Simulation–optimization model for optimum water allocation between environmental and agricultural demand using a coupled WEAP-MODFLOW model: Application in Miyandoab plain, Urmia basin, Iran

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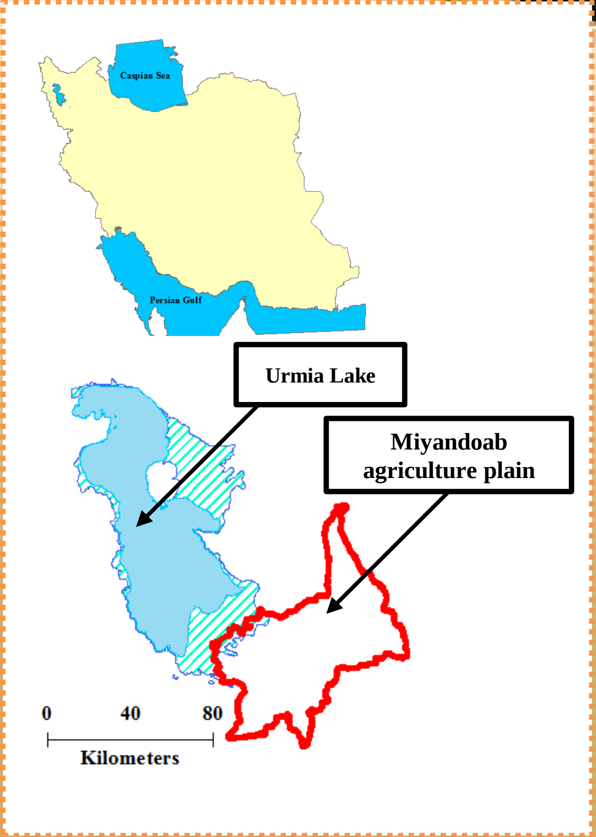
Goal

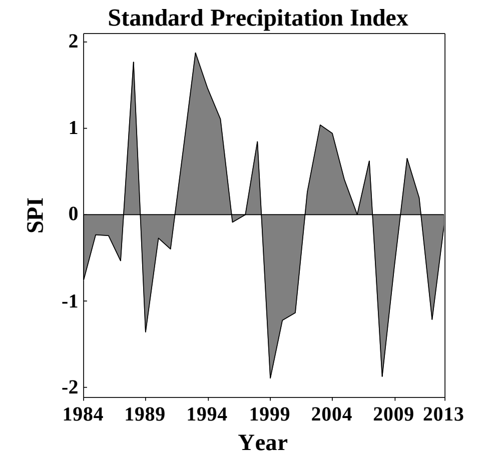
Develop and apply the first simulation-optimization model for optimum water allocation to meet environmental flow requirements and agricultural demand in the Miyandoab plain, one of the strategic agricultural areas in the Urmia Basin in the semi-arid northwest of Iran.



Motivation

Drought and water mismanagement led to complex water problems in the Urmia Lake basin:

- Decreasing environmental flows to Lake Urmia and shrinking of the lake.
- Increasing competition between the environmental and agricultural demand



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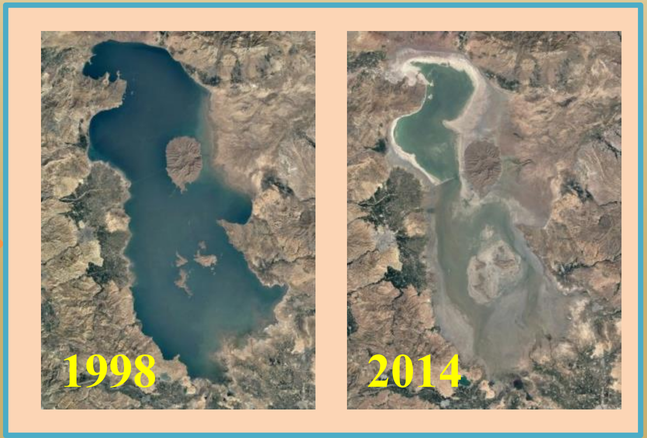
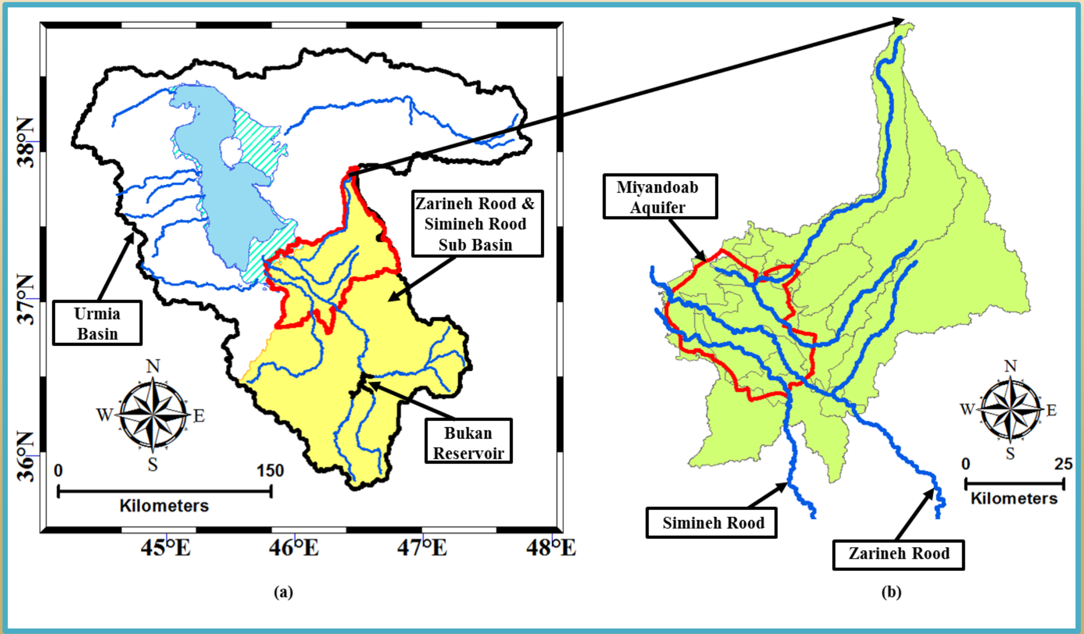


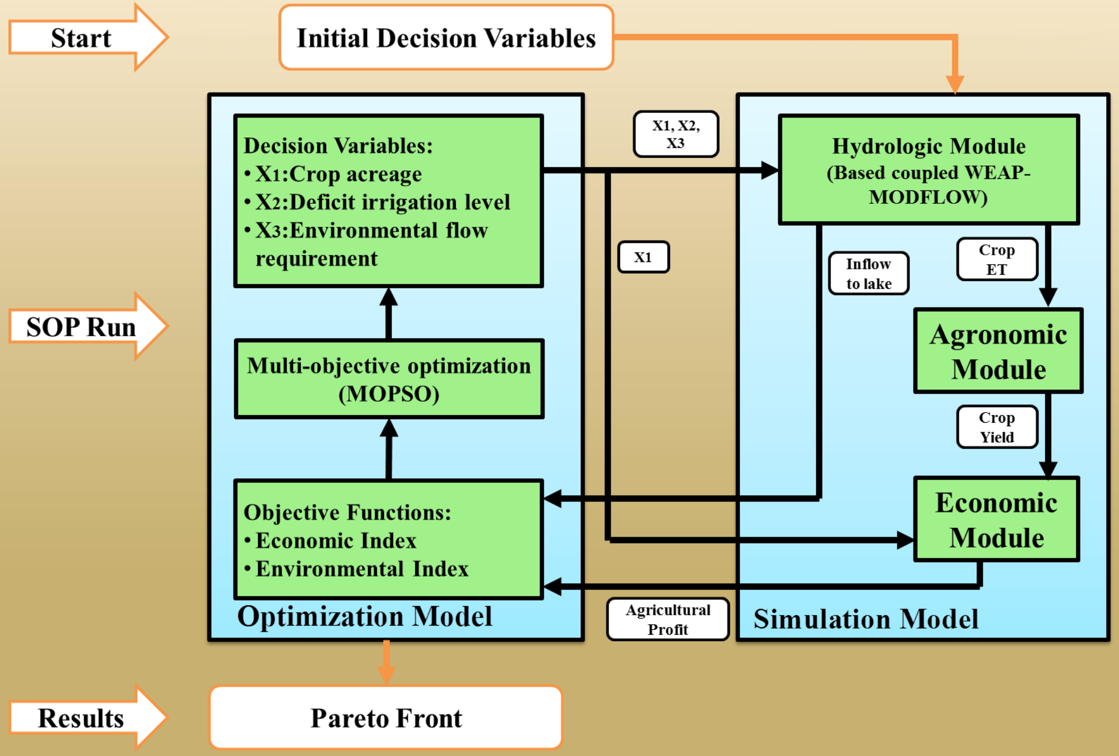
(Reference: Google Earth)

Case Study: Miyandoab Plain

- Total area: 1,524 km2
- Total irrigated area: 100,000 hectares
- Annual precipitation: 290mm
- Average temperature: 14°C
- Zarrineh Rood annual discharge: 2000 MCM (40% of total inflow to Urmia lake)
- Simineh Rood annual discharge: 350 MCM (10% of total inflow to Urmia lake)
- Bukan storage: 808 MCM



Simulation-Optimization Model (SOP)



Objective Functions

- **Maximize Economic Index**

F_1= Function (annual average (agricultural net benefit))

- **Maximize Environment Index**

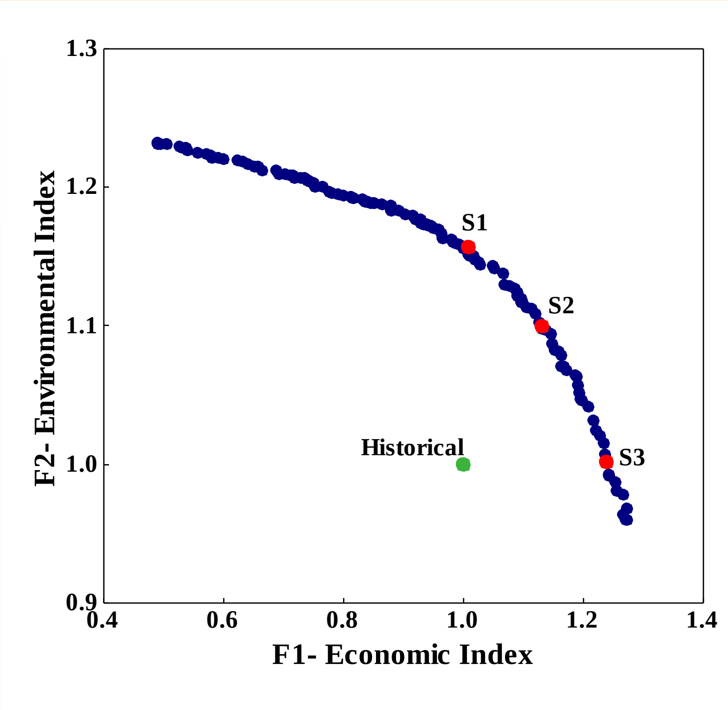
F_2= Function (annual average (Downstream flow to lake/Upstream flow))

Result-Pareto Front

- Increase environmental flow up to 16% in scenario 1 (S1) compared to historical condition

- Increase agricultural profit up to 24% in scenario 3 (S3) compared to historical condition

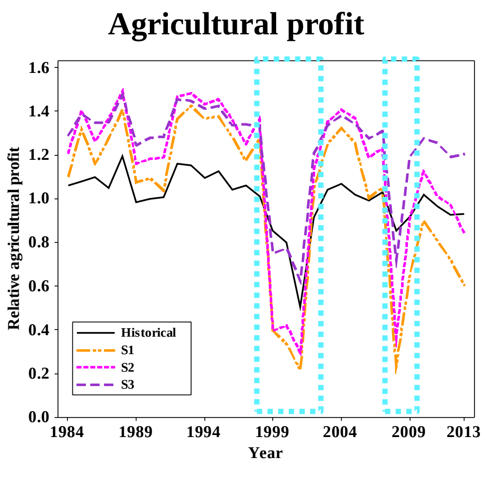
- Increase environmental flow and agricultural profit in scenario 2 (S2) as a win-win scenario, compared to historical condition.

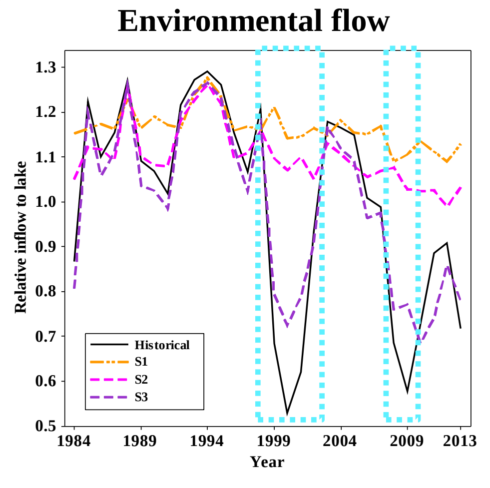


Result
Agricultural profit and inflow to Lake Urmia

- In the extreme drought years (1999-2001, and 2008), a sharp decrease occurs in agricultural profit for scenarios 1 and 2 (S1 and S2).

- Crop acreages are near-zero for scenarios 1 and 2 in extreme drought years, and agricultural production limited to orchards.



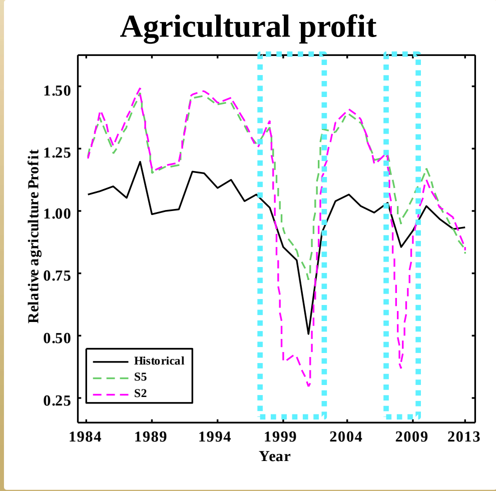


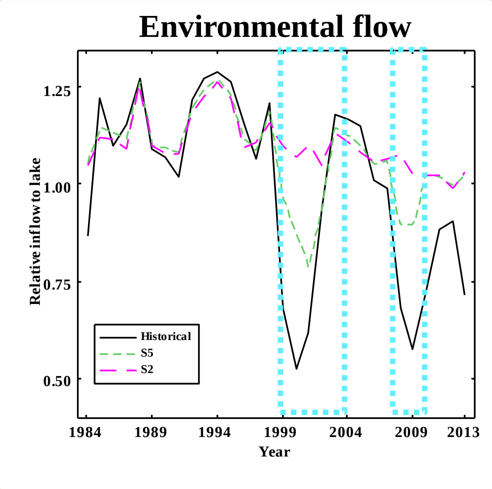
Result

We see a sharp decrease in crop acreage in dry years. Can this be countered with more GW pumping?

- We define a new scenario (S4) that compared to the corresponding scenario 2, crop acreage is set equal to 75% maximum area, while GW pumping capacity is doubled in extreme drought years.

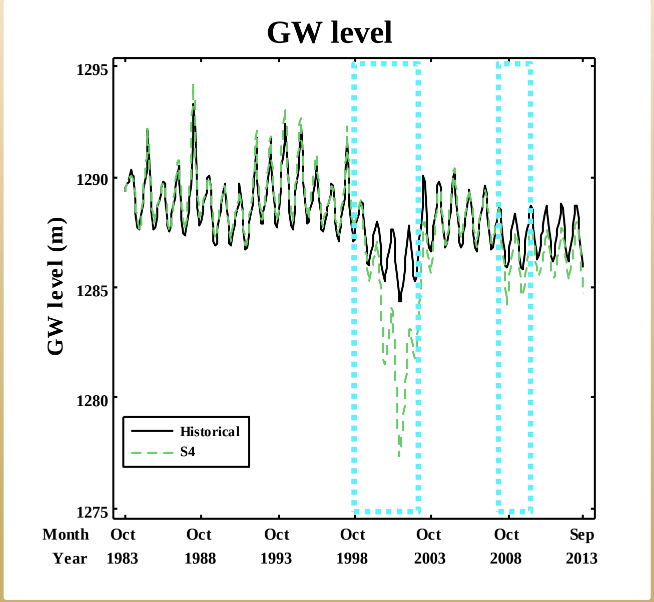
- Increasing GW pumping capacity led to prevent the sharp decrease of agricultural profit in the extreme drought years.





Result
GW level

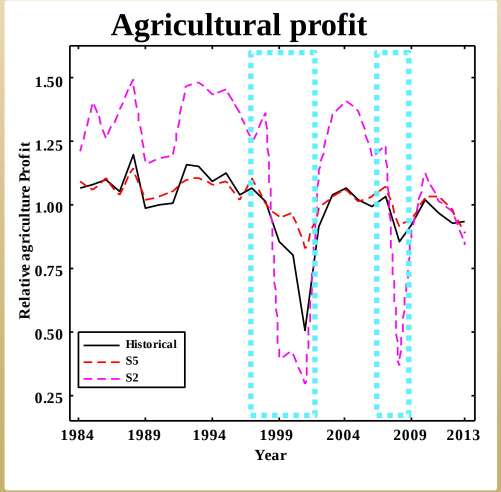
- Although the GW level of scenario 4 was decreased in extreme drought years, GW levels for this scenario fully recover after the end of each extreme drought years.

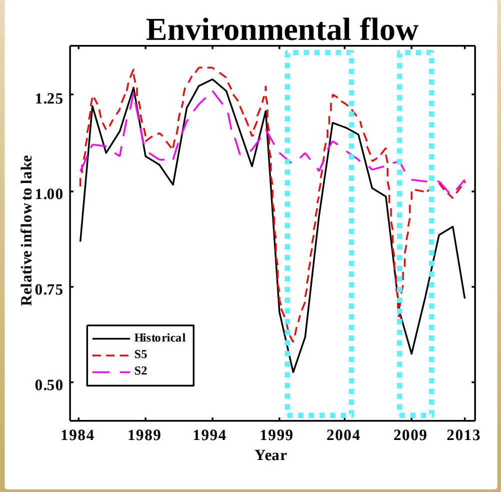


Result

We see a sharp decrease in crop acreage in dry years. Can this be countered with reducing environmental flow requirements?

- We define a new scenario (S5) that compared to the corresponding scenario 2, crop acreage is set equal to the 75% maximum area in all years, while minimum environmental flow requirement deceased by 60% in extreme drought years.
- The sharp decrease of agricultural profit in the extreme drought years can be avoided in this scenario. Moreover, Inflow to lake fully recover after end of each extreme drought years.





Conclusions

- Changes in minimum environmental flow requirements, deficit irrigation, and crop selection increase environmental flow (up to 16%) and agricultural profit (up to 24%) compared to historical conditions
- Significant temporary drops in agricultural profit occur during droughts when long-term profit is maximized
- This can be avoided by increasing GW pumping capacity and temporarily reducing the lake's minimum environmental flow requirements
- These are sustainable strategies as long as resulting declines in groundwater and lake water levels fully recover after end of each drought

References for further reading

- *Dehghanipour, A. H., Zahabiyoun, B., Schoups, G., & Babazadeh, H. (2019). A WEAP-MODFLOW surface water-groundwater model for the irrigated Miyandoab plain, Urmia lake basin, Iran: Multi-objective calibration and quantification of historical drought impacts. Agricultural Water Management, 223, 105704.*
- *Dehghanipour, A., Zahabiyoun, B., & Schoups, G. (2019). Simulation–optimization modeling for sustainable conjunctive water management in irrigated agriculture: WEAP-MODFLOW application in the Miyandoab plain, Urmia basin, Iran. Poster session presented at EGU General Assembly 2019, Vienna, Austria.*
- *Dehghanipour, A., Schoups, G., & Zahabiyoun, B. (2019). A WEAP-MODFLOW model for conjunctive water management in the Urmia Lake Basin, Iran. Oral session presented at the 15th Nederlands Aardwetenschappelijk Congres (NAC), Utrecht, The Netherlands.*

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