

Editorial

Enhancing Planning in the Management of Urban Water Systems to Increase Resilience

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Urban water infrastructures are vital to cities, yet they are complex and vulnerable to both climate-related events—such as extreme precipitation, urban floods, droughts, heat waves, and cyclones—and other disruptive events like earthquakes, tidal effects, and tsunamis. Enhancing resilience in urban water systems—including drinking water, wastewater, and stormwater networks—is crucial to ensure the sustainability of these essential urban services and cities.

With ageing infrastructure, growing demand or changes in demand behaviour, as well as the need to improve resource and energy efficiency, traditional planning approaches are no longer sufficient. The paradigm is shifting towards integrated, flexible, and systemic planning frameworks incorporating uncertainty, long-term scenario building, and hybrid solutions, including decentralised networks, multiple water sources, and nature-based approaches. At the same time, practical methods for diagnosis, decision-making, implementation, monitoring, and revision are essential, especially for utilities with limited resources.

Despite these advances, significant challenges remain:

- Limited approaches for integrated planning: Strategies, tactics, and operational frameworks that incorporate resilience, risk management, uncertainty, and scenario-based methods are scarce.
- Lack of accessible diagnostic and monitoring tools: Utilities require practical, affordable, and cost-effective methods to assess, diagnose, and track system performance.
- Insufficient integration of efficiency, resource recovery, and nature-based solutions: Incorporating the water–energy–nutrient nexus, water reuse, and nature-based solutions into urban water systems remains limited.
- Unclear trade-offs between centralised and decentralised systems: Evidence-based guidance for hybrid or context-specific configurations is lacking.

Ten articles are published in this Special Issue:

1. Water–Energy Nexus-Based Optimization of the Water Supply Infrastructure in a Dryland Urban Setting;
2. The Role of Scenario-Building in Risk Assessment and Decision-Making on Urban Water Reuse;
3. Water Supply Security—Risk Management Instruments in Water Supply Companies;
4. Assessing Pipe Condition in Water Distribution Networks;
5. Integrating Uncertainty in Performance Assessment of Water Distribution Networks by Scenario Building;
6. Water–Energy–Nutrients Nexus of Urban Environments;
7. A Framework for Operational Management of Urban Water Systems to Improve Resilience;



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8. Water Resources Carrying Capacity Based on the DPSIRM Framework: Empirical Evidence from Shiyao City, China;
9. Stormwater Harvesting Potential for Local Reuse in an Urban Growth Area: A Case Study of Melton Growth Area in the West of Melbourne;
10. How Scale Influences the Resilience of Urban Water Systems: A Literature Review of Trade-Offs and Recommendations.

These papers address the mentioned gaps in complementary ways:

1. Planning, Risk Management
 - Contributions 3 and 8 present structured approaches for risk assessment in water supply systems and to determine city-level water resources' carrying capacity, supporting long-term strategic planning. Contribution 3 proposes using semi-dynamic Balance Sheet Structure Models (BSM) for vulnerability analysis, as a valuable addition to existing instruments. Contribution 8 contributed with an evaluation index system based on the DPSIRM framework to determine the water resource carrying capacity of Shiyao City.
 - Contributions 1, 4, and 7 demonstrate how optimisation, condition assessment, and operational frameworks can enhance short and medium-term planning decisions in utilities. Contribution 1 integrates a genetic algorithm to generate pumping patterns and uses the EPANET hydraulic simulator to optimise pump schedules, ensuring water distribution at minimal operational costs. Contribution 4 developed and applied a methodology for predicting the physical condition of water distribution pipes without requiring visual inspection, to support prioritisation of rehabilitation interventions. Contribution 7 proposed a methodology for the operational management of hydraulic infrastructures that incorporates concepts of asset management, risk management, and technical management. It is organised into three operational areas (assessment, operation, and intervention) and aims to increase the efficiency of water utilities.
 - Contributions 2 and 5 introduce innovative frameworks for integrating uncertainty in water reuse planning and distribution network performance assessment. In Contribution 2, the proposed framework for health risk assessment and management of urban non-potable water reuse includes an additional step to establish the context, and the risk identification step is extended to include a description of activities from which hazard exposure scenarios can be derived. Contribution 5 presents a novel scenario-building methodology that integrates contextual and future-time uncertainties into the performance assessment of water distribution networks.
2. Efficiency and Nexus Approaches
 - Contributions 1, 6, and 7 show how the water–energy(–nutrient) nexus can be embedded in planning to improve efficiency, sustainability, and resource recovery. In Contribution 1, the proposed methodology, optimising the Water Distribution Network (WDN) and its management, also presents a model to save energy by optimising pump schedules. Contribution 6 presents a literature review highlighting the strong connections among water, energy, and nutrients at the building level, integrating results from different studies and demonstrating the global importance of this nexus. In Contribution 7, a methodology for the operational management of hydraulic infrastructures is proposed, addressing energy efficiency and consumption.
3. Alternative water sources, decentralisation and Nature-Based Solutions

- Contributions 6, 9, and 10 explore alternative water sources, stormwater harvesting and scale-dependent trade-offs, providing insights for hybrid centralised–decentralised system design and adaptive management, considering nature-based solutions. Contribution 6 focuses on alternative water sources in buildings within the water–energy nexus. Contribution 9 presents a methodology for assessing stormwater quantity and quality under land-use change and varying climatic conditions, considering alternative water sources for water-service planning in new developments in urban areas. Contribution 10 presents a systematic review to understand the trade-offs associated with the adoption of different scales in urban water systems’ design, addresses nature-based solutions, and examines how this impacts systems’ resilience. Collectively, these contributions illustrate that enhancing planning—through strategic foresight, operational tools, and systemic integration—is central to building resilient urban water systems.

To further advance resilience, research should focus on:

- Developing robust, simple, and open-source planning tools for water utilities with diverse capacities, incorporating risk assessment and management principles.
- Incorporating nature-based and hybrid solutions into planning frameworks to balance centralised and decentralised infrastructure.
- Strengthening multi-resource integration (water, energy, nutrients, ecosystems) as a guiding principle.
- Utilising digital technologies (IoT, AI, big data) for adaptive planning and real-time decision support.
- Broadening understanding of governance and social dimensions, including stakeholder engagement and adaptive policy frameworks.

This Special Issue emphasises the transformative potential of planning as a driver of resilience. By combining strategic foresight, operational efficiency, and systemic integration, urban water systems can address the challenges of climate change and urban growth whilst ensuring sustainability and resilience for future generations.

Conflicts of Interest: The authors declare no conflict of interest.

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