Member States must ensure that competent authorities or operators of sewer systems conduct representative monitoring of stormwater overflows and urban runoff discharges. This monitoring must enable the estimation of pollutant concentrations and loads to inform effective management strategies.

4.2 Water Framework Directive: relevance for diffuse urban pollution

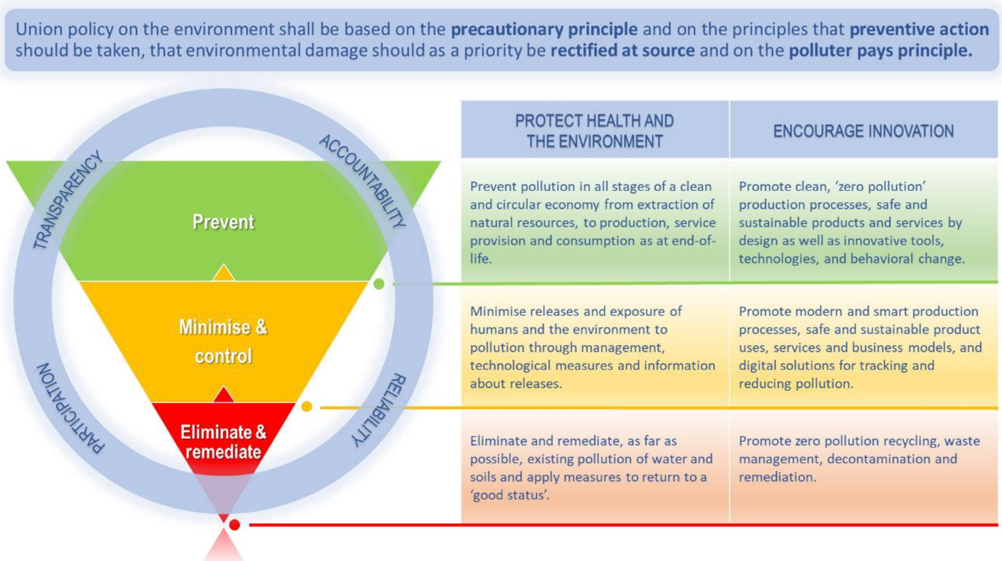
The Water Framework Directive (WFD) plays a pivotal role in safeguarding aquatic ecosystems and ensuring the sustainable management of water resources across the European Union. Some of the WFD environmental objectives are directly linked with urban water runoff management, and they include the prevention of further deterioration of water bodies, the protection and improvement of the status of aquatic ecosystems, the progressive reduction and further prevention of groundwater pollution (European Parliament, 2000). To achieve these objectives, the WFD requires EU Member States to identify and estimate significant diffuse source pollution originating from urban, industrial, agricultural, and other activities. This process includes analyzing land use patterns and identifying key urban, industrial, and agricultural areas that contribute to water contamination. Urban diffuse pollution, in particular, must be addressed to achieve the good ecological status of water bodies. This involves the removal of hazardous and priority substances, as well as pesticides, which can account for up to 30% of water contamination due to urban pesticide use.

4.3 Zero Pollution Action Plan: strategic driver for UWRM

The European Green Deal encompasses the Zero Pollution Action Plan (European Commission, 2021), through which the EU has placed strong emphasis on tackling pollution in air, soil and water. The long-term vision for 2050 aims to bring levels of pollution in these environments down to thresholds that are no longer harmful to human health or natural ecosystems and that remain within limits the planet can sustain, ultimately moving towards a non-toxic environment.

This Action Plan underlines the need for a more effective “zero pollution hierarchy” ensuring that EU environmental policies are based on the precautionary principle and on the principles that preventive action should be favored, that environmental damage should, as a priority, be rectified at source and that the polluter should pay. This logic also applies to urban water runoff. This is particularly evident in the way the European Commission requires Member States to develop integrated wastewater management plans, which explicitly include the management of urban runoff. Within these plans, the Directive introduces a clear hierarchy of measures: first, prevention; then, optimisation of existing systems; and finally, mitigation measures where necessary (Figure *3*).

Figure 3 The Union policy on the environment according to EU Zero Pollution Action Plan



Source: (European Commission, 2021)

4.4 Water Resilience Strategy: fostering sponge cities

The Water Resilience Strategy is a non-legal initiative that underscores the EU's commitment to viewing water as a key asset for sustainable development. The strategy is built around three main objectives:

1. Restoring and protecting the water cycle
2. Building a water-smart economy together with citizens and economic actors
3. Securing clean and affordable water and sanitation for all at all times.

The Strategy emphasizes the need to improve water retention on land, giving priority to using the full potential of ecosystems to store, purify, release, and restore water on land and at sea. It recognizes the need to redress the natural sponge function of landscapes to replenish groundwater reserves and to protect biodiversity. To better coordinate and scale up existing initiatives aimed at increasing water retention on land, “the Commission will develop a “Sponge Facility”, providing a coherent framework for new and existing initiatives to increase water retention on land. […] In urban areas, “sponge cities”, carved with nature-based solutions to absorb and release water in a controlled way, are to be promoted” (European Commission, 2025).

Funded by the European Union

5 Potential impacts of the UWWTD recast and the Water Resilience Strategy on UWRM

The UWWTD recast and the Water Resilience Strategy are introducing significant changes in urban water runoff management which will result in important investment needs and a shift towards "sponge city" design.

5.1 Assessing the economic impacts of the UWWTD recast: implications for UWRM capex, opex and cost allocation

The Commission impact assessment[2] of the UWWTD recast (European Commission, 2022) estimated the implementation costs of two categories of expenses related to urban runoff:

1. The costs of establishing integrated urban water management plans, including monitoring costs.
2. The costs of implementing measures included in these plans, aimed at limiting untreated releases to 1% of the dry-weather load[3].

The timing assumptions used in the impact assessment foresee that:

- By 2025, monitoring is in place;
- By 2030, integrated plans for agglomerations larger than 100.k p.e. are established and areas at risk identified;
- By 2035, integrated plans in place for agglomerations at risk between 10 and 100k p.e. are established;

[2] Impact assessments are a systematic, evidence-based procedure used to evaluate the potential economic, social and environmental effects of a proposed public policy or regulatory initiative before it is adopted, ensuring that decision-makers consider alternatives and trade-offs and that the chosen option will effectively achieve its objectives. In the EU, impact assessments are undertaken by the European Commission for its most important initiatives and those expected to have the most far-reaching impacts across Member States. The results of the impact assessment process are presented in a Commission Staff Working Document—the formal report that accompanies a proposal—subject to quality scrutiny by the independent Regulatory Scrutiny Board and published alongside the Commission's proposal so that the European Parliament, the Council and the public can examine and comment on the analysis.

[3] The impact assessment was conducted in 2022 whereas the final text of the Directive was adopted in a modified version in 2024. This time lag explains why the impact assessment considered the value of 1% whereas the final text of the Directive states the value of 2%.

- By 2040, indicative EU target in force for all agglomerations larger than 10.000 p.e.[4]

The cost of developing integrated urban runoff plans was estimated at €0.09 per year per population equivalent (p.e.), with an additional annual monitoring cost of €0.09 per year per p.e.. The costs of the actual measures were calculated under the assumption that all overflows would be treated in constructed wetlands before discharge. Since the integrated plans are designed to optimize infrastructure and reduce future investment costs, the assessment accounted for potential savings—estimated at an average of 24%—expected from the use of optimized solutions and green infrastructure for urban water planning and management.

The scenario adopted in the Directive impact assessment estimates annual costs for stormwater and urban runoff management at €372.4 M, with additional administrative costs of €57.6 M. Consequently, for all 27 EU Member States, the total annual cost of implementing the Directive in the context of urban runoff was projected at €430 M (Table 2).

Table 2 Cost assessment for UWR measures in the UWWTD recast

€/year	Costs	Administrative costs	Total costs	Monetised benefits	Proportionality (Benefits/Costs)
Storm water and urban runoff	372.472.648	57.600.000	430.072.648	785.687.648	2.11

Source: (European Commission, 2022)

The European Commission's estimates were derived from a macroeconomic analysis of the entire Directive. However, the stormwater management sector is highly fragmented, both in terms of stakeholders and responsibilities, leading to dispersed investments and cost allocation. A significant portion of the costs will be shouldered by private developers constructing new buildings and housing estates, particularly those required to implement on-site stormwater management solutions. Such measures can substantially reduce the burden on public budgets. Municipalities may enforce these installations through spatial planning

[4] The timing used in the impact assessment is not aligned with the timing embedded in the final text of the Directive because the impact assessment was conducted two years before the final text of the Directive was adopted.

policies, thereby alleviating pressure on the stormwater network and reducing the need for infrastructure expenditures.

On the other hand, there are concerns that the Commission's cost estimates may be underestimated. The impact assessment was prepared in 2022, and since then, the final text of the Directive was validated, and high inflation and new challenges have emerged. This assumption is further compounded by the estimation of the funding needs for stormwater asset management in France which shows an important gap (Box 1).

Box 1 Stormwater asset management in France: funding remains far below actual needs

A 2017 report from of the French General Council for the Environment and Sustainable Development (CGEDD; which became the General Inspectorate for the Environment and Sustainable Development in 2022) estimates that the actual costs—operations and investment—associated with stormwater management in France require an annual budget of around €2 billion (± €500 million).

Economic analyses show a steady increase in operating expenditures, rising:

- from €157 million in 2004,
- to an average of €205 million over 2013–2016 (French Office for Biodiversity, 2019).

The French Water Agencies also allocated:

- €15.9 million in 2019,
- €55.5 million in 2020, under the "stormwater management" line of their 11th intervention programmes, and planned to mobilize more than €300 million for 2022–2024 to support source-control stormwater management in mainland France.

France's stormwater network is estimated at 95,225 km (OIEau & Ernst & Young, 2012), a length slightly smaller than the combined sewer network. The reference cost for valuing this asset ranges between €320/mL and €440/mL, based on French rural and urban average cost benchmarks. This places the current replacement value of the network between €30.5 billion and €41.9 billion.

Assuming an asset lifespan of 60–80 years, the annual renewal need required to maintain network value ranges from €381 million to €698 million, or 1.3% to 1.7% of total asset value. Stormwater retention infrastructure is even less well documented. Available data indicate that the number of retention basins increased from 11,747 in 2001 to 15,750 in 2004 in France, but no more recent national figures exist, nor any estimate of total storage capacity (CGEDD, 2017). This lack of updated national data prevents a reliable valuation of this important category of stormwater assets.

Despite their partial nature, available data clearly show that current expenditures—both operational and capital—on stormwater management in France remain far below actual needs. Strengthening asset knowledge, monitoring of expenditures, and establishing a sustainable and well-structured governance and financing system are essential to ensure effective stormwater management in France.

Source: (Salvetti, 2022)

5.2 Fostering integrated and decentralised UWRM approaches through "sponge city" design

The Water Resilience Strategy clearly calls for the promotion and development of "sponge cities", carved with nature-based solutions to absorb and release water in a controlled way. The sponge city concept represents an innovative approach to urban planning, seamlessly integrating urban infrastructure with water-sensitive urban management to enhance the absorption, detention, retention, and utilization of rainwater in urban environments. Originating in China and attributed to landscape architect Kongjian Yu, this model emerged as a response to pressing urban challenges, including water scarcity, urban flooding, the urban heat island effect, and the need for expanded green spaces, parks, wetlands, and water features. As a set of nature-based solutions, sponge city design uses natural landscapes to catch, store, and clean water, focusing on flood prevention and stormwater management through green infrastructure rather than relying solely on traditional drainage systems. By incorporating urban parks, gardens, green spaces, wetlands, nature strips, and permeable paving, the sponge city approach not only improves ecological biodiversity for urban wildlife but also reduces flash floods by serving as reservoirs for capturing, retaining, and absorbing excess stormwater. Additionally, it helps minimize pollution carried by surface runoff, making cities more resilient and sustainable.

The model of sponge city incorporates a diverse array of technological and nature-based solutions, structured around five core components (Tarek, 2025) (Figure 4):

1. Water management and water-sensitive urban design (WSUD)

This component focuses on minimizing the negative environmental impacts of urbanization through effective water management practices. It leverages natural processes such as infiltration, filtration, and biological treatment, promoting the restoration of natural hydrological cycles and improving water retention within urban areas.

2. Green spaces

Green infrastructure lies at the heart of the sponge city model. It encompasses a variety of elements, including green roofs, rain gardens, urban forests, and permeable pavements, among other vegetated solutions. These features are designed to capture and utilize rainwater at its source, reducing surface runoff, supporting biodiversity, and enhancing the overall quality of the urban environment for residents.

3. Permeable surfaces

This component involves the use of infrastructure that allows water to infiltrate through surfaces, replacing traditional impermeable materials commonly found in urban settings. By facilitating water absorption, permeable surfaces help to reduce stormwater runoff and increase groundwater recharge, contributing to more sustainable urban water cycles.

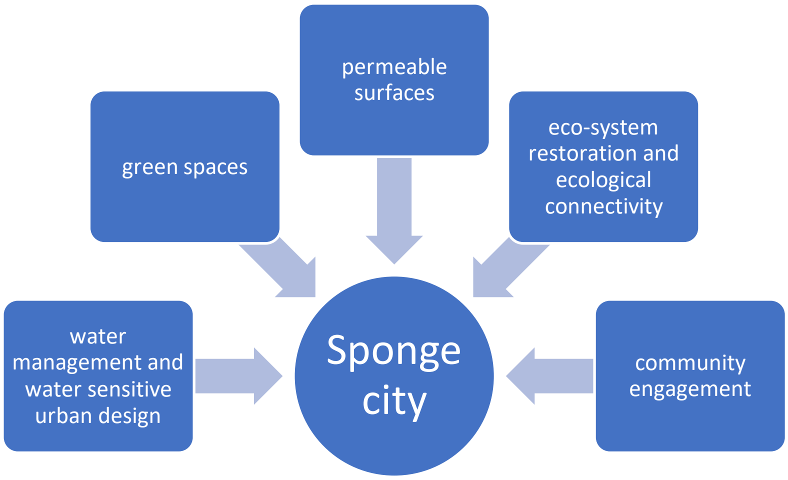
4. Ecosystem restoration and ecological connectivity

This aspect focuses on the renaturation of degraded areas and the improvement of ecological connectivity. It involves increasing the presence of water in the landscape, creating ecological corridors, and restoring the natural functions of ecosystems. These efforts help to revitalize urban ecosystems, fostering greater biodiversity and resilience within the cityscape.

5. Community engagement

A critical component of the sponge city model is the involvement of residents in the planning and management of urban spaces. Raising public awareness about the water cycle and surface runoff is essential for ensuring effective, city-wide water management at the source. Engaging the community fosters a sense of ownership and responsibility, which is vital for the long-term success and sustainability of sponge city initiatives.

Figure 4 Five core components of Sponge City



Source: (Tarek, 2025)

A series of key indicators and parameters are assigned to each of the five core components of the sponge city model (Table 2).

Table 3 Key parameters/indicators describing each component of the Sponge City concept

Components	Parameters and indicators used to describe Sponge City components
Water management and water sensitive urban design	Rainwater harvesting capacity Rainwater harvesting system Retention basin capacity Reduction in urban flooding incidents Reduction in surface runoff Increased infiltration rates Rainwater detention ponds
Green spaces	Coverage of green roofs Coverage of tree canopy Green corridors connecting habitats Number of urban parks

	Native plant proportion Presence of diverse plant species Habitat creation for urban wildlife Increased vegetation cover Recreational opportunities in green spaces Multi-functional public spaces
Permeable surfaces	Percentage of permeable pavements Bioswale effectiveness Rain garden performance Permeable infrastructure
Eco-system restoration and ecological connectivity	Biodiversity indices Length of wildlife corridors Rain garden performance Reduction in urban heat island effect Flood prevention ability Native plant proportion Improved air and water quality Carbon sequestration through vegetation
Community engagement	Community participation rates Public awareness surveys Volunteer engagement

Source: (Tarek, 2025)

The sponge city concept involves the use of a wide range of technical solutions at all stages of urban runoff management. Its implementation is based on the 3R principle: retention, recharge and reuse (Ministry of Foreign Affairs of the Netherlands, 2019). Retention focuses on capturing water at the point of rainfall and reducing surface runoff. For this purpose, storage facilities are created to slow down urban outflow and enable the later use of collected water. Recharge aims to optimize infiltration and groundwater replenishment, improving both the quality and the hydrological conditions of aquifer systems. Reuse allows stormwater to be used for domestic, municipal, industrial, irrigation, and ecological purposes.

Within the 3R framework, a variety of solutions is applied, including (Ministry of Foreign Affairs of the Netherlands, 2019):

- **Surface water storage (off-stream):** valley tanks, water pans and small ponds, green areas supporting infiltration and groundwater recharge
- **Shallow groundwater storage:** sand dams, subsurface dams, road drift systems, Managed Aquifer Recharge: tube recharge wells, riverbank infiltration
- **Runoff reduction measures:** check-dams and gully plugs, swales and bunds, permeable paving
- **Hard surface water storage:** rooftop water harvesting, road water harvesting, underground cisterns and storage tanks

The sponge city model relies on the synergy between these solutions to maximise the effectiveness of retention, infiltration, and reuse. The selection of specific technologies must take local climatic, hydrological, and urban conditions into account to ensure optimal performance. A well-designed combination of technical and nature-based measures ensures effective water management at its source.

6 FROM BARRIERS TO ENABLING FRAMEWORKS FOR GREY–BLUE–GREEN SOLUTIONS

Conventional engineering solutions are focused on implementing grey infrastructure and stormwater basins to improve the retention capacity of the wastewater system. Although this infrastructure can be effective in controlling combined sewerage overflow, they are land intensive and difficult to implement in urban settings. Furthermore, recent research suggests that these strategies are less efficient and more costly than decentralised hybrid strategies combining grey infrastructure and blue-green solutions. Thus, the shift towards a resilient and sustainable water runoff management implies implementing decentralised urban stormwater green infrastructure for retention, infiltration and storage. But to achieve this shift, a certain number of barriers must be overcome.

6.1 Key regulatory, financial and institutional barriers to scaling up UWR solutions

Nature-Based Solutions (NBS), hybrid systems, and sponge city concepts are already well-established and have been implemented for years as key components of urban management strategies. A wide range of technologies is available on the market, enabling ready-to-use deployment and scalability across various projects. However, despite their potential, these solutions remain underutilized. Traditional (grey) stormwater drainage systems continue to dominate urban infrastructure, largely because new systems are rarely built from scratch and must often be integrated with existing infrastructure, creating challenges for the adoption of nature-based and hybrid approaches.

Biasin et al. (Biasin, 2025) analyzed the main barriers to implementing Nature-Based Solutions, drawing on interviews with stakeholders and existing literature. The study identified several key challenges:

- **Financial issues** – funding mechanisms and instruments do not always allow for sufficient revenue collection to ensure adequate funding for UWRM and asset management.
- **Cultural and knowledge gaps** – Investors typically prefer simple, fast project delivery, while nature-based solutions are more complex, require higher financial input, and demand specialized expertise. There remains a lack of awareness and competence in stormwater management among design offices, water utilities, and municipal administrations, especially in smaller municipalities.
- **Social acceptance** – There is limited public demand for these solutions. Residents often view them as unnecessary expenses or aesthetically unappealing. Some oppose water features in urban areas due to concerns about mosquitoes, while investors worry about additional maintenance burdens.
- **Economic sustainability concerns** – Investors and municipalities frequently reject nature-based solutions, arguing they generate extra costs and are more expensive than traditional grey infrastructure. However, at the city-wide scale, these solutions can be significantly more cost-effective, though this advantage is not always apparent in individual projects.

- **Impact assessment challenges** – There is a lack of clear criteria for evaluating the environmental and economic benefits of NBS. No standardized methods exist to assess how a specific solution improves environmental conditions or reduces economic impacts.
- **Legal and institutional hurdles** – Nature-based solutions often require additional approvals and permits from multiple institutions (e.g., environmental agencies), making the permitting process longer and more complex than for grey infrastructure.
- **Contextual constraints** – Numerous factors influence the adoption of NBS, including limited space, poor soil permeability, and the need for a long-term perspective to observe benefits. Benefits are primarily visible at the city scale and over time, making it harder to initiate projects. Additionally, institutional size matters—large organizations have the financial and human resources to implement NBS, while smaller entities face operational constraints.

The example of the Cloudburst Management Plan in Copenhagen illustrates how targeted legal reform, coupled with innovative financing mechanisms and close cooperation between municipalities and utilities, can unlock large-scale investment in integrated, nature-based climate adaptation, and overcome legal and financial barriers (Box 2).

Box 2 Overcoming legal and financial barriers to implement Copenhagen's Cloudburst Management Plan

The design and implementation of Copenhagen's Cloudburst Management Plan (CMP) required overcoming significant legal and financial barriers rooted in Denmark's water governance framework. These barriers reflected a traditional separation between underground wastewater infrastructure and surface-level urban interventions, which proved ill-suited to the integrated, nature-based solutions needed to address extreme rainfall and pluvial flooding.

Before 2013, national legislation strictly limited water utilities to financing and operating "below-ground" infrastructure such as sewers and pipes. Surface measures—including parks, roads, swales, and retention areas—fell solely under municipal responsibility, even when primarily intended for flood mitigation. As a result, HOFOR, the Greater Copenhagen Utility, was legally prevented from financing surface-based solutions, despite being responsible for stormwater management and despite the cost-effectiveness of such measures compared to conventional grey infrastructure.

This legal separation became a critical obstacle following a series of extreme rainfall events in 2010–2011, including a 1,000-year storm that caused damages exceeding €800 million. Recognizing that effective cloudburst management required coordinated investments across both underground and surface systems, the City of Copenhagen and HOFOR jointly petitioned for legislative reform. Supported by strong political momentum and public awareness after the floods, the Danish government amended the legislation in 2013.

The amendment allowed water utilities to finance surface-based climate adaptation measures with a clear stormwater function. During a transitional period (2013–2015), HOFOR could fund up to 100 percent of eligible projects; from 2015 onward, a co-financing model applied, with HOFOR covering up to 75 percent of costs and municipalities contributing the remaining 25 percent. While the City retained ownership and planning authority over public spaces, HOFOR could now finance hydraulic components embedded within them, such as swales, retention basins, and drainage structures.

Financial barriers were addressed through a restructured funding model. Given the scale of the CMP, HOFOR was authorized to recover investments through water tariffs, subject to political approval and public consultation. Tariffs increased by approximately 10–15 percent, enabling long-term financing while maintaining transparency and public legitimacy. The City continued to finance non-hydraulic urban amenities, while private property owners funded on-site flood protection measures.

Following these regulatory changes, the CMP emerged as a comprehensive, citywide strategy combining grey and green infrastructure. It comprises roughly 300 projects implemented over a 20-year horizon, including cloudburst boulevards, multifunctional parks and retention areas, green streets and swales, and large underground tunnels. Fully integrated into urban planning processes, these interventions deliver flood protection

alongside co-benefits for public space quality, biodiversity, and urban liveability. The total investment cost is estimated at €1.8–2.0 billion, widely considered cost-effective given the avoided flood damages and long-term resilience gains. Source: (The Nature Conservancy, 2019)

Besides the specific example of the Cloudburst Management Plan in Copenhagen, a variety of policy, regulatory and economic tools have been implemented by different cities to address the barriers preventing to upscale NbS for UWR.

6.2 Policy, regulatory and economic instruments to support transformative UWRM

In the EU, several Member States have implemented a variety of policy, regulatory and economic tools to accelerate the adoption of grey-blue-green solutions for UWRM. These instruments have emerged to overcome persistent barriers. Rather than relying on a single regulatory approach, cities and national authorities have combined economic incentives, mandatory standards, spatial planning tools, and innovative financing mechanisms to create enabling frameworks for UWRM. Financial constraints have been addressed through runoff-based stormwater fees, development impact charges, tax incentives, grants, and green municipal bonds, which help internalise runoff-related externalities while reducing upfront investment barriers for households, developers, and municipalities. Legal and regulatory challenges have been tackled by embedding green infrastructure requirements into building codes, zoning regulations, and performance-based retention standards, thereby ensuring minimum levels of adoption while preserving flexibility in design and implementation.

Technical and operational barriers have been mitigated through performance-oriented regulation, real-time control systems, and digital monitoring tools that optimise storage capacity and system efficiency under variable rainfall conditions. Social and cultural barriers—often linked to risk perception, behavioural change, and acceptance of multifunctional spaces—have been addressed through instruments that promote co-benefits such as urban amenity, climate adaptation, public space enhancement, and reduced flood insurance premiums. Finally, contextual constraints related to urban density, land availability, and exposure to climate risks have been managed through integrated land-use planning approaches, sponge city concepts, and insurance- and risk-based instruments tailored to local conditions.

Table 4 provides illustrative examples of these policy, regulatory, and economic tools as implemented in selected European and international cities. Together, they demonstrate the diversity of concrete solutions available to policymakers and practitioners, as well as the increasing convergence towards integrated, multi-instrument strategies for fostering the large-scale deployment of grey–blue–green infrastructure in urban environments.

Table 4 UWRM policy, regulatory and economic tools to foster the adoption of grey-blue-green solutions

UWRM instrument	UWRM instrument description	City where it was implemented
Stormwater Fees (Runoff-Based Charges)	Tariff charged to property owners based on impervious surface area owned (roofs, parking lots). Incentive to reduce impervious surfaces and install GI.	**Berlin**: Runoff fees ("Niederschlagswassergebühr") differentiated by surface characteristics, encouraging green roofs and infiltration.
Green Infrastructure Mandates/ Standards	Requirements embedded in construction codes to include GI in new developments or major renovations. Ensures baseline adoption of GI across the urban fabric.	**Copenhagen**: Mandates blue-green solutions in new districts as part of Cloudburst Management Plan. Paris: Requires green roofs or solar panels on all new commercial buildings.
Stormwater Retention Standards (Performance-Based Regulation)	Developments required to retain a specific rainfall amount on-site. Developers can choose any GI solution that meets the performance target (flexibility).	**Rotterdam**: Flood-resilient new districts must meet multifunctional stormwater storage requirements.
Development Impact Fees / Stormwater Offsets	Fees charged to developers for additional runoff burden created; can avoid or reduce fees by installing GI. Encourages low-impact design and	**London**: Developers contribute to sustainable drainage (SuDS) retrofit funds.

	funds public GI in disadvantaged neighborhoods.	
Tax Incentives, Rebates, and Grants	Local governments offer financial support for GI installation. Increases uptake among homeowners, businesses, and community institutions.	**Toronto**: Green Roof Incentive Program provides CAD 100/m² for installations.
Zoning and Land-Use Planning for Sponge City Design	Urban zoning codes that reserve land for multifunctional blue–green corridors, floodable parks, wetlands, and infiltration zones.	**Rotterdam**: "Water plazas" and blue–green streets embedded in city zoning.
Insurance and Risk-Based Instruments	Using insurance pricing or risk-sharing mechanisms to reward properties that reduce runoff-related flood risk. Links GI to reduced premiums and long-term resilience planning.	**Copenhagen**: Flood-risk maps and insurance data to guide neighborhood-level GI investment. **Zurich**: Property insurance incentivize permeable surfaces and improved drainage.
Digital Regulation and Real-Time Control	Policies that require or reward smart sensors use and controlled drainage systems. Optimizes storage capacity and protects downstream areas.	**Barcelona**: Smart drainage network integrated with green corridors.
Urban Resilience Bonds / Green Municipal Bonds	Bond instruments earmarked for large-scale GI or integrated stormwater systems. Attracts investors and reduces upfront fiscal pressure.	**Gothenburg**: Green bonds financing integrated blue–green climate adaptation projects.

7 APPLICATION OF WATERUN SOLUTIONS

7.1 WATERUN methodology as a support tool for policy, regulation and economic decision-making

The WATERUN project aims to develop an innovative methodology to support the implementation of urban water runoff management plans in cities, grounded in the Water-Sensitive Urban Design (WSUD) concept. This methodology delivered preventive and mitigation solutions, along with best management practices, adopting a holistic approach—from source identification to remediation strategies—for controlling diffuse water pollution in urban catchments. The project seeks to transform urban water runoff management by creating identification, planning, and risk-based tools, as well as new working procedures and guidance. A key feature of this approach is the early involvement of urban water management and governance stakeholders through a co-creation process, ensuring wider and faster adoption of the proposed solutions.

The WATERUN project uses three case studies—the cities of Santiago de Compostela, Århus, and Amman—to gather data, develop, implement, and validate its proposed methodology. These cities were selected based on their diverse climate conditions, land use patterns, and varying levels of implementation of diffuse pollution measures, ensuring the tools are validated across different scenarios. Key stakeholders, including research and technology organizations (RTOs), industry representatives, public authorities, urban planners, and citizens, engaged in a continuous, multidisciplinary co-creation process. This collaborative approach ensured that decisions on urban water runoff management fully integrate environmental, social, and economic considerations (Box 3).

Box 3 Co-creation process of UWR solutions as part of WATERUN project

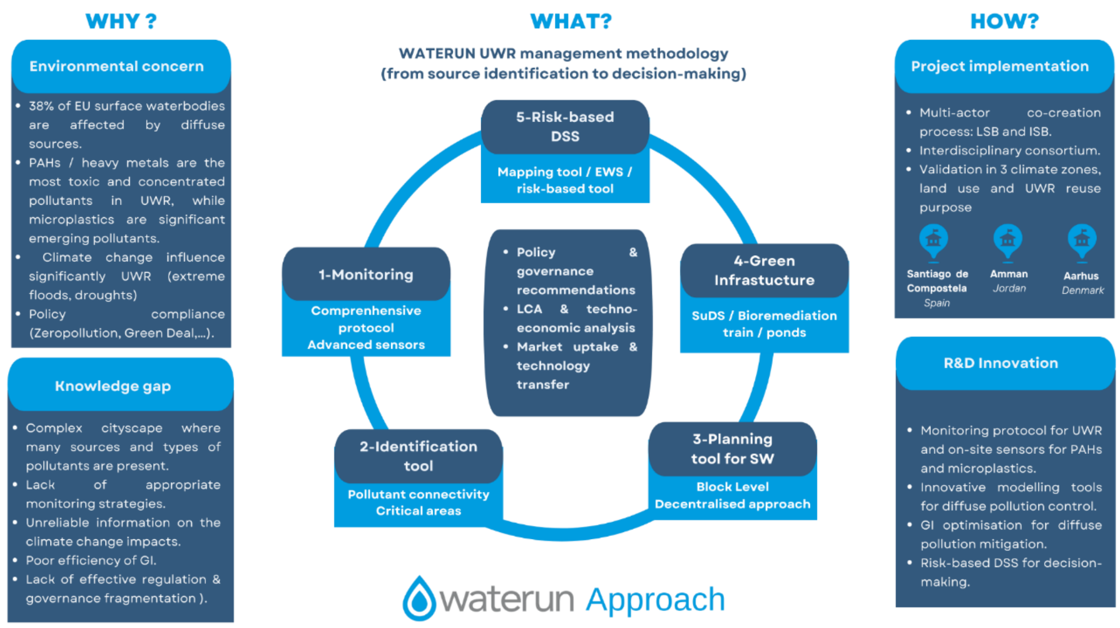
Despite the substantial benefits of early consideration of GI for land developers and the citizens, their implementation has found numerous barriers of governance (e.g., lack of leadership, lack or incompatible policy), socio-cultural (e.g., stakeholders' perception, community involvement), knowledge (lack of general knowledge about GI and impact on biodiversity and ecosystem services), technical-physical (e.g., urban morphology, construction challenges) and funding and market nature. Out of these, *stakeholders' involvement, clear leadership, and effective communication between management groups have been identified as key issues to take into account to guarantee success and sustainability of GI implementation,* through building trust and developing consistent relationships.

As part of WATERUN, various GI solutions based on SuDS and NBS were implemented in the CS of Santiago and Aarhus, counting on the inputs of involved stakeholders and citizens, from the design to the construction and operational and maintenance phase, to overcome possible barriers and hence ensure the sustainability of GI implementation and support the creation of future policy and institutional frameworks for its management. In each case study, a series of rounds of discussion were held with stakeholders within the framework of "Co-creation committees". These meetings were dedicated to promoting a user-centred design approach to co-developing solutions.

Source: Waterun

Beyond delivering sustainable urban water management solutions, the WATERUN methodology (Figure 5) also advanced knowledge on diffuse water pollution in cities, particularly in the context of climate change. By doing so, it contributes to protecting water bodies and the environment, while ensuring high water quality for all.

Figure 5 WATERUN methodology



Source: (WATERUN Consortium, s.d.)

The implementation of WATERUN solutions triggered a shift toward zero-pollution, thanks to prevention and mitigation solutions to minimise the pollutants impact on human health and environment. In addition, WATERUN solutions enable a more sustainable water use, since it is estimated that they will treat 80% of the total urban water runoff of a targeted area. The WATERUN project includes following outcomes:

- **OER1 - Advanced monitoring solution** - Advanced monitoring solution refers to a set of strategies and protocols for a reliable identification and quantification of pollutants in the urban surface, backed on innovative portable and microfluidic-based sensors for on-site detection of PAH and microplastics
- **OER2 - Identification tool for source pollution** - The identification tool for source pollution refers to an open-source and web-based tool for the identification of critical source areas and pollutants pathways of urban diffuse pollution.
- **OER3 - Planning tool for Storm Water management** - The planning tool for storm water management aims to set up methods for modelling the reduction of pollution runoff by decentralised SW management at city block level.
- **OER4 - Risk-based DSS for UWR management** - The Risk-based Decision-Support System (DSS) for urban water runoff management refers to a DSS based on environmental and health-risk assessment helping in the decision-making on the selection of appropriate Green Infrastructure for a safe water use.
- **Non-commercially exploitable result** - Guidance for the implementation of future UWR management plans aiming to explain the methodological implementation of risk assessment in UWR management including the use of WATERUN new developed software tools (identification tool, planning tool and risk-based DSS, as well as the best management practices of Gis). It will be a ready-made output for decision-making and governance in urban areas facilitating the elaboration of UWR management plans of cities.

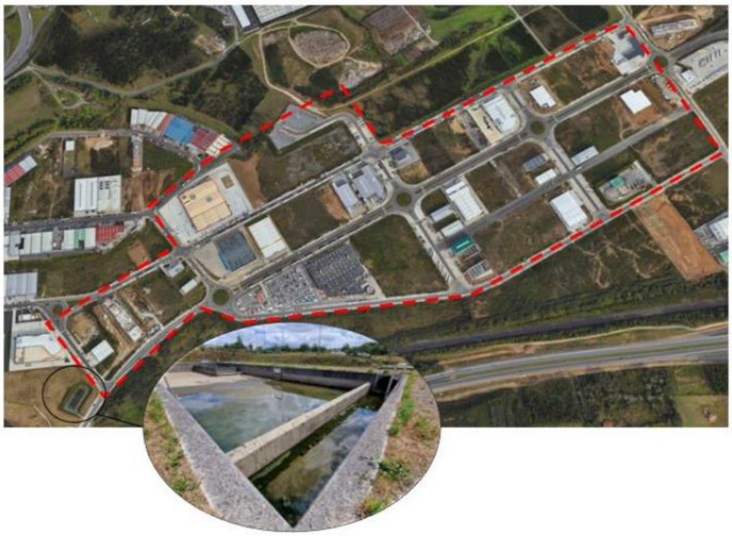
7.2 Pioneering case studies: Santiago de Compostela (Spain) and Århus (Denmark)

Santiago de Compostela - Sustainable Urban Drainage Systems implementation

Santiago de Compostela, located in northwestern Spain, has a population of 98,179 inhabitants (as of 2022). The city experiences a temperate oceanic climate, heavily influenced by the Atlantic Ocean, characterized by mild, rainy winters and mild to pleasantly warm summers. Average daily temperatures range from 5°C in winter to 25°C in summer, while mean monthly rainfall varies between 23 mm and 141 mm.

Santiago de Compostela features two catchments within an industrial area chosen to test WATERUN products. Both catchments collect UWR, directing it toward Sustainable Urban Drainage Systems (SuDS). In the first catchment, a Surface Sand Filter serves as the SuDS element, draining stormwater into a separate sewer network. In the second catchment, located in Sionlla Park, a bioretention area functions as the SuDS, where stormwater can be harvested and potentially reused (Figure *6*). This second catchment and its green infrastructure will be modeled using SWMM (Storm Water Management Model) to conduct a risk analysis related to stormwater reuse and management.

Figure 6 Santiago de Compostela CS - Sionlla park



Source: (WATERUN Consortium, s.d.)

Within the WATERUN project, the Sustainable Urban Drainage (SuD) system at Sionlla Park underwent design improvements to enhance its capacity for stormwater management. The upgraded system incorporates various biofilters and retention basins to optimize performance. Critical data for this catchment—including sewer network characteristics, elevation data (Digital Elevation Model, DEM), and historical rainfall records—have been provided by consortium partners to develop the SWMM (Storm Water Management Model) simulation. Additionally, data on chemical contaminants and pathogens, once available from ongoing monitoring campaigns, will be integrated to further refine the model and support comprehensive risk assessments.

Santiago de Compostela – Barriers identified by stakeholders

The deployment of innovative and nature-based UWRM solutions in Santiago de Compostela faced several institutional, regulatory, and capacity-related barriers. Stakeholders highlighted a general lack of awareness and limited regulatory support for NbS, with stormwater management not yet perceived as a strategic priority at the local level. NbS remain largely non-mandatory, and the absence of a dedicated local regulatory framework or incentive mechanisms constrains their broader uptake.

During the planning phase, local authorities reported limited familiarity and confidence with NbS, which are often viewed as distant from established practices focused on the integrated management of stormwater and wastewater through conventional systems. Financing represents an additional challenge, as municipalities are reluctant to allocate budgets to NbS due to perceived higher costs relative to traditional grey infrastructure, a perception reinforced by the lack of binding requirements. In the project design phase, spatial constraints within urban areas and limited local expertise in NbS design complicated the integration of such solutions. Implementation was further hindered by delays in permitting procedures and a shortage of qualified construction companies experienced in delivering NbS. Finally, operation and maintenance activities are affected by limited technical capacity at the local level, while monitoring remains constrained by the continued reliance on traditional data collection methods and the limited uptake of innovative monitoring technologies.

Århus – Sustainable Urban Drainage Systems implemented

Århus, Denmark's second-largest city, is situated on the east coast of the Jutland peninsula and has a population of 346,968 inhabitants (as of 2023). The city experiences an oceanic climate, with rainfall occurring throughout the year. The average annual temperature is 11°C, with approximately 226 mm of rainfall per year and 168 dry days annually, accompanied by an average humidity of 81%. These climatic conditions, combined with ongoing urban development, make Århus particularly relevant for the testing and deployment of innovative UWRM solutions.

Within the framework of WATERUN project, Århus serves as a test site for evaluating SuDS in UWRM. Seven SuDS elements have been identified across different sub-catchments, including five wet detention ponds and two infiltration systems. One notable example is the Tulipgrunden district in western Århus where two different approaches are implemented within the same catchment. In the eastern section of the sub-catchment (Tulipgrunden 1), stormwater is conveyed by gravity through underground pipes and collected in a wet detention pond (Figure 7). In the western section (Tulipgrunden 2), stormwater flows along open ditches and is collected in an internally connected basin, illustrating the coexistence of conventional and more nature-based solutions within the urban fabric.

Figure 7 Århus CS - Tulipgrunden 1

Source: (WATERUN Consortium, s.d.)

Stormwater harvested in the Tulipgrunden 1 sub-catchment can be evaluated for potential reuse applications. Additionally, environmental risk assessments related to the impact of stormwater discharges on receiving environments—such as water bodies and soil—can be conducted across other sub-catchments. The SuDS in Århus have been equipped with devices and sensors to measure flow rates and collect water samples for laboratory analysis, enabling a chemical and physical characterization of stormwater. Historical rainfall data, sewer network characteristics, and elevation data (Digital Elevation Model, DEM) were provided by consortium partners to develop SWMM (Storm Water Management Model) simulations for various sub-catchments in Århus.

Århus - Barriers identified by stakeholders

The deployment of innovative UWRM solutions in Århus faced several regulatory and financial barriers. According to the local utility, Aarhus Vand, traditional grey infrastructure solutions remains easier to authorise, while the regulatory framework tends to prioritise short-term economic efficiency over broader environmental and public health benefits. Regulation was described as largely reactive, applying mainly to established technologies and limiting the proactive uptake of innovative or nature-based solutions. At the planning stage, a key constraint relates to the absence of future-proof regulatory provisions, particularly with respect to emerging pollutants such as microplastics.

Financial constraints further limit innovation, as restricted budgets and cost-efficiency requirements imposed by regulators reduce the capacity to fund experimental or non-standard solutions. During the project design phase, ambiguity regarding the institutional classification of blue–green infrastructure—falling between wastewater management and urban planning—created additional uncertainty and delays. Implementation is often challenged by difficulties in securing permits for non-traditional technologies, while during operation and maintenance, higher costs associated with blue–green infrastructure compared to conventional systems raised concerns about long-term affordability. Finally, monitoring activities are constrained by the reactive nature of regulation, which lacks long-term strategies for tracking emerging pollutants and assessing the performance of innovative UWRM solutions over time.

Grey-blue-green solutions implemented and their benefits

The following grey-blue-green infrastructure solutions were analyzed, implemented, and validated in the Santiago and Århus case studies:

- **Stormwater (SW) harvesting roofs:** Stormwater can be collected, stored, and treated from roofs and other impermeable surfaces using systems such as gravel roof facilities, porous pavement roofs, or green roof installations.
- **Bioretention systems:** These are shallow, landscaped depressions designed to reduce UWR rates and volumes while treating pollution through filtration, adsorption, and biodegradation processes, using engineered soils and vegetation.
- **Permeable pavement:** A porous urban surface that captures precipitation and surface runoff, storing it in a reservoir while allowing gradual infiltration into the groundwater.
- **Bioremediation treatment train:** A multi-stage system consisting of a coarse filter (pre-treatment), a retention pond (treatment stage), and an adsorption filter (post-treatment) to enhance pollutant removal.
- **Wet pond:** An engineered nature-based solution (NBS) planted with hydrophytes, capable of removing targeted pollutants from runoff and drainage. Wet ponds can also be enhanced with reactive media to improve performance.
- **Dry pond:** An engineered NBS designed to capture, control, and filter UWR from roofs, roads, parking areas, and other urban settings. It temporarily holds water before allowing it to discharge to nearby streams or infiltrate into the ground.

Blue-green infrastructure leverages various pollutant removal mechanisms, including sedimentation, filtration, plant uptake, biodegradation, and sorption, each playing a distinct role depending on the technology type, location, and design factors. The benefits of using blue-green infrastructure for urban water runoff management have yielded strong, evidence-based results (Table 5).

Table 5 Benefits arising/expected from blue-green infrastructure for urban water runoff

Environmental	Social	Economic
Habitat and Biodiversity. Green streetscapes enhance urban biodiversity as native species provide habitats for birds, insects, and other species. Native vegetation is	**Amenity and Landscape Design**. Landscape design contributes to a city's character and identity. Planting complements the built environment, softens	**Energy**. By reducing local temperatures and shading building surfaces, green infrastructure reduces the cooling demand of buildings, thus cutting energy needs.

better suited to the rainfall of the local area. Enhancement of biodiversity in cities can increase environmental awareness among urban residents.	appearance of hard surfaces, and provides a visual screen.	
Water Quality. Green infrastructure improves stormwater quality by reducing the load of sediment, unwanted minerals, and other contaminants that are carried with runoff from impermeable surfaces.	**Urban Cooling**. Trees and green infrastructure provide significant reductions in urban temperatures. Large trees with good soil moisture can reduce local temperatures through shading and evapotranspiration. Trees can reduce air temperatures in parks and green areas by as much as 2–8°C, and they have been linked to the prevention of unnecessary loss of life during heatwaves.	**Lifespan of Infrastructure**. Green infrastructure complements grey infrastructure such as catch basins and drainage pipes, and lengthens the lifespan of grey infrastructure.
Flow Management. Retaining runoff in landscaped areas and slowing the rate of flow from the catchment area reduces the risk of erosion of the soil bed. Slower flow rates reduce stress on downstream waterways as well.	**Encourage Outdoor Activity**. Green cover encourages outdoor activity, including walking, cycling, and other recreation.	**Water Systems**. The impacts on drainage systems and the cost of managing erosion in waterways can be significant. Streets with green infrastructure slow the rate of runoff, reducing the pressure on these systems and lowering maintenance costs.
Natural Hydrology. Where local soils are suitable, rain gardens are used to treat stormwater before it permeates the groundwater.	**Air Quality**. Vegetation improves air quality and reduces greenhouse gases. Trees remove carbon dioxide, nitrous oxides, sulphur dioxide, carbon monoxide, and ozone from the atmosphere. The most effective species in trapping pollutants are those with large leaf surface areas and high transpiration rates.	**Property Values and Marketability**. Street trees and green infrastructure enhance aesthetic qualities and provide a significant neighborhood amenity. Properties on tree-lined streets are valued at up to 30% more than those on streets without trees.

Passive Irrigation. Directing stormwater to irrigate the planting reduces the need for manual watering and increases soil moisture.		

7.3 Policy and regulatory recommendations derived from WATERUN implementation

Stakeholder consultations conducted within WATERUN project highlighted a set of converging policy and regulatory recommendations aimed at enabling more effective, risk-based, and forward-looking UWRM. These recommendations reflect practical planning and operational realities faced by municipalities, utilities, consultants, and regulators, as well as emerging regulatory pressures at EU level.

1. Strengthen policy recognition of UWR as a distinct pollution source

Urban runoff should be clearly and operationally recognised in EU and national policy as a distinct and significant source of chemical and microbiological pollution, and systematically integrated into urban hydrological planning and municipal regulatory frameworks. This recognition should clarify how obligations are to be implemented, combining proportionate enforcement mechanisms—where necessary, including penalties—with enabling measures such as financial incentives, technical guidance, and capacity-building support. Given the diffuse and highly variable nature of stormwater flows and contamination, regulatory frameworks should promote risk-based management approaches and define minimum performance and monitoring expectations adapted to urban runoff. Current public concern regarding flooding and water-related crises provides an opportunity to link water quantity and quality objectives and to promote multifunctional solutions, including nature-based solutions (NbS) and sustainable drainage systems. National authorities, potentially supported by EU funds, should establish dedicated programmes that equip municipalities with the resources and tools required for implementation beyond pilot scale, while maintaining clear compliance expectations where support is available but action is not taken.

2. Improve regulatory alignment with existing EU water legislation

Urban runoff management frameworks should be more closely aligned with existing EU water legislation, particularly the Water Framework Directive (WFD) and the Urban Wastewater Treatment Directive (UWWTD). Increasingly stringent discharge permit conditions and receiving water quality requirements are key drivers of local decision-making, yet uncertainty remains regarding how UWRM tools and approaches can be used to demonstrate compliance. Clearer guidance is needed on how modelling outputs, risk assessments, and scenario-based analyses can support permitting procedures and long-term planning under evolving regulatory conditions. Simplified and proportionate monitoring approaches should also be recognised, where appropriate, as valid components of compliance strategies. Strengthening the integration of UWRM-related tools within established WFD and UWWTD processes would reduce institutional uncertainty, enhance legal clarity, and create a more enabling environment for innovation.

3. Clarify institutional roles and facilitate cross-sector coordination

Effective urban runoff management requires clear allocation of responsibilities across governance levels and sectors. While municipalities are typically responsible for local planning and implementation, their mandates must be matched with adequate financial and technical capacity, as well as transparent accountability frameworks. Delegation of operational tasks—such as compliance with discharge standards—to utilities may be appropriate, provided that mandates, cost responsibilities, and regulatory oversight are clearly defined. In particular, responsibilities for monitoring receiving water quality should be explicitly allocated. As receiving water status reflects cumulative pressures from multiple sectors, monitoring should primarily remain under state or basin-level authorities to ensure neutrality, comparability, and alignment with Water Framework Directive objectives, with clear cost-sharing rules where utilities contribute to data collection. Horizontal coordination (e.g. environment, spatial planning, infrastructure, construction) and vertical coordination (municipal, basin, national levels) should be formalised through structured mandates, shared data frameworks, and funding-linked cooperation mechanisms to ensure coherent and accountable implementation.

4. Promote risk-based and proportionate regulatory approaches

Regulatory approaches to urban runoff management should be risk-based, proportionate, and adapted to the diffuse and variable nature of stormwater. Existing practices often apply prescriptive requirements developed for wastewater systems, which may not adequately reflect the specific risk profiles of urban runoff discharges or reuse scenarios. Policies should explicitly allow and encourage the use of quantitative chemical and microbial risk assessment methods to inform prioritisation, permitting decisions, and phased implementation strategies. Such approaches enable more targeted interventions and help justify alternative or hybrid solutions where full compliance with conventional standards may be disproportionate to actual environmental or public health risks. Embedding risk-based methodologies within regulatory frameworks would support evidence-based decision-making while maintaining alignment with EU environmental objectives.

5. Support flexible data requirements and adaptive monitoring strategies

Policy frameworks should promote proportionate, risk-based, and adaptable data requirements for urban runoff management. Comprehensive monitoring of all discharge points is often neither technically feasible nor economically justified; where multiple outlets exist, representative sampling strategies should consider network size, catchment characteristics, land use, and pollutant profiles to provide a reliable basis for estimating pollutant loads and supporting permitting and planning decisions. Regulatory guidance should distinguish between minimum data requirements for credible risk assessment and enhanced expectations for higher-risk contexts, enabling municipalities with limited resources to engage in evidence-based management. Adaptive monitoring approaches—combining targeted measurements, modelling tools, generic datasets, and scenario analysis—should be explicitly recognised as legitimate instruments for decision-making under uncertainty. This proportionate approach lowers entry barriers, ensures comparability across municipalities of different sizes, and supports progressive improvement of data quality over time.

6. Enhance policy support for innovation, nature-based solutions, and retrofitting

Policy frameworks should strengthen support for innovation, NbS, and the retrofitting of existing infrastructure, recognising that cost-effectiveness and performance must be assessed on a case-by-case basis. While NbS are increasingly integrated into the operational toolbox of utilities in some Member States, they may not fully remove all pollutants present in urban runoff. Integrated treatment trains combining green and grey solutions are therefore often required, particularly where diverting runoff to wastewater treatment plants would entail disproportionate investments. Greater emphasis should also be placed on upstream prevention, including the reduction or substitution of hazardous materials at source (e.g. certain construction materials), which requires coordination across water, environmental, and construction authorities. Flexible regulatory approaches—such as carefully designed pollutant offsetting mechanisms—may be explored under strict environmental safeguards, ensuring no net deterioration and alignment with EU water legislation. Continued investment in research and development is essential to improve treatment performance, monitoring techniques, and cost-efficiency of hybrid solutions.

7. Improve usability, clarity, and targeting of decision-support tools

Decision-support tools for urban runoff management should be clear, accessible, and tailored to different user profiles to effectively inform planning and regulatory processes. A clear distinction should be made between preliminary diagnostic tools and comprehensive decision-support systems, with transparent communication of their respective purposes, input requirements, and limitations. Tools should specify their intended users—such as planners, utilities, regulators, or decision-makers—and present outputs in a format that directly supports permitting, investment planning, and compliance assessment. Policies and funding programmes should encourage the development of interoperable, modular tools with standardised data interfaces and clearly documented methodologies. Enhancing usability and transparency will increase uptake, facilitate cross-institutional collaboration, and strengthen the integration of technical analysis into policy and regulatory decision-making.

8 CONCLUSIONS

UWRM has emerged as a critical yet still under-institutionalised component of sustainable urban water policy in Europe. As climate change intensifies rainfall variability, urbanisation continues to increase impervious surfaces, and water quality objectives become more stringent, the costs of fragmented, end-of-pipe approaches are rising. This policy brief has shown that UWRM is no longer a purely technical challenge, but a systemic governance issue that cuts across planning, environmental regulation, infrastructure finance, and service delivery.

The analysis demonstrates that nature-based and hybrid UWRM solutions—such as those promoted through the WATERUN approach—are technically mature and increasingly cost-competitive. However, their uptake remains constrained by regulatory silos, misaligned incentives, and weak coordination between urban, water, and environmental authorities. The central barrier is not a lack of innovation, but the absence of enabling institutional and regulatory conditions that allow such solutions to be deployed at scale and maintained over time.

A key conclusion emerging from this work is that effective UWRM requires a shift from project-based experimentation to system-level integration. The policy recommendations stemming from WATERUN stakeholders underline the importance of embedding UWRM objectives explicitly within urban planning frameworks, stormwater regulations, and investment decision-making processes. Where UWRM remains treated as an ancillary environmental add-on, solutions tend to remain small-scale and vulnerable to budgetary or political shifts. Conversely, jurisdictions that anchor runoff management within binding planning instruments and performance standards are better positioned to achieve cumulative, city-wide impacts.

Institutional coordination is equally decisive. Responsibilities for runoff management are often dispersed across multiple actors, with limited incentives for collaboration. Strengthening coordination between municipalities, utilities, basin authorities, and environmental agencies—while clarifying roles and accountability—emerges as a precondition for effective implementation.

Financing mechanisms represent another critical lever. While UWRM solutions can deliver long-term economic and environmental benefits, their upfront costs and diffuse returns often deter investment. There is a need to align financing instruments with the multi-benefit nature of UWRM, including through dedicated runoff charges, blended finance approaches, and the integration of UWRM criteria into existing urban infrastructure funding streams. Without such alignment, innovative solutions risk remaining dependent on short-term pilot funding.

From a policy perspective, this brief underscores that regulatory evolution must accompany technical innovation. Performance-based standards, outcome-oriented regulation, and flexibility in compliance pathways can create space for WATERUN-type solutions, while still safeguarding environmental and public health objectives. Importantly, regulation should support learning and adaptation, allowing cities to progressively refine their approaches as experience accumulates.

In conclusion, scaling up sustainable UWRM in Europe will not occur through technology deployment alone. Success will also depend on coherent governance frameworks, integrated planning, and financial and regulatory incentives that reward long-term, systemic solutions. By addressing these enabling conditions, policymakers can move UWRM from the margins of urban water policy to a central pillar of climate-resilient and sustainable cities.

9 BIBLIOGRAPHY

Biasin, A. M. (2025). *The Role of Water Utilities in Implementing Urban Nature-Based Solutions: An Italian Perspective.*

European Commission. (2021). *EU Action Plan: "Towards Zero Pollution for Air, Water and Soil".*

European Commission. (2022). *Impact Assessment accompanying the Proposal for a Directive of the European Parliament and of the Council concerning urban wastewater treatment (recast). SWD(2022) 541 final.*

European Commission. (2025). *European Water Resilience Strategy – COM(2025) 280 final.*

European Environment Agency. (2020). *Water use and environmental pressures.* Retrieved from https://www.eea.europa.eu/themes/water/european-waters/water-use-and-environmental-pressures

European Parliament. (2000). *Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for Community action in the field of water policy.*

European Parliament. (2024). *Directive (EU) 2024/3019 of the European Parliament and of the Council of 27 November 2024 concerning urban wastewater treatment (recast).*

Maryland Department of the Envionment. (n.d.). Why stormwater matters. *Maryland Department of the Envionment Stormwater Manual*, 25-30.

Ministry of Foreign Affairs of the Netherlands. (2019). *"How to Create a Sponge Town? Sponge Town Guideline.".* Retrieved from ViaWater / Aqua4All: https://roadsforwater.org/wp-content/uploads/2019/05/Sponge-Town-guideline-small-size.pdf

Salvetti, M. (2022). *Patrimoine eau, assainissement, pluvial - Une approche des enjeux financiers de la sécurité hydrique.* Union des Industriels de l'Eau et de l'Environnement.

Tarek, S. (2025, Vol. 13, No. 4). "Sponge Cities Framework for Achieving Ecological Development in Egyptian Cities". *Civil Engineering and Architecture*, pp. pp. 2847 - 2861.

Texas Department for Transportation. (n.d.). *Design Storm. In Hydraulic Design Manual: Chapter 4 – Hydrology, Section 15: Glossary of Hydrology Terms.* Retrieved from https://www.txdot.gov/manuals/des/hyd/chapter-4--hydrology/section-15--glossary-of-hydrology-terms/design-storm.html

The European Commission. (2021). Zero Pollution Action Plan.

The Nature Conservancy. (2019). *Investing in nature for European water security.*

Turenscape. (n.d.). *Sponge City – Theory and Practice with Turenscape.* Retrieved from https://www.turenscape.com/topic/en/spongecity/index.html

WATERUN Consortium. (n.d.). *WATERUN project*. Retrieved from https://www.waterun.eu/.

Funded by the European Union

10 ACRONYMS

CAPEX	Capital Expenditures
CGEDD	General Council for the Environment and Sustainable Development
CMP	Cloudburst Management Plan
CS	Case Study / Combined Sewer (context-dependent)
DEM	Digital Elevation Model
DSS	Decision Support System
EPA	Environmental Protection Agency
EU	European Union
GI	Green Infrastructure
ISB	Industry and Stakeholder Board
LSB	Local Stakeholder Board
NBS	Nature-Based Solutions
OPEX	Operational Expenditures
PAH	Polycyclic Aromatic Hydrocarbons
p.e.	Population Equivalent
RTO	Research and Technology Organisation
SuDS / SUDS	Sustainable Urban Drainage Systems
SW	Stormwater
SWMM	Storm Water Management Model
UWR	Urban Water Runoff
UWRM	Urban Water Runoff Management
UWWTD / rUWWTD	Urban Wastewater Treatment Directive (recast)
WFD	Water Framework Directive