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Interactions between urban water services and natural areas for asset management and resilience assessment

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Urban areas are characterized by strategic services and assets that are interconnected and interdependent. The increasing interrelationship between ecosystems, human settlements, and urban services emphasizes the critical need to deepen asset management (AM) practices and strengthen resilience across all systems (UNDRR, 2023). Resilience is significantly related to AM practices. On one hand, best practices in AM promote reliable services and assets, contributing to their resilience. On the other hand, enhancing resilience in one area sometimes leads to unforeseen or unintended impacts on others or on AM objectives. In its Vision 2030 study, the World Health Organization (WHO, 2009) stressed the importance of conducting systematic resilience assessments for all utilities of urban services, in response to the challenges posed by climate change (CC). Examining in parallel the provided services and the infrastructure, supporting them within a unified framework, offers significant advantages by leveraging their interconnections. This paper focuses on the urban water services (water supply, wastewater, and stormwater) and natural areas, considered as a service provided to the city, its citizens, and other stakeholders (Brito et al., 2024).

A holistic resilience assessment framework was developed within the RESCCUE and the ICARIA European projects (https://toolkit.resccue.eu, https://www.icaria-project.eu). This paper presents the similarities provided in the Resilience Assessment Framework (RAF) for the addressed services, highlighting the opportunities for AM and resilience improvement for CC, by capitalizing on the interactions between them. The RAF has a tree structure that considers resilience Dimensions and, for each, unfolds from resilience Objectives, Criteria and Metrics. For the *functional* resilience dimension (which focuses on the *service* provided), Table 1 presents an overview of the assessment system, including the number of resilience metrics for each criterion, emphasizing between brackets those that are similar in other services (in **bold)**, and those that have underlying AM concerns (in blue). The same information is provided in Table 2, for the *physical* dimension (which focuses on the infrastructure).

It can be perceived that 60-80% of the metrics are common between services, which promotes integrated planning and implementation of holistic solutions. It streamlines resource allocation, enables consistent benchmarking and improves breaking down silos. This approach also facilitates stakeholder engagement and helps to identify synergies between services, such as how stormwater management can support natural habitats or provide an alternative water source. From the common metrics, nine specifically focus on interactions between the services. These metrics address e.g. cascading effects, dependencies, autonomy, and the impact of one service's failure on another. Additionally, over 75%-90% of the metrics reflect both resilience and AM concerns. This integration promotes a holistic understanding of service continuity, enables prioritization of investments with a dual focus, and supports decision-making that emphasizes intergenerational responsibility across multiple dimensions.

Table 1. Overall *functional* metrics, shared between services (in **bold**) or with AM focus (in blue)

OBJECTIVE / Criterion	Water Supply	Wastewater	Stormwater	Natural areas
SERVICE PLANNING AND RISK MANAGEMENT				
Strategic planning	5 **(5)** (5)	5 **(5)** (5)	5 **5** (5)	12 **(4)** (8)
Resilience engaged service	12 **(6)** (3)	6 **(6)** (3)	6 **(6)** (3)	19 **(5)** (3)
Risk management	12 **(7)** (12)	12 **(7)** (12)	12 **(7)** (12)	6 **(6)** (6)
Reliable service	11 **(6)** (11)	6 **(6)** (6)	6 **(6)** (6)	5 **(4)** (4)
Flexible service	4 **(1)** (4)	4 **(1)** (4)	4 **(1)** (4)	3 **(1)** (3)
AUTONOMOUS SERVICE				
Service importance to the city	2 **(2)** (1)	2 **(2)** (1)	2 **(2)** (1)	2 **(2)** (1)
Service inter-dependencies considering CC	2 **(2)** (2)	2 **(2)** (2)	2 **(2)** (2)	2 **(2)** (2)
SERVICE PREPAREDNESS				
Service preparedness for disaster response	4 **(4)** (1)	4 **(4)** (1)	4 **(4)** (1)	4 **(4)** (1)
Service preparedness for CC	8 **(8)** (6)	8 **(8)** (6)	8 **(8)** (6)	8 **(8)** (6)
Service preparedness for recovery & build back	15 **(10)** (15)	10 **(10)** 10	10 **(10)** 10	9 **(9)** 9

Table 2. Overall *physical* metrics, shared between services (in **bold**) or with AM focus (in blue)

OBJECTIVE / Criterion	Water Supply	Wastewater	Stormwater	Natural areas
SAFE INFRASTRUCTURE				
Infrastructure assets criticality and protection	5 **(5)** (5)	5 **(5)** (5)	5 **(5)** (5)	4 **(4)** (4)
Infrastructure assets robustness	14 **(8)** (14)	14 **(8)** (14)	14 **(8)** (14)	12 **(3)** (12)
AUTONOMOUS AND FLEXIBLE INFRASTRUCTURE				
Infrastructure assets importance to and dependency on other services	4 **(4)** (4)	4 **(4)** (4)	4 **(4)** (4)	4 **(4)** (4)
Infrastructure assets autonomy	6 **(4)** (6)	5 **(5)** (5)	6 **(5)** (6)	3 **(2)** (3)
Infrastructure assets redundancy	3 **(3)** (3)	3 **(3)** (3)	2 **(2)** (2)	2 **(0)** (2)
INFRASTRUCTURE PREPAREDNESS				
Contribution to the area's resilience	3 **(2)** (1)	3 **(2)** (1)	3 **(2)** (1)	2 **(2)** (2)
Infrastructure assets exposure to CC	3 **(3)** (3)	3 **(3)** (3)	3 **(3)** (3)	3 **(2)** (3)
Preparedness for climate change	2 **(0)** (2)	2 **(0)** (2)	2 **(0)** (2)	2 **(0)** (2)
Preparedness for recovery and build back	9 **(3)** (9)	9 **(3)** (9)	9 **(3)** (9)	5 **(2)** (5)

Ultimately, a unified framework improves the efficiency, resilience and sustainability of urban management. This framework is being applied to three case studies in Europe and will be made freely available upon the completion of ICARIA project, in late 2025.

Key words: asset management; climate change; natural areas; resilience; water services

References

Brito, R.S., Cardoso, M.A., Sfetsos, A., Cruz, A., Russo, B. (2024). Inclusion of natural areas in a holistic resilience assessment framework. 8th IAHR Europe Congress – Water across boundaries. Lisboa.

UNDRR (2023). United Nations Office for Disaster Risk Reduction. GAR Special report: measuring resilience for the Sustainable Development Goals. Geneva. ISBN 9789210028301.

WHO (2009). The resilience of water supply and sanitation in the face of climate change. World Health Organization. United Kingdom. Department for International Development (DFID), ISBN 978 92 4 159842 2.