



## **Reducing regional vulnerabilities and multi-city robustness conflicts using many-objective optimization under deep uncertainty**

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Emerging water scarcity concerns in southeastern US are associated with several deeply uncertain factors, including rapid population growth, limited coordination across adjacent municipalities and the increasing risks for sustained regional droughts. Managing these uncertainties will require that regional water utilities identify regionally coordinated, scarcity-mitigating strategies that trigger the appropriate actions needed to avoid water shortages and financial instabilities. This research focuses on the Research Triangle area of North Carolina, seeking to engage the water utilities within Raleigh, Durham, Cary and Chapel Hill in cooperative and robust regional water portfolio planning. Prior analysis of this region through the year 2025 has identified significant regional vulnerabilities to volumetric shortfalls and financial losses. Moreover, efforts to maximize the individual robustness of any of the mentioned utilities also have the potential to strongly degrade the robustness of the others. This research advances a multi-stakeholder Many-Objective Robust Decision Making (MORDM) framework to better account for deeply uncertain factors when identifying cooperative management strategies. Results show that the sampling of deeply uncertain factors in the computational search phase of MORDM can aid in the discovery of management actions that substantially improve the robustness of individual utilities as well as the overall region to water scarcity. Cooperative water transfers, financial risk mitigation tools, and coordinated regional demand management must be explored jointly to decrease robustness conflicts between the utilities. The insights from this work have general merit for regions where adjacent municipalities can benefit from cooperative regional water portfolio planning.