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Future proofing urban water systems under uncertainty: a resilience assessment approach

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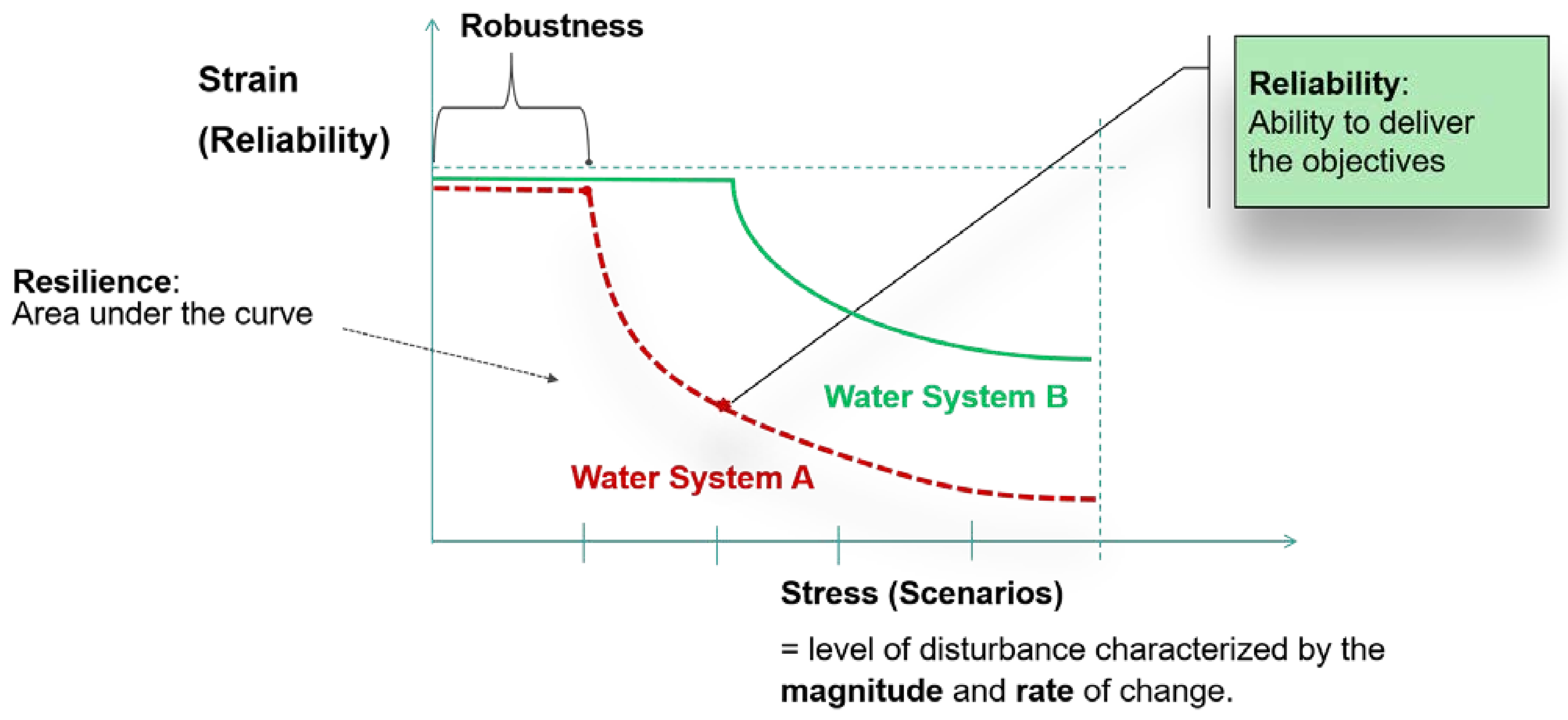
Introduction

Water services are currently and for the foreseeable future facing significant challenges in the form of internal and external pressures. The idea of resilience emerges as an alternative way of thinking about systems' performance under pressure and dominates the policy discourse [1]. Building on previous work [2] we propose a definition to operationalize resilience, as: "the degree to which an urban water system continues to perform under progressively increasing disturbance" We describe a resilience assessment method, as a 'stress-test' of different urban water system configurations, under increasingly stressful scenarios. These scenarios vary in both the magnitude of pressure and the rate at which this pressure builds up within a specified design horizon, ranging from very mild to extreme future world views. We also implemented the idea of wildcards: extreme events whose probability of occurrence is unknowable, but whose impact may be critical to the system's performance. The method is demonstrated in a real world system.

Resiliense assessment

- Stress – Strain Approach
- Reliability can be estimated by various metrics, e.g:
  - Volumetric $R_v = 1 - \sum deficit / \sum demand$
  - Customer Minutes Lost (CML)



- Scenario creation

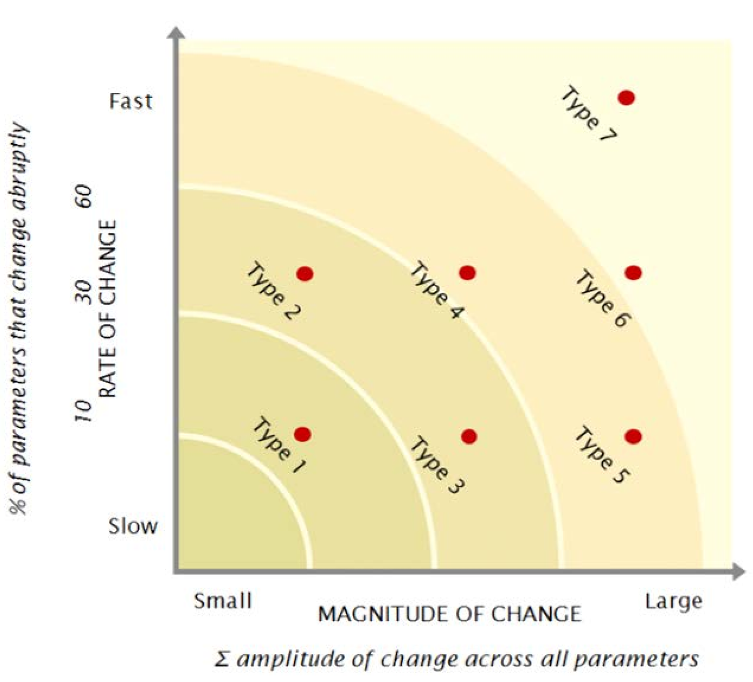


Figure 2 – Scenario types

- Topology model in UWOT [6]
  > Explore various interventions to the urban water cycle

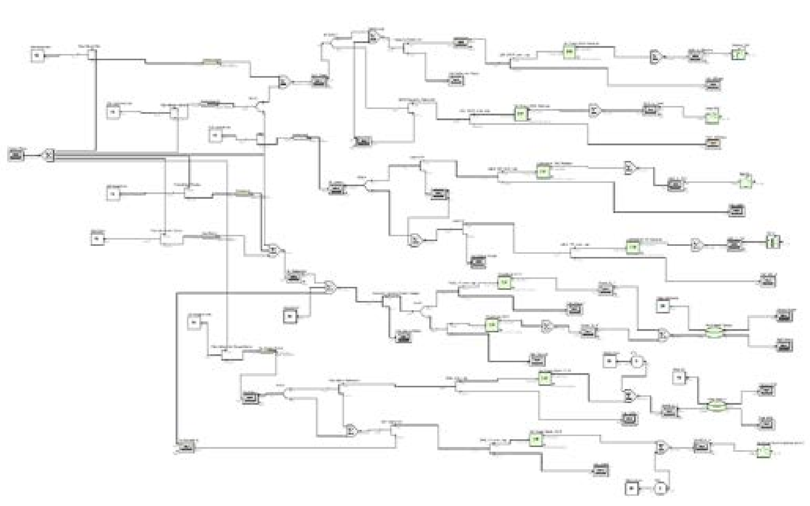
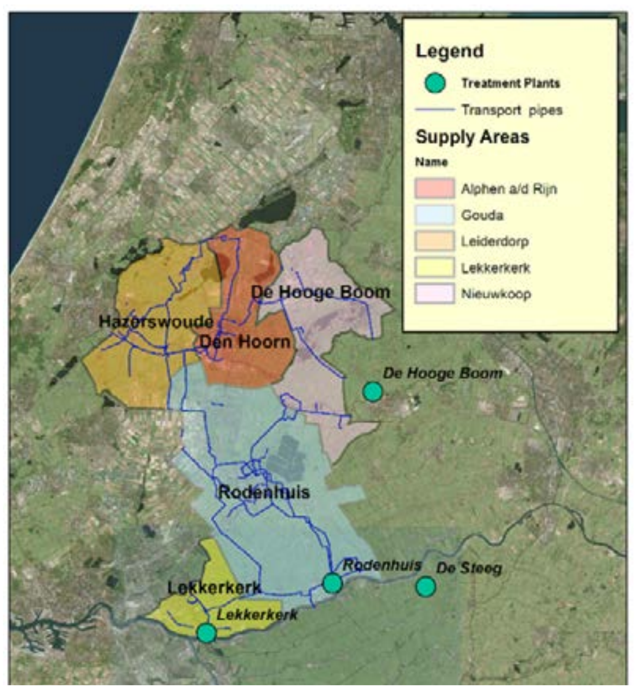


Figure 3 – UWOT model

Case study

(part of) OASEN



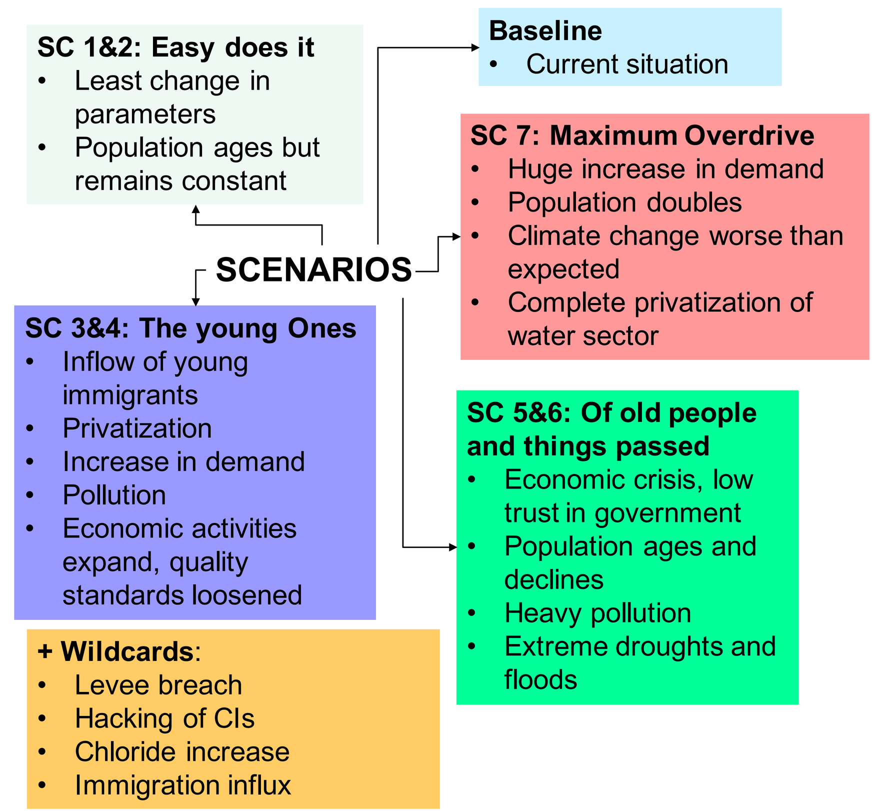


Figure 4 – Simplified OASEN case study

- 500 000 customers served
- 6 Supply Areas
- 4 Water Treatment Plants
- 15 deep and shallow groundwater fields, river-bank filtration
- Industrial and horticultural uses
- 25 year design horizon

Configurations:

- BAU: business as usual
- Next Step (NS): Plant Decentralization, RO technology
- Further Ahead: Distributed very local RO TPs, domestic Rainwater Harvesting, inclusion of brackish sources

Results & discussion

- Comparison between BAU-NS-FA.
- **NS performs as good as FA** for most of the **regular scenarios** and it is 'only' at the more extreme ones where the value of FA (very distributed) really comes into play!
- Scenarios with 'more change' are not necessarily the worst ones: the **direction** of change that stresses the system more is a **case-specific** factor ('young' vs 'old' scenarios)

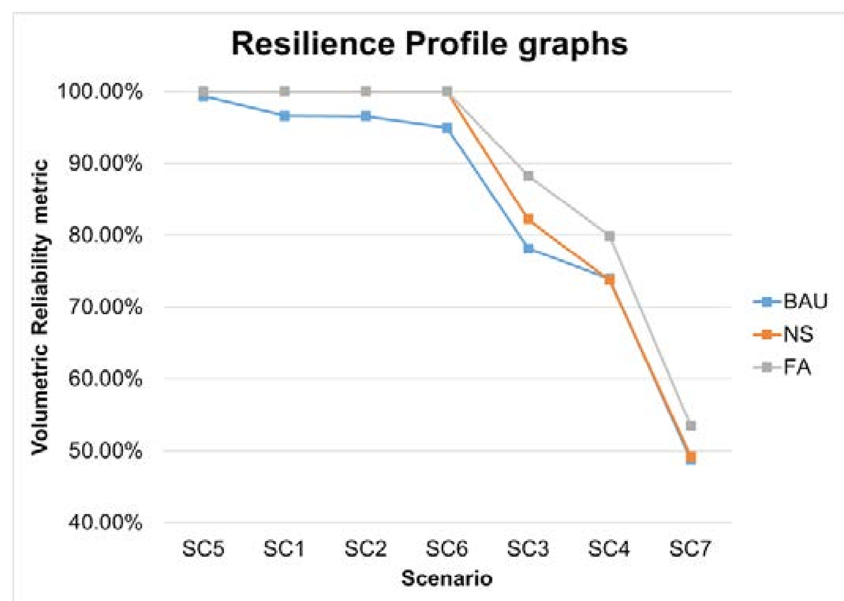


Figure 5 – Resilience profiles, scenarios ordered by severity

Conclusions:

- We propose an 'operationalization' of resilience to help water companies deal with a volatile environment imposing high order uncertainties to system operations.
- The method allows for both long term scenarios, as well as 'wildcards" and looks at how the system responds under pressure.
- We (further) develop tools to quantify resilience: UWOT [3], Scenario Planner.
- We conclude that the resilience assessment method is easy to implement on practically any water system, and is able to take into account a wide range of specific hazards/ events/scenarios and infrastructure options and can greatly enhance strategic planning under uncertainty and provide evidence-based support to investment decisions of future proofing the cities of tomorrow.

References:
[1] Rockström, et al., 2014. Water resilience for human prosperity. Cambridge, UK: Cambridge University Press. [2] Makropoulos, C., D. Nikolopoulos, L. Palmen, S. Kools, A. Segrave, D. Vries, S. Koop, H. J. van Alphen, E. Vonk, P. van Thienen, E. Rozos & G. Medema (2018) A resilience assessment method for urban water systems, Urban Water Journal, 15 (4), 316-328 [3] Rozos, E. and Makropoulos, C., 2013. Source to tap urban water cycle modelling. Environmental Modelling & Software, 41, 139-150.