An operational sociohydrological model to understand the feedbacks between community sensitivity and nvironmental flows for an endorheic lake basin, Lake Bakhtegan Iran

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Introduction

- Climate change, drought, overuse of water from surface(-ground) water resources has caused major problems in endorheic basins across the world. One such basin is Bakhtegan Lake Basin, southwest of Iran. The water entering Bakhtegan Lake has decreased, which has led to a decrease in the water level of this lake. Secondly, groundwater level has decreased in the Bakhtegan aquifer. These problems occurred in the Bakhtegan basin as a result of neglecting human roles as the active agency within the hydrology of the region.

- In this study, we present a sociohydrological model in order to simulate dynamic relationship between community sensitivity, which responds to environmental well-being, and water use state variables as key to understanding the competition between water allocation between agriculture and the environment in the basin.

Methods and materials

- The presented sociohydrological model (Fig 1) consists of the three sub-models:

1) Hydrological model (WEAP (Water Evaluation And Planning) model)
2) Society model (Roobavannan et al., 2017)
3) Optimization algorithm (Elitist Non-Dominated Sorting Genetic (NSGAII) Algorithm)

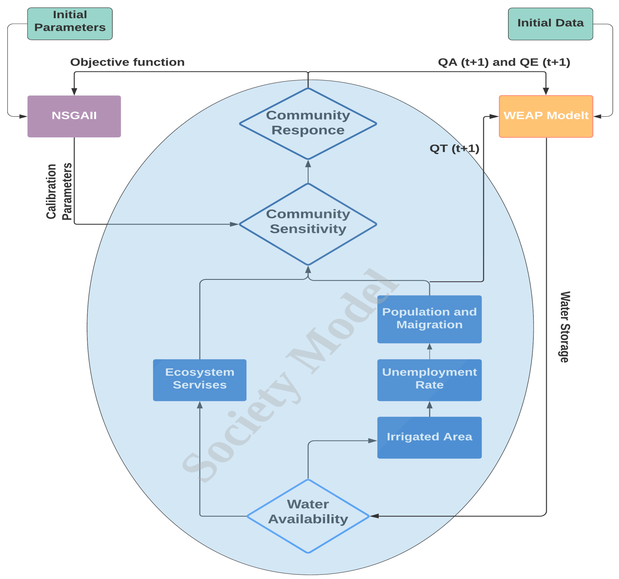

Fig 1. Society and WEAP Coupled model conceptual framework used to study the dynamics of Bakhtegan River Basin

Case study

- Bakhtegan River Basin (BRB) is the endorheic basin that, located in the southwest of Iran. Kor and Sivand river are major rivers in this basin. Bakhtegan and Tashk Lake at the most downstream are the most important places of breeding birds.

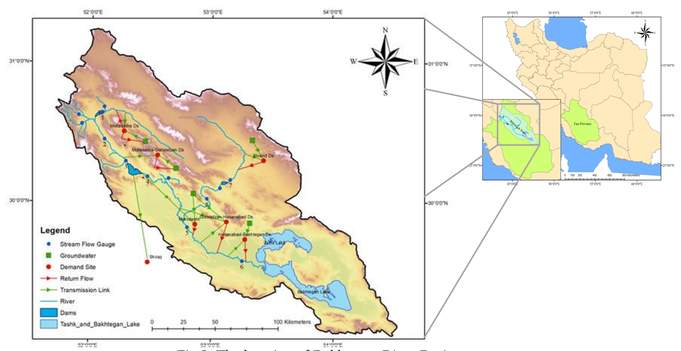

Fig 2. The location of Bakhtegan River Basin

Results

- The squared difference of observed discharge and discharge that is estimated by the coupled model at gauge number 4 (Fig 2) is the first objective function (Agriculture demand). A similar formulation for environmental demand is assumed to gauge number 6 (Fig 2). The squared difference of historical unemployment rate and the estimated unemployment rate is third objective function.

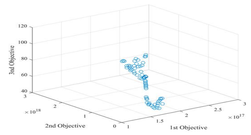

Fig 3. Pareto front for the multi optimization after 2000 WEAP and Society coupled model simulations.

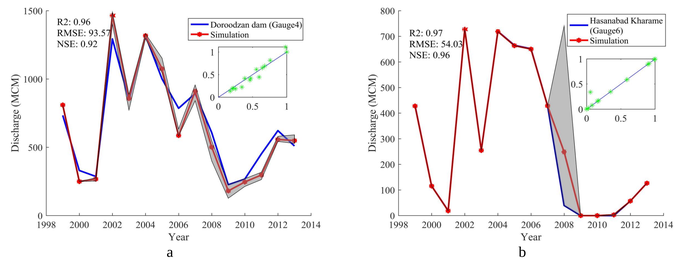

Fig 4. Time-series of observed discharge and "pareto optimally" (shown in gray) modelled discharge obtained by NSGAII for Gauge number 4 (a) and Gauge number 6 (b). Median shown in red.

Validation

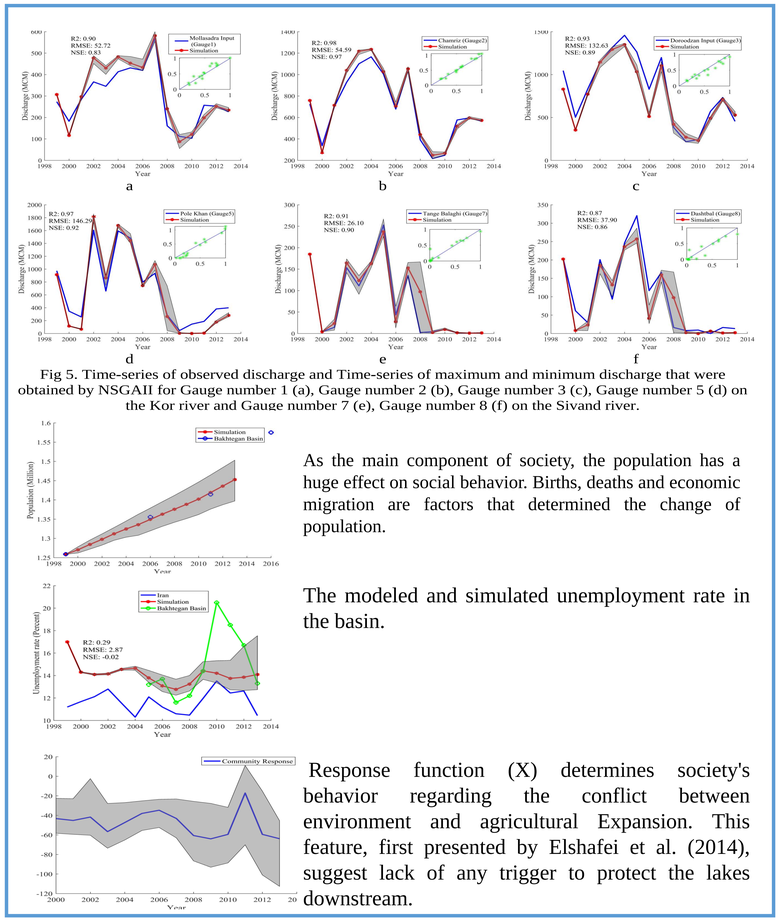

Fig 5. Time-series of observed discharge and Time-series of maximum and minimum discharge that were obtained by NSGAII for Gauge number 1 (a), Gauge number 2 (b), Gauge number 3 (c), Gauge number 5 (d) on the Kor river and Gauge number 7 (e), Gauge number 8 (f) on the Sivand river.

As the main component of society, the population has a huge effect on social behavior. Births, deaths and economic migration are factors that determined the change of population.

The modeled and simulated unemployment rate in the basin.

Response function (X) determines society's behavior regarding the conflict between environment and agricultural Expansion. This feature, first presented by Elshafei et al. (2014), suggest lack of any trigger to protect the lakes downstream.

Conclusion

- The results demonstrate that the calibrated coupled model is able to simulate past allocations of water to agriculture and the environment in the basin, which we compare with available records.

- Further, we provide a non-dominated Pareto set of parameters, that demonstrate equifinality in Pareto superior parameters of community sensitivity.