



## An interactive visual-analytic system to support dynamic and adaptive infrastructure pathways for urban water supply planning

Ziv Hochman<sup>1</sup>, Angelos Chatzimparmpas<sup>1</sup>, and **David Gold**<sup>2</sup>

<sup>1</sup>Utrecht University, Computer Science, Netherlands (z.hochman@uu.nl)

<sup>2</sup>Utrecht University, Physical Geography, Netherlands (d.f.gold@uu.nl)

Water supply managers worldwide are challenged by climate change and population growth. To maintain reliable water supplies, many urban water systems require significant infrastructure investment. Deep uncertainty in future water demand growth, the nature and speed of climate impacts, and financial conditions challenge the development of sustainable infrastructure investment portfolios. If water managers under-invest or construct new infrastructure too slowly, they risk water supply shortfalls under challenging future conditions. However, if challenging conditions do not manifest, the cost of large, near-term investments raises the risk of financial instability and stranded assets. Recent work has shown that adaptive pathway approaches using stochastic multiobjective reinforcement learning (MORL) and state-aware risk-of-failure (ROF) based rule systems can develop robust infrastructure adaptation policies that balance supply reliability and financial stability. ROF-based infrastructure pathway policies tailor investment decisions to observed future conditions, generating unique infrastructure pathways for each future state of the world.

A core challenge with the adoption of ROF-based infrastructure pathways is the volume of information they produce, which can overwhelm water managers and lead to decision paralysis. Recent innovations in visual analytics (VA) and explainable AI (XAI) offer new tools for exploring large and complex data sets. These tools emphasize interactive visualizations to incorporate human expertise into the analysis and provide multiple perspectives for the data, the model, and their outcomes. In this work, we develop a new interactive VA system that allows water managers to explore dynamic adaptive infrastructure pathway policies interactively. Our framework centers on interactive Set Streams, a visual technique that represents pathways on a timeline of branching and merging streams to explore adaptive pathway alternatives. The system allows users to interact dynamically with pathway alternatives and apply preferences across performance objectives and infrastructure sequencing. We demonstrate our system on the Sedento Valley test case, an urban water supply benchmarking problem where three water utilities seek to develop cooperative and adaptive water supply pathway policies.