

Multi-Objective Optimization of Desalinated Water Allocation in Lake Kinneret: Ensuring Ecological and Economic Stability

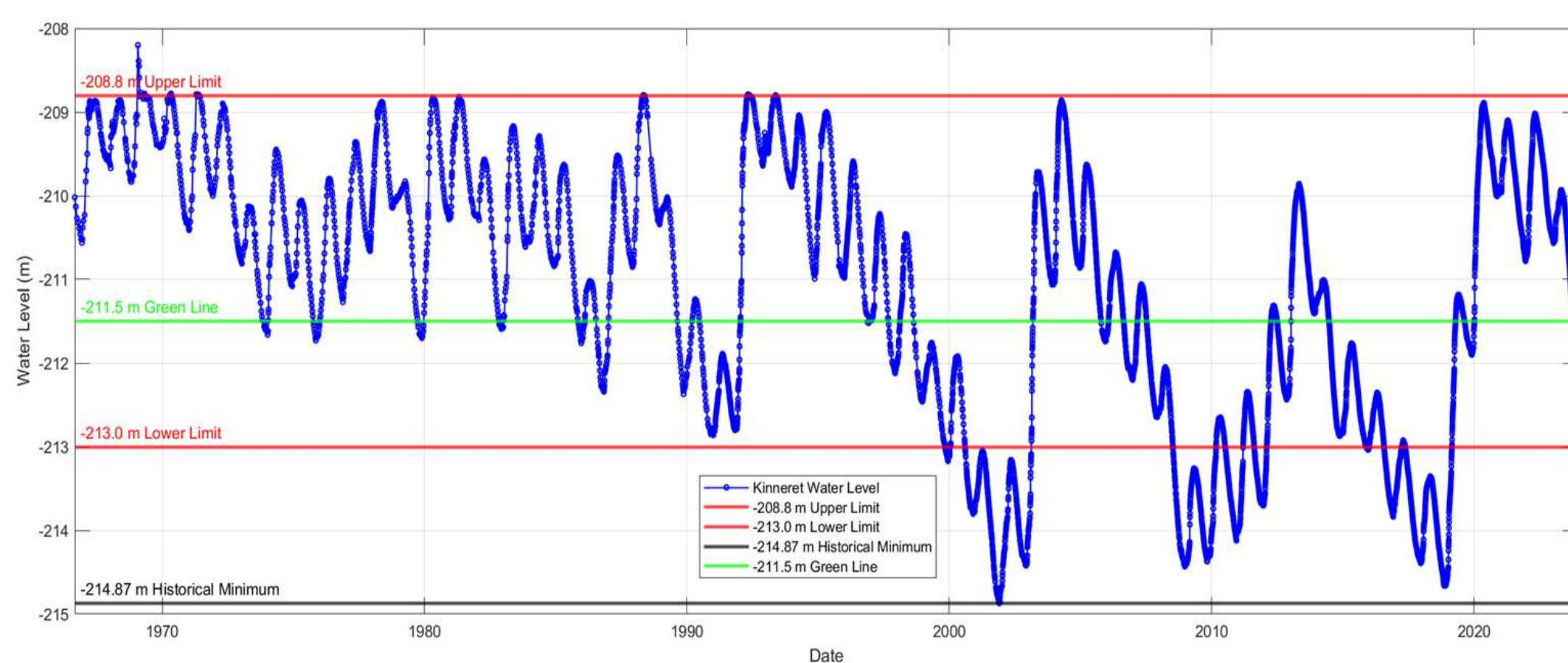
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INTRODUCTION & AIM

Lake Kinneret (Sea of Galilee) is Israel's main freshwater reservoir, providing critical resources for domestic, agricultural, and ecological needs. However, climate variability, increased demand, and recurrent droughts have reduced water levels, heightened salinity, and threatened ecosystem stability. To address these challenges, the Israeli government is integrating desalinated water into the national water supply system. However, such integration requires strategies that balance economic feasibility with ecological preservation.

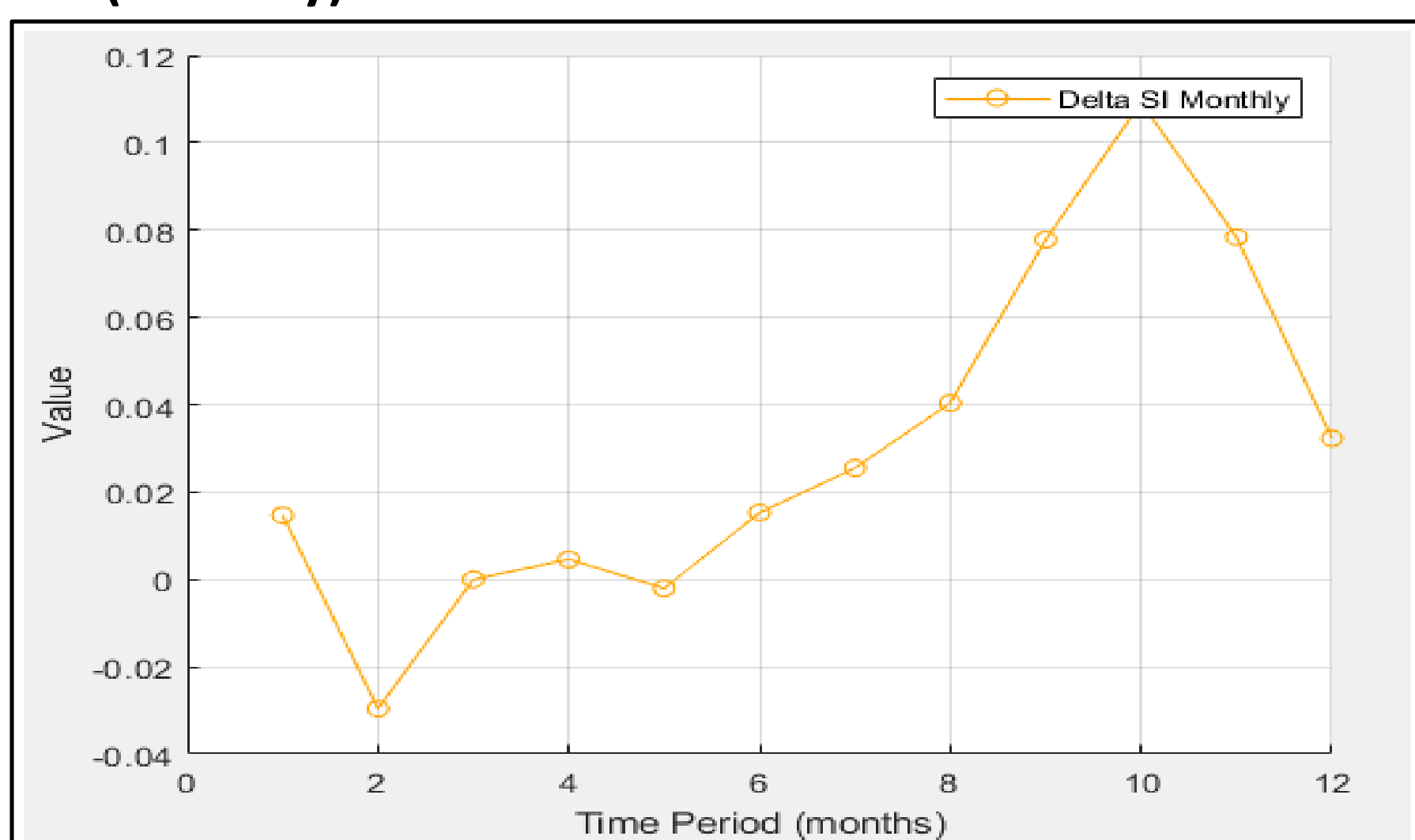
Figure 1.
Kinneret Lake water levels by year, 1960-2023 (Source: Gov.il, 2024)



METHOD

This study develops a multi-objective optimization model for managing desalinated water allocation into Lake Kinneret. The model minimizes operational costs while maintaining ecological health, represented through the stratification index (SI), a surrogate for thermal stability and nutrient cycling. The optimization was implemented in MATLAB R2024a using IPOPT and Ip_solve solvers. Several management scenarios were tested, varying the timing and volume of desalinated water inputs in response to seasonal demand and hydrological conditions.

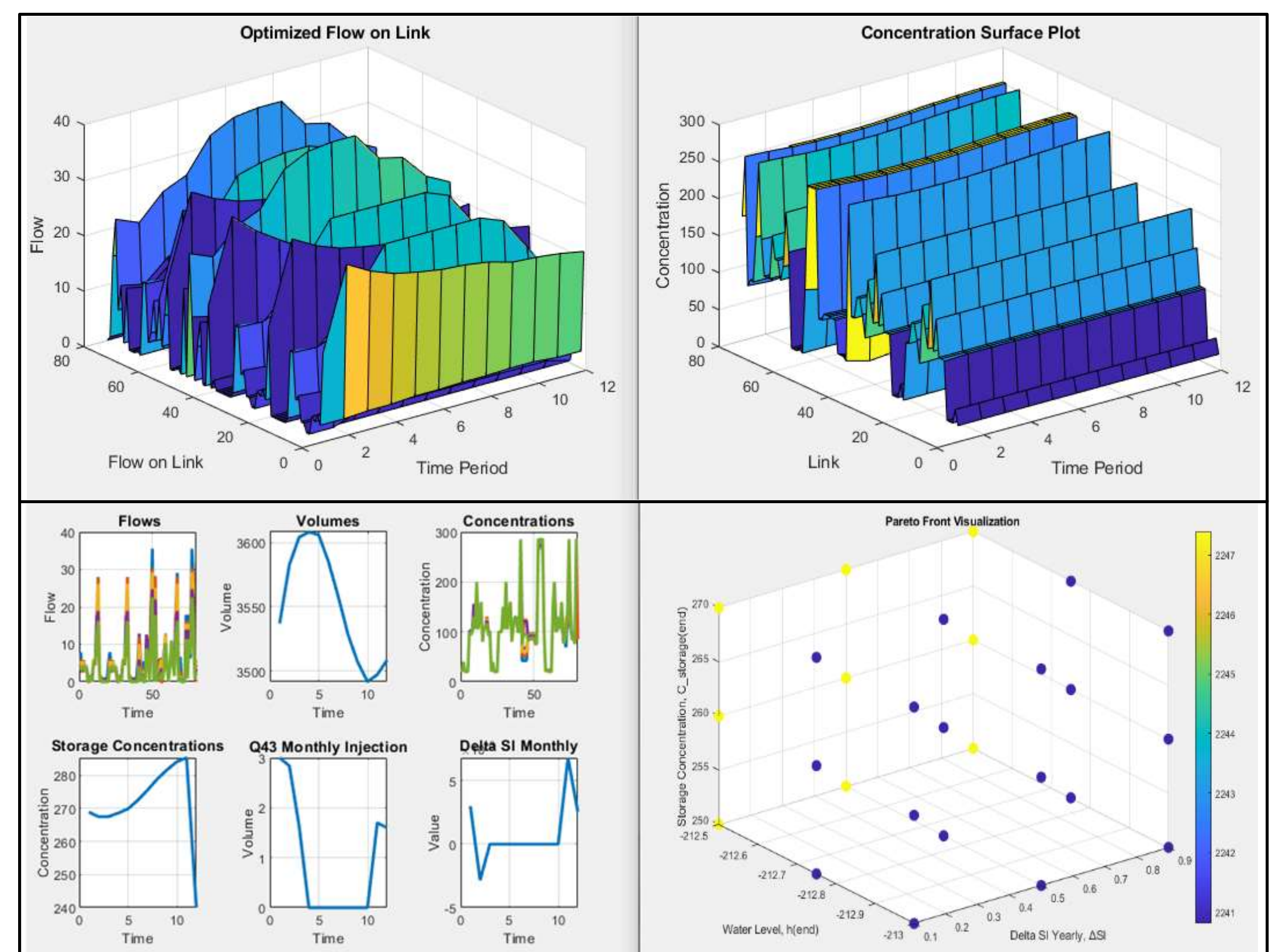
Figure 2.
Delta SI (monthly)



RESULTS & DISCUSSION

Model simulations demonstrate that desalinated water integration stabilizes lake levels and mitigates salinity impacts. Optimal strategies highlight trade-offs between economic and ecological goals. In particular, scenarios with desalinated water introduction during periods of weakened natural stratification minimized ecological disruption while maintaining economic efficiency. Pareto-optimal solutions revealed strategies that maintain SI values without significantly increasing operational costs, providing a clear understanding of the balance between economic and ecological objectives.

Figure 3.
Model results for a specific management scenario



CONCLUSION

The results confirm that multi-objective optimization is a robust approach for managing desalinated water allocation in Lake Kinneret. By simultaneously addressing cost and ecological indicators, the model supports informed decision-making for policymakers. Strategic and dynamic integration of desalinated water ensures both economic viability and ecological sustainability, offering a transferable framework for other freshwater ecosystems under similar conditions.

REFERENCES

- [1] Gov.il (2024). *The Geological Survey of Israel*. Available online: <https://www.gov.il/en/pages/mapping-main-subject> (accessed on 10 January 2025)