Identifying Major Hydrologic Change Drivers in a Transboundary Highly Managed Endorheic Basin: Integrating Hydro-ecological Models and Time Series Data Mining Techniques

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Abstract

Saline endorheic lakes play a crucial role in ecological regulation and biodiversity conservation in semi-arid regions. They provide a wide range of ecosystem services such as habitat for aquatic life and migratory birds, water supply, mineral extraction, and recreation. Although saline lakes are critical to ecological health and human wellbeing, they are being shrunk at alarming rates in recent decades, representing some of the most threatened ecosystems in the world. Factors contributing to lake degradation are directly linked to the expansion and intensification of agriculture in the 20th century and its intertwined effect with global warming. However, quantifying the relative contribution of climate variability and anthropogenic stressors in water budget dynamics of the lakes is challenging. Hydrologic processes of highly managed agricultural landscapes are complex and the lack of spatial data in endorheic basins with transboundary water issues further contribute to this problem. In this study, we developed a modeling framework that integrates the Soil and Water Assessment Tool (SWAT) simulations with seasonal trend decomposition by LOESS (STL), residual analysis for anomaly detection, and time series clustering, to identify the major drivers of lake trend and seasonal shrinking patterns. This modeling framework was applied to the Salton Sea Basin (SSB), host of the largest inland lake in California. Salton Sea's water level has declined by 32% over the last 25 years, causing a massive bird and fish die-off, and a regional asthma crisis due to the spreading of toxic dust from the exposed playa. Results suggest that decreases in Colorado River allocation are causing the lake to shrink, not changes in the irrigation efficiency or the climate regime as commonly believed. Our results are expected to assist decision-makers with a robust modeling tool to evaluate the environmental tradeoffs in formulating and implementing timely adaptation and mitigation strategies across the SSB while minimizing their economic consequences.

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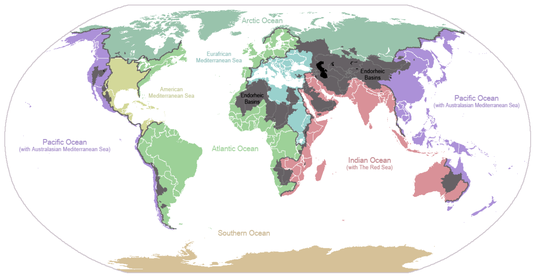
Endorheic Basins

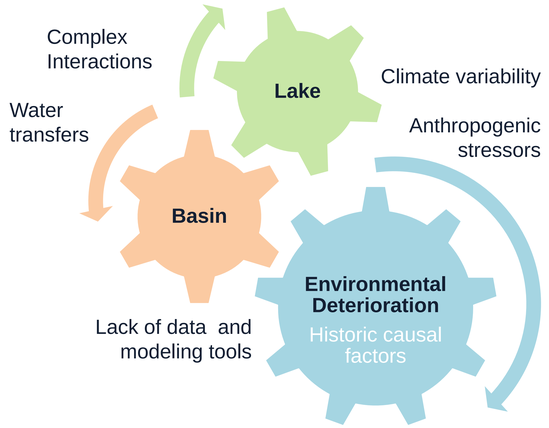


~25% of Earth's land surface

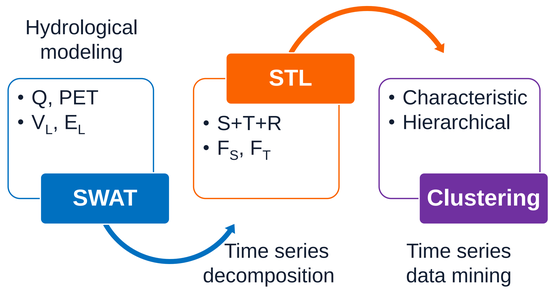
~50% of water stressed regions

Among the most threatened systems

Study Motivation

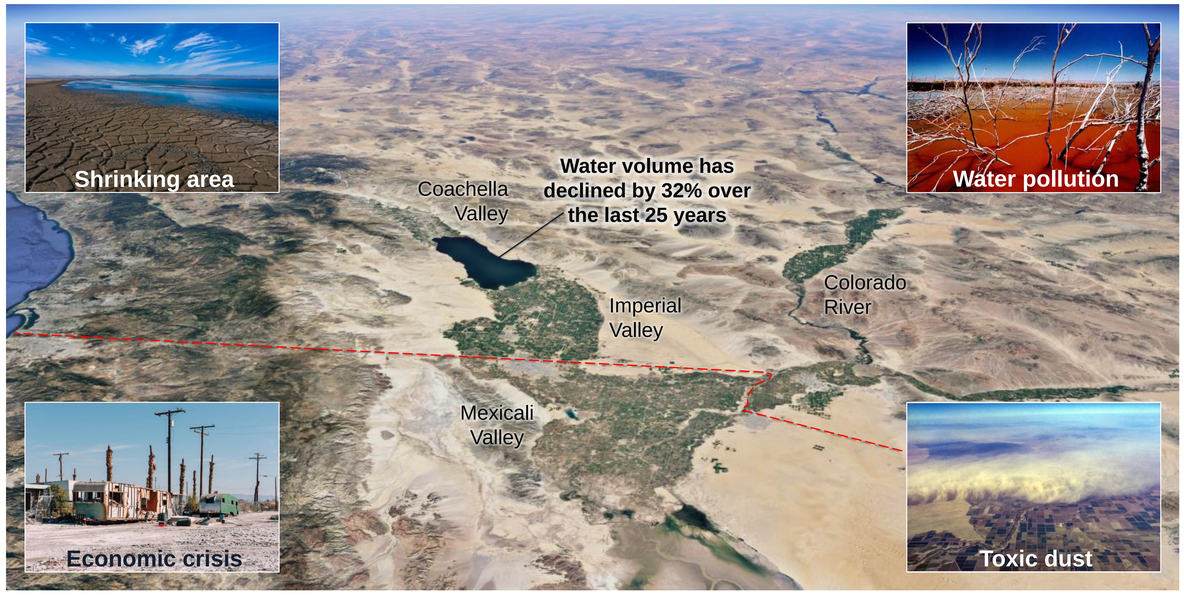


Methodology

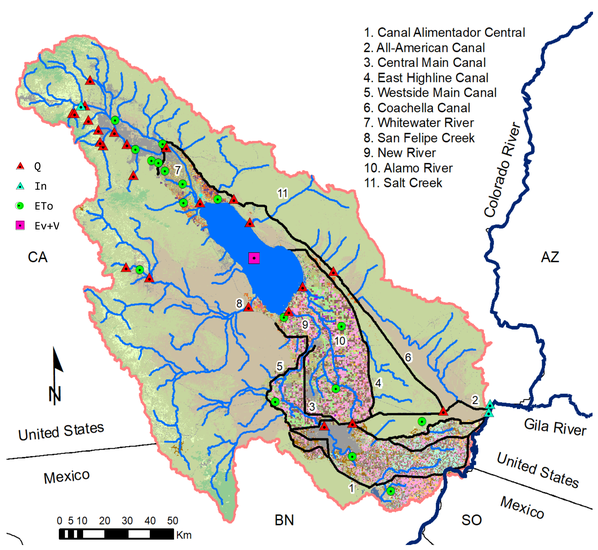


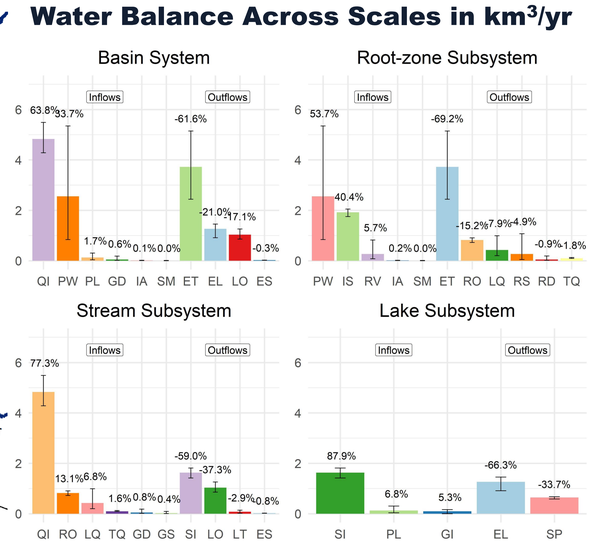
Salton Sea Transboundary Basin

host of California's largest inland lake

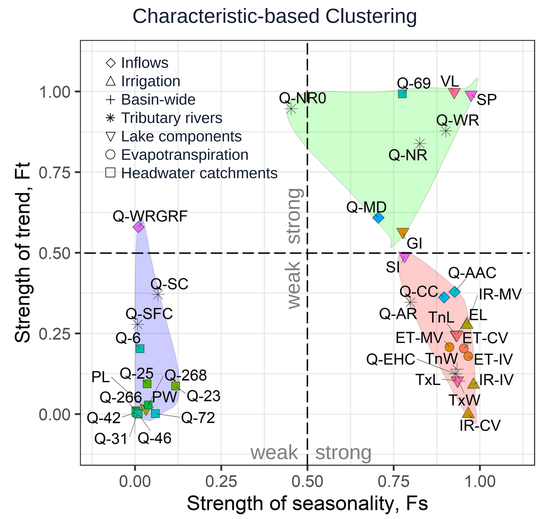


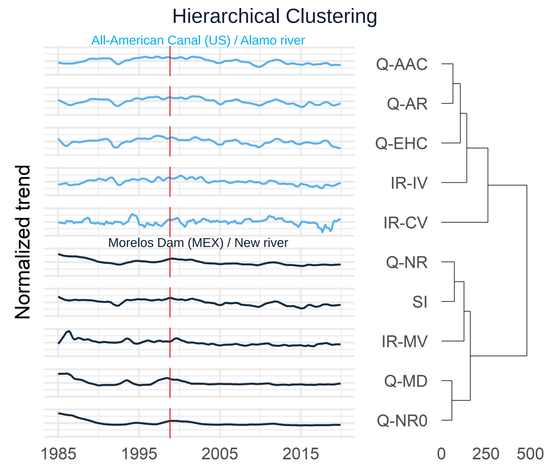
Decreases in Colorado River allocation are causing the Salton Sea to shrink, not changes in the irrigation operation as commonly believed





Major Hydrologic Drivers





It is not clear if the Salton Sea shrinkage is being mainly caused by the implementation of the California 4.4 Plan, the decline of Colorado River flows due to global warming, or both. A holistic approach that considers both basins is required.

Acknowledgements

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