WAVES OF CHANGE

Urban Resilience Pathways to Flood and Water Scarcity Risk

MCR 2030 Making Cities Resilient

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For additional information, please contact:

MCR2030 Europe and Central Asia Secretariat

United Nations Office for Disaster Risk Reduction (UNDRR), 37-40 Boulevard du Régent,
Brussels 1000, Belgium
mcr2030-eca@un.org

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MCR 2030 Making Cities Resilient

UNDRR
UN Office for Disaster Risk Reduction

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- Prof. Dilanthi Amaratunga, Professor of Disaster Risks and Climate Resilience at Loughborough University, United Kingdom
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- Christine Ballarin, Member of the Water Resources and Environmental Hygiene Department, Green and Environment Directorate, City of Milan, Italy
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- Lisa Bitossi, Member of the Urban Resilience Department, Green and Environment Directorate, City of Milan, Italy
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- Ilaria Giuliani, Director of the Urban Resilience Department, Green and Environment Directorate, City of Milan, Italy
- David Hodcroft, Head of Strategic Infrastructure, Greater Manchester Combined Authority, United Kingdom
- Adam Lechmere, Head of Sustainability, United Utilities, Greater Manchester, United Kingdom
- Sharon Miller, Interim Assistant Director – Local Resilience Forum, Greater Manchester, United Kingdom
- Guido Minucci, Member of the Urban Resilience Department, Green and Environment Directorate, City of Milan, Italy
- Linda Nilsson, Water strategist, City of Malmö, Sweden

- Susanne Nolden, Department of International Affairs and Global Sustainability, City of Bonn, Germany
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- Oleksandra Sladkova, Deputy Head of Economic Development Department, City of Lviv, Ukraine
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- Maksym Terletskyi, (former) Acting Director at the City Institute of Lviv, Ukraine
- Anastasios Valvis, Assistant Professor (elect), Department of Political Science & International Relations, University of the Peloponnese, Greece
- Iryna Vlasiuk, (former) Project Manager at the City Institute of Lviv, Ukraine
- Stefan Wagner, Head of Department of International Affairs and Global Sustainability, City of Bonn, Germany

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Foreword

Across Europe and Central Asia, the relationship between cities and water is changing. Floods and droughts — once considered separate and distant threats — are now compounding realities shaping urban life across our region. From flash floods and glacial lake outburst floods in Central Asia's mountain cities, to prolonged droughts and water stress affecting millions of Europeans each year, the scale and complexity of water-related risks demand urgent, coordinated and informed action.

Waves of Change: Urban Resilience Pathways to Flood and Water Scarcity Risk is our response to this growing challenge. Building on the momentum of the Flames of Change series on urban heat, this report brings together insights and experiences from cities and partners across the MCR2030 network who are navigating these risks on the ground every day. Their knowledge, commitment and innovation are at the heart of this publication, and we are deeply grateful for their contributions.

This report also reflects a core conviction of UNDRR's regional strategy: that resilience must be systemic, locally driven, informed by experience, and forward-looking. Managing water-related risks requires us to move beyond reactive and sectoral approaches, and to integrate disaster risk reduction, climate adaptation, and urban planning into a coherent vision for the future.

I hope this report will inspire cities, national governments, and partners to deepen cooperation, scale up investment, and place risk-informed decision-making at the centre of urban development. The path to resilience is one we must walk together.

Natalia Alonso Cano,
Chief of the Regional Office for Europe and
Central Asia, UNDRR

Introduction

Across Europe and Central Asia, cities are increasingly exposed to the dual and compounding challenges of flooding and water scarcity. Climate change is intensifying hydrological extremes, altering precipitation patterns, accelerating snow and glacier melt, and increasing the frequency of both sudden-onset events, such as flash floods, and slow-onset crises, such as prolonged droughts. These dynamics are reshaping urban risk profiles and placing growing pressure on citizens, critical infrastructure systems, public services, ecosystems, and local economies.

Flooding remains one of the most recurrent and costly hazards affecting urban areas across Europe and Central Asia. The scale of these impacts is evident at the urban level. The *European State of the Climate 2024* report shows that floods and associated storms across Europe in 2024 affected around **413,000 people**, led to at least **335 fatalities**, and resulted in **more than €18 billion in damage**[1] placing sustained pressure on cities and critical infrastructure systems. Between 1980 and 2023, floods accounted for around **44–47% of total climate-related economic losses**,[2] underlining the central role of hydrological hazards in shaping urban risk.

Riverine floods, pluvial flooding, and coastal storm surges continue to disrupt transport networks, damage housing and public assets, interrupting essential services across European cities. In Central Asia, many urban areas are increasingly exposed to flash floods, mudflows, and glacial lake outburst floods originating in upstream mountainous catchments. These risks are often intensified by rapid urban expansion, soil sealing, ageing drainage systems, and development in flood-prone areas, which amplify both direct damages and long-term recovery costs.

1 Copernicus Climate Change Service & World Meteorological Organization, *European State of the Climate 2024*, (Geneva: WMO, 2025), page 6, https://library.wmo.int/viewer/69475/

2 European Environment Agency (EEA), *Economic losses from weather- and climate-related extremes in Europe*, 2024. https://www.eea.europa.eu/en/analysis/indicators/economic-losses-from-climate-related

In parallel, water scarcity is emerging as a critical urban risk, even in regions historically perceived as water abundant. Prolonged droughts, declining groundwater levels, reduced river flows, and growing competition between urban, agricultural, industrial, and energy uses are straining water supply systems. **In 2023, water scarcity conditions affected approximately 28% of the territory of the European Union and nearly 32% of its population during at least one season**,[3] as measured by the Water Exploitation Index Plus, indicating significant levels of water stress. In the European Union, **droughts are estimated to cost up to €9 billion per year**,[4] due to agricultural losses, disruptions to economic activity, and increasing pressure on public services and infrastructure.

In Central Asia, the impacts of water scarcity are often more acute and closely linked to long-term climatic and hydrological changes. **A widespread drought in 2021 led to water shortages, crop failures, and significant livestock mortality across more than 40% of certain areas of the region**,[5] highlighting the combined effects of prolonged water stress on both rural and urban economies. Changing cryospheric conditions and rising temperatures are further altering seasonal water availability, with long-term implications for cities dependent on transboundary river basins.

Urban water-related risks are rarely isolated. Floods and droughts frequently interact with other hazards, including heatwaves, landslides, and infrastructure failures, creating cascading effects across interconnected urban systems. As cities grow denser and more complex, managing these risks requires a shift away from sectoral and reactive responses toward systemic, risk-informed planning that bridges disaster risk reduction, climate adaptation, water management, and urban development.

Coastal cities in Europe are also increasingly exposed to tsunami risk — a hazard that, while lower in frequency than riverine or pluvial flooding, can have catastrophic and irreversible consequences for urban infrastructure, water systems and public safety. Recent awareness-raising exercises, such as those conducted in Athens and the wider Attica region in March 2026, highlight the growing recognition that tsunami risk must be integrated into urban resilience frameworks, alongside floods and water scarcity. In the Mediterranean basin, where seismic activity creates conditions for tsunamis, coastal cities must consider this hazard within their multi-risk planning approaches, including the protection of critical water infrastructure such as desalination plants, coastal intake systems and wastewater treatment facilities located near shorelines.

3 European Environment Agency (EEA), *Water Scarcity conditions in Europe.* 2025 https://www.eea.europa.eu/en/analysis/indicators/use-of-freshwater-resources-in-europe-1
4 European Commission, *Water scarcity and droughts in the European Union*, 2024. https://environment.ec.europa.eu/topics/water/water-scarcity-and-droughts_en
5 Caspian Policy Center, *Central Asia's future melts away: Water down the drain*, 2021. https://www.caspianpolicy.org/research/environment/central-asias-future-melts-away-water-down-the-drain

Against this backdrop, cities play a pivotal role. Local governments are at the frontline of managing water-related risks through land-use planning, infrastructure investment, emergency preparedness, and community engagement. Across Europe and Central Asia, cities are already implementing a range of approaches combining improved risk knowledge, strengthened governance, structural and nature-based solutions, and early warning systems. However, persistent gaps remain in financing, coordination across scales, long-term planning, and the integration of future climate scenarios into decision-making.

Methodology

In this context, this report has been developed within the framework of the Making Cities Resilient 2030 (MCR2030) initiative to support cities in strengthening disaster risk reduction and climate resilience in line with the Sendai Framework for Disaster Risk Reduction 2015–2030. Focusing on floods and water scarcity at the urban scale, the report reflects experiences and practices emerging across Europe and Central Asia, drawing on a range of city-level engagements, technical inputs and policy frameworks. It synthesizes practical insights, highlights emerging good practices, and identifies common gaps and opportunities related to knowledge, governance, implementation and future resilience pathways.

By documenting how cities are responding to both excess and shortage of water, this report seeks to contribute to risk-informed, and forward-looking urban water management. It is intended as a resource for city officials, practitioners, and partners engaged in water-related disaster risk reduction, climate adaptation, and sustainable urban development, supporting collective efforts to reduce losses, safeguard livelihoods, and strengthen urban resilience in a changing climate.

For this purpose, a questionnaire was developed and shared with the MCR2030 member cities and Regional Coordinating Committee (RCC) members in Europe and Central Asia, receiving responses from 15 cities and partners. These inputs were complemented by targeted interviews and desk-based research. The report examines two key urban water management challenges – flooding and water scarcity – and analyses city responses in line with the MCR2030 Resilience Roadmap, structured around knowledge and data, planning and governance, and implementation. Based on the analysis, the report identifies key gaps and opportunities and formulates recommendations to support city practitioners in advancing the risk-informed and resilient urban water management.

Figure 1: **The MCR2030 Resilience Roadmap: from knowledge and planning to implementation**

Activities along a continuum

Integration across activities to ensure coordination/comprehensive and systematic responses, strategies, and action

Cities Know Better Stage A

Induction and orientation

Key themes and activity areas

1. Spread the message: awareness raising on disaster risk reduction and resilience

Cities Plan Better Stage B

Progression

2. Improving risk analysis
3. Improving diagnostic skills for planning
4. Improving strategies, planning, policies, and responses

Cities Implement Better Stage C

Implementation

5. Increase access to finance
6. Improving the ability to design and build critical resilient infrastructure
7. Developing and scaling of nature-based solutions
8. Improving inclusion
9. Ensuring climate risk is factored into DRR and resilience strategies

Themes that cut across all three stages

10. Increasing national/regional links and alignment with local governments
11. Improving knowledge exchange with city structures and sectors
12. Improving knowledge exchange between cities

Outcomes

Disaster risk reduction and resilience mainstreaming: Horizontal and vertical integration of resilience and sustainability across municipal agencies and departments, as well as within city functions

Impact

Cities improve resilience and are on sustainability pathways to deliver **Sustainable Development Goal 11**

A. Too Much Water: How Cities Are Reducing Flood Impacts Through Integrated Solutions

Flood risk in urban areas is shaped by processes that extend beyond municipal boundaries. Rainfall-runoff dynamics, river behaviour and drainage systems are governed by catchment-scale interactions that connect upstream and downstream territories, rural and urban areas, surface water and underground networks. As a result, effective flood-risk management requires cities to act within hydrological systems that rarely align with administrative borders.

In Europe, this systemic understanding has been progressively embedded in policy frameworks over the past two decades. In the European Union (EU) context for example, the EU Water Framework Directive, adopted in 2000, established river basin districts as the fundamental unit for water management, promoting integrated planning across entire catchments. Subsequent policy instruments, including flood-risk management frameworks, have reinforced this approach by encouraging coordination across sectors, jurisdictions and scales. For cities, this has meant operating within governance structures and planning processes that link local action to basin-wide objectives, while retaining responsibility for urban drainage, land-use planning and emergency response.

Across Europe and Central Asia, urban flood risk is increasingly influenced by a combination of catchment-scale processes and local urban dynamics. Intense rainfall, accelerated runoff from sealed surfaces, constrained drainage capacity and development in flood-prone areas interact with upstream hydrological conditions, often leading to rapid-onset events such as pluvial flooding and flash floods. In many contexts, cities must respond within very short timeframes, where the ability to anticipate, coordinate and act is as critical as the presence of physical protection measures.

In this context, **reducing flood impacts in cities depends on integrated approaches that connect knowledge, governance and implementation across scales.** Reliable risk information, institutional coordination and operational preparedness enable cities to translate basin-level frameworks into effective local action. The following sections examine how cities are strengthening flood resilience through improved data and monitoring, coordinated governance arrangements, and targeted implementation measures, illustrating how urban authorities are navigating the interface between hydrological systems and administrative responsibilities.

A.1 Knowledge & Data

Effective flood-risk management in urban areas relies on the availability and use of reliable, spatially explicit and actionable information. Across Europe and Central Asia, cities increasingly recognize that understanding where floods may occur, how water moves through urban systems, and which assets and populations are exposed is a prerequisite for informed planning, preparedness and early action.

Over recent decades, urban expansion has significantly increased exposure to flood risk, particularly where development has taken place along rivers, in low-lying areas, or within fast-responding catchments. In this context, strengthening the knowledge base for flood risk has become a strategic enabler of urban resilience, supporting the transition from reactive emergency response to more anticipatory and risk-informed approaches.

Across the region, cities are progressively moving beyond basic hazard awareness towards integrated flood-risk analysis, combining hydrological and hydraulic modelling, flood hazard and risk mapping, and the systematic integration of exposure and vulnerability data. In the EU, the Floods Directive (2007/60/EC) has played a central role in institutionalizing this approach, requiring Member States to carry out preliminary flood-risk assessments, develop flood hazard and risk maps, and prepare flood-risk management plans at river-basin scale. These processes have supported the wider adoption of modelling tools and spatial analysis to inform land-use planning, infrastructure design and emergency preparedness at the local level.

In Central Asia, urban flood-risk assessments increasingly highlight the influence of upstream hydrometeorological processes, including intense rainfall, snowmelt and glacial dynamics. For cities located downstream of mountainous catchments, this underscores the importance of linking urban flood-risk knowledge with catchment-scale processes, rather than treating cities as isolated systems.

Risk knowledge becomes most effective when it is connected to monitoring, early warning and operational decision-making. Many cities are therefore strengthening hydrometeorological monitoring networks and integrating real-time data into early-warning systems and predefined response procedures. At the same time, digital tools such as geographic information systems, high-resolution terrain models, sensor networks and emerging AI-based applications are expanding cities' capacity to analyse flood dynamics, identify system bottlenecks and support both strategic planning and day-to-day operations.

Taken together, these developments illustrate a shared regional trajectory: robust flood-risk knowledge forms the first step of the urban resilience roadmap. A trusted and well-used evidence base enables more coherent governance, better-targeted investments and more effective early-warning systems. The case studies presented below illustrate how cities across Europe and Central Asia are translating data, modelling and monitoring into practical tools for flood-risk management, while also highlighting remaining challenges related to data coverage, integration and long-term operational use.

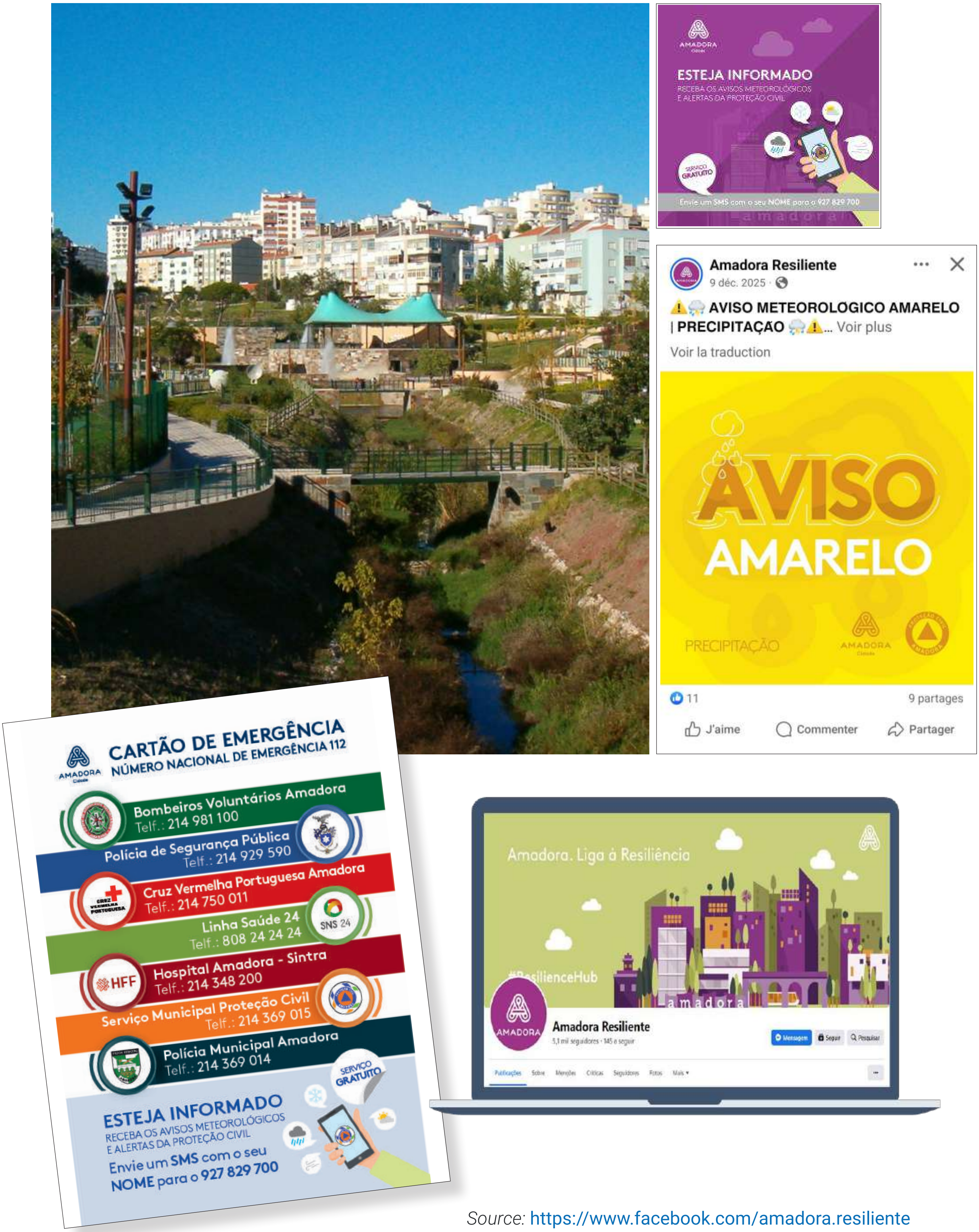
Amadora, Portugal: Strengthening early-warning systems and risk mapping at municipal scale

Amadora has operated a local early-warning system since 2016, demonstrating a sustained commitment to strengthening the knowledge base for flood risk. In 2024, the city issued 24 flood warnings, disseminated through SMS alerts and complemented by updates shared via the municipality's official communication channels, including its dedicated Facebook page, to support rapid communication with exposed populations.

The warning system combines municipal-level observations with meteorological information provided by the national weather service, using predefined thresholds to trigger alerts and response procedures. This integration ensures consistency between national forecasts and local decision-making, while allowing warnings to be tailored to municipal risk conditions.

Flood-risk maps, prepared at municipal scale and embedded in the Municipal Emergency Plan, guide the interpretation of warning information and support preparedness, prevention and response. By linking risk mapping with a functioning multi-channel alert system, Amadora ensures that flood-risk knowledge is not only documented but actively used in emergency operations and public communication.

Figure 2: **Early-warning communication materials supporting flood preparedness in Amadora**



Source: https://www.facebook.com/amadora.resiliente

Barcelona, Spain: Operating a real-time control centre for drainage and coastal monitoring

Barcelona has established a comprehensive control centre, managed by *Barcelona Cicle De l'Aigua* SA (BCASA), that integrates several dimensions of water management, including drainage, coastal surveillance and flood-related early warning.[6] The system oversees 15 stormwater retention tanks with a combined capacity of 477,020 m³, which help manage runoff during heavy rainfall.

The control centre receives real-time information on the state of the drainage network, rainfall intensity, and water levels in key infrastructure. Operators can optimize storage, pumping, and flow regulation throughout rainfall events. By bringing together data streams, Barcelona can maintain an updated picture of hydrological dynamics and anticipate situations in which drainage capacity may be exceeded.

In addition to managing urban runoff, the system integrates early-warning information for the Besòs River and monitoring of coastal conditions, supporting decisions related to beach management and public safety. The combination of surface-water management, coastal dynamics and infrastructure monitoring illustrates how comprehensive information systems can support operational coordination across different municipal services.

Barcelona has a platform to provide alerts for any incident that may occur in the city: *Barcelona in your pocket*. This mobile application makes it easy to quickly alert the population and to follow the instructions issued by the civil protection authorities in the event of any incident.

https://www.barcelona.cat/bcnalabutxaca/en

6 Pla d'emergència fluvial - River basin and flood emergency management. https://parcs.diba.cat/ca/web/fluvial/la-gestio/pla-d-emergencia

Figure 3: **Extracts from BCASA's *Memòria de Sostenibilitat 2023* illustrating urban drainage and coastal monitoring systems in Barcelona**

5 Treballem pel medi ambient

5.2. El centre de control del cicle de l'aigua

BCASA compta amb un Centre de Control a través del qual es realitza l'explotació centralitzada dels diferents àmbits del cicle de l'aigua: clavegueram, aprofitament d'aigües subterrànies, platges, fonts i sistema d'alerta del Parc Fluvial del Besòs.

El sistema de telegestió rep informació en temps real sobre el funcionament de les diferents instal·lacions i serveis, cosa que **permet actuar de manera immediata anticipant-se als possibles problemes, i garantir així una gestió més eficient dels serveis i recursos.** Una de les altres funcions és preveure, informar i coordinar les alertes i emergències relacionades amb el cicle de l'aigua que poden implicar l'activació de protocols d'avís i protecció cap a la ciutadania.

El seguiment del sistema de drenatge

El sistema de control supervisa diferents variables del sistema de drenatge i clavegueram, com els nivells d'aigua de la xarxa, la qualitat de l'aigua i l'estat de les estacions de bombament, les comportes i els dipòsits. **La gestió completa i coordinada en temps real permet implementar diferents estratègies operacionals en episodis de pluja.**

La gestió del clavegueram està basada en una regulació hidràulica que permet modificar els cabals que circulen per la xarxa. Aquestes modificacions es fan, per exemple, distribuint els cabals punta cap a les àrees amb més capacitat, de manera que es fa un aprofitament òptim de les capacitats de la xarxa i es minimitzen inundacions i abocaments del sistema unitari al medi receptor en temps de pluja.

Totes aquestes actuacions permeten portar a terme una gestió intel·ligent del conjunt de la xarxa de drenatge, amb l'aplicació de noves eines tecnològiques i la realització de projectes innovadors que en milloren progressivament la capacitat de regulació.

Ajuntament de Barcelona

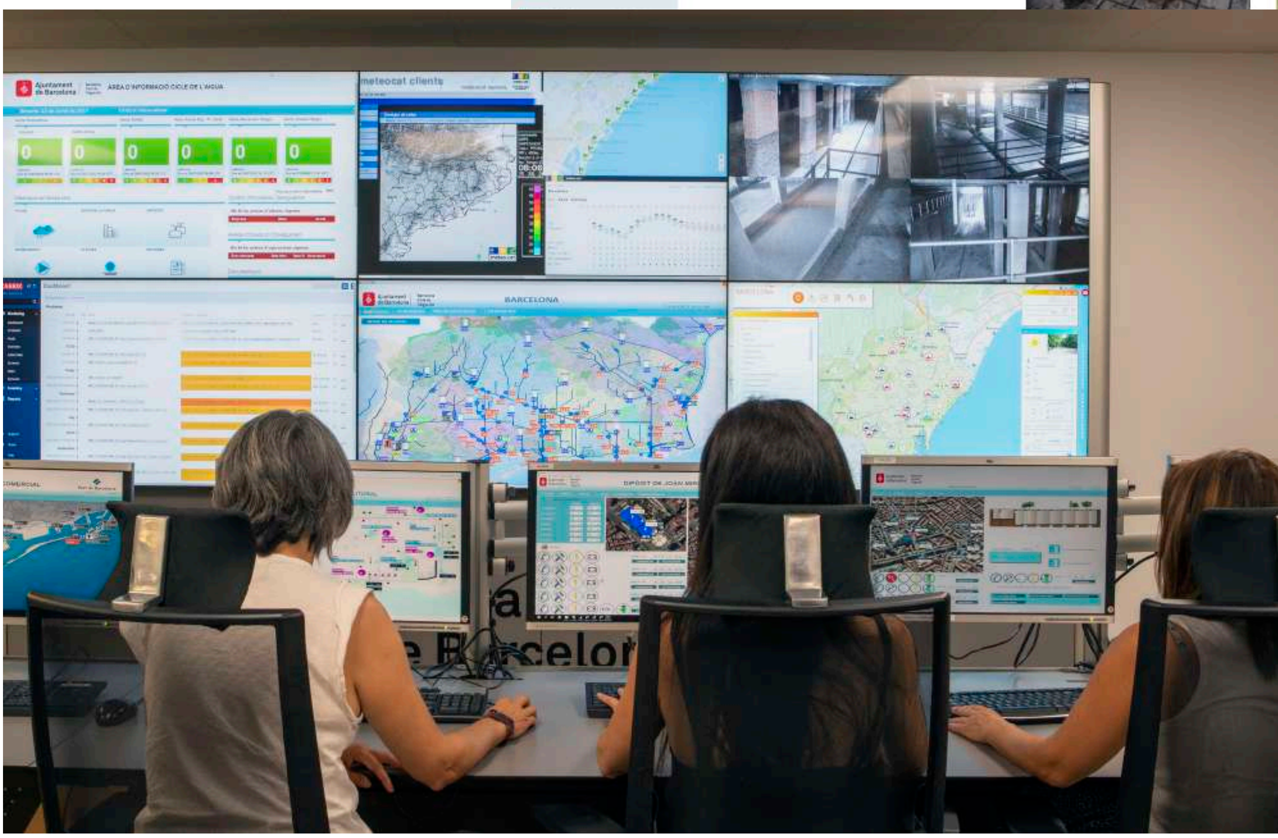
7 Informació transparent per a la comunitat

Coneixedors que la ciutadania té dret a accedir a la informació, l'estratègia comunicativa de l'Ajuntament de Barcelona s'emmarca en diferents accions concretes de sensibilització i comunicació a la ciutadania per a la consolidació d'una cultura de l'aigua basada en l'eficiència i l'estalvi, així com la consideració de l'aigua com un bé comú. I es treballa en base a cinc línies estratègiques:

- Difondre mesures preventives d'estalvi i eficiència en la gestió dels recursos per avançar cap a una ciutat resilient.
- Informar proactivament de les afectacions i talls en els subministraments de l'aigua i acompanyar a la ciutadania en les situacions de restricció, per minimitzar les molèsties i incerteses i facilitar la màxima col·laboració ciutadana.
- Diferenciació d'objectius conductuals per fases:
  - Prealerta: Informació-Motivació
  - Alerta: Cooperació
  - Excepcionalitat, Preemergència i Emergència: Acció.
- Implicar a la ciutadania en la cultura de l'estalvi i l'ús racional d'aigua en benefici de tothom.
- Governança compartida: Generalitat de Catalunya, AMB i Ajuntament de Barcelona.

Source: https://www.bcasa.cat/PDF/Mem_Sostenibilitat_2023.pdf

Figure 4: **BCASA control centre**



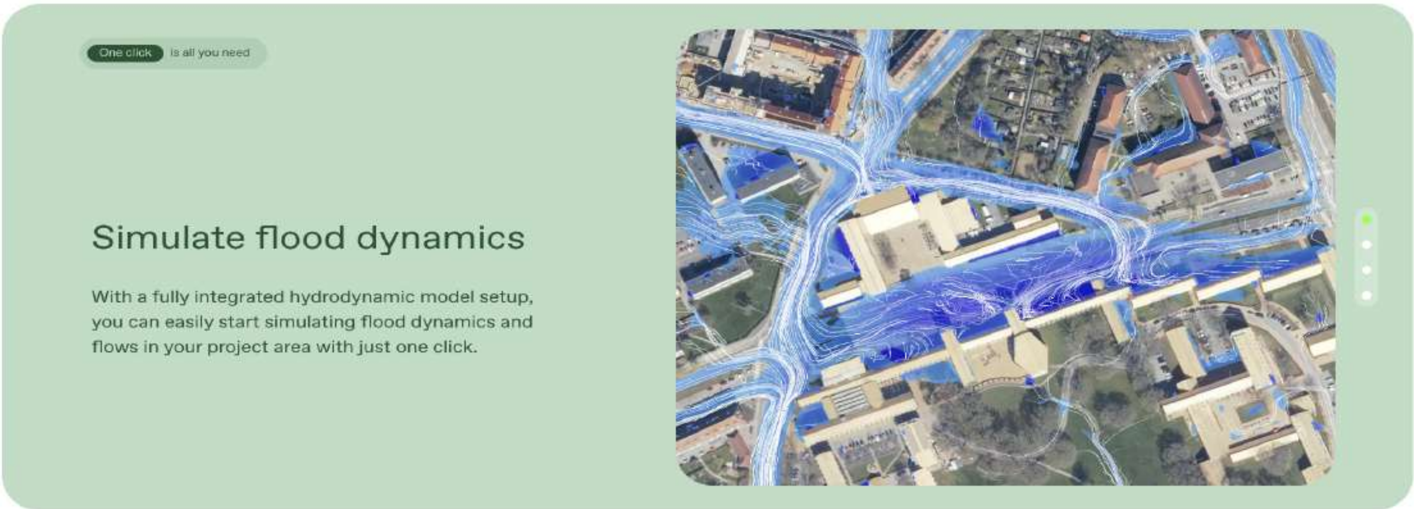
Source: Jorge Yaregui, Barcelona Cicle de l'Aigua SA

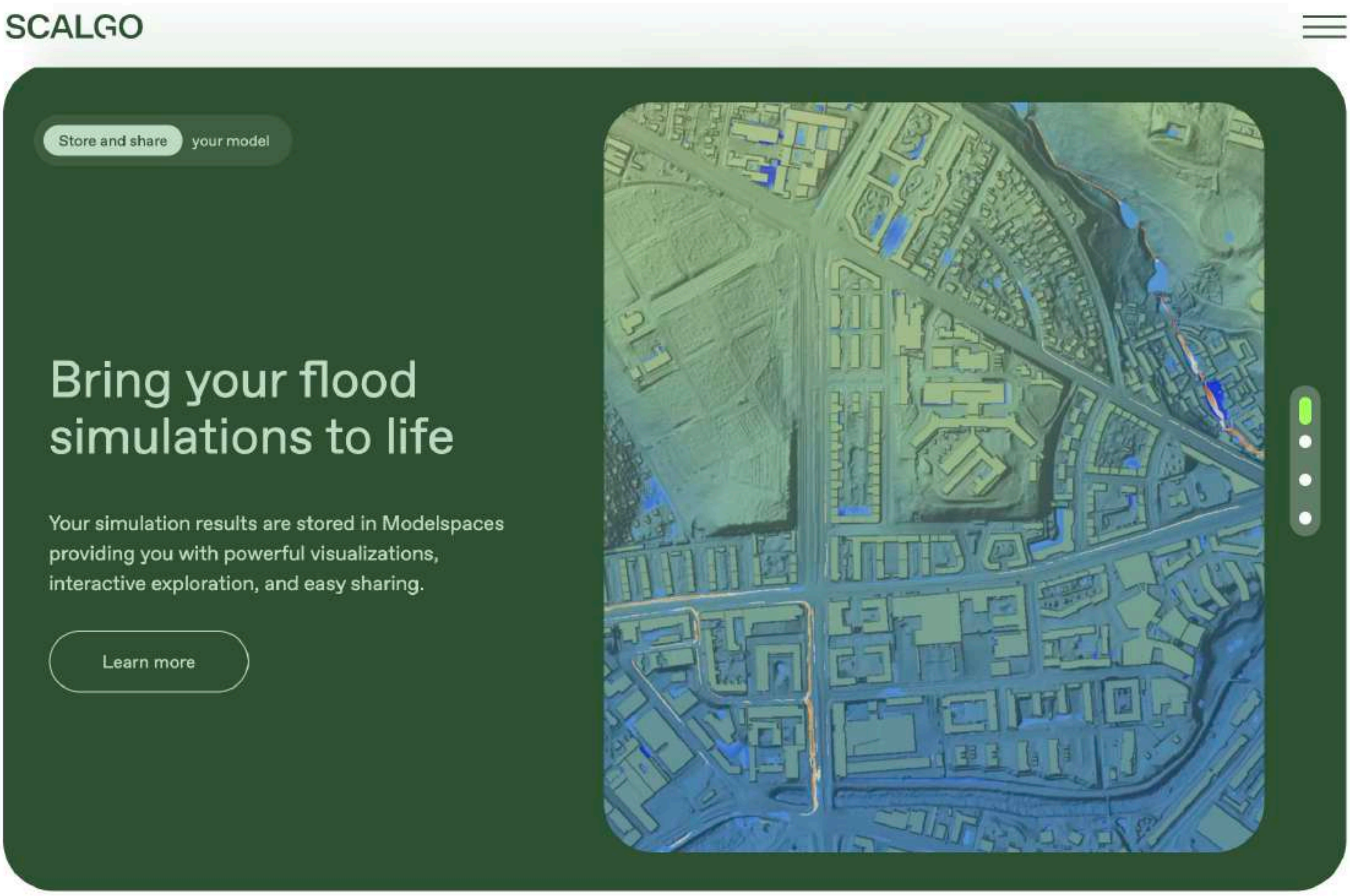
Lviv, Ukraine: Advancing digital mapping and sensor-based monitoring

Lviv has taken significant steps to improve its knowledge of flood risk by combining digital mapping tools with emerging technologies for network monitoring. Through cooperation with the city of Aarhus (Denmark) and the use of the Scalgo platform, Lviv developed a digital flood-risk map that identifies areas where rainfall-driven runoff accumulates and where localized flooding may occur. This mapping exercise supports both planning and prioritization of interventions by providing a detailed understanding of the dynamics of surface-water flows within the city.

Together, the mapping platform and the sensor network contribute to a more complete evidence base on flood dynamics. They also illustrate the potential of digital technologies to support risk monitoring in cities where traditional hydrometric networks may be limited.

Figure 5: Digital hydrodynamic modelling for urban flood-risk mapping: the Scalgo platform





Source: https://scalgo.com/en-US/core-plus-products/coreplus-dynamicflood

Milan, Italy: Using hydrodynamic modelling and real-time monitoring to inform action

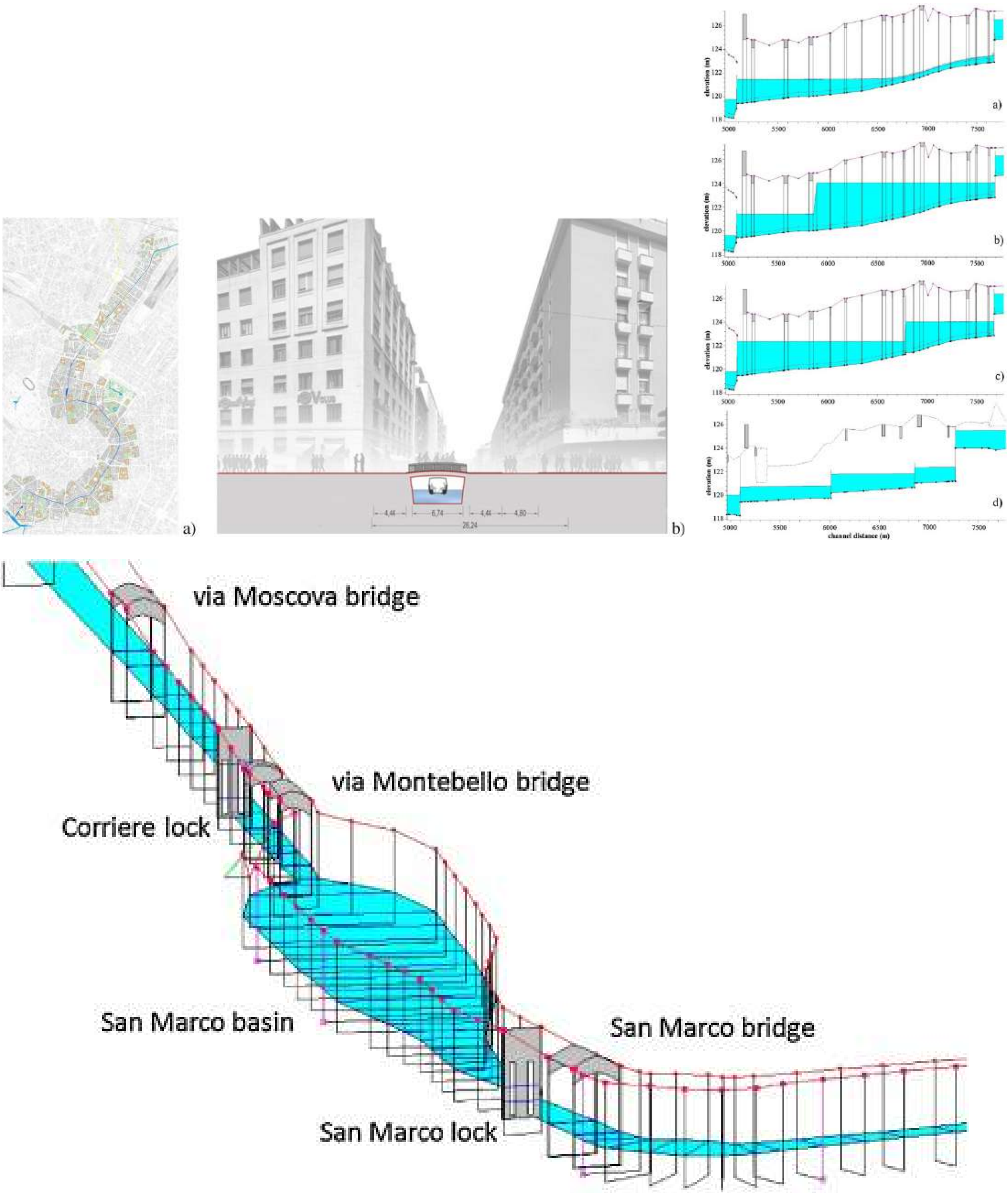
Milan has developed an integrated approach to flood-risk information that brings together hydrodynamic modelling, hazard mapping, and real-time monitoring. This framework provides a coherent understanding of the city's waterways, including those that flow underground.

Milan's technical teams apply advanced 1D and 2D hydraulic models to rivers, streams, and culverted sections.[7] These simulations generate flood maps for several return periods, from 10 to 500 years, and classify hazard levels across the territory. The results are consolidated into a city-wide flood hazard map that serves as a reference for land-use planning, infrastructure design reviews, and civil-protection preparedness. The integration of culverted channels is particularly relevant in a dense and historically modified urban environment, as these underground structures often create significant reductions in flow capacity and can become critical points of constraint during extreme rainfall.

The modelling work is complemented by a real-time monitoring network that measure rainfall and river levels at key locations. The data transmitted to municipal services allows them to track evolving hydrological conditions and to identify early signals of stress within the system. These observations are directly linked to the city's early-warning mechanism, which activates predefined alert levels and operational procedures. In this way, Milan ensures that knowledge is continuously updated and used to support operational decisions, from preventive interventions to the mobilization of civil-protection teams.

[7] Sibilla, S., Sciandra, M. C., Rosso, R., & Lamera, C. (2017). Hydraulic approach to Navigli canal daylighting in Milan, Italy. Sustainable Cities and Society, 32, 247–262. https://doi.org/10.1016/j.scs.2017.03.017

Figure 6: **Hydraulic modelling of culverted channels and flood dynamics in Milan**



Source: https://www.sciencedirect.com/science/article/abs/pii/S2210670716304486

Kyrgyz Republic: Real-time monitoring to support early warning

In the Kyrgyz Republic, early-warning capacities have been strengthened through the expansion of hydrometeorological monitoring and the integration of real-time data into national and local decision-making. Supported by the United Nations Development Programme, the system focuses on hazards that frequently affect the country's mountainous regions, including floods, flash floods, and mudflows.[8] Automated rain gauges, river-level sensors, and meteorological stations provide continuous observations that help detect rapid rises in water levels and intense precipitation.

These data are transmitted to the Hydrometeorological Service and the Ministry of Emergency Situations, where they are analysed against predefined thresholds. When conditions indicate a potential flood or mudflow, alerts are disseminated through SMS, sirens, and local communication networks. Training for municipal authorities and communities supports the effective interpretation and use of warning information. By improving the timeliness and reliability of hydrometeorological data, the system enhances anticipatory action in a highly dynamic environment.

8 United Nations Development Programme (UNDP) (2023). *Early warning system in the Kyrgyz Republic: real-time risk monitoring.* https://www.undp.org/kyrgyzstan/stories/early-warning-system-kyrgyz-republic-real-time-risk-monitoring

Figure 7: **Daurbek Sakyev, Director of the Department of Monitoring and Forecasting at the Kyrgyz Ministry of Emergency Situations. In Kyrgyzstan there are over 2,000 high-altitude lakes, of which 368 are recognised as potentially hazardous**

Source: https://www.undp.org/kyrgyzstan/stories/early-warning-system-kyrgyz-republic-real-time-risk-monitoring

Astana, Kazakhstan: Academic–municipal collaboration to strengthen flood-risk knowledge

Astana illustrates how collaboration between municipal actors and academic institutions can strengthen flood-risk knowledge and data-driven preparedness. The city has supported an applied flood-risk programme developed with Astana IT University, which focuses on hydrological analysis, digital modelling, and the use of real-time data to improve understanding of urban flood dynamics. The initiative brings together hydrometeorological information, hydraulic modelling and geospatial analysis to support flood-risk assessment, scenario analysis, and early-warning functions at city scale.[9]

Figure 8: Examples of how the activities of Astana IT University support flood-risk monitoring, knowledge sharing and international cooperation

Source: https://flood.astanait.edu.kz/news

[9] Flood Risk Modelling and Forecasting Programme, Astana IT University: https://flood.astanait.edu.kz/program

A.2 Governance

Effective flood-risk management in cities depends not only on technical knowledge and data, but also on **governance that shapes how decisions are made, responsibilities are allocated, and actions are coordinated**. As flood risk increasingly cuts across administrative boundaries, sectors and time horizons, governance enables coherent and timely responses, including using financial incentives that help steer behaviour, prioritize action and support preventive investment.

Across Europe and Central Asia, urban flood governance involves a wide range of actors, including local authorities, regional and national institutions, water utilities, emergency services and infrastructure operators. In many contexts, cities operate within multi-level governance frameworks, where responsibilities for planning, investment, operation, and emergency response are distributed across institutions. The effectiveness of flood-risk management therefore depends on the clarity of roles, the quality of coordination mechanisms, and the ability to align sectoral policies, regulatory frameworks and investment priorities, supported where appropriate by targeted financial incentives.

Governance arrangements play a critical role in supporting urban flood resilience, building on institutional coordination, policy integration, and decision-making processes at the city level. Each city context is unique, but all organize collaboration across departments and sectors, embed flood risk into urban planning and infrastructure management, and deploy regulatory instruments to link long-term risk reduction with emergency preparedness.

It is important to underline the importance of governance arrangements that can accommodate the rapid onset of flood events, particularly flash floods, while maintaining continuity with longer-term planning and investment cycles. In this context, adaptive, inclusive and participatory governance mechanisms, combined with enabling financial frameworks, play a critical role in strengthening the effective use of risk information, accelerating the mobilization of resources and ensuring that flood-risk reduction measures are understood, accepted and supported by local communities.

The case studies presented in this section illustrate how cities are addressing these governance challenges in practice, highlighting different institutional models, coordination approaches and policy tools, including financial incentives, that contribute to more resilient urban flood management.

Amadora, Portugal: Institutionalizing roles and citizen engagement through the Municipal Emergency Plan

Amadora demonstrates how municipal emergency planning can serve as an enabling governance framework for urban flood-risk reduction. Flood-risk considerations are embedded within the Municipal Emergency Plan, which establishes clear roles, responsibilities and coordination mechanisms for preparedness, response and recovery, ensuring continuity between day-to-day management and crisis situations.

Within this framework, citizen engagement is treated as a core component of prevention and preparedness, rather than as a separate or ad hoc activity. Building on its long-term participation in international resilience initiatives, the municipality has put in place coordination structures that link civil protection services, municipal departments and community-facing actors to support sustained engagement with residents.

Participation is operationalized through structured and recurring actions, including public awareness activities, training sessions, school-based programmes and neighbourhood-level outreach. These measures aim to strengthen risk awareness, promote protective behaviors and ensure that residents in flood-prone areas are informed and prepared, in coordination with local councils and social institutions.

By embedding citizen-oriented prevention and preparedness actions within formal planning and governance instruments, Amadora reinforces shared responsibility for flood-risk reduction. This approach supports a sustained culture of prevention and complements institutional coordination, contributing to more effective, inclusive and risk-informed urban flood governance.

Figure 9: **Civil protection awareness and preparedness activities in Amadora**

Source: Local Strategy For Resilience presentation – Municipality of Amadora

Potenza, Italy: Coordinating technical and emergency functions in a mountainous context

Flood-risk governance in Potenza is supported by close collaboration between municipal engineering services and civil-protection authorities. Updated hazard and risk maps provide a shared reference framework for land-use planning, infrastructure management and emergency protocols. These instruments help align technical assessments with regulatory and operational decisions, ensuring consistency across planning and response functions.

Regular coordination between technical units enables a shared interpretation of rainfall forecasts, river behaviour and slope conditions, supporting more coherent decision-making during periods of heightened risk. This governance arrangement facilitates timely prioritization of interventions, mobilisation of resources, and coordination of actions across municipal departments and emergency services.

Academic work conducted in the Basilicata region further highlights the potential role of citizen-oriented risk communication tools in strengthening awareness, preparedness, and self-protection in flood- and landslide-prone contexts. Such approaches can complement institutional governance by supporting a shared understanding of risk and reinforcing preventive behaviours, particularly alongside structural measures.[10]

[10] Albano, R., Mancusi, L., Sole, A., Adamowski, J., & Sivakumar, B. (2015). *READY: A web-based geographical information system for enhanced flood resilience through raising awareness in citizens*. Natural Hazards and Earth System Sciences, 15, 1645–1660. https://doi.org/10.5194/nhess-15-1645-2015

Lviv, Ukraine: Governance supported by dedicated environmental and utility structures

Lviv illustrates how institutional structures, international cooperation, and participatory processes can jointly strengthen urban resilience. Flood-risk governance is supported by the establishment of an Environment Status Control Office within the municipal water utility, which provides a formal mechanism to integrate environmental considerations into water management, planning and emergency preparedness. This structure facilitates coordination across operational services and strategic planning functions.

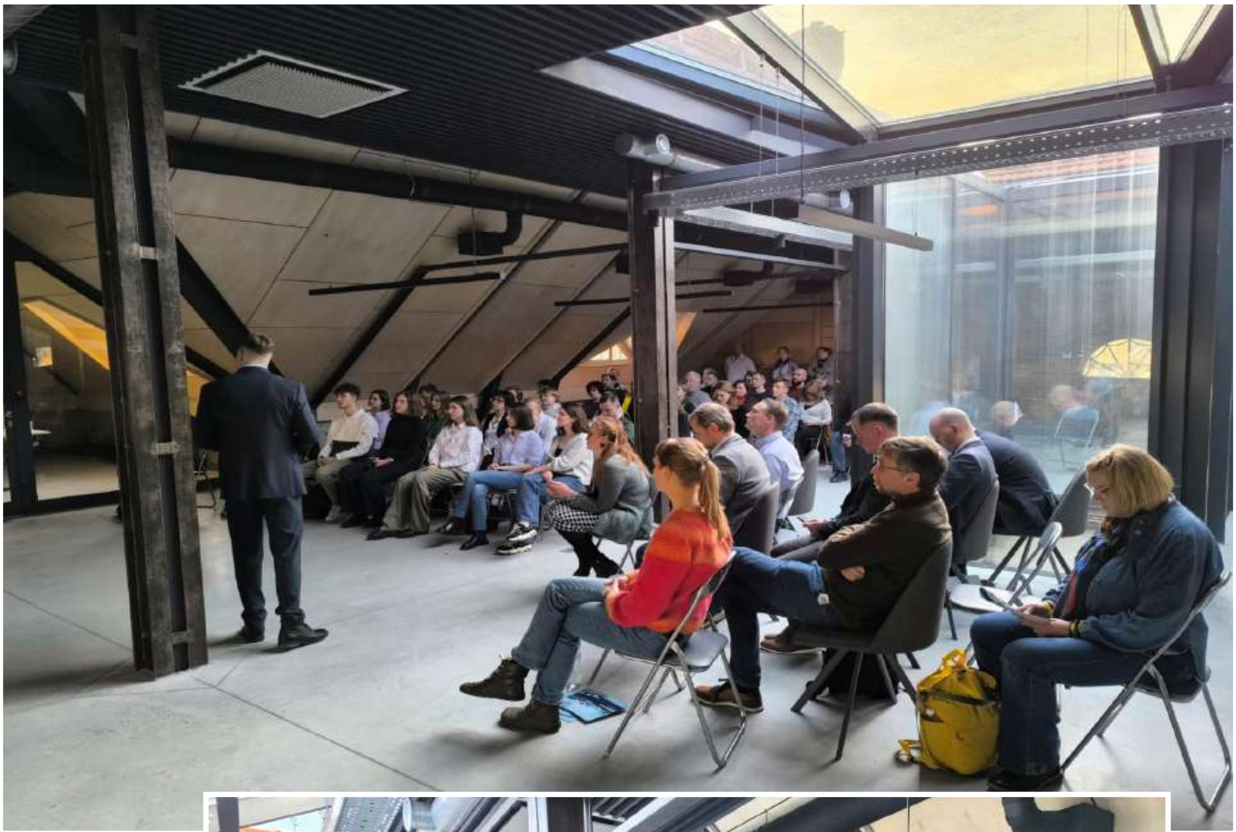
Governance is further advanced through the development of the *Lviv 2100: Water Vision*, which provides a shared framework for guiding water-related decisions in the context of climate change and urban development. The vision is being developed through sustained cooperation with the City of Aarhus (Denmark) and its water utility, drawing on Aarhus' experience in integrated water planning and climate adaptation. The programme is supported by an indicative budget of approximately €4 million, reflecting a dedicated institutional investment in future-oriented water governance.

The development of the Lviv 2100 Water Vision is supported by academic partnerships, including collaboration with Ivan Franko National University of Lviv, which contributes scientific expertise on hydrology, climate trends and urban infrastructure. These partnerships strengthen the evidence base for policy choices and help align governance decisions with evolving risk conditions.

Beyond technical coordination, Lviv is also exploring participatory governance mechanisms at a metropolitan scale. The launch of a Citizens' Assembly process in the Lviv agglomeration,[11] supported by the Council of Europe, aims to strengthen dialogue between public authorities, experts and residents on key urban challenges. While not sector-specific, such processes create enabling conditions for integrating citizen perspectives into policy discussions, reinforcing transparency, trust and shared responsibility within urban resilience governance.

[11] Council of Europe (2024). *Stakeholders' forum kicks off preparations for the Citizens' Assembly in the Lviv agglomeration*. Council of Europe Office in Kyiv. Available at: https://www.coe.int/en/web/kyiv/-/stakeholders-forum-kicks-off-preparations-for-the-citizens-assembly-in-the-lviv-agglomeration

Figure 10: **Presentation of Lviv's Water Vision 2100**



Source: https://www.linkedin.com/posts/eco-water-lviv_ecowaterlviv-lvivcommunity-activity-7304879899092123648-E7Sl/

Greater Manchester, United Kingdom: Multi-agency governance at metropolitan scale

Greater Manchester provides an example of metropolitan-scale flood-risk governance structured around formal multi-agency coordination mechanisms. Responsibility for flood risk is shared across several organisations. Under the Flood and Water Management Act 2010 designated Risk Management Authorities each hold defined responsibilities and a statutory duty to co-operate and share data.

Emergency preparedness for flooding in Greater Manchester is coordinated through the Local Resilience Forum, a statutory partnership that brings together local authorities, emergency services, utilities, infrastructure operators and public agencies to oversee emergency planning and ensure coherent multi-agency response arrangements are in place across the city-region.

Governance arrangements are supported by strategic and district-level flood plans, which align spatial planning, infrastructure management, and emergency protocols across multiple jurisdictions. Regular joint exercises and coordination activities help maintain operational readiness and reinforce a shared understanding of risk amongst participating organisations.

Citizen engagement is built into the governance framework through community preparedness activities, clear public communication, and collaboration with voluntary and community organisations, particularly those supporting vulnerable groups. This approach shows how metropolitan governance can link institutional coordination with community-level participation to deliver more inclusive and coherent flood-risk management.

Sîngera, Moldova: Building governance capacity through targeted risk assessments

Sîngera illustrates how a small municipality can strengthen flood-risk governance by improving its understanding and management of the sewer network. The city carried out detailed assessments of its wastewater system to identify structural weaknesses, capacity constraints and locations prone to surcharge during heavy rainfall events.

These assessments provided a shared technical reference for municipal services and helped clarify responsibilities for operation and maintenance of the sewer system. They also informed the prioritization of interventions and supported more structured planning of upgrades and routine works.

Sîngera allocates approximately 15% of its annual municipal budget to water management, including flood-related measures. This dedicated budgetary allocation strengthens governance capacity by enabling predictable planning, improving coordination between maintenance and emergency response, and supporting requests for technical or financial assistance from higher-level authorities.

Paris: Risk-informed monitoring and anticipatory sewer governance[12]

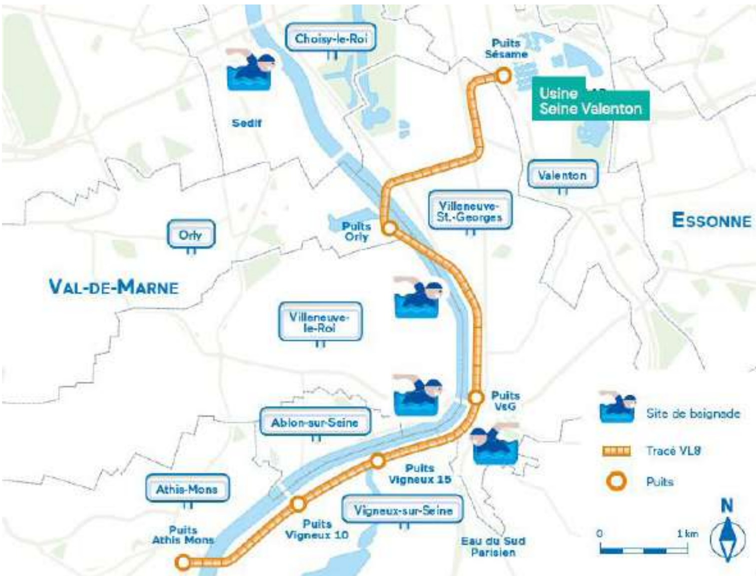
Several European cities are strengthening disaster risk reduction through integrated monitoring and anticipatory management of urban drainage systems. In Paris, the MAGES (*Modélisation et Anticipation pour la Gestion des Eaux de Surverse*/Modelling and Forecasting for Stormwater Management) project, developed by SIAAP (*Syndicat Interdépartemental pour l'Assainissement de l'Agglomération Parisienne*/ Interdepartmental Syndicate for Sanitation in the Paris Metropolitan Area), illustrates how real-time data and forecasting can be embedded into sewer system governance to reduce pluvial flood risk.

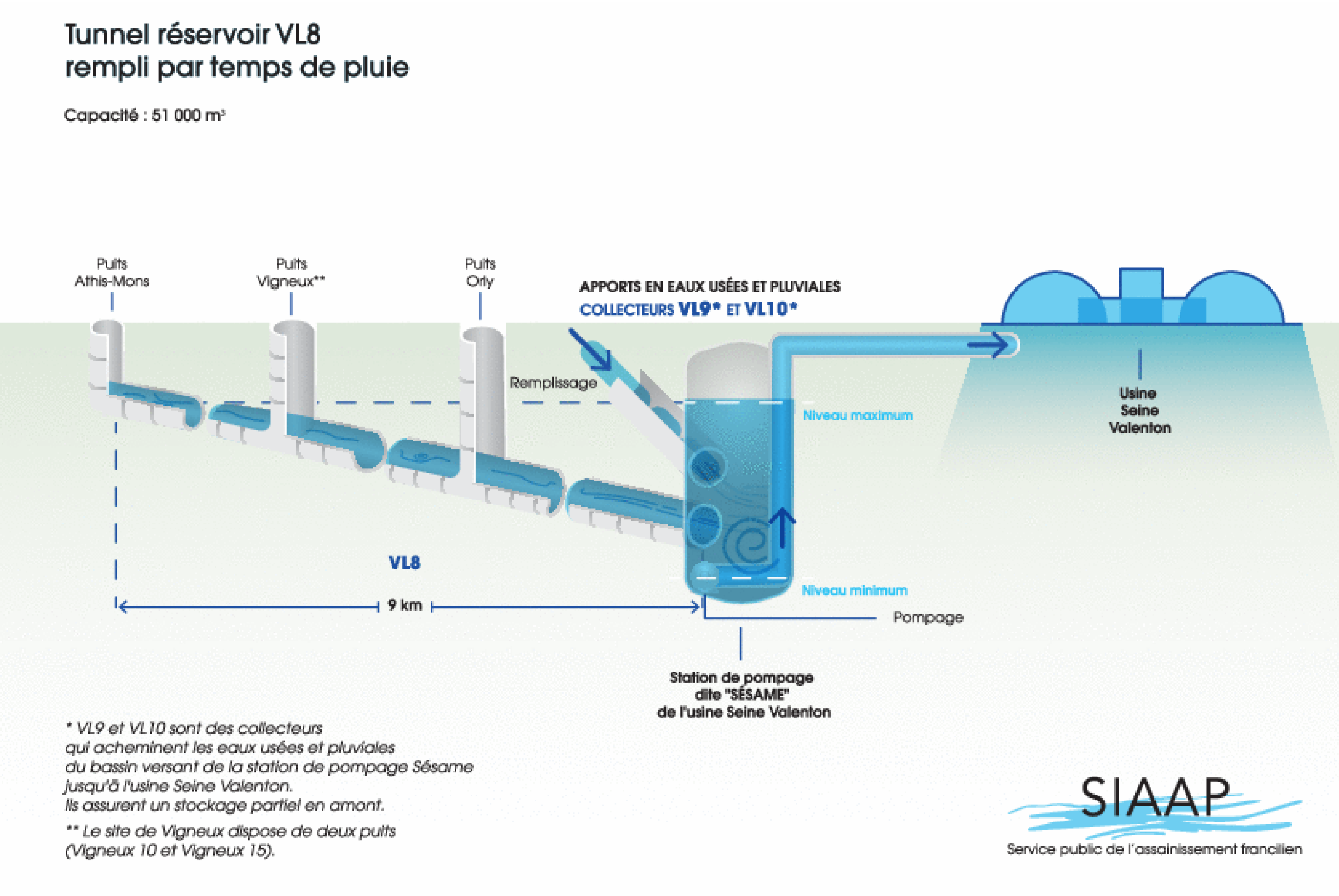
MAGES links hydrological and hydraulic monitoring of the sewer network with short-term rainfall forecasts from Météo-France, enabling operators to anticipate inflows, assess available storage capacity, and take proactive decisions ahead of rainfall events. This risk-informed approach supports early flow routing, storage and treatment actions, reducing sewer surcharging, uncontrolled overflows and downstream flooding.

By managing the sewer network as a dynamic system rather than a fixed asset, the initiative strengthens both operational decision-making and longer-term infrastructure planning, while contributing to improved water quality outcomes. It demonstrates how closer integration between urban drainage governance and meteorological services can support anticipatory risk management at city scale.

12 SIAAP – Syndicat Interdépartemental pour l'Assainissement de l'Agglomération Parisienne (2024). *VL8 network: large-scale wastewater conveyance infrastructure.* https://www.siaap.fr/equipements/le-reseau/tout-savoir-sur-le-vl8/

Figure 11: Map, cross-section and photo of the VL8 tunnel, a strategic component of Paris's drainage system used to manage stormwater flows during extreme rainfall





Source: https://www.siaap.fr/equipements/le-reseau/tout-savoir-sur-le-vl8/

Copenhagen: Governance levers for pluvial flood risk reduction[13]

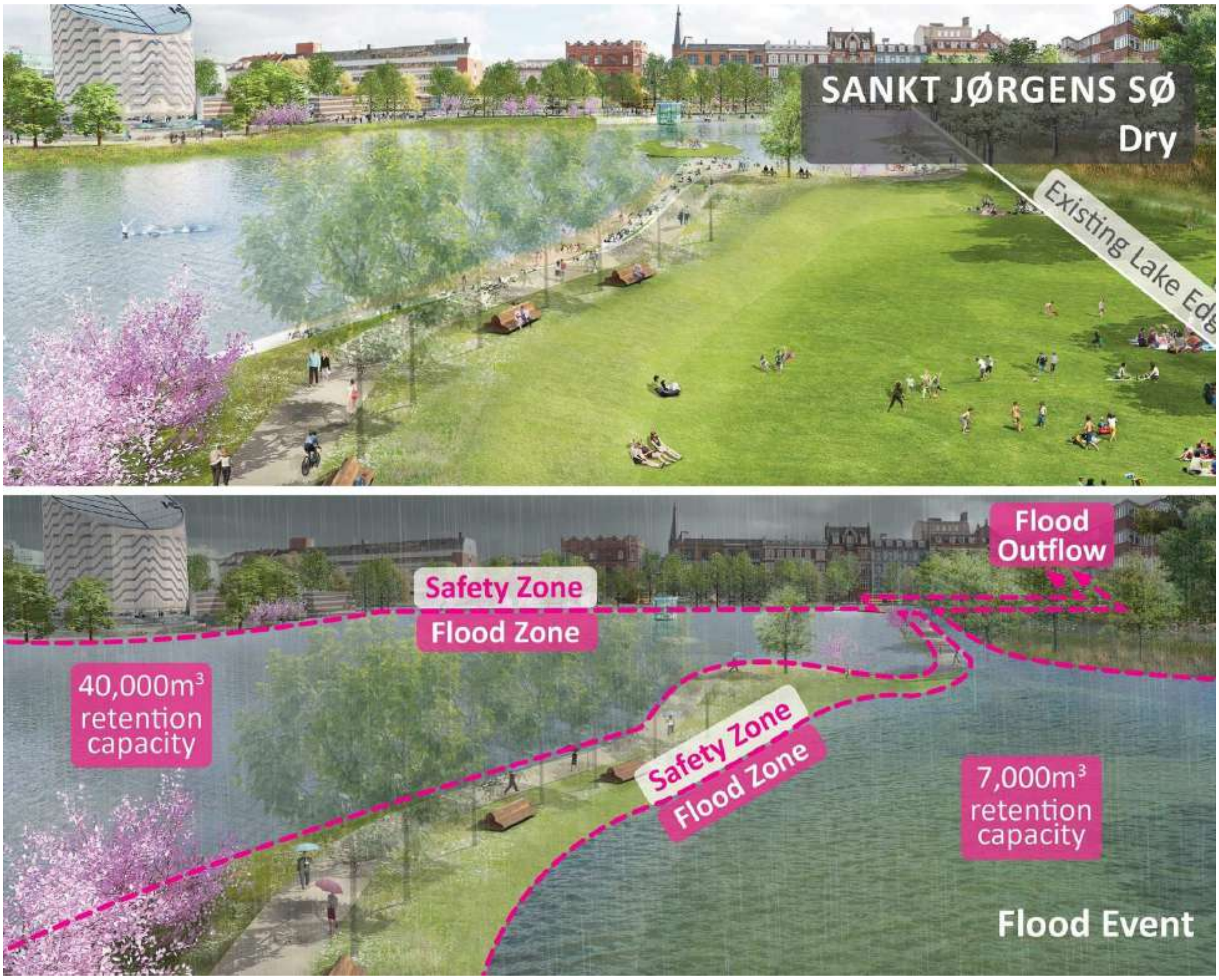
Following severe cloudburst events, including the 2011 storm that caused an estimated DKK 5–6 billion (€700–800 million) in damages in a single day, Copenhagen adopted its Cloudburst Management Plan in 2012. The plan sets out a 20-year investment programme, estimated at DKK 3.8 billion (€500 million, 2012 prices), providing a stable governance framework to systematically reduce pluvial flood risk.

The strategy is grounded in risk-informed planning, using flood mapping and loss assessments to define design thresholds that guide prioritization and investment decisions. A central feature is its catchment-based, multi-actor governance model, jointly implemented by municipalities, utility operators and neighbouring authorities, aligning governance with hydrological systems rather than administrative boundaries.

Through a mixed financing model and a strong emphasis on blue-green and multifunctional solutions, complemented where necessary by underground infrastructure, the plan supports a shift towards living with flood risk while enhancing urban resilience, climate adaptation and liveability. Emergency preparedness measures are maintained throughout phased implementation, ensuring continuity of protection as long-term measures are delivered.

[13] Presentation from Stefan Werner, Urban Planner from Copenhagen, 2022. https://www.iflaeurope.eu/assets/docs/Stefan_WERNER.pdf

Figure 12: **Various aspects of landscape management embodied in Copenhagen's Cloudburst Management Plan**



SØNDER BOULEVARD

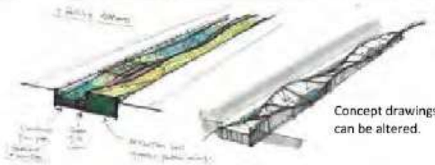
LADEGÅRDSÅ, FREDERIKSBERG EAST & VESTERBRO

Under dry weather conditions the road function as a green recreational park.

Plan of Sønder Boulevard

During everyday rain runoff infiltrate to drainage layers where excess stormwater is conveyed out of the area.

During cloudburst large volumes of water can be conveyed in the surface.



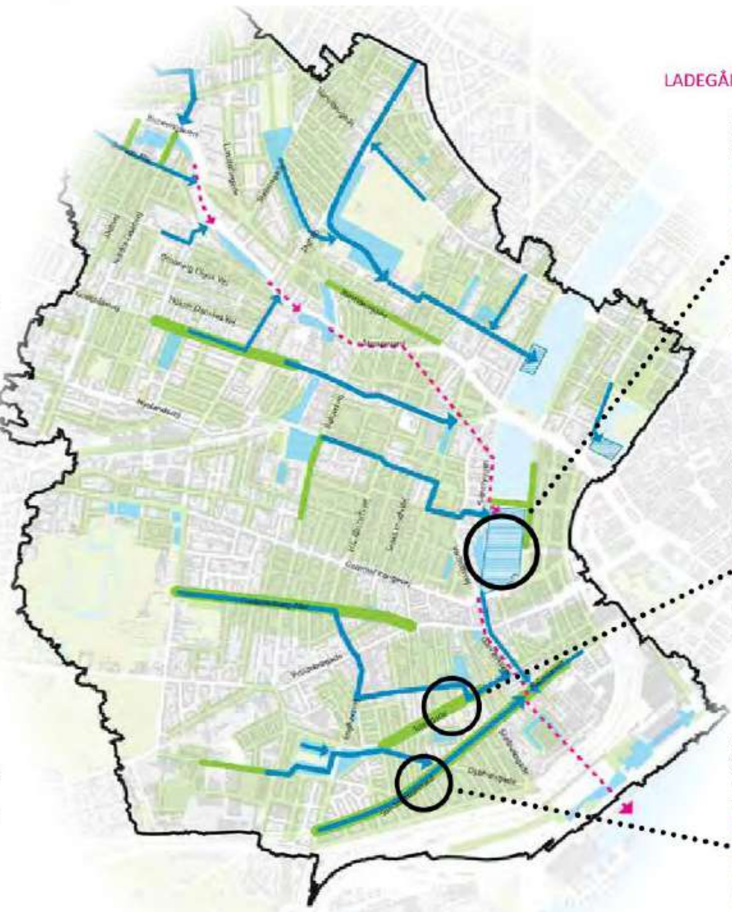
Concept drawings illustrating how the terrain can be altered.

DESCRIPTION

The masterplan are developed based on a principle made up of 4 overall elements:

- Cloudburst roads conveying water towards recipients through v-profile, super profile, trenches or hollow sidewalks. Many cloudburst roads are supplemented with separate stormwater piping for everyday rain.
- Detention roads and green roads detaining water before conveyance to cloudburst roads. Detention through roadbeds, permeable paving, road bumps or in trenches with weirs.
- Central detention detaining water in plazas or parks in order to reduce capacity and sizes of downstream cloudburst roads to reduce effect on especially accessibility and parking.
- Cloudburst piping conveying water on traditionally.

The cloudburst roads will by an large be designed to collect everyday rain as well as to convey cloudburst water. Roofs and roads with below 5000 annual daily cars will sought disconnected. Everyday rain will be cleaned before discharge to recipients. Cleaning will primarily consist of filtering through a combination of mold, chalk and sedimentation.



LADEGÅRDSÅ, FREDERIKSBERG EAST & VESTERBRO

SAINT JØRGENS LAKE
Central rention

ISTEDGADE
Cloudburst road

SØNDER BOULEVARD
Green road and detention

Sources: https://interlace-hub.com/cloudburst-management-plan-copenhagen, https://www.asla.org/2016awards/171784

A.3 Implementation & Financial Incentives

Effective flood-risk management ultimately depends on the ability of cities to translate risk knowledge and governance arrangements into coherent and sustained action on the ground. Across Europe and Central Asia, cities are deploying a wide range of measures to reduce the impacts of floods, flash floods and intense rainfall, reflecting growing recognition that urban resilience cannot rely on a single type of intervention.

Implementation approaches increasingly combine structural infrastructure, nature-based and sustainable drainage solutions, digital tools, early-warning mechanisms, land-use controls and community-level measures. Rather than being developed as isolated projects, these interventions are progressively embedded within broader urban development, infrastructure renewal, and climate-adaptation processes.

Table 1: Categories of flood-risk implementation measures reported by MCR2030 member cities and partners:

Category	Examples Mentioned
Grey Infrastructure	Detention basins (storage volumes), diversion canals, embankments stabilization, stormwater and sewer system upgrades
SUDS / NBS	Rain gardens, permeable pavements, depaving, green roofs, disconnecting roof runoff from the combined sewer system, *wetlands restoration, ecological riverbank restoration*
Monitoring & Digitalization	Modernized meteorological stations, AI to model multiple disaster scenarios, smart hydrological sensors,
Early Warning Systems	SMS and mobile alert notifications, sirens and acoustic warning systems, automated threshold-based alarms
Land-Use Controls	Hazard-zone restrictions, Master Plan
Community Measures	evacuation signage, public awareness and education campaigns, participatory decision-making & local engagement
Financing Tools	National/Regional public investment funds, EU funding mechanisms (LIFE, Horizon Europe), Municipal Green Bonds, PPPs (Greater Manchester: GMCA, Environment Agency, United Utilities), Green Climate Fund (GCF)

While implementation pathways vary depending on local context, exposure, and institutional capacity, several common patterns can be observed across the region. These include the use of distributed retention and infiltration measures, the integration of flood-management functions into public spaces, and the growing role of real-time monitoring and operational control systems. Cities such as Malmö, Sweden also report that implementation on private property remains uneven, often constrained by weak economic incentives, fragmented ownership structures, and limited coordination mechanisms to support collective action across neighbouring properties.

The case studies presented in this section illustrate how cities are operationalizing these approaches in practice. They highlight how implementation choices respond to local constraints and opportunities, and how combining structural, nature-based and digital measures can reduce flood impacts while delivering co-benefits for urban liveability, environmental quality and climate adaptation.

Barcelona, Spain: Integrated retention and surface drainage for urban flood reduction[14]

Barcelona has strengthened its capacity to manage intense rainfall through a combined system of large underground stormwater tanks and surface-level drainage improvements. Since the late 1990s, the city has built a network of retention tanks with a total storage capacity of around 477,020 m³ across 15 facilities, including the iconic Joan Miró Park tank (≈70,000 m³) beneath the Eixample district. These tanks temporarily store excess runoff during cloudburst events, reducing sewer overflows and protecting coastal water quality.

At street level, Barcelona complements these works with permeable pavements, drainage corridors and infiltration features integrated into public spaces and mobility corridors.[15] These systems increase local infiltration and delay peak flows entering the combined sewer network. Under recent urban plans, the city intends to roughly double its storage capacity, with 29 additional tanks planned to bring total retention to more than 1 million m³, as part of climate-change adaptation and flood-prevention efforts.

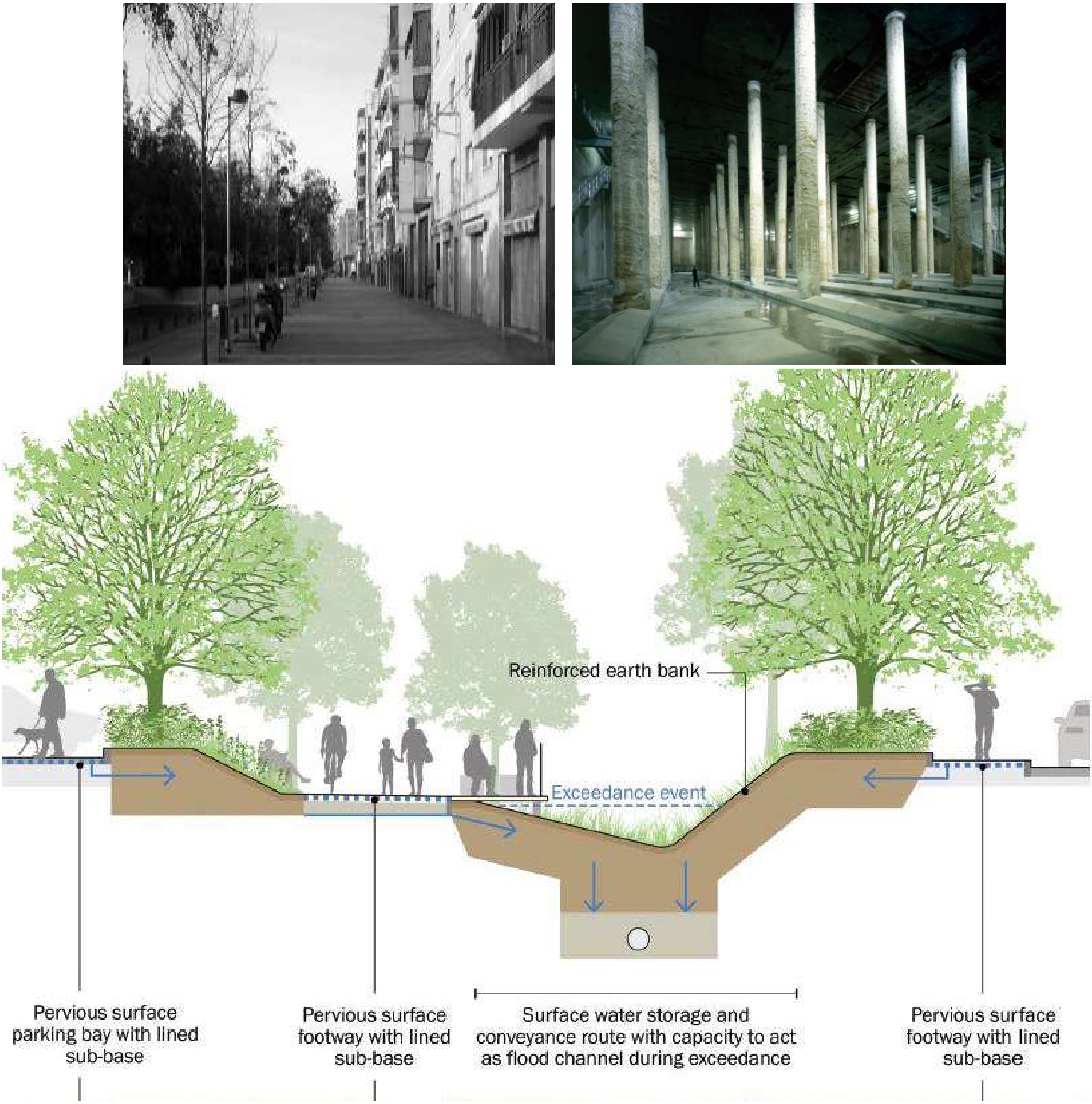
By combining large-scale storage, permeable surfaces and network monitoring, Barcelona has significantly reduced pluvial flooding in dense neighbourhoods while improving the quality and resilience of its public space. Since 2019, the city has nearly tripled the surface area of operational flood-management and sustainable urban drainage infrastructure, from 49,854 m² to 145,567 m² by 2024, supporting progress toward the achievement of relevant SDG targets.[16]

14 https://www.barcelona.cat/infobarcelona/en/tema/climate-emergency/actualitzat-el-projecte-del-diposit-pluvial-de-la-rambla-de-prim-juliol-2025_1538605.html

15 MULTICLIMACT Project (2024). *Barcelona demo site: climate adaptation and resilience measures.* https://multiclimact.eu/demo-sites/spain-barcelona/

16 Indicator 6.5.3 - Increase the operational surface area of sustainable urban drainage systems - Indicators For The Sustainable Development Goals

Figure 13: **Integrated stormwater management in Barcelona, combining storage infrastructure, permeable surfaces and green spaces to reduce pluvial flooding**



Source: https://ajuntament.barcelona.cat/agendasostenible/ca/cataleg-de-recursos/les-entranyes-de-la-ciutat-diposit-de-regulacio-daigues-pluvials
Metropolitan Area of Barcelona. https://www.amb.cat/s/home.html

Bonn, Germany: River restoration and diversion systems to reduce flash-flood impacts[17]

In Bonn, flood-risk management combines engineered diversion infrastructure with stream restoration in the southern district of Mehlem. The Mehlemer Bach drains an 18.3 km² catchment shared between the Municipality of Wachtberg and Bonn. After repeated flash floods in 2010, 2013 and 2016 damaged homes, shops and critical infrastructure in Bonn-Mehlem, the city and its regional partners adopted a package of measures focused on this small but highly exposed stream.

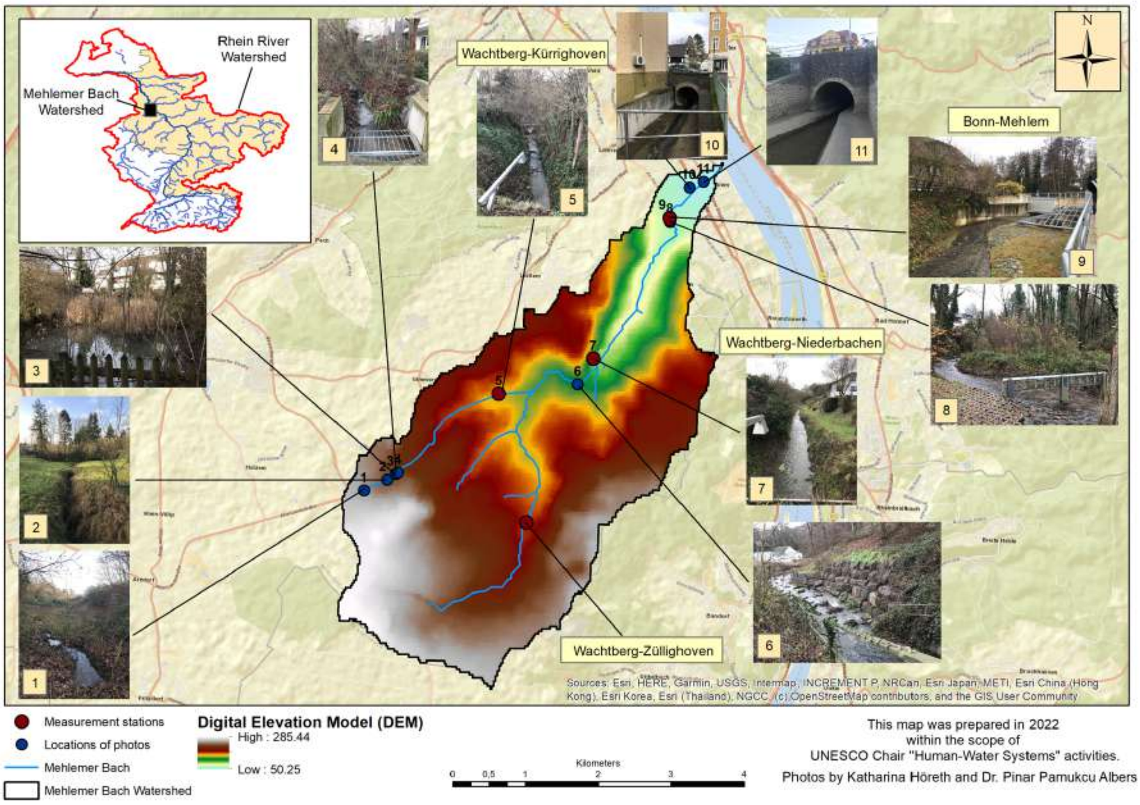
A central intervention is a 1,050-metre bypass tunnel (three metres in diameter) built by the City of Bonn's civil engineering department. The bypass inlet, located at Bachemer Straße in Bonn-Mehlem, diverts high flows under the railway, main road (B9) and Drachenstein Park directly to the Rhine once water levels exceed a defined threshold. The project, completed around 2019 at a cost of about €12 million, is complemented by local channel upgrades, debris-raking structures and ongoing river-restoration works along the Mehlemer Bach.

During the July 2021 extreme rainfall event, which caused a severe flood in the Ahr Valley and other districts in the surrounding areas of Bonn, this hybrid system successfully conveyed floodwaters to the Rhine and prevented severe damage in the stream's mouth area, illustrating how targeted gray–green measures at stream scale can protect a vulnerable urban district.

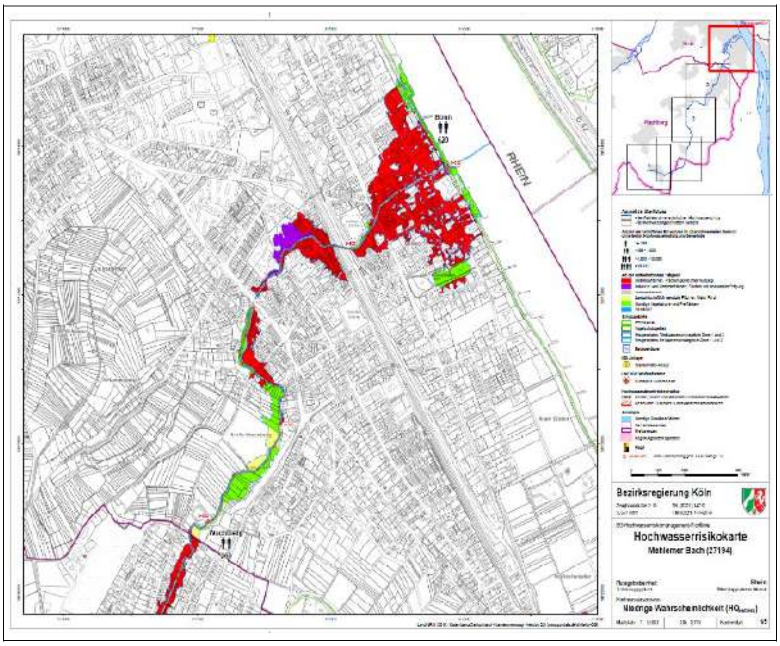
[17] Subramanian, S., Höreth, K., Sänger, N., Jara, D., & Becker, L. (2022). *Catchment, Streams and Sewers: Strengthening Flood Resilience in Bonn*. Bonn Water Network. Bonn. Available at: https://www.idos-research.de/fileadmin/migratedNewsAssets/Files/DIE-Non-Paper_Bonn_Water_Network_2022-02.pdf

Figure 14: **The Mehlemer Bach Watershed. Top: Map of measures introduced along the stream in January 2022. Bottom: Flood-risk map of downstream urban area**

Figure 1: Map of the Mehlemer Bach showing the elevation of the watershed, including impressions of the status quo and structural measures introduced along the stream in January 2022



Source: UNESCO Chair “Human-Water Systems” (2022).



Source: https://www.idos-research.de/fileadmin/migratedNewsAssets/Files/DIE-Non-Paper_Bonn_Water_Network_2022-02.pdf

Milan, Italy: Connected urban green spaces to reduce pluvial flood risk[18]

Milan is addressing pluvial flood risk by developing connected networks of urban green infrastructure that absorb, slow and store stormwater across the metropolitan area. Rather than relying only on underground pipes, the city and its partners are testing scenarios where parks, tree-lined corridors, rain gardens, bioswales and permeable surfaces work together as a "sponge" distributed through the urban fabric.

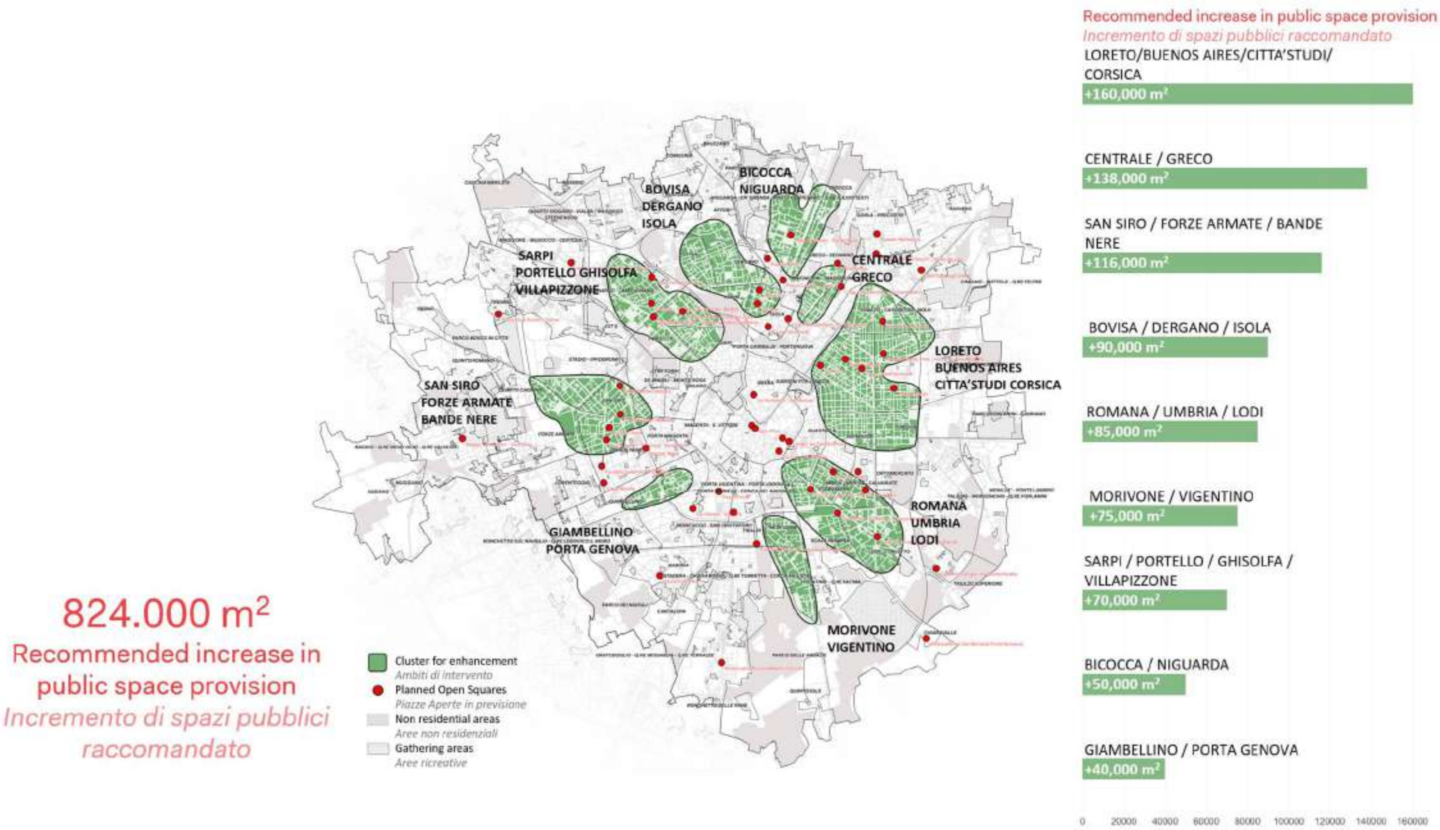
Recent modelling for the Metropolitan Area of Milan shows that extending green networks by about 25% can halve direct pluvial flood damages to buildings and reduce the population exposed by roughly one-third to 40%, depending on the scenario.

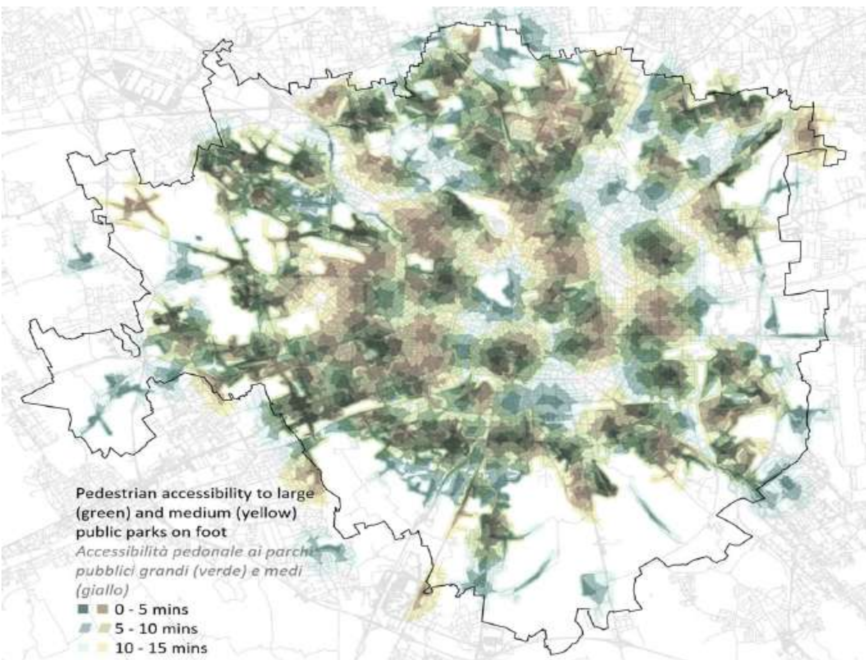
Green corridors, retrofitted parks, and permeable public spaces are designed to temporarily store runoff during intense rainfall, while providing everyday recreational and ecological benefits.

These measures are supported by real-time hydrometeorological information and local early-warning tools, such as rainfall and water-level sensors and local alert protocols in parks like Lambro. Building on these insights, Milan's strategy demonstrates how connected green infrastructure, when planned at metropolitan scale, can significantly reduce pluvial flood impacts while advancing climate adaptation, urban cooling and nature-based regeneration.

[18] Staccione, A., Hrast Essenfelder, A., Bagli, S., Mysiak, J., & The Authors. (2024). *Connected urban green spaces for pluvial flood risk reduction in the Metropolitan area of Milan.* In Sustainable Cities and Society (Vol. 104, p. 105288). https://www.sciencedirect.com/science/article/pii/S2210670724001161?via%3Dihub

Figure 15: **Recommended increase in public space provision and pedestrian accessibility to large and medium public parks in Milan**





Source: https://transformtransport.org/research/livable-streets/access-to-green-areas-and-public-realm-the-case-of-milan/

Potenza, Italy: Targeted interventions in a topographically constrained context

Flood-risk governance in Potenza is supported by close collaboration between municipal engineering services and civil-protection authorities, particularly in relation to flood-prone areas along the Basento Valley, where hydrometeorological hazards are amplified by steep topography and concentrated runoff. This coordination enables shared interpretation of risk information and alignment between technical interventions and emergency preparedness.

Implementation of flood-risk reduction measures in the Basento corridor has been enabled through a blended financing framework, combining national hydrogeological-risk funds, including resources from the *Proteggi Italia* (Protect Italy) programme, regional environmental and public-works budgets, and EU cohesion funding (from the European Regional Development Fund) dedicated to climate adaptation and disaster-risk reduction. This multi-source financing approach created incentives for preventive action and facilitated cooperation across institutional levels.

The Potenza experience illustrates how targeted interventions supported by coordinated governance and diversified funding can translate risk knowledge into concrete action, even in territorially constrained contexts, and contribute to strengthening long-term resilience at local and sub-regional scale.

Greater Manchester, United Kingdom: A hyper-collaborative approach to flood management

Greater Manchester coordinates flood risk governance at a metropolitan scale through statutory multi-agency mechanisms and planning led approaches. The Greater Manchester Local Resilience Forum provides the formal structure for bringing together local authorities, emergency services, water utilities, environmental agencies and other partners to prepare for flood emergencies and to ensure a coordinated multi-agency approach to response and recovery across the city region.

These arrangements are further strengthened through a public-private partnership approach to funding and investment. Collaboration between Greater Manchester Combined Authority, the Environment Agency and United Utilities helps to align public funding, utility investment programmes and regulatory responsibilities, enabling more integrated rainwater management and preventive action on surface-water flooding.

Planning policy plays a central role in this governance framework. New developments are required to meet greenfield runoff rates and incorporate sustainable drainage systems and nature-based solutions, ensuring that private development contributes directly to managing surface water and reducing flood risk.

In 2025, the UK Government commissioned an independent review of the water sector, with a series of recommendations now feeding into an imminent national Water White Paper. This is expected to bring significant changes, including how water is managed in an integrated way in Greater Manchester.

Together, these arrangements illustrate how coordinated governance frameworks, supported by regulatory and financial mechanisms, can align public and private actors around shared flood-risk objectives and strengthen anticipatory, risk-informed flood management at metropolitan scale.

Venice, Italy: Implementing large-scale flood defence to reduce extreme coastal flood risk

Venice is highly exposed to coastal flooding due to the combined effects of relative sea-level rise, land subsidence and storm surges. Since the late nineteenth century, relative sea level in Venice has risen by approximately 32 cm, including around 12 cm associated with local subsidence, contributing to a marked increase in the frequency of high-water events and flood impacts across the city.

To reduce the impacts of extreme tidal flooding, Italy implemented the MOSE system, a movable barrier system at the three lagoon inlets, which has been operational since October 2020. The system is designed to temporarily limit the propagation of storm surges into the lagoon during exceptional events and can maintain a water-level difference of up to 2 metres between the sea and lagoon levels when activated.

Since entering operation, MOSE has been activated on numerous occasions, including during severe storm events in November 2022, contributing to a significant reduction in flood impacts. The system operates only under critical conditions and interrupts tidal exchange for a limited proportion of time, allowing normal lagoon dynamics to be maintained outside extreme events.

By reducing the likelihood and severity of extreme flooding, the implementation of MOSE supports a more anticipatory approach to flood-risk management in Venice and enables complementary measures to protect critical assets and support longer-term adaptation within the lagoon. This experience illustrates how large-scale technical interventions, when carefully operated, can contribute to disaster risk reduction in highly exposed coastal cities.

The Venice experience also resonates with broader coastal risk considerations across the Mediterranean, where cities such as Athens have recently advanced tsunami risk awareness to complement existing flood and water management strategies, reflecting a growing recognition of multi-hazard coastal exposure in urban resilience planning

Figure 16: MOSE flood defence system protecting Venice's Basilica, Piazza and lagoon

Source: Presentation From Pierpaolo Campostrini (CORILA) for the Holcim Foundation Forum

Athens, Greece: Managing dual flood and water scarcity risks through integrated urban water infrastructure

Athens illustrates a situation common across the Mediterranean, where water scarcity and flood threats intensify simultaneously under climate change. Due to its high urbanization level and increased surface sealing, Athens is prone to flash floods due to torrential rains, as evidenced by general trends in Mediterranean regions.[19] Governance and infrastructural development are shifting towards decentralization and circularity within Athens' wastewater management policies, although they continue to be characterized by fragmentation within an institutional landscape consistent with the Water Framework Directive and the Floods Directive. While the city continues to focus on centralized approaches, such as the expansion of sewerage networks and improved water treatment capacity through modern facilities such as the Psittalia Wastewater Treatment Plant, there is also experimentation with small sewage management units and sewer mining techniques, which facilitate the creation of decentralized water recycling systems.

In this context, the emergence of the Attica Water Lab, an initiative coordinated by the Athens Water Supply and Sewerage Company, represents a significant step toward collaborative and innovation-driven governance. The lab functions as a multi-stakeholder platform bringing together public authorities, academia, industry, and civil society to promote water conservation, reuse, and the development of a supportive regulatory framework.

19 Intergovernmental Panel on Climate Change (IPCC). (2022). Climate Change 2022: Impacts, Adaptation and Vulnerability. Cambridge University Press; Diakakis, M., Deligiannakis, G., Pallikarakis, A., & Skordilis, A. (2016). Factors controlling the spatial distribution of flash flooding in urban areas. Hydrological Sciences Journal, 61(7), 1349–1360.

London: private-sector engagement and risk financing for flood protection

London's Thames Tideway Tunnel ("super sewer") showcases how large-scale flood mitigation infrastructure can be delivered through public-private collaboration and innovative risk financing.[20] Designed to capture and divert sewage and rainwater that would otherwise overflow into the River Thames, the tunnel spans approximately 25 km beneath central London and is expected to significantly reduce polluting discharges and improve urban water quality.

The project's capital cost is in the order of £4.3–£5 billion (≈ €5 to 6 billion), making it one of the largest urban water infrastructure investments in the United Kingdom. Financing is delivered through Tideway, a special purpose company owned by a consortium of long-term institutional investors — including Allianz, Amber Infrastructure, Dalmore Capital and DIF — that acts as the licensed infrastructure provider responsible for the tunnel's construction, maintenance and operation.

Allianz, as part of this consortium, holds approximately 34% of the invested equity capital, demonstrating how private capital can be mobilized at scale to support essential resilience infrastructure.[21] The funding model combines equity from investors with long-term debt and is underpinned by a regulated asset base framework, supported by the UK government and regulatory authority Ofwat, which provides certainty on returns and risk allocation over the project's lifespan.

From a disaster risk reduction perspective, the London example underscores how private-sector engagement and innovative financing structures can bridge infrastructure investment gaps that public budgets alone cannot fill. By coupling long-term institutional investment with regulatory oversight and risk sharing mechanisms, cities can advance critical resilience measures at scale while managing fiscal and operational risk.

[20] Tideway Project (2024). *The Thames Tideway Tunnel: large-scale infrastructure to reduce sewer overflows in London.* https://www.tideway.london/the-tunnel/

[21] Allianz Capital Partners (2024). *Thames Tideway Tunnel: infrastructure investment supporting urban water management in London.* https://ch.allianzgi.com/en-ch/pro/fr-nos-expertises-cles/allianz-capital-partners/theme-portefeuille/thames-tideway-tunnel

Figure 17 (from left to right): **Photo, cross-section and map of the Thames Tideway Tunnel**

Source (from left to right): Tomasz Stańczak / Thames Water / FLO JV https://ch.allianzgi.com/en-ch/pro/fr-nos-expertises-cles/allianz-capital-partners/theme-portefeuille/thames-tideway-tunne

Additional Insights

Brussels, Belgium

The Brussels-Capital Region has progressively introduced on-site rainwater retention requirements[22] within its urban planning framework, illustrating an approach that seeks to manage stormwater closer to its source. Under current regulations, new developments and major renovations are required to provide a minimum storage capacity of 33 litres per square metre of roof surface, allowing rainfall to be temporarily retained and released in a controlled manner rather than being discharged directly into the sewer network.

[22] Brussels Environment (2024). *Rainwater management obligations and requirements.* https://environnement.brussels/citoyen/reglementation-et-inspection/obligations-et-autorisations/gestion-des-eaux-de-pluie

A.4 Gaps & Opportunities

Effective flood-risk management ultimately depends on the ability of cities to translate risk knowledge and governance arrangements into coherent and sustained action on the ground. Across Europe and Central Asia, cities are deploying a wide range of measures to reduce the impacts of floods, flash floods and intense rainfall, reflecting growing recognition that urban resilience cannot rely on a single type of intervention.

While implementation pathways vary depending on local context, exposure and institutional capacity, several common patterns can be observed across the region. These include the use of distributed retention and infiltration measures, the integration of flood-management functions into public spaces, and the growing role of real-time monitoring and operational control systems.

The case studies presented in this section illustrate how cities are operationalizing these approaches in practice. They highlight how implementation choices respond to local constraints and opportunities, and how combining structural, nature-based and digital measures can reduce flood impacts while delivering co-benefits for urban liveability, environmental quality and climate adaptation.

Gap 1: Ageing and undersized drainage systems under increasing rainfall extremes

Across Europe and Central Asia, many urban drainage systems were designed for rainfall conditions that no longer reflect current or projected extremes. Cities report increasing pressure on combined sewer systems, undersized pipes and critical bottlenecks, resulting in surface water accumulation and sewer surcharging during intense rainfall events.

Opportunity 1: Reorient investment towards source-based stormwater management

Experience from several European regions, and academic literature[23] indicate that while full separation of stormwater and wastewater networks is technically feasible, it often requires substantial investment and long construction periods, while delivering limited additional benefits at city scale. In response, many cities are prioritizing local stormwater disconnection, infiltration, and decentralized retention.

Managing rainwater close to where it falls, through infiltration areas, green roofs, small storage volumes and local reuse, can significantly reduce pressure on existing networks, improve flexibility under climate uncertainty and deliver long-term cost effectiveness. This approach offers cities an opportunity to strengthen resilience while avoiding large-scale underground works where space and budgets are constrained.

[23] Willems, P., Olsson, J., Arnbjerg-Nielsen, K., Beecham, S., Pathirana, A., Bülow Gregersen, I., Madsen, H., & Nguyen, V. T. V. (2012). Impacts of climate change on rainfall extremes and urban drainage systems. In IWA Publishing. **https://afwasakm.afwasa.org/wp-content/uploads/2019/10/wio9781780401263.pdf**

Gap 2: Limited feasibility of nature-based retention in dense urban districts

Cities increasingly recognize the value of nature-based solutions for flood mitigation, yet implementation remains challenging in dense urban districts where space is limited and competing land uses are intense. The expansion of parks, wetlands or retention areas is often constrained by existing development patterns and institutional or planning priorities.

Opportunity 2: Reconvert and valorize existing urban spaces to accommodate stormwater

Across Europe and Central Asia, cities are increasingly exploring landscape-based solutions that complement decentralized retention by making better use of existing urban spaces. Evidence from modelling and planning exercises shows that connected parks, green corridors and vegetated public spaces can significantly reduce pluvial flood peaks, while also delivering benefits for urban cooling, biodiversity and public amenities. Similar assessments in rapidly growing cities highlight the role of wetlands, open corridors, and multifunctional spaces in increasing infiltration and buffering runoff.

A commonly cited constraint is the perceived limited availability of space, particularly in dense urban districts. However, experience from several European contexts suggests that effective solutions often emerge from reconfiguring and upgrading existing surfaces, rather than creating new land. Parks, schoolyards, transport corridors, public squares and underused plots can be redesigned to safely accommodate excess water during heavy rainfall while continuing to serve everyday social, recreational or ecological functions.

For cities in Europe and Central Asia, developing such multifunctional green and blue infrastructure offers a practical opportunity to expand infiltration capacity within existing spatial constraints and to strengthen resilience through flexible, adaptive and community friendly urban design.

Gap 3: Limited integration of local monitoring into operational early-warning systems

Cities increasingly recognize the value of hydrometeorological monitoring and early-warning systems. However, in many contexts, local monitoring is not always fully integrated with municipal preparedness and response services. Observations suggest that rainfall sensors, water-level gauges, or warning platforms often operate in isolation, with limited integration into day-to-day operational procedures.

Opportunity 3: Strengthen locally anchored monitoring and operational linkages

Cities can strengthen flood preparedness by expanding local hydrometeorological monitoring networks and ensuring that real-time data is directly linked to early-warning procedures, operational dashboards, and emergency protocols. Experience from cities with advanced systems shows that when local sensors are combined with clear thresholds and predefined response actions, municipal services can act earlier and more effectively, even under rapidly evolving conditions.

In regions exposed to frequent flash floods, particularly in parts of Central Asia, reinforcing locally anchored monitoring capacities, in coordination with national hydrometeorological services, offers a practical pathway to improve early warning, preparedness and response without relying solely on centralized systems.

Gap 4: Integrating flood-risk considerations into land-use planning

In many urban contexts, land-use planning and development control do not yet fully reflect available flood-risk information. Although hazard mapping and risk assessments are increasingly established, their consistent integration into statutory spatial plans, zoning regulations and permitting processes remains variable. This can result in continued development or constrained retrofitting in floodplains, low-lying areas and along watercourse corridors, contributing to the gradual accumulation of exposure over time.

Opportunity 4: Enhance the role of spatial planning frameworks in managing long-term flood exposure

Strengthening the integration of flood-risk considerations into spatial planning frameworks offers a clear opportunity to reduce long-term exposure. Embedding hazard and risk information into master plans, zoning regulations and building codes can help align development decisions with local flood dynamics, particularly in high-hazard and low-lying areas.

Experience from Bonn shows the value of catchment-based planning that links land use, streams and drainage systems, while Barcelona demonstrates how systematically integrating flood-risk layers into public works can reduce exposure in dense urban contexts. In rapidly growing cities such as Tashkent, recent risk analyses underline the importance of steering new development away from hazard-prone areas to prevent the accumulation of future risk.

Gap 5: Strengthening coordination between institutions responsible for water, planning and emergency management

Flood risk management involves a range of institutions operating across water services, spatial planning and civil protection. While roles and responsibilities are generally defined, coordination across these domains can be complex, particularly where mandates span multiple administrative levels. Differences in planning cycles, data management practices and operational procedures may reduce coherence between prevention, preparedness and response, especially during extreme events. This challenge is particularly evident where flood protection depends on coordinated measures across multiple private properties, and where no single institution has the mandate or resources to convene and guide collective implementation.

Opportunity 5: Reinforce institutional coherence across water management, spatial planning and emergency functions

Strengthen cross-departmental coordination and formalize cooperative governance mechanisms. Bonn's catchment-streams-sewers model shows the value of integrated flood governance. Tashkent's assessment similarly calls for greater institutional capacity, shared information flows and alignment between municipal utilities and national agencies. Regular joint planning and operational exercises can significantly reduce response times.

Gap 6: Ensuring sustainable financing for long-term flood-resilience measures

Ensuring sustained investment in flood-resilience measures remains a challenge in many cities. Financing arrangements often rely on time-bound programmes, project-based funding or emergency resources, which can limit long-term planning, implementation and maintenance of infrastructure, monitoring systems and nature-based solutions. In some contexts, limited incentives for private property owners further constrain implementation, particularly where insurance coverage reduces the perceived urgency to invest in preventive adaptation measures.

Opportunity 6: Support the development of stable and diversified financing frameworks for flood resilience

Cities can benefit from broadening their financing strategies through instruments such as public–private partnerships. Barcelona and Milan already combine municipal budgets, EU programmes and private-sector contributions to advance large-scale adaptation projects. Development partners also play an important role in supporting multi-year investment programmes, as illustrated by Tashkent's resilience planning. Other cities, such as Malmo, underline the importance of clearer national guidance, financial support and coordination roles to help unlock collective investment in property-level flood adaptation.

Gap 7: Strengthening community preparedness and local engagement for flood-risk management

Approaches to community preparedness and local engagement differ across urban contexts, reflecting variations in institutional arrangements, available resources and risk profiles. While early warning and awareness mechanisms are in place in many cities, the degree to which these systems are adapted to local conditions and effectively reach all population groups varies. In the context of rapid-onset events such as flash floods, further efforts may be needed to ensure that risk communication, preparedness measures and response protocols are consistently understood and actionable at neighbourhood level.

Opportunity 7: Enhance locally anchored preparedness and risk communication approaches

Strengthening citizen engagement and locally adapted alert mechanisms represents a high-impact opportunity to reduce flood impacts. Experience from Milan, Amadora and Bonn shows how translating technical thresholds into clear evacuation routes, signage, sirens and targeted communication can significantly reduce casualties when infrastructure is overwhelmed.

In Central Asian cities, there is strong potential to expand localised SMS alerts, sirens, community-level signage and preparedness training aligned with hydrometeorological information. Embedding these measures into municipal emergency plans and working closely with community organisations can help bridge the gap between national warning systems and effective local action.

A.5 Recommendations

1. Institutionalize risk-informed decision-making across urban systems

National and local authorities are encouraged to formalize the use of flood-risk information across planning, infrastructure investment, and emergency management. This includes embedding risk considerations into statutory decision-making processes, ensuring that hazard and exposure data systematically inform development approvals, infrastructure renewal and preparedness planning. Strengthening these institutional linkages helps translate existing knowledge into consistent and durable risk-reduction outcomes.

2. Strengthen multi-level and cross-sector governance arrangements

Urban flood resilience benefits from governance frameworks that align responsibilities across water management, spatial planning and civil protection, and across local, regional and national levels. Clarifying mandates, harmonizing planning cycles, and reinforcing coordination platforms can reduce fragmentation and improve coherence between prevention, preparedness, and response. Particular attention should be given to supporting cities with limited technical or administrative capacity through shared tools, guidance, and coordination mechanisms.

3. Ensure continuity and sustainability of flood-resilience financing

Long-term flood resilience requires financing frameworks that extend beyond short project cycles and emergency funding. Public authorities are encouraged to promote multi-year investment planning, integrate maintenance and operation needs into funding strategies, and align disaster risk reduction, climate adaptation and infrastructure budgets. Blended financing approaches, combining public resources with private and development finance, can help sustain investments over time and reduce future losses.

4. Strengthen the operational link between monitoring, early warning and local action

Monitoring and early-warning systems are most effective when they are directly connected to predefined decision-making procedures and response responsibilities. Authorities may consider formalising data flows, thresholds and activation protocols that link observations to actionable measures at local level. Reinforcing coordination between national hydrometeorological services and municipal actors can improve lead times, situational awareness and anticipatory action, particularly for rapid-onset events.

5. Embed community preparedness within formal risk-management frameworks

Community preparedness is a critical component of flood resilience and should be recognized as a core public function rather than an ad hoc activity. Integrating risk communication, awareness-raising and preparedness actions into official emergency and resilience plans can help ensure continuity, inclusiveness and clarity of roles. Supporting locally adapted communication mechanisms and partnerships with community organisations strengthens trust and enhances the effectiveness of response during extreme events.

B. Too Little Water: How Cities Are Building Resilience to Drought and Water Shortages

Urban and regional exposure to **water scarcity** has increased markedly across Europe and Central Asia over the last two decades. Climate change, demographic growth, and rising water demand are placing unprecedented pressure on rivers, aquifers and supply systems. Recent analyses show that **over one-third of the EU population is now exposed to water stress during the summer months**,[24] and several regions are already operating near or beyond sustainable extraction levels. According to the European Environment Agency, the share of EU territory affected by **meteorological drought nearly doubled** between 1976 and 2020, with severe dry conditions recorded in Southern, Eastern and parts of Western Europe.

24 European Environment Agency (EEA) (2024). *Use of freshwater resources in Europe.* https://www.eea.europa.eu/en/analysis/indicators/use-of-freshwater-resources-in-europe-1

In parallel, climate projections indicate a continued decline in water availability. The World Meteorological Organization warns that **renewable freshwater resources in Europe have decreased by around 15% over the past two decades**, while Central Asia faces some of the most dramatic long-term reductions globally, with **glacier volume losses exceeding 30% since the 1960s**.[25] These trends accelerate reductions in summer river flows and groundwater recharge, intensifying competition among domestic, agricultural, industrial and ecological needs.

Recent events illustrate the urgency of strengthening water scarcity management. The droughts of 2022 and 2023 were among the most severe in decades, affecting nearly two-thirds of Europe's territory, disrupting energy production, limiting navigation on major rivers such as the Rhine and Danube, and triggering agricultural losses estimated at **over €9 billion in the EU alone**. Central Asian countries have experienced simultaneous crises, with critically low water levels in the Amu Darya and Syr Darya, reduced hydropower generation, and growing tensions between upstream and downstream users.

These developments highlight the importance of timely and actionable data to understand evolving water balances, anticipate shortages and guide decision-making. Hydrological monitoring, drought indicators, groundwater assessments, demand forecasting and climate-informed scenario modelling are essential tools for managing scarcity in both rural and urban environments.

Finding solutions is now critical. As temperatures rise and rainfall patterns become more variable, cities must adopt new strategies to diversify water sources, improve efficiency, strengthen storage and enhance cooperation between sectors and across borders. Addressing today's water scarcity challenges is vital not only for urban supply, but also for public health, economic stability, food security and long-term regional resilience.

25 Agnès Bardon, "*Glaciers, the fragile mirrors of climate change*," *UNESCO Courier*, 6 January 2025, https://courier.unesco.org/en/articles/glaciers-fragile-mirrors-climate-change

B.1 Knowledge & Data

Effective management of water scarcity in urban areas depends on the availability and use of reliable, timely, and decision-oriented information. As droughts become more frequent and prolonged, cities increasingly need to understand how water availability, demand and system performance evolve over time, and how these dynamics interact with climate variability, urban growth and infrastructure constraints.

Across Europe and Central Asia, cities are expanding their knowledge base beyond traditional supply-focused indicators toward more integrated assessments of water balance. This includes monitoring surface water and groundwater resources, tracking consumption and losses within distribution networks, and using drought indicators to anticipate stress on water systems. In parallel, climate projections and scenario modelling are increasingly used to assess future risks and inform long-term planning.

Risk knowledge becomes most effective when it is operational. Cities are therefore strengthening hydrological and demand monitoring, deploying digital tools to detect losses and inefficiencies, and integrating data into early-warning and decision-support systems. These developments support a shift from reactive drought response toward anticipatory and adaptive water management.

The case studies presented in this section illustrate how cities are building and using knowledge and data to detect emerging water scarcity, guide operational decisions and support longer-term resilience strategies, while also highlighting remaining challenges related to data integration, coverage and sustained capacity.

Milan: Integrated monitoring, water safety planning and digital innovation

Milan illustrates how integrated monitoring and risk-based planning can strengthen the knowledge base for urban water-scarcity management under increasingly variable hydrological conditions. Fluctuations in aquifer recharge and rising demand have reinforced the importance of continuous oversight of groundwater abstraction, network performance and water losses. These functions are coordinated by the integrated water service operator, Gruppo CAP, through a regularly updated Water Safety Plan that supports risk identification and operational decision-making across the water supply chain.

In parallel, Milan has invested in digital innovation to enhance real-time knowledge of network performance. Through initiatives such as the Safe Water programme, Gruppo CAP deploys advanced monitoring and data analytics to identify potential water losses and leaks within the distribution system, supporting early detection and targeted interventions.[26] This approach is further complemented by Milan's participation in the EU-funded Digital Water City initiative, which tests AI-supported leak detection, real-time groundwater monitoring and predictive tools for drought-related decision-making.[27] Together, these systems contribute to reducing non-revenue water, strengthening situational awareness and improving the reliability of water supply during periods of stress.

[26] Gruppo CAP (2024). *Safe water services and water-supply management.* https://www.gruppocap.it/en/what-we-do/safe-water
[27] Digital Water City (EU Horizon 2020): https://digital-water.city

Figure 18: **Digital solutions implemented in Milan to support monitoring, decision-making and urban water resilience**

Source: https://www.digital-water.city/city/milan/

Potenza, Italy: Multi-indicator drought monitoring and emergency phases

The Province of Potenza, within the Basilicata region, provides an example of how multi-indicator monitoring supports structured drought management in a water-stressed context. During one of the most severe droughts in recent decades, inflows into key reservoirs fell to around 21 million m³, an estimated 80% reduction compared to historical averages, requiring timely and evidence-based decision-making.

To support preparedness and response, the region relies on a diversified monitoring system combining hydrometric data, meteorological observations, reservoir levels, soil-moisture indices, and groundwater monitoring. Interpreted together, these data streams provide a comprehensive picture of evolving water availability and system stress.

The monitoring framework feeds into a phased drought management system with three escalation levels: attention, pre-alert, and emergency. Each phase is associated with predefined measures such as demand-reduction campaigns, restrictions on non-essential uses, and activation of regional crisis-management units. This approach strengthens transparency, predictability, and coordination during periods of increasing water scarcity.

Figure 19: The Camastra reservoir, a key indicator in Potenza's drought monitoring and emergency management system

Source https://ilmanifesto.it/acqua-oscura-lucana

Greater Manchester, United Kingdom: Drought planning through thresholds and demand management[28]

In Greater Manchester, statutory water resource planning is led by the regional water provider, United Utilities. Water resource management plans (produced every 5 years) are designed to ensure that minimum standards of resilience are maintained in the face of population growth, climate change and demand changes over a 25-year planning period. This includes making assessments of peak demand and resilience to a 1 in 500- year drought.

In combination with the water resource management plan, United Utilities is also required to develop and maintain a Drought Plan, which sets out how drought conditions are monitored, forecast and managed in the near term in line with national regulatory requirements. The plan is updated every five years to reflect the latest guidance and information.

The drought plan is underpinned by continuous monitoring of meteorological conditions, hydrological indicators and water demand. These data inform trigger thresholds related to reservoir storage and abstraction licenses, activating an escalating sequence of actions ranging from voluntary water-use restraint and leakage reduction to pressure management, temporary use bans and, if necessary, emergency supply measures. It is important to note that the implementation of drought actions is strictly governed by environmental regulators.

By clearly linking indicators, thresholds and operational responses, the drought plan supports transparent and predictable decision-making under prolonged dry conditions, while maintaining flexibility to adapt actions as conditions evolve. It illustrates how formalized planning, grounded in systematic monitoring, can enhance supply reliability and proactive water-scarcity management.

[28] Greater Manchester. (2024). Greater Manchester climate change risk assessment. https://www.greatermanchester-ca.gov.uk/media/qtrhgi2y/gm-ccra-report_final.pdf

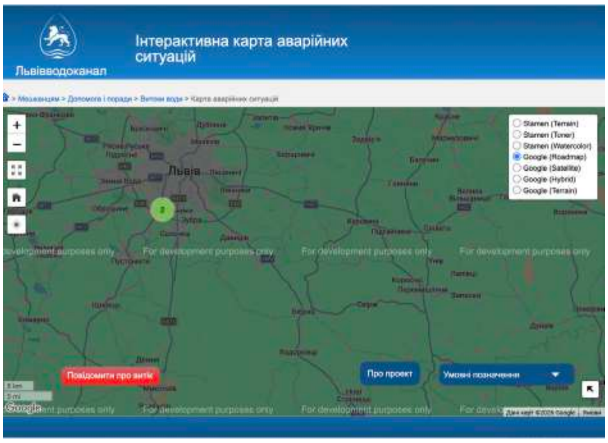
Lviv, Ukraine: AI-based flow and leakage detection for enhanced water efficiency

Lviv is strengthening its knowledge base for water-scarcity management by deploying digital tools to better understand and reduce losses within its water distribution system. Through its municipal water utility, Lvivvodokanal, and in partnership with Siemens, the city is piloting AI-enabled flow and leakage sensors on major collectors, generating real-time data on network behavior and performance.

These digital tools support early detection of leaks, reduction of non-revenue water and improved operational oversight of the distribution network. By continuously analysing flow patterns, the system helps identify anomalies that may indicate structural weaknesses or inefficiencies, enabling more targeted maintenance and repair. Information on detected leakages is also made accessible through an online platform managed by Lvivvodokanal, supporting transparency and situational awareness for both operators and residents.[29]

Beyond immediate loss reduction, the accumulation of high-resolution operational data contributes to a more detailed understanding of system dynamics, supporting evidence-based planning and prioritization of future investments. Lviv's experience illustrates how digital monitoring and AI-based analysis can enhance the evidence base for water-scarcity management, particularly in cities where ageing infrastructure and resource constraints make efficiency gains a critical resilience strategy.

Figure 20: Lvivvodokanal's interactive map for citizen reporting and real-time monitoring of water leakages across Lviv



Source: https://lvivvodokanal.com.ua/residents/help/waterleakages/map/

29 Lvivvodokanal (2024). *Interactive map of reported water leakages.* https://lvivvodokanal.com.ua/residents/help/waterleakages/map/

Matosinhos, Portugal: Data-driven leakage control to reduce water losses[30]

Matosinhos illustrates how systematic monitoring and data-driven management can significantly reduce water losses and strengthen urban resilience to water scarcity. The municipality and its water utility have prioritized non-revenue water reduction through extensive network monitoring, combining smart metres, flow and pressure sensors, and real-time data analysis.

Advanced digital tools, including AI-supported analytics, enable early leak detection, targeted maintenance, and optimized pressure management. This approach has contributed to achieving one of the lowest water-loss rates in Portugal, improving supply efficiency and operational reliability.

By using high-quality data to guide both day-to-day operations and long-term investment planning, Matosinhos demonstrates how reducing losses within existing networks can play a central role in water-scarcity resilience, particularly in contexts where expanding water supply options is limited.

30 Municipality of Matosinhos (2023). *Matosinhos is where the least water is wasted in Portugal.* https://www.nmmatosinhos.com/post/matosinhos-is-where-the-least-water-is-wasted-in-portugal?lang=en

B.2 Governance

Water scarcity is not solely a technical challenge but a governance issue that cuts across sectors, institutions and scales. Managing drought and water shortages in cities requires clear mandates, coordinated decision-making and alignment between water utilities, municipal authorities, regional institutions and emergency services. As scarcity becomes more structural, governance frameworks play a central role in shaping how risks are anticipated, managed and communicated.

Across Europe and Central Asia, cities operate within multi-level governance systems where responsibilities for water allocation, infrastructure operation, environmental protection and emergency response are distributed across institutions. The effectiveness of drought management therefore depends on the clarity of roles, the quality of coordination mechanisms, and the ability to link long-term water planning with short-term crisis management.

Increasingly, cities are embedding drought governance within broader risk-management and urban-policy frameworks. This includes integrating water scarcity into municipal emergency plans, establishing formal drought phases and thresholds, and strengthening coordination between technical services, political leadership, and communication units. Citizen participation and stakeholder engagement are also emerging as important governance dimensions, particularly to support behavioural change and public acceptance of drought measures.

The case studies in this section highlight how cities are strengthening institutional coordination, formalizing drought governance, and engaging communities to manage water scarcity more coherently and transparently.

Lviv, Ukraine: Building integrated water governance and citizen participation

Lviv illustrates how institutional reform within the water sector can strengthen governance for water-scarcity resilience. The city has reinforced its governance architecture through the creation of an Environment Status Control Office within the municipal water utility, providing a dedicated structure to coordinate monitoring of local water bodies, consolidate environmental data and assess ecosystem health.

This office also serves as a platform for cross-departmental coordination, linking the utility with environmental services, spatial planners and civil protection authorities. These arrangements support more coherent decision-making across sectors and contribute to long-term strategic planning through the development of the Water Vision 2100, a forward-looking roadmap aligning drinking-water services, wastewater management, green infrastructure and climate-adaptation objectives.

Citizen participation is explicitly embedded within this governance framework. By integrating public engagement into water governance, Lviv strengthens the legitimacy and acceptance of drought-related measures and supports behavioural change during periods of water scarcity. The case highlights how combining institutional coordination with participatory approaches can enhance both governance capacity and societal preparedness.

Barcelona, Spain: Embedding drought governance into municipal emergency plans

Barcelona demonstrates how drought governance can be embedded within an all-hazards emergency management framework while being complemented by structured citizen participation. Drought-management measures are fully integrated into the Municipal Emergency Plan, ensuring that water scarcity is addressed alongside floods, heatwaves and other climate-related risks within a single operational structure.

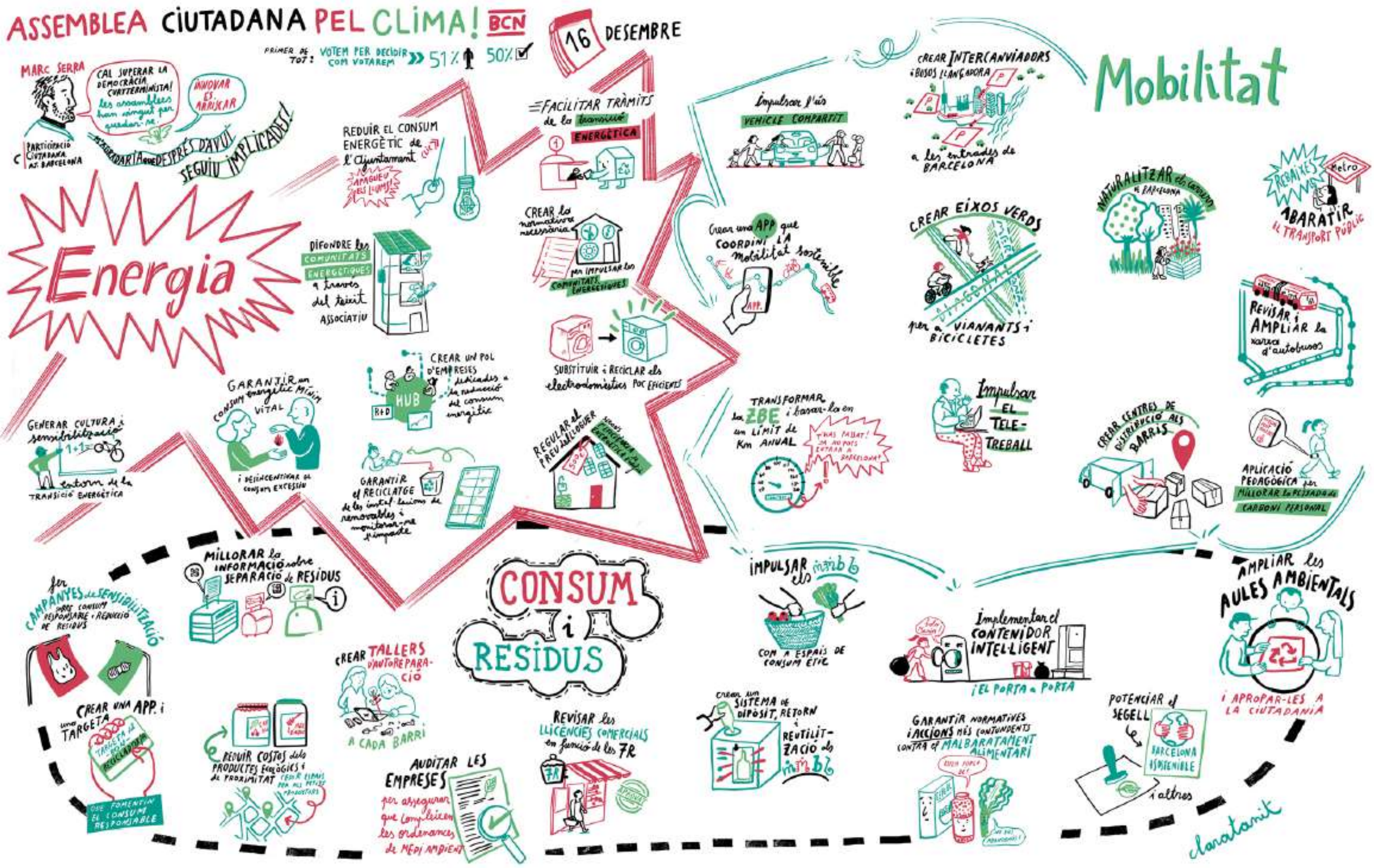
This integration enables standardized activation protocols once drought indicators reach predefined thresholds and supports clear coordination between the municipal water-cycle agency, civil-protection services, communication units and political leadership. Drought phases are incorporated into existing emergency communication systems, allowing consistent and timely guidance to be provided to the population during periods of increasing water stress.

Beyond operational preparedness, Barcelona has strengthened the societal dimension of drought governance through participatory processes such as the *Assemblea Ciutadana pel Clima*.[31] This citizen assembly provides a structured forum for informed public deliberation on climate-related challenges, including water scarcity, and has contributed to shaping policy recommendations and public narratives around resource conservation. By linking emergency planning with participatory governance, the city reinforces transparency, public understanding and social acceptance of drought-related measures.

By treating drought as both an operational risk and a collective governance challenge, Barcelona strengthens institutional clarity, avoids duplication of procedures and supports coordinated action across municipal services and society. This combined approach enhances the city's capacity to manage water scarcity with the same level of preparedness, legitimacy and coordination as other urban hazards.

[31] Barcelona Citizens Assembly for the Climate/ Assemblea Ciutadana pel Clima https://partizipation.at/praxisbeispiele/barcelona-citizen-assembly-for-the-climtate-assemblea-ciutadana-pel-clima-english-only/

Figure 21: **Barcelona's Citizen Assembly for the Climate — participatory deliberation process and visual summary of outcomes**



Sources: https://partizipation.at/praxisbeispiele/barcelona-citizen-assembly-for-the-climtate-assemblea-ciutadana-pel-clima-english-only/
https://elglobusvermell.org/serveis/actuaciones/asamblea-ciudadana-por-el-clima-de-barcelona/

Potenza, Italy: Multi-level drought governance and the challenge of coordination

The Province of Potenza operates within a highly complex water-governance environment, involving regional authorities, river basin institutions, irrigation consortia, the regional water utility, civil protection services and municipalities. Managing drought in this context requires coordination across multiple sectors and administrative levels.

Recent drought crises have highlighted both the necessity and the difficulty of such coordination, particularly for smaller municipalities with limited technical capacity. Decision-making involves aligning reservoir management, agricultural water allocations, prioritization of essential urban uses, emergency declarations and communication, as well as monitoring and reporting obligations.

In response, greater emphasis is being placed on strengthening horizontal and vertical governance linkages through improved data-sharing, joint planning processes, and capacity-building for local administrations. The Basilicata experience underscores how institutional coordination is a central determinant of effective drought management in regions facing structural water scarcity.

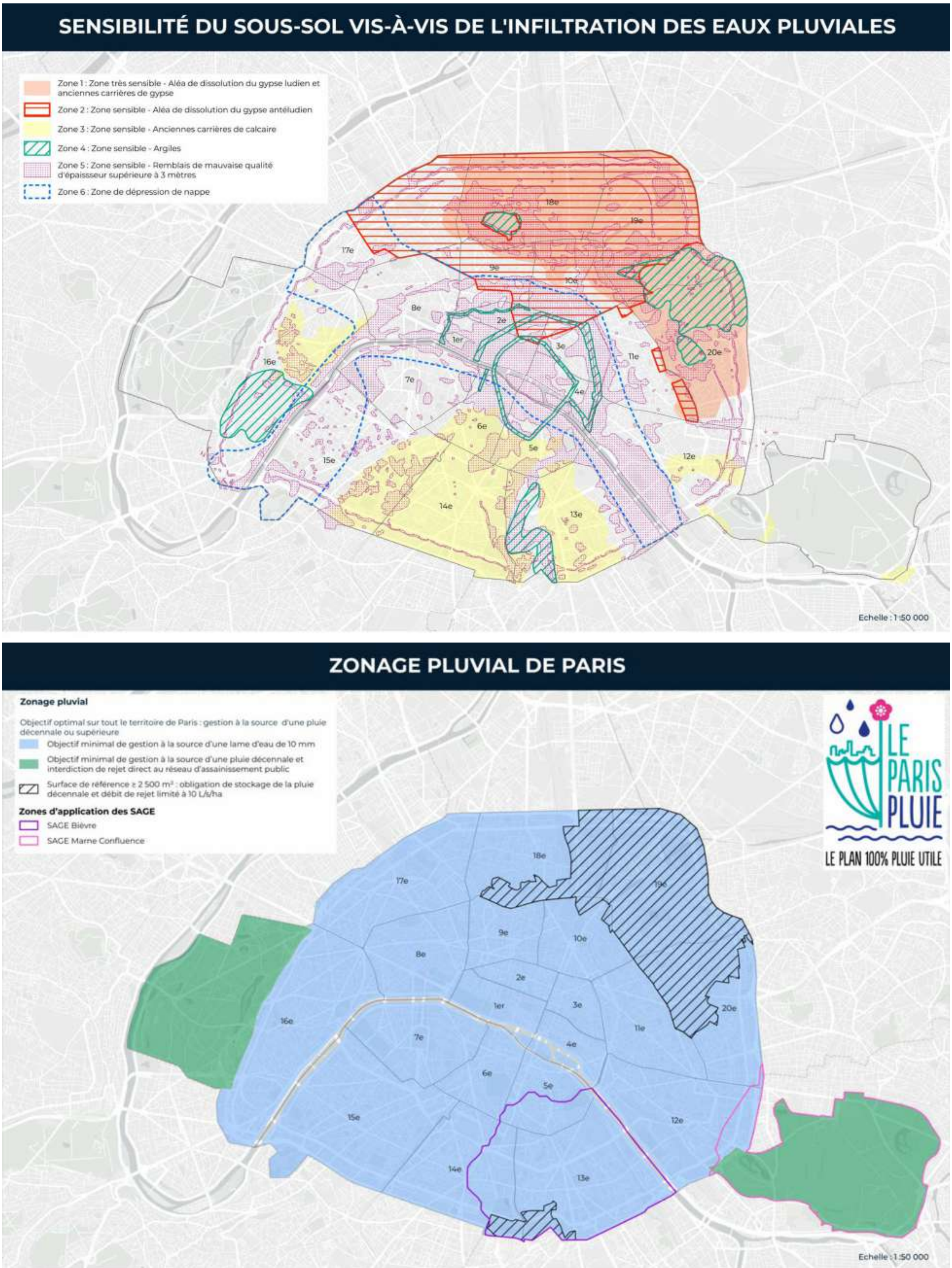
Scaling urban rainwater valorization: the example of Paris and the *Plan ParisPluie*

The *Plan ParisPluie* (Paris Rainwater Plan) provides an example of how rainwater can be repositioned from a drainage constraint to a strategic urban resource.[32] The plan promotes the recovery and infiltration of rainwater across the city through a combination of sustainable urban drainage systems, regulatory requirements for rainwater harvesting in new developments, and on-site infiltration integrated into public-space redesign. Decentralized retention in courtyards, roofs and green spaces further supports this approach. Stored rainwater is reused for street cleaning, irrigation and urban cooling, while measures in several areas limit direct discharge into the sewer system.

By acting at metropolitan scale and across the full water cycle, this approach contributes to reducing demand on potable water supplies and mitigating drought impacts. It also helps limit combined sewer overflows and strengthens the ecological functioning of urban catchments. The experience illustrates how rainwater-focused master planning can support water-scarcity resilience while delivering co-benefits for heat mitigation, biodiversity and urban liveability.

32 City of Paris (2024). *Gestion des eaux pluviales : le Plan ParisPluie* https://www.paris.fr/pages/le-plan-parispluie-5618

Figure 22: Paris rainwater zoning and subsurface sensitivity to infiltration under the *Plan ParisPluie*



Source: https://www.paris.fr/pages/le-plan-parispluie-5618

B.3 Implementation & Financial Incentives

While knowledge and governance frameworks set the conditions for action, resilience to water scarcity ultimately depends on effective implementation. Across Europe and Central Asia, cities and utilities are deploying a growing range of measures to secure water supply, reduce demand and improve system efficiency under increasingly constrained conditions.

Implementation strategies are evolving from emergency-driven responses toward more proactive and diversified approaches. These include reducing water losses in distribution networks, diversifying water sources through reuse and alternative supplies, improving storage and operational flexibility, and promoting efficiency and conservation among users. Financial and regulatory incentives increasingly support these measures, helping to align individual behaviour and investment decisions with collective water-security objectives.

Implementation pathways vary widely depending on local context, water availability and institutional capacity. However, common patterns emerge across the region, including the prioritization of leakage reduction as a cost-effective adaptation measure, the expansion of non-potable and reused water for specific uses, and the growing role of digital tools in optimizing operations and demand management.

The case studies presented in this section illustrate how cities are operationalizing these strategies in practice, highlighting both technical solutions and enabling financial instruments that support sustained action on urban water scarcity.

Milan, Italy: Reducing water losses and expanding reuse across multiple sectors

Milan demonstrates how a diversified portfolio of operational measures, supported by coordinated governance and long-term planning, can contribute to urban resilience to water scarcity. The city has progressively strengthened demand management and alternative supply strategies, combining infrastructure optimization with sustained efforts to reduce water losses through targeted maintenance and smart monitoring, bringing leakage levels well below the national average.

In parallel, Milan has expanded the reuse of treated wastewater, particularly for agricultural irrigation in areas surrounding the metropolitan region. This approach is supported by regulatory authorizations, dedicated infrastructure and cooperation between the water utility, regional authorities and agricultural stakeholders. Within the city, non-potable standpipes are used for municipal services such as street cleaning and construction works, reducing pressure on drinking-water supplies; measures initially introduced during drought periods have since been consolidated as permanent operational practices.

Adaptive management of urban green spaces forms another pillar of implementation. During drought events, irrigation tankers supplied by non-potable filling stations are deployed to protect vulnerable urban trees and priority green areas, while coordination with groundwater monitoring wells and geothermal systems enables the recovery and reuse of low-temperature groundwater for selected municipal uses.

These measures are complemented by the preparation and regular updating of a Water Safety Plan by the integrated water service operator, in close coordination with the Municipality of Milan.

Barcelona, Spain: Implementing PLARHAB to expand alternative water sources

Barcelona operationalizes water-scarcity adaptation through the *Plan de Recursos Hídricos Alternativos* (Alternative Water Resources Plan, PLARHAB), a comprehensive strategy designed to diversify local water resources and reduce dependence on external reservoirs. The plan is embedded within municipal planning and water-cycle governance, ensuring alignment between strategic objectives, operational delivery and regulatory instruments.

PLARHAB promotes the development of multiple alternative water sources, including sustainable groundwater abstraction, large-scale use of regenerated water for irrigation, industry and environmental flows, and the deployment of greywater reuse systems in buildings and public facilities. Rainwater harvesting is encouraged through municipal subsidies and technical guidelines, while Sustainable Urban Drainage Systems integrated into public spaces support infiltration, retention and aquifer recharge. Additional measures include the controlled use of mountain torrents to replenish groundwater and direct seawater use for specific non-potable municipal operations.

A recent municipal ordinance further strengthens these measures by reinforcing requirements and incentives for greywater systems in residential and commercial developments. Barcelona's experience illustrates how combining planning instruments, regulatory frameworks and targeted financial incentives can enable large-scale implementation of alternative water sources and embed water reuse as a core component of urban drought resilience.

Figure 23: **Barcelona's technical plan for the use of alternative water resources (PLARHAB 2020)**

Pla tècnic per a l'aprofitament dels recursos hídrics alternatius a Barcelona. Edició 2020.

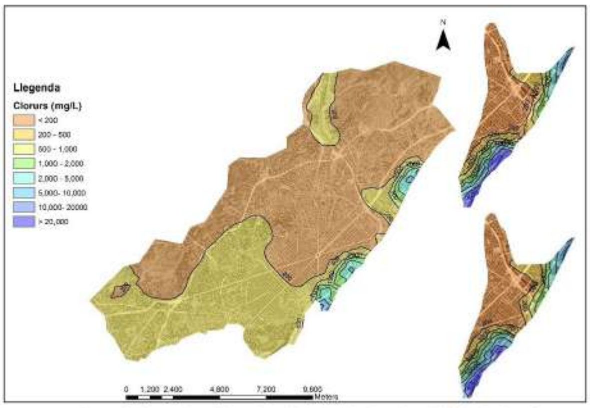


Figura 32. Mapes de salinitat als aqüífers superior(centre), mitjà (dalt a la dreta) i profund (baix a la dreta) al 2017.

Amb l'objectiu d'analitzar distribució geogràfica de la qualitat de l'aigua del subsòl i la seva evolució en els darrers anys, s'han recollit les dades de diferents paràmetres corresponents a dues campanyes de mostreig: hivern 2013 i hivern 2017. Els rangs obtinguts per als diferents paràmetres mesurats permeten establir una certa zonificació de la qualitat de l'aigua freàtica, que es pot resumir, a títol orientatiu, a la Figura 33.

A la Taula 13 i la Taula 14 s'indiquen els paràmetres mesurats i els rangs obtinguts per a cada zona a partir de les dades de qualitat obtingudes als diferents punts de mostreig indicats.

Als plànols 3.3 es representa geogràficament els valors qualitatius dels diferents paràmetres analitzats en els punts de control de l'aqüífer.

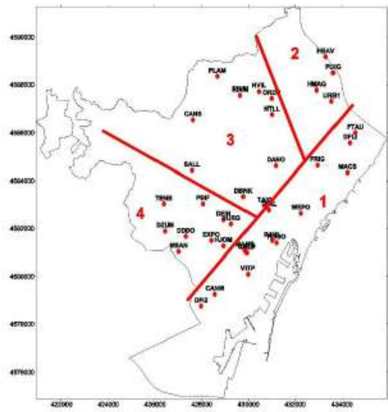


Figura 33. Representació de la zonificació orientativa segons qualitat fisicoquímica de l'aigua freàtica i punts de mostreig.

Campanya de camp Hivern 2013

Paràmetre	Rang habitual Z. Llobregat (4)	Rang habitual Z. Centre (3)	Rang habitual Z. Besós (2)	Rang habitual Z. Litoral (1)
pH a 20 ºC (upH)	7 - 8	7 - 8	7 - 8	7 - 8
Conductivitat a 20 º C (µS/cm)	1500 - 2000	1000 - 1300	1000 - 1500	1500 - 2500
Clorurs (mg Cl/l)	200 - 400	50 - 200	100 - 200	200 - 400
Bor (mg B/l)	< 0,20	< 0,20	< 0,50	< 0,50
Nitrats (mg NO_3/l)	50 - 125	75 - 125	< 100	< 100
Sulfats (mg SO_4/l)	200 - 350	150 - 250	150 - 250	200 -350
Sodi (mg Na/l)	100 -150	50 - 100	100 - 150	150 - 250
Calci (mg Ca/l)	150 - 200	100 - 150	100 - 150	150-250
Magnesi (mg Mg/l)	50 - 75	40 - 60	20 - 40	50 - 100
Potassi (mg K/l)	1 - 5	1 - 5	1 - 15	1 - 25
Alcalinitat (mg $CaCO_3$/l)	250 - 325	200 - 350	300 - 350	300 - 450
Ferro (ppb)	< 50	< 40	< 40	< 50
Manganès (ppb)	< 5	< 5	< 20	< 20

Taula 13. Rangs habituals dels paràmetres de qualitat en aigües freàtiques a Barcelona. 2013

Ajuntament de Barcelona | Barcelona Cicle de l'Aigua SA

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pot cobrir usos molt concrets, i cal adaptar les instal·lacions per tal de què suportin l'atac químic dels components corrosius que conté. Aquests són:

- Obtenció d'aigua potable en plantes dessaladores. Aquest ús no es contempla en el Pla, ja que l'aigua dessalada té una qualitat superior a la que es requereix per als usos establerts en el Pla.
- Ompliment de piscines.
- Sistemes de refrigeració amb circuit tancat.
- Sistemes contra incendis.

9.2. BALANÇ DE RECURSOS I DEMANDES

El balanç de recursos i demandes es realitza tenint en compte els usos previstos i els recursos disponibles a l'àmbit públic. En el present Pla no es preveu la utilització dels recursos potencialment disponibles a l'àmbit privat per a usos públics (tant municipals com no municipals), ja que actualment no existeix una regulació al respecte.

De l'anàlisi de tots els recursos hídrics alternatius disponibles a la ciutat a l'àmbit públic, s'extreu que el recurs potencial màxim, sense incloure les extraccions d'aigua del subsòl que s'estan realitzant actualment, i sense comptar l'aigua de mar, és de **31,6 hm³/any,** dels quals es podrien aprofitar **23,8 hm³/any** (correspon aproximadament a un 75%). No obstant, cal destacar que en l'actualitat l'Ajuntament de Barcelona disposa de concessions amb els organismes competents de cada recurs per a la utilització d'un total de **7 hm³/any.** (veure taula 12 de l'apartat 7.1.6).

Pel que fa a les demandes actuals, la demanda total d'aigua dels usos que no requereixen la qualitat de l'aigua potable i que es podria cobrir amb recursos hídrics alternatius per a usos municipals és de **4,95 hm³/any** (veure Taula 4 de l'apartat 8.1.13). Si es té en compte el volum anual servit per a usos públics no municipals des de les instal·lacions d'abastament d'aigua freàtica municipals, i la demanda potencial actual per aquests usos, la demanda total actual de recursos hídrics alternatius per a usos públics de la ciutat ascendeix a **5,04 hm³/any**, volum inferior al concessionat actualment.

Analitzant la demanda total màxima dels serveis municipals (suma de les demandes actuals i les demandes futures planificades), veiem que aquesta ascendiria a **5,69 hm³/any.** Aquest valor és sensiblement superior al volum concessionat actualment, per tant, amb el desenvolupament de les actuacions previstes en el present Pla, caldrà revisar en un futur les concessions vigents i preveure, si s'escau, la seva ampliació.

El consum actual d'aigua (potable + freàtica) dels serveis municipals exposats a l'apartat 3.1. del present document equival a **6,79 hm³/any.** En el cas que s'arribés al sostre del Pla, és a dir, que s'arribin a cobrir les demandes actuals i potencials dels servies municipals establertes a l'anàlisi de la demanda (equivalent a **5,69 hm³/any**), i tenint en compte els criteris fixats (en quant a consum mínim anual), **l'índex de sostenibilitat del consum d'aigua de l'Ajuntament** (calculat a partir dels consums de 2018) arribaria al **83,79%.**

9.2.1. Balanç en funció de l'origen del recurs i del tipus de demanda

Un cop exposat el balanç global de recursos i demandes, en aquest apartat es fa un creuament dels recursos disponibles i les demandes potencials que es podrien cobrir amb cadascun dels recursos.

- **Aigua del subsòl:** El recurs total disponible correspontent a les masses d'aigua subterrànies de la ciutat (sense tenir en compte les extraccions actuals) és d'uns 18 hm³/any, segons les dades exposades a l'apartat 7.1.1. No obstant, la demanda de recursos hídrics alternatius de la ciutat que es podria servir amb aigua del subsòl és de 5,69 hm³/any. Per tant, el recurs potencialment disponible és superior a la demanda estimada. A la Figura 34 es representa el volum potencial disponible d'aquest recurs i la demanda potencial estimada en el present Pla.

Figura 34. Balanç de recurs-demanda de l'aigua del subsòl.

- **Aigua regenerada:** El recurs total que és capaç de generar la ERA d'El Prat és de 50 hm³/any. D'aquest volum total generat, la demanda estimada al terme municipal de Barcelona que es podria cobrir amb aquest recurs és de 5,5 hm³/any per a injecció a l'aqüífer, 2,56 hm³/any per a usos industrials, i 0,73 hm³/any per al reg de zones verdes, dels quals estan concessionats actualment a l'Ajuntament de Barcelona 0,14 hm³/any. A la Figura 35 s'exposa el volum potencial disponible i els possibles usos que es poden cobrir amb aquest recurs.

Source: https://bcnroc.ajuntament.barcelona.cat/jspui/handle/11703/121227?locale=en

Potenza, Italy: Leakage reduction, agricultural reuse and coordinated drought response

In the Basilicata region, extremely high levels of water loss, reaching up to 70% in some networks, make leakage reduction a critical implementation priority. Regional and municipal authorities, together with the regional water utility, have therefore focused on comprehensive network diagnostics using digital mapping, flow measurements, and pressure analysis to identify priority intervention areas.

Operational measures include targeted pipe replacement based on risk and age indicators, deployment of pressure-management systems to stabilize consumption and reduce bursts, and the use of digital monitoring tools to detect anomalies and track performance improvements over time. These actions are supported by regional investment programmes and, in some cases, by EU funding instruments aimed at infrastructure renewal and climate adaptation.

Alongside network rehabilitation, the region promotes wastewater reuse for agricultural purposes, supported by EU rural-development funds and coordination with irrigation consortia. During declared drought phases, municipalities implement restrictions, public guidance and awareness campaigns in line with regional emergency frameworks. The Basilicata experience highlights how regions facing structural water scarcity must combine infrastructure upgrades, governance coordination, and regulatory measures to reduce systemic vulnerability.

Uzbekistan, Central Asia: Smart water metres for urban demand management

Uzbekistan is advancing digital water-management systems under a national modernization programme supported by the Asian Development Bank. The initiative aims to improve monitoring of water consumption, strengthen utility operations and enhance transparency in billing through the use of digital technologies.

Beyond improving operational efficiency, smart metering strengthens governance by providing reliable data to utilities and regulators, enabling beter control of pressure zones, identification of losses and evidence-based planning. At household level, accurate metering and billing create financial incentives for water-saving behaviour, linking consumption more directly to cost.

Early indications from digital water-management initiatives in Uzbekistan suggest potential improvements in operational efficiency and resource management, including gains in revenue collection and utility sustainability. Such experiences illustrate how digital transformation, when paired with supportive financial and regulatory frameworks, can contribute to demand management and resilience to water scarcity in urban settings.

Athens, Greece: Diversified supply systems and demand-side innovation under chronic water scarcity

Water shortages are a persistent feature of Athens; the city water company therefore relies on a complex system of reservoirs and transportation through pipelines from other regions of Greece. Specifically, the metropolitan area depends on a complex system of reservoirs (Mornos, Evinos, Yliki) and long-distance water transfers, making it particularly sensitive to prolonged droughts and hydrological variability. The water management system of Athens incorporates both historical aspects and innovations. One example is the Hadrian's Aqueduct, constructed during the Roman Empire period and still partly operational.[33] Modern technology, such as smart metering), has also been used to enhance the monitoring process, control leakages, and manage demand side effects. Decentralized units implemented in locations such as Markopoulo[34] take wastewater from the sewer system and recycle it in situ, creating water of excellent quality for irrigation purposes, thus relieving the strain on fresh water. Another example, located in urban locations including Goudi, involves the use of modular treatment units, which recycle the water in-situ and produce compost as well.[35]

33 https://www.eydap.gr/en/SocialResponsibility/Enviroment/CULTURALHIDRANT
34 https://climate-impetus.eu/
35 Plevri, Argyro & Monokrousou, Klio & Makropoulos, Christos & Lioumis, Christos & Tazes, Nikolaos & Lytras, Efthymios & Samios, Stylianos & Katsouras, George & Tsalas, Nikolaos. (2021). Sewer Mining as a Distributed Intervention for Water-Energy-Materials in the Circular Economy Suitable for Dense Urban Environments: A Real World Demonstration in the City of Athens. Water. 13. 2764.

B.4 Gaps & Opportunities

Despite growing awareness and important progress in monitoring, governance and implementation, cities across Europe and Central Asia continue to face significant challenges in adapting to water scarcity. The responses collected through the MCR2030 questionnaire reveal a common pattern: **cities understand the risks, perceive their growing intensity, and recognize the urgency of adaptation, yet operational and financial constraints often limit their capacity to act at the required scale.**

Urban water scarcity is no longer an episodic crisis, but an emerging structural reality driven by climate change, demographic pressures, ageing infrastructure and competition between sectors. Building future-proof urban water systems therefore requires a transition from reactive drought management to integrated, circular and climate-resilient water strategies, capable of reducing vulnerability while generating new environmental and societal benefits.

This section identifies s transformative solutions cities can adopt to bridge existing gaps and align with long-term resilience trajectories.

Gap 1: Fragmented risk knowledge and monitoring for water scarcity

In many urban contexts, information on water availability, demand and system performance remains fragmented across institutions and indicators, in some cases based on outdated or unverified assumptions. Monitoring of groundwater, surface water, soil moisture, consumption patterns, and network performance is often uneven, and smaller municipalities may face constraints in maintaining hydrometric or digital systems. Reliance on legacy data, such as historical estimates of per-capita water use that have not been empirically validated, limits the accuracy of risk assessments and undermines evidence-based decision making, preparedness planning, and the ability to anticipate drought conditions.

Opportunity 1: Integrated and multi-source monitoring for drought preparedness

Strengthening integrated monitoring and shared data frameworks, underpinned by regularly updated and validated datasets, can improve the operational use of knowledge for drought management. Combining multiple indicators into coherent decision-support systems, supported by inter-institutional data sharing and scalable digital tools, can enhance early detection of stress and support anticipatory action across urban and basin scales.

Gap 2: Structural water losses and ageing infrastructure

High levels of non-revenue water and ageing infrastructure remain a major source of vulnerability in many cities. Leakage rates are particularly high in older networks, where delayed renewal cycles and budget constraints reduce system efficiency and resilience. These structural losses increase pressure on available water resources, especially during prolonged dry periods.

Opportunity 2: Systematic leakage reduction and performance-based asset management

Targeted investment in leakage reduction, supported by risk-based asset management and performance monitoring, offers a cost-effective pathway to strengthen water security. Combining infrastructure renewal with pressure management, digital diagnostics and sustained financing mechanisms can significantly reduce losses and improve system reliability over time.

Gap 3: Limited diversification of urban water sources

Urban water supply in many cities continues to rely on a narrow range of dominant sources, often surface water or deep aquifers. The integration of alternative sources such as reused wastewater, greywater systems, rainwater harvesting or nature-based infiltration remains limited, constraining adaptive capacity during drought events.

Opportunity 3: Diversification of urban water sources through reuse and circular approaches

Diversifying water sources through reuse, decentralized systems and circular water approaches can reduce dependency on single supplies and increase flexibility under stress. Embedding alternative water sources into urban planning, building regulations and sectoral strategies enables cities to progressively strengthen resilience while supporting environmental and climate objectives.

Gap 4: Insufficient integration of drought governance and societal engagement

Drought is frequently managed through short-term emergency measures rather than as a structural urban risk. Formal drought management frameworks, climate-informed allocation rules and coordinated governance arrangements are not always fully developed. At the same time, sustained citizen engagement and behavioural-change mechanisms remain uneven, limiting the effectiveness of demand-side measures.

Opportunity 4: Integrated drought governance and sustained societal engagement

Embedding drought governance within broader urban risk-management and policy frameworks can improve coherence, predictability and coordination. Coupling formal planning instruments with participatory approaches, targeted communication and incentive-based behavioural tools helps position water conservation as a shared responsibility and strengthens societal readiness for water scarcity.

B.5 Recommendations

1. Institutionalize integrated and multi-source monitoring for water scarcity

Urban water-scarcity management benefits from monitoring frameworks that combine hydrological, meteorological, groundwater and infrastructure-performance data into a coherent evidence base. Institutionalizing such integrated monitoring systems supports early detection of stress, improves situational awareness and enables more timely and coordinated decision-making across sectors and scales.

2. Formalize drought governance frameworks within existing urban risk-management systems

As drought becomes a more recurrent and structural risk, cities and regions are encouraged to move beyond ad hoc crisis responses toward formalized drought-management frameworks. Embedding drought plans within existing water-management or emergency-planning systems, with clear thresholds, escalation phases and responsibilities, strengthens clarity, continuity and rapid activation during periods of water stress.

3. Prioritize water-loss reduction as a core adaptation strategy

Reducing non-revenue water remains one of the most cost-effective and widely applicable measures to strengthen resilience to water scarcity. Supporting systematic diagnostics, pressure management and infrastructure renewal through sustained financing and asset-management frameworks can significantly improve efficiency and reduce pressure on limited water resources, particularly during prolonged droughts.

4. Enable diversification of urban water sources through planning and regulation

Long-term water-scarcity resilience is strengthened when cities reduce reliance on single supply sources. Integrating alternative water sources, including treated wastewater, groundwater and rainwater, into urban planning, building regulations and sectoral strategies increases flexibility and adaptive capacity. Such diversification supports continuity of essential services while contributing to circular water-management objectives.

5. Leverage digitalization to strengthen operational efficiency and governance

Digital tools play an increasingly important role in improving water-scarcity management by enhancing monitoring, forecasting and operational control. Supporting the uptake of smart metering, real-time dashboards and predictive analytics within existing governance and regulatory frameworks can accelerate efficiency gains and support evidence-based decision-making at both utility and municipal levels.

6. Embed societal engagement and long-term vision into water-scarcity strategies

Effective water-scarcity management depends not only on technical solutions but also on sustained societal engagement. Integrating communication, participation, and behavioural-change mechanisms into formal governance frameworks strengthens public understanding, transparency, and compliance during drought periods. In parallel, long-term strategic planning that aligns climate projections, environmental protection and infrastructure investment pathways supports more coherent and anticipatory urban water policies.

Conclusion - Towards integrated urban water resilience: aligning policy, practice and long-term transformation

Across Europe and Central Asia, cities are increasingly confronted with water-related risks that may appear contradictory, flooding during intense rainfall events and water scarcity during prolonged droughts. In practice, these risks are deeply interconnected. Both are symptoms of a broader systemic challenge: the progressive disruption of natural hydrological processes caused by urbanization, land sealing, river regulation, and fragmented approaches to water management.

The case studies presented throughout this report demonstrate that cities are no longer addressing floods and droughts as isolated hazards. Instead, they are gradually moving toward more integrated approaches that recognize the water cycle as a continuous system, linking rainfall, runoff, infiltration, storage, use and reuse across spatial and temporal scales. This shift is reflected in the growing use of multi-source monitoring, risk-informed planning, diversified water sources, coordinated governance frameworks, and demand-side management.

A key lesson emerging from the analysis is that effective urban water resilience depends less on individual technical solutions than on the conditions that enable cities to act coherently over time. Where progress has been achieved, it is typically supported by four reinforcing pillars: robust and integrated knowledge systems, institutional coordination across sectors and levels, sustained investment and financing mechanisms, and active engagement of communities and stakeholders. Weakness in any one of these dimensions tends to limit the effectiveness of the others.

Within this broader transition, the sponge city concept can provide a powerful integrative vision. By seeking to restore, protect and mimic natural hydrological functions within urban environments, sponge city approaches offer a common framework to address both excess water and water scarcity. Measures such as infiltration, retention, reuse, decentralized storage and nature-based solutions contribute simultaneously to flood mitigation, groundwater recharge, water-quality improvement, urban cooling, and ecosystem restoration. Importantly, these approaches help reduce reliance on grey infrastructure alone and support more adaptive and cost-effective long-term management.

However, the sponge city should be understood not as a single model to be replicated, but as a guiding principle that can be adapted to diverse climatic, institutional, and socio-economic contexts. Its successful implementation depends on governance arrangements, regulatory frameworks and investment strategies that embed water considerations into everyday urban decision-making, from land-use planning and building design to infrastructure renewal and public-space management.

Based on the collective lessons from the cities analysed in this report, several policy-level orientations emerge to support this transition.

First, urban water resilience benefits from embedding flood and drought considerations within integrated policy frameworks, rather than treating them through separate sectoral or emergency-driven approaches. Aligning water management with spatial planning, climate adaptation, disaster risk reduction, and environmental policy strengthens coherence and reduces duplication.

Second, multi-level governance and coordination are essential. Clear roles, shared data platforms and harmonized planning instruments between municipalities, utilities, basin authorities and national institutions enable more timely and consistent responses to water-related risks, particularly in regions facing structural scarcity or rapid urban growth.

Third, sustained and predictable financing is a critical enabler. Moving beyond short project cycles toward multi-year investment frameworks, including operation and maintenance, supports the durability of resilience measures. Blended financing and incentives can further accelerate leakage reduction, water reuse, and nature-based solutions.

Fourth, strengthening societal engagement is not optional. Cities that integrate communication, participation, and behavioural-change mechanisms into formal governance frameworks are better positioned to implement demand-management measures and to maintain public trust during periods of stress.

Finally, long-term strategic vision matters. Cities that articulate forward-looking water strategies, informed by climate projections and environmental objectives, are better able to align short-term actions with long-term resilience pathways.

As members of the MCR2030 network continue to advance along their resilience journeys, this report highlights that floods and water scarcity should be addressed as two sides of the same challenge. By embracing integrated, systemic and inclusive approaches to urban water management, cities can move toward a future where water is no longer perceived primarily as a hazard or a constraint, but as a central asset for resilience, liveability and sustainable development.

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