



## Urban Nature-Based Solutions in Italy: The Role of Water Utilities, Finance, and Governance

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### Abstract

Rapid urbanisation and severe soil sealing have critically diminished natural rainwater infiltration capacities across European cities. In Italy, alternating periods of water scarcity and extreme rainfall have exposed profound systemic vulnerabilities, leaving most municipalities at risk of landslides, floods, avalanches, and coastal erosion. While Nature-based Solutions (NbS) and Sustainable Drainage Systems (SuDS) are globally recognised for mitigating these climate risks, water utilities, which serve as critical hybrid public-private entities, have historically favoured traditional, engineering-heavy "grey" infrastructure. This technical article explores the current implementation landscape and outlines actionable strategies for financial actors and policymakers to mainstream NbS investments.

### Introduction

Since the early 2000s, rapid urbanization processes, often occurring without adequate spatial planning, have led to increased land consumption and widespread soil sealing in urban areas [8]. This progressive impermeabilization has reduced the natural capacity of soils to intercept and infiltrate rainfall, thereby intensifying both short- and long-term climate-related impacts. Consequently, urban systems are increasingly exposed to environmental, social, and economic pressures, particularly in relation to flood risk.

In Italy, these challenges are exacerbated by alternating periods of prolonged drought and extreme rainfall events, which frequently result in sewer overflows, urban flooding, and water quality deterioration. According to [ISPRA \(2025\)](#), a high percentage of Italian municipalities are exposed to hydrogeological risks, including floods, landslides, and coastal erosion. Inefficient stormwater management further contributes to pollutant transport into surface and groundwater bodies, highlighting the need for integrated and adaptive water management approaches [13].

Within this context, **Nature-based Solutions (NbS)** have emerged as a strategic approach for addressing urban water challenges while enhancing ecosystem services and resilience. **Sustainable Drainage Systems (SuDS)**, as a key operational component of NbS, aims to replicate natural hydrological processes in urban environments. These systems support runoff reduction, flood mitigation, water quality improvement, and biodiversity enhancement through interventions such as green roofs [7], permeable pavements [12], vegetated swales [5], constructed wetlands [11, 1], and bioretention systems [9, 10].

A growing body of literature highlights the contribution of stormwater management infrastructures to climate adaptation through runoff reduction, enhanced infiltration, and broader urban co-benefits, supporting



integrated “sponge city” approaches that combine blue, green, and grey infrastructures [2, 3, 4, 6]. Recent European policy frameworks, such as the Water Framework Directive and the Water Resilience Strategy further confirm increasing support for the integration of SuDS and NBS in urban water management.

Despite the continued relevance of conventional hydraulic infrastructure, including sewer expansion and detention basins, such approaches are increasingly constrained by land availability, financial limitations, and long-term operational costs. As a result, the need to complement grey infrastructure with more flexible and multifunctional solutions is increasingly recognised.

International case studies also show that water utilities can play an active role in implementing NBS, although empirical evidence on their strategies and investment behaviours is still limited. Against this background, this article investigates the emerging role of water utilities in the implementation of NbS in Italy, with particular attention to institutional, financial, technical, and regulatory dimensions.

## 1. Italian Water Governance and Regulatory Context

The Italian water sector operates within a **multi-level governance** framework characterised by shared responsibilities and institutional complexity. Following Law 36/1994, water services were reorganised into the **Integrated Water Service (IWS)** to improve efficiency and ensure financial sustainability through tariff-based cost recovery. Service provision is structured within Optimal Territorial Areas (ATO), which coordinate water supply and wastewater management.

Although stormwater management formally remains under municipal responsibility, operational functions are often outsourced to water utilities through concession arrangements or public-private partnerships. This hybrid governance structure significantly influences the potential integration of NbS into urban water management.

As a result of fragmented responsibilities among the IWS, the potential and effective development of NBS also involves multiple institutional actors. European and national frameworks define regulatory principles, while river basin authorities ensure alignment with water policy objectives. Regional and municipal administrations are responsible for spatial planning, and regulatory authorities establish tariff methodologies and performance standards. Water utilities function primarily as operational entities responsible for infrastructure implementation and service delivery.

Financing mechanisms in the sector are predominantly tariff-based, complemented by public and European funding sources. However, existing regulatory and accounting frameworks tend to favour conventional infrastructure, which is more easily capitalised and integrated into tariff systems. In contrast, NbS, due to their distributed and multifunctional nature, remain insufficiently embedded in financial and asset valuation systems.

Water utilities, as hybrid organisations combining public service obligations with managerial autonomy, possess the technical and financial capacity to support the transition toward more sustainable water management systems. However, their role in NbS deployment remains limited and underexamined.

## 2. Methodological Approach

This article adopts a qualitative research design based on semi-structured interviews conducted across the Italian water sector. A total of 18 interviews were carried out with 23 respondents, including utility managers, institutional representatives, and sector experts. Participants were selected based on their institutional



relevance and professional roles. Interview data were analysed using inductive thematic analysis to identify recurring patterns related to barriers, enabling factors, and operational roles in NbS implementation. The findings were subsequently synthesised using a SWOT analytical framework to structure internal and external determinants of adoption. In addition, selected case studies of water utility involvement in NbS projects were examined to complement interview findings and provide illustrative evidence of emerging practices.

### 3. Results

#### 3.1 Barriers to NbS Implementation by Water Utilities

The analysis identifies multiple structural barriers affecting NbS integration within Italian water utilities. Financial constraints represent a primary limitation. Tariff-based revenue systems prioritise maintenance and renewal of existing infrastructure, leaving limited financial space for innovative investments. Moreover, current regulatory frameworks provide limited mechanisms for capitalising NbS, reducing their investment attractiveness. Organisational and technical constraints further hinder adoption. Many utilities lack multidisciplinary expertise spanning engineering, ecology, urban planning, and environmental economics. In addition, established engineering cultures and institutional path dependencies continue to favor conventional grey infrastructure solutions. Social acceptance also represents a significant barrier. Limited public awareness of NbS benefits, combined with concerns regarding land use changes and perceived inefficiencies, contributes to resistance among stakeholders and citizens. Economic evaluation challenges further restrict implementation. Existing cost-benefit frameworks insufficiently capture long-term co-benefits and ecosystem services, resulting in underestimation of NbS value relative to conventional infrastructure. Institutional fragmentation and regulatory complexity add further constraints. Unclear allocation of responsibilities, procedural delays, and limited standardisation of ecosystem service assessment hinder implementation and scalability. Contextual constraints, including urban density, land scarcity, and regional disparities, further limit the feasibility of large-scale NBS deployment.

#### 3.2 Drivers for NbS Implementation

Despite these constraints, several enabling factors support NbS adoption. Access to European and national funding programs provides a key financial driver, particularly for projects aligned with climate adaptation and biodiversity objectives. The multifunctional nature of NbS facilitates access to multiple funding streams. Innovative financial instruments, including green bonds and pooled financing mechanisms, are increasingly relevant, particularly for larger utilities capable of accessing capital markets. Capacity-building initiatives and knowledge transfer mechanisms enhance technical expertise and support organisational learning. Inter-sectoral collaboration between utilities, municipalities, research institutions, and private stakeholders facilitates integrated planning and improves implementation capacity. Regulatory evolution, including the integration of sustainability objectives into performance frameworks and tariff methodologies, also contributes to enabling conditions. Finally, improved methodologies for ecosystem service valuation are increasingly recognised as essential for strengthening the economic justification of NbS investments.

### 4. SWOT Analysis

A SWOT analysis was conducted to synthesise qualitative insights, classifying internal (organisational) and external (contextual) factors in strengths, weaknesses, opportunities, or threats. This structured framework highlighted internal and external pressures, enabling the identification of potential areas for intervention and policy support. Strengths included the technical expertise and operational capacity of water utilities.



Weaknesses related to limited interdisciplinary skills, restricted financial flexibility, and institutional reliance on conventional infrastructure approaches. Opportunities raised from increasing regulatory support, availability of European funding, and growing awareness of climate adaptation needs. Threats included institutional fragmentation, regulatory uncertainty, and financial constraints. Overall, the analysis indicated that *while enabling conditions are emerging, systemic barriers continue to constrain widespread adoption of NbS* within the water utility sector.

## 5. Role of Water Utilities in NbS Implementation

The SWOT matrix results suggest several complementary roles that water utilities may play in advancing nature-based solutions (NbS). As technical experts, they contribute to design, implementation, and performance monitoring. As innovators, they promote pilot projects and hybrid infrastructure solutions. As knowledge intermediaries, they support capacity building and dissemination of best practices. As financial actors, utilities can mobilise investment through tariffs, public funding, and innovative financial instruments. As strategic partners, they facilitate coordination among municipalities, regulators, private stakeholders, and research institutions. The effective integration of these roles can significantly enhance the scalability and effectiveness of NbS within urban water systems.

## 6. Conclusions

This article highlights that water utilities have the potential to play a central role in advancing Nature-based Solutions within urban water management systems in Italy. However, their current involvement remains limited due to structural financial, regulatory, institutional, and technical constraints. Strengthening the role of water utilities requires coordinated regulatory adaptation, improved integration of ecosystem service valuation, enhanced institutional capacity, and greater alignment between governance levels. Addressing these factors is essential for enabling a broader transition toward resilient and multifunctional urban water systems.





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