WP6.1 – Data-driven Environmental Modelling and Optimization for Water Resources Management

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Results: Zeeuws-Vlaanderen

We present a mathematical optimization framework to assess the potential of decentralized water supply networks. The model considers local brackish water sources with varying quality, measured in terms of Chloride (Cl^-) concentration. Reverse Osmosis (RO) is explored as a potential treatment option. The model aims to determine the most cost-effective water network layout and RO facility specifications, including size (e.g., number of pressure vessels), and operating parameters (e.g., pressure), to meet the region's demand and quality requirements.

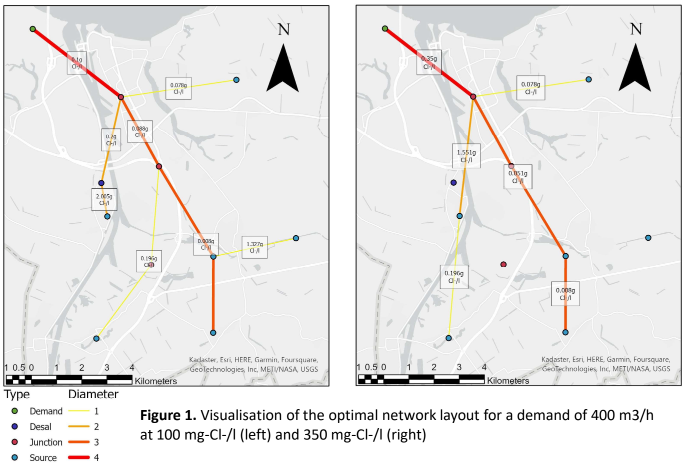

Figure 1. Visualisation of the optimal network layout for a demand of 400 m3/h at 100 mg-Cl-/l (left) and 350 mg-Cl-/l (right)

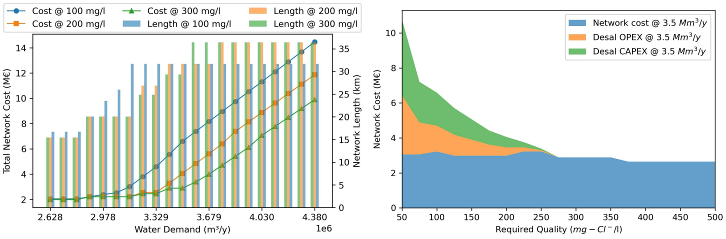

Figure 2. Network cost and length under changing demand and salinity (left) and cost breakdown at fixed demand (3.5 Mm^3/y) with varying salinity (right).

The model, formulated as a Mixed Integer Quadratic Program (MIQP), ensures meeting network demand at required quality with minimum economic cost, considering water supply network and desalination facility construction and operation. It yields: (1) optimal pipeline layout and diameters, (2) optimal water flows, (3) water salinity at mixing points, and (4) optimal BWRO facility configuration. Applied to the case of Terneuzen, the study showed the potential for implementing local water supply networks. This model facilitates trade-off analysis considering various technologies, demand, and quality requirements.

Results: Amsterdam Region

We introduce a mathematical optimization framework designed to evaluate mitigation strategies against drought in urban green infrastructure under future climate scenarios. Our approach integrates local soil and vegetation characteristics with climate data from KNMI scenarios. Through the analysis, we investigate the intricate relationships among soil properties, vegetation types, and evolving climate conditions. By considering essential physical processes, such as soil moisture balance and evapotranspiration, the model determines the minimum size of the local rainwater capture, storage, and irrigation system required to prevent plant stress. The applicability of our approach is demonstrated through a real case study at the Bajeskwartier, located in the Venserpolder, in the east of Amsterdam.

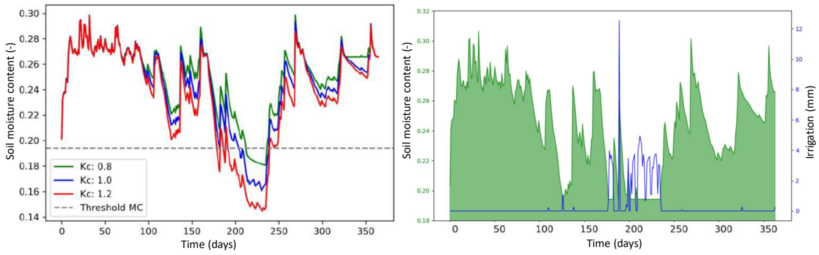

Figure 3. Modelled soil moisture content (left) without irrigation and for 3 different crop coefficients (Kc); modelled soil moisture content with irrigation for Kc = 1.2 (right).

The results presented in Figure 3 pertain to a particular area designated as Zone 1 within the Bajeskwartier. A comparable methodology was applied to assess soil moisture levels and determine water storage and irrigation needs for the remaining zones. Further analyses are illustrated in Figure 4.

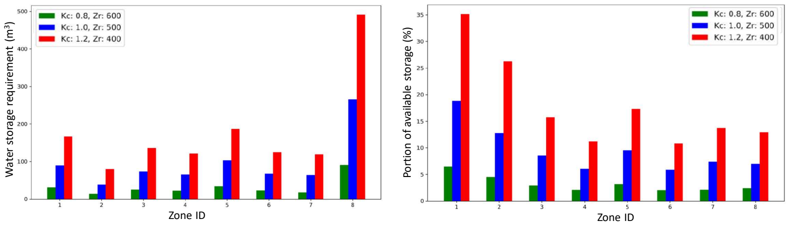

Figure 4. Minimum amount of storage required to avoid plant stress expressed in m^3 (left) and in percentage of total available storage capacity (right).

The model was tested across various vegetation types (e.g., rooting depth) and and soil properties(e.g., water retention capacity). The analysis revealed the model's effectiveness in highlighting relationships among different parameters and their impact on the system's resilience against drought. The model effectively identified the minimum irrigation requirements, consequently determining the necessary water storage capacity. Considering rainwater capture and storage system, the optimized water resource allocation approach provided valuable insights into mitigating drought stress. The findings demonstrated that the Bajeskwartier possesses sufficient water storage capacity to fulfil the demand during a 1-in-30-year drought scenario in the year 2085.

Stakeholders

Stakeholders

Future work

In the future we will (1) enhance computational efficiency by testing different approximations and relaxations, (2) incorporate uncertainty in water demand and (3) explore additional sources like rainwater and WWTP effluent.

Missing links

Aadditional input from stakeholders would be valuable Tools developed in this research are based on synthetic data but require additional real-world data to be tested and applied effectively.

Future work

In the future we will perform additional analysis and validation of different soil parameters and associated processes. Additionally, improving time resolution and testing the model with additional climate scenarios is advised.

Missing links

Aadditional input from stakeholders would be valuable. Information about soil properties and vegetation characteristics could make the model more accurate.

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