Disentailing Sources of Future Uncertainties for Water Management Policies in a Subtropical Water System

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Case Study Description

Study area

Legend:
- River Basin
- River Network
- Maputo City
- Dams
- Irrigation Districts

a. Umbeluzi River Basin

b. Model

Maputo City

Maputo bay

Catchment

Reservoir

Upstream irrigation

Dams

Hydropower

Downstream irrigation

Diversion dam

Pipeline
Objectives

EMODPS

Optimal control policies

Uncertainties characterization

States of the world

Robustness assessment

Robust policies

GLUE

PAWN

Behavioral perturbations

Sensitivity Index

OPTIMIZATION

ROBUSTNESS

UNCERTAINTY & SENSITIVITY

SOURCES OF VULNERABILITY

Methodological flowchart
Methods and tools

\[ K_S(x_i) = \max_{(y)} |F_y(y) - F_{y|x_i}(y|x_i)| \]

\[ S_i = \max_{(x_i)} [K_S(x_i)] \]

Sensitivity Analysis conceptual framework. A– Unconditional objective function distribution and; B– Conditional objective function distribution
Numerical results

Robustness: Probabilistic tradeoffs

Left panel: Ranking of the best control policy according to each stakeholder, together with where such policy would fall when ranked according to the other stakeholders. Right panel: Cumulative distributions for the four objectives considering the most robust alternatives for each stakeholder.
Numerical results
Sensitivity and Uncertainty

Behavioural perturbations (top panel) and sensitivity index (bottom panel) for downstream irrigation in case of Best Irrigation (left) and Best Urban (right) policy.
1. **Robustness analysis**: how robust management solutions can dramatically improve multi-objective tradeoffs in deeply uncertain conditions.
   
   **Example**: How the red non-robust solution, despite being optimal in the current conditions, is largely dominated under deeply uncertain scenarios.

2. **Uncertainty analysis**: how exogenous perturbations unevenly shape system performance across objectives and policies
   
   **Example**: downstream irrigation. No deficit is created even for streamflow reductions up to 35% if robust solution is adopted. Possibility of supporting agricultural expansion across deeply uncertain states of the world.

3. **Sensitivity Analysis**: understanding the main sources of vulnerability across policies in a multi-dimensional objective space
   
   **Example**: for all the stakeholder analysed, non robust policies have been consistently more vulnerable to social and infrastructural uncertainty sources.