Assessing the impact of climate variability and human activities on the drawdown of Lake Urmia (Iran) using SWAT-LU

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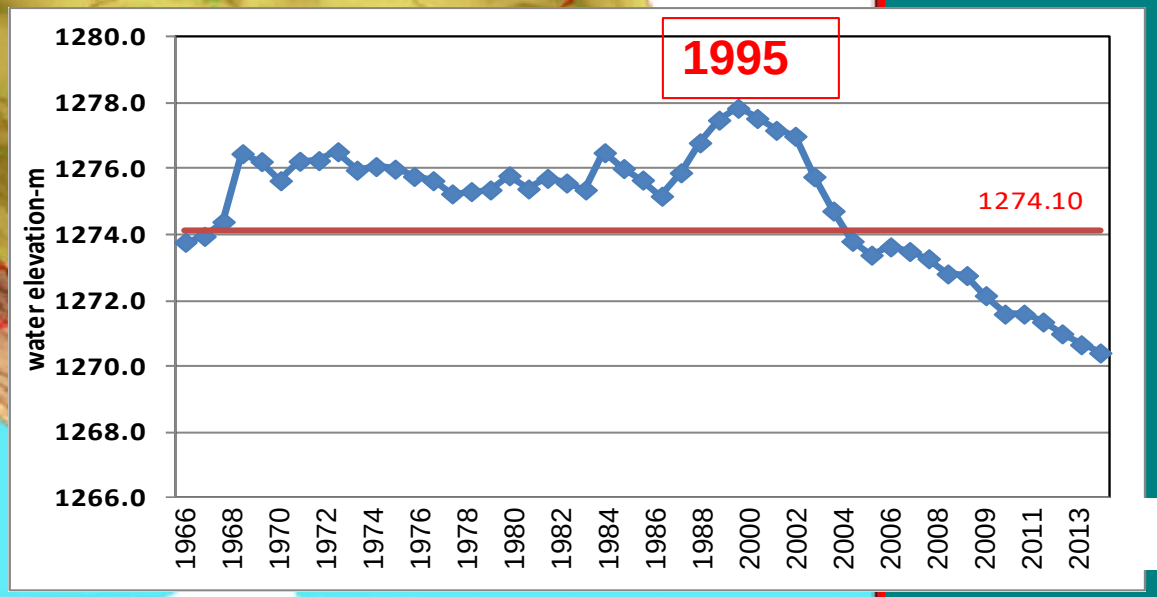
URMIA LAKE BASIN

Lake Urmia Basin



Persian Gulf

Total Area of 52000 km2

Salt storm

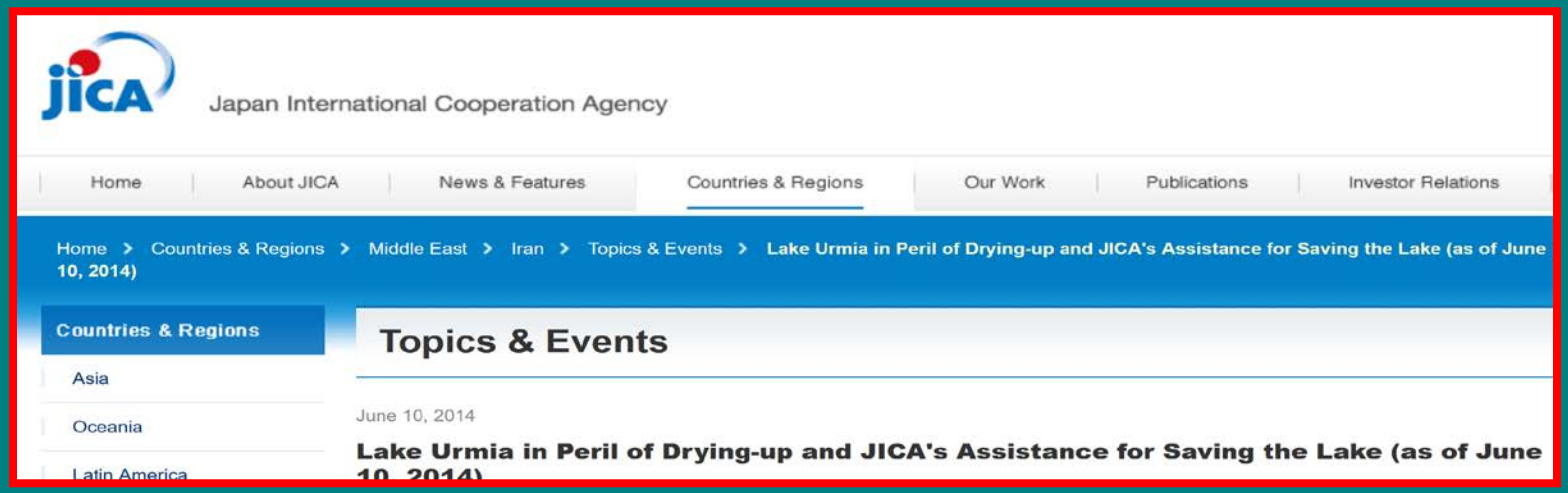
Efforts to Restore Lake Urmia

An integrated plan to save the lake was drawn by stakeholders, which was facilitated by the UNDP/GEF/DOE Conservation of Iranian Wetlands Project (CIWP). With the cooperation of the LU provinces, the Integrated Management Plan for Lake Urmia Basin (IMPLUB) was developed. The plan helps provincial and national agencies address the current critical ecological state of the lake, which is also required by the 4th National Development Plan. The most important agreement in this plan is to allocate 3100 MCM of water per year to the lake.

Department of Environment

UNDP

Conservation of Iranian Wetlands Project



Main questions for the lake restoration

- ***What are the causes for the lake's drawdown?***
- ***What is the water accounting of the basin?***
- ***What can be the impacts of new agricultural policies on restoration of lake?***
- ***etc***

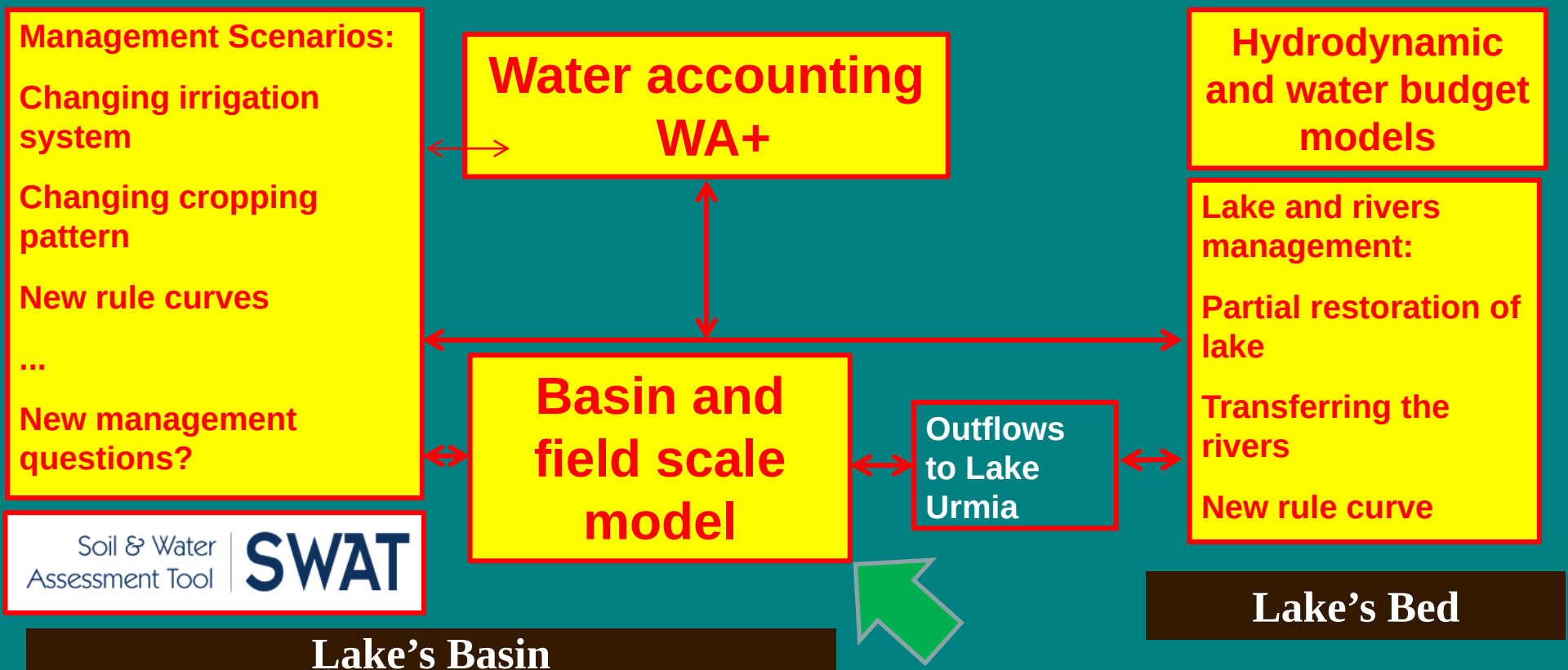
Conceptual framework for Integrated modeling of Lake Urmia Basin

Revisiting the "IWMI Paradigm:"

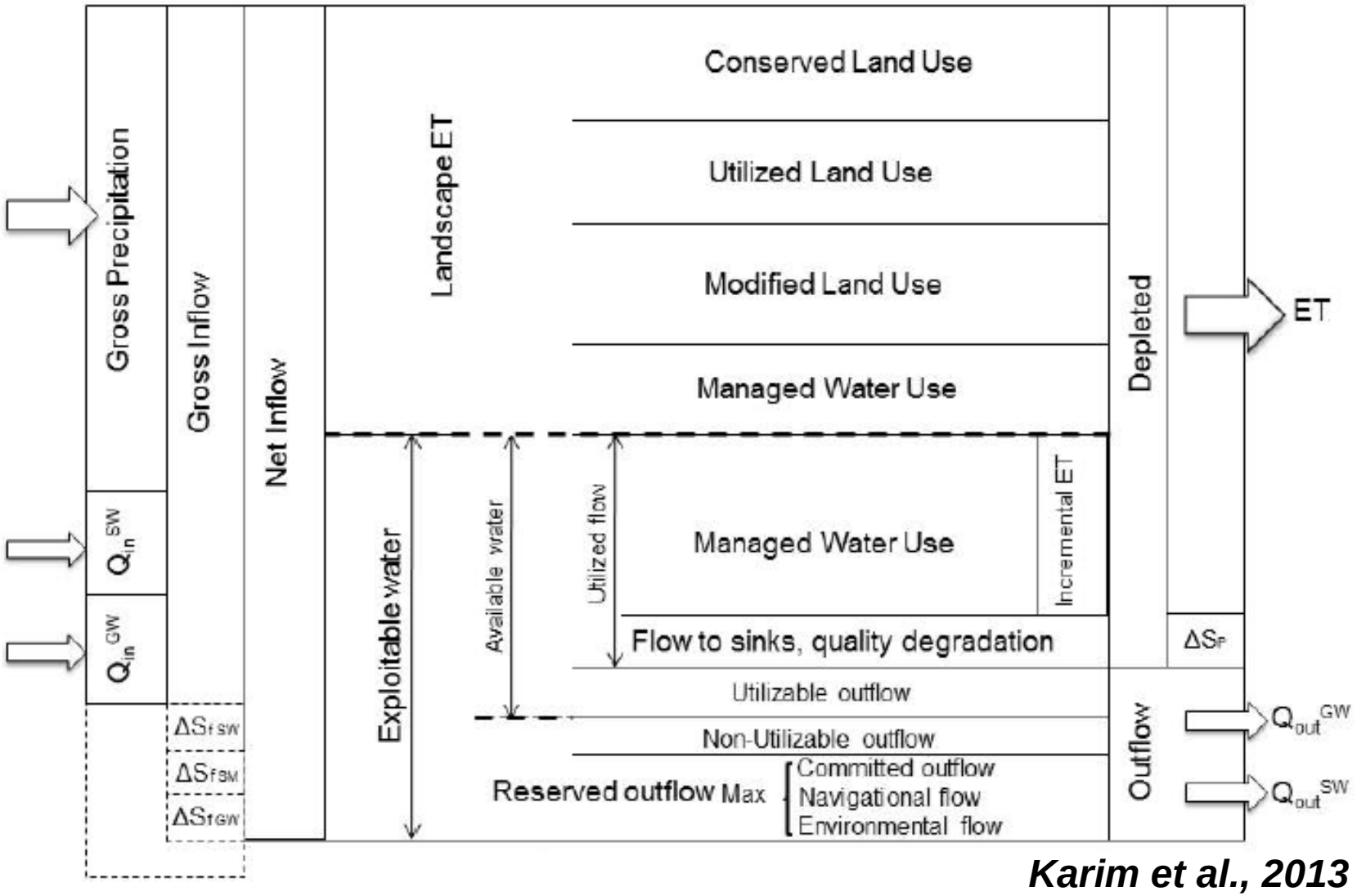
Increasing the Efficiency and Productivity of Water Use

Mike21

SWAT-LU



Water Accounting WA+, Resource Report



Karim et al., 2013

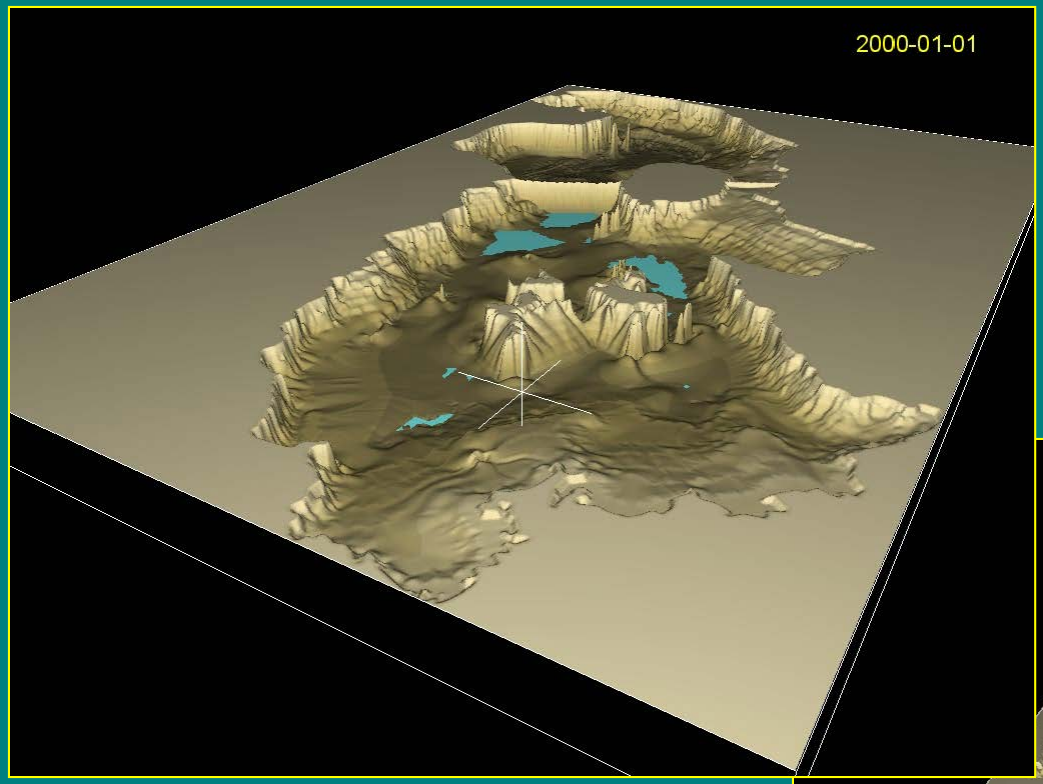
The main advantages

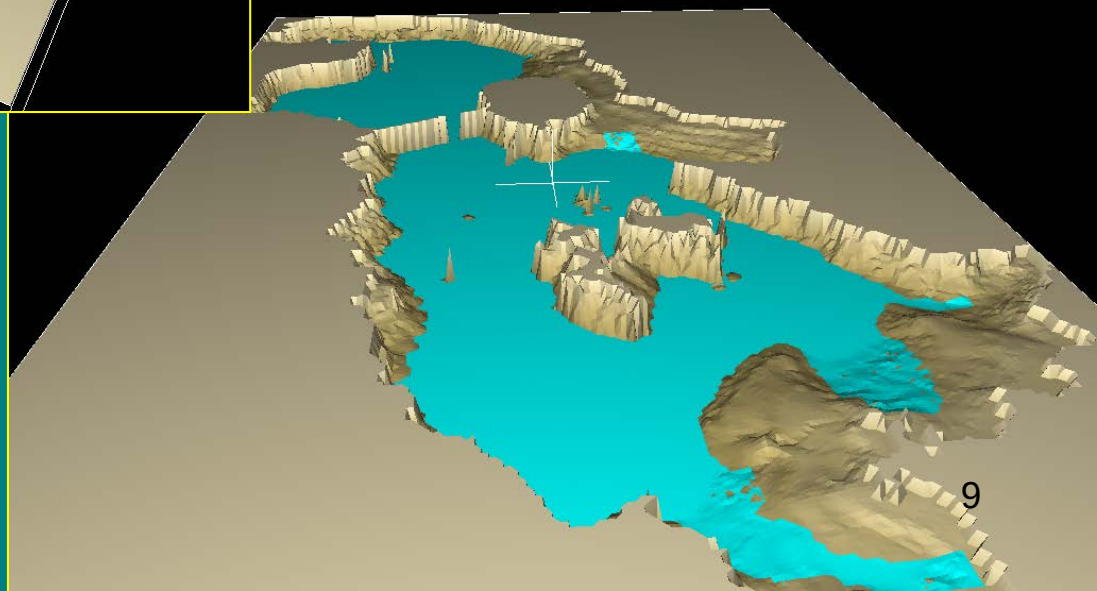
Real Water Saving

Distinction between withdrawal and demolition

Realistic evaluation of technologies on water saving

Dimensions of Lake Urmia





140 Km length
50-20 Km width

Maximum 20 meters depth
Average 6 meters depth

Lake Urmia Drying Up, 1984-2012

Some the features added to SWAT for SWAT-LU

- *Simulation of losses between the first and second boundaries*

➔ **rtday.f**

- *Updating of wet/dry parts of the lake's bed*

➔ **urmia.f, simulate.f**

- *Evaporation from the lake as an hyper saline lake (ppm=400mg/lit)*

- **Change in the volume-area relation**

➔ **res.f**

- *Updating land use*

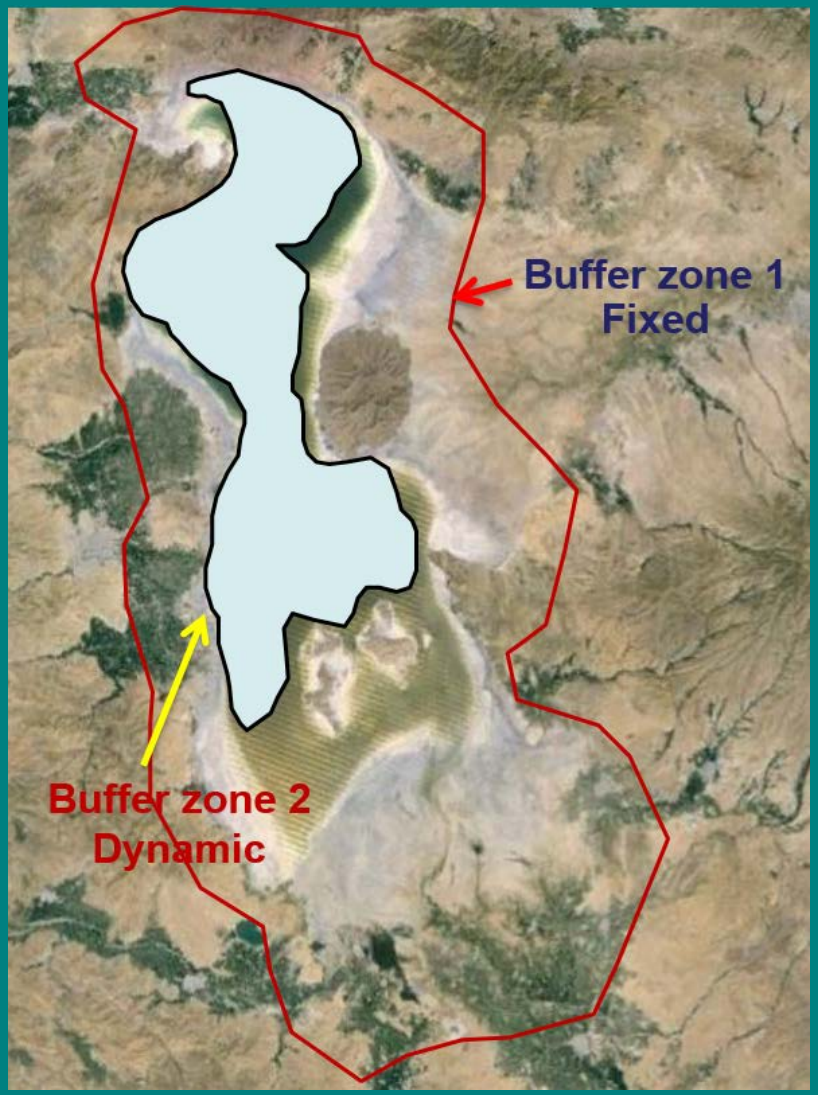
➔ **resetlu.f**

- *Irrigation efficiency*

➔ **irrsub.f ،irr_res.f ،irr_rch.f ،subbasin.f , gwmod.f**

- *Change in spatial estimation of rainfall and temperature*

➔ **snom.f ،clicon.f و readsub.f**

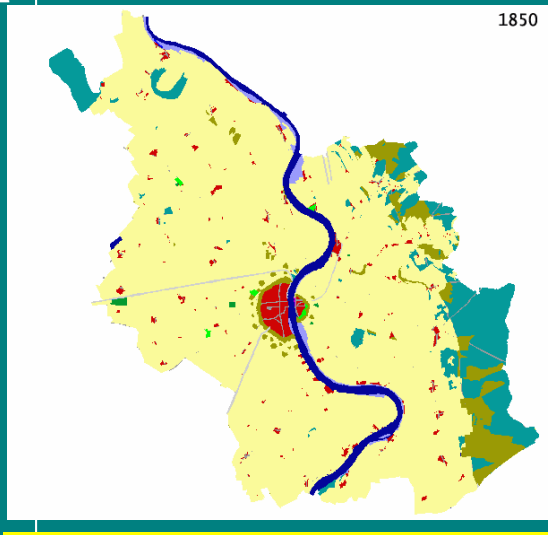


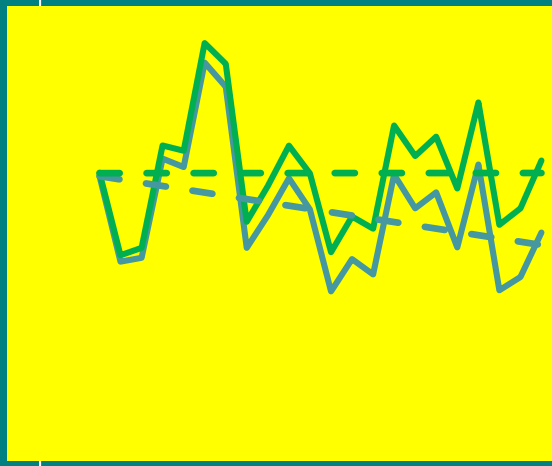
The question of the present presenation

- ***What are the causes for the lake's drawdown?***
- ***i.e. role of humand activites and climate variability?***
- ***How is the water accounting of the basin?***
- ***What can be the impacts of new agricultural policies on restoration of lake?***
- ***etc***

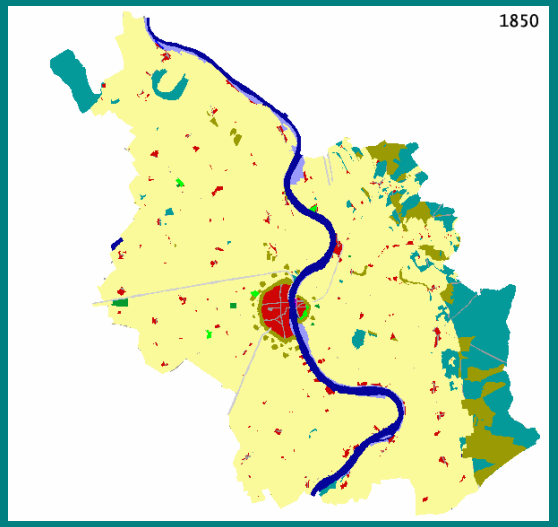
Simulation Framework to distinguish human activities and climate variability impacts on Lake Urmia drawdown

- 1st attempt) Running SWAT-LU using recorded temperature and rainfall data and updating land use
- 2nd attempt) Running SWAT-LU using fixed historical land use (1988) and recorded temperature and rainfall data
- 3rd attempt) Running SWAT-LU using de-terended temperature and rainfall data and updating land use
- 1st Run – 2nd Run = Human Impact
- 1st Run – 3rd Run = Climate variability Impact

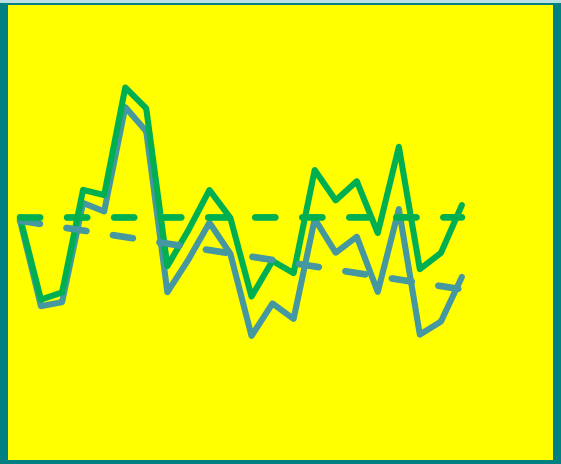




Simulation Framework to distinguish human activities and climate variability impacts on Lake Urmia drawdown



$$\Delta V_{Total} = \Delta V_{Climate} + \Delta V_{Human} + \Delta V_{(Climate,Human)}$$

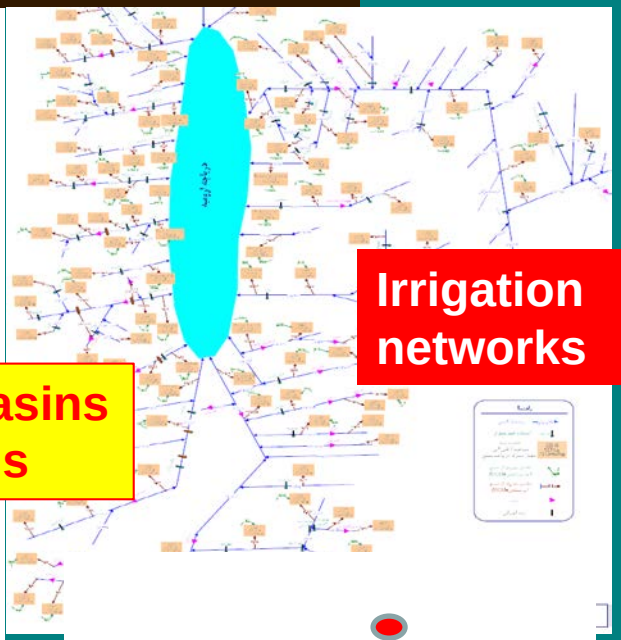


- **Modeling Set up, calibration and validation**

Producing Land Use Map the basin 1988 and 2007, Landsat images

Rainfed 19%
Irrigated lands 10%
Orchards 270%

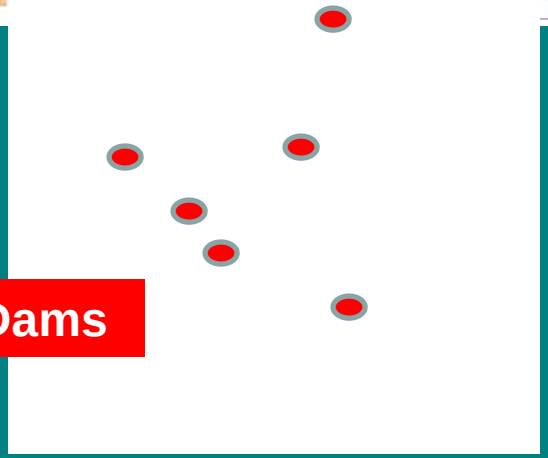
Major data/information and discretization of the basin and HRUs



112 subbasins
3114 HRUs

Irrigation networks

Lake's basimetry



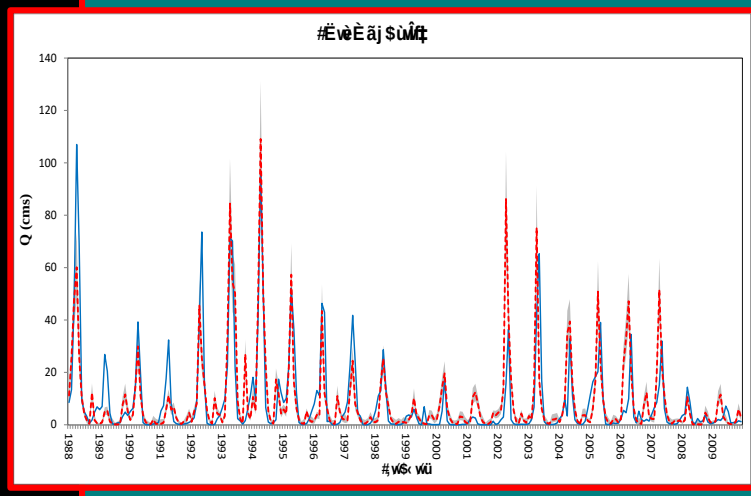
Dams

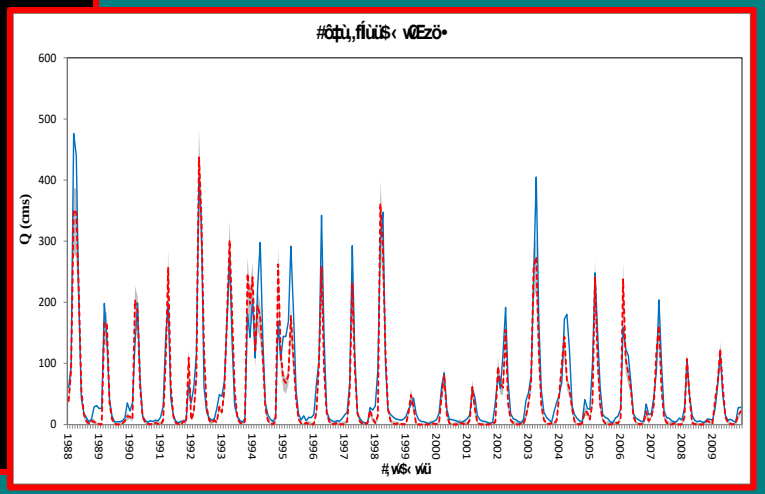
- DEM (30 meter)
- Soil map (FAO)
- 51 discharge stations
- 11 Temp. gauging stations
- 25 Rain gauge stations
- Cal. and val. period 1986 to 2009
- SWAT-CUP with parallel processing module

- 4 major crops and respected managements
- 6 major dams

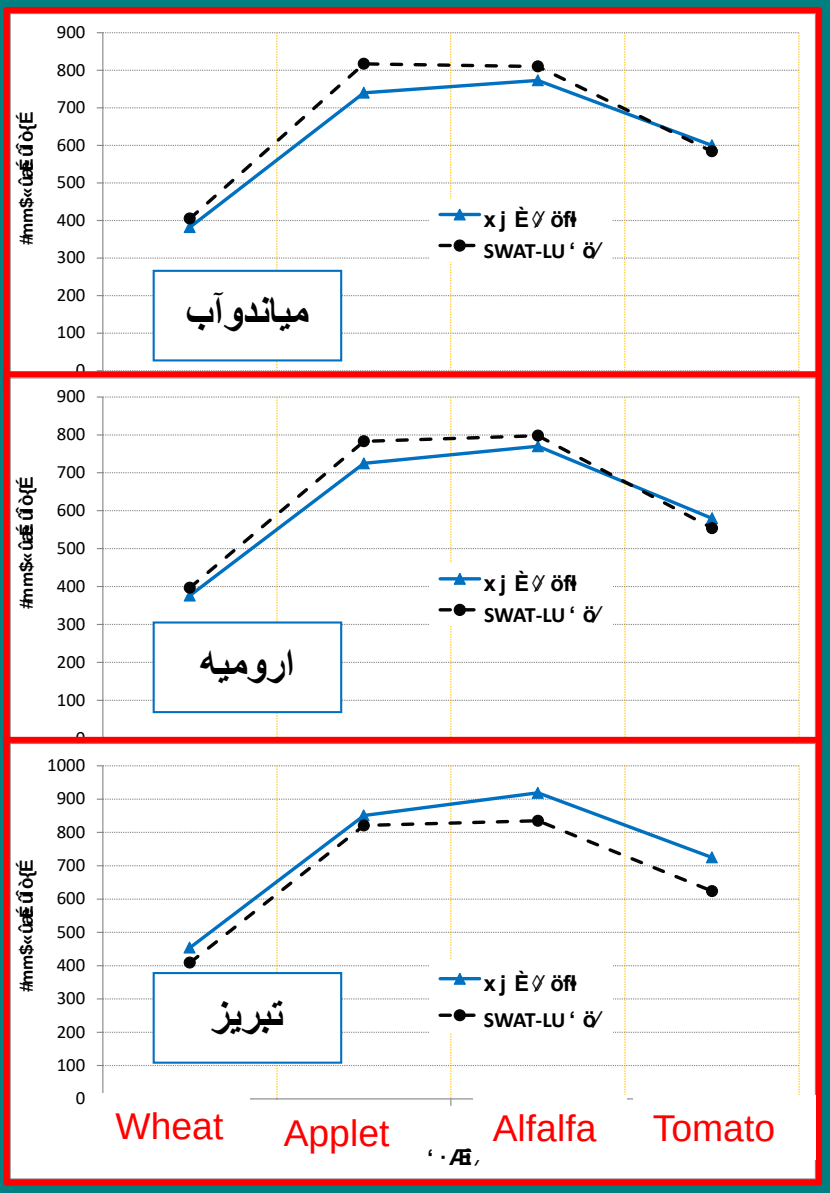
Calibration/validation of river flows

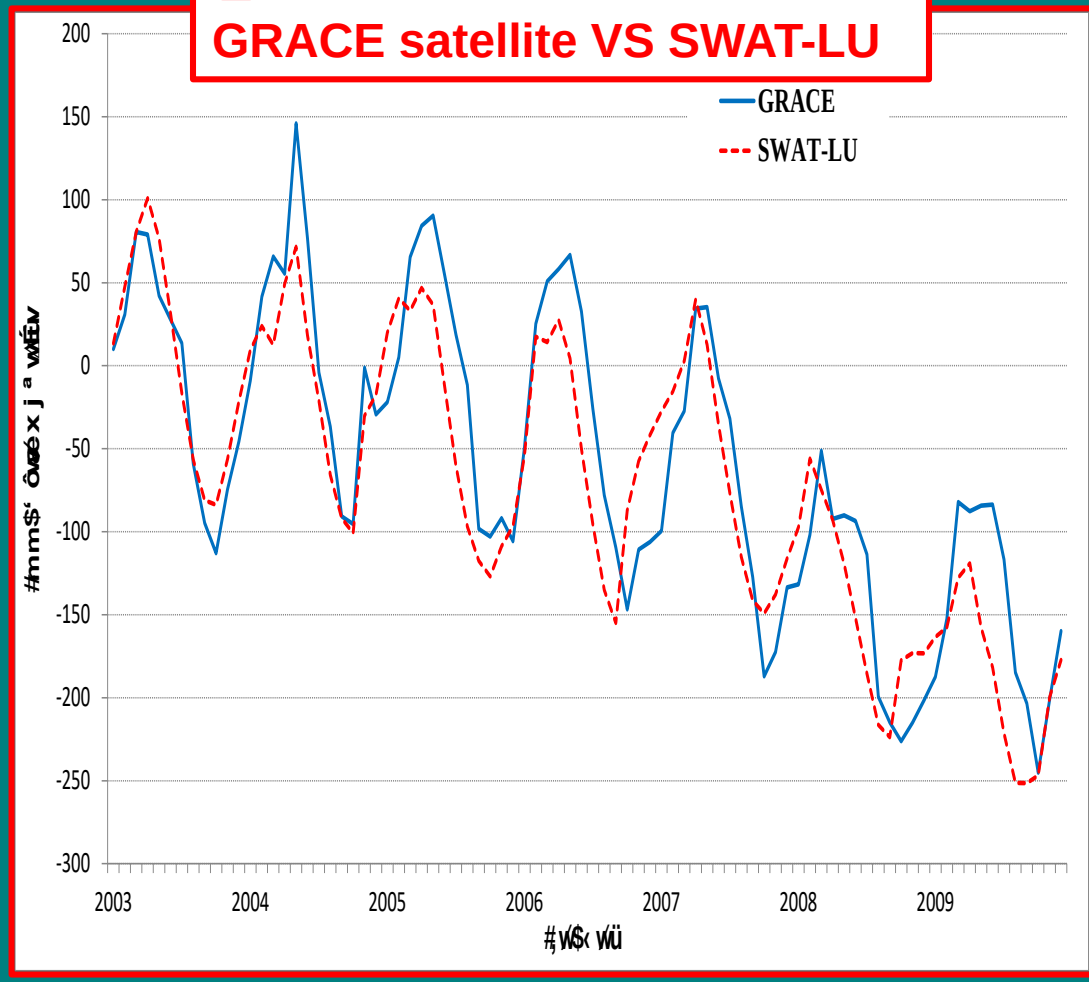
R2 and Nash are greater than 0.7 in the main stations



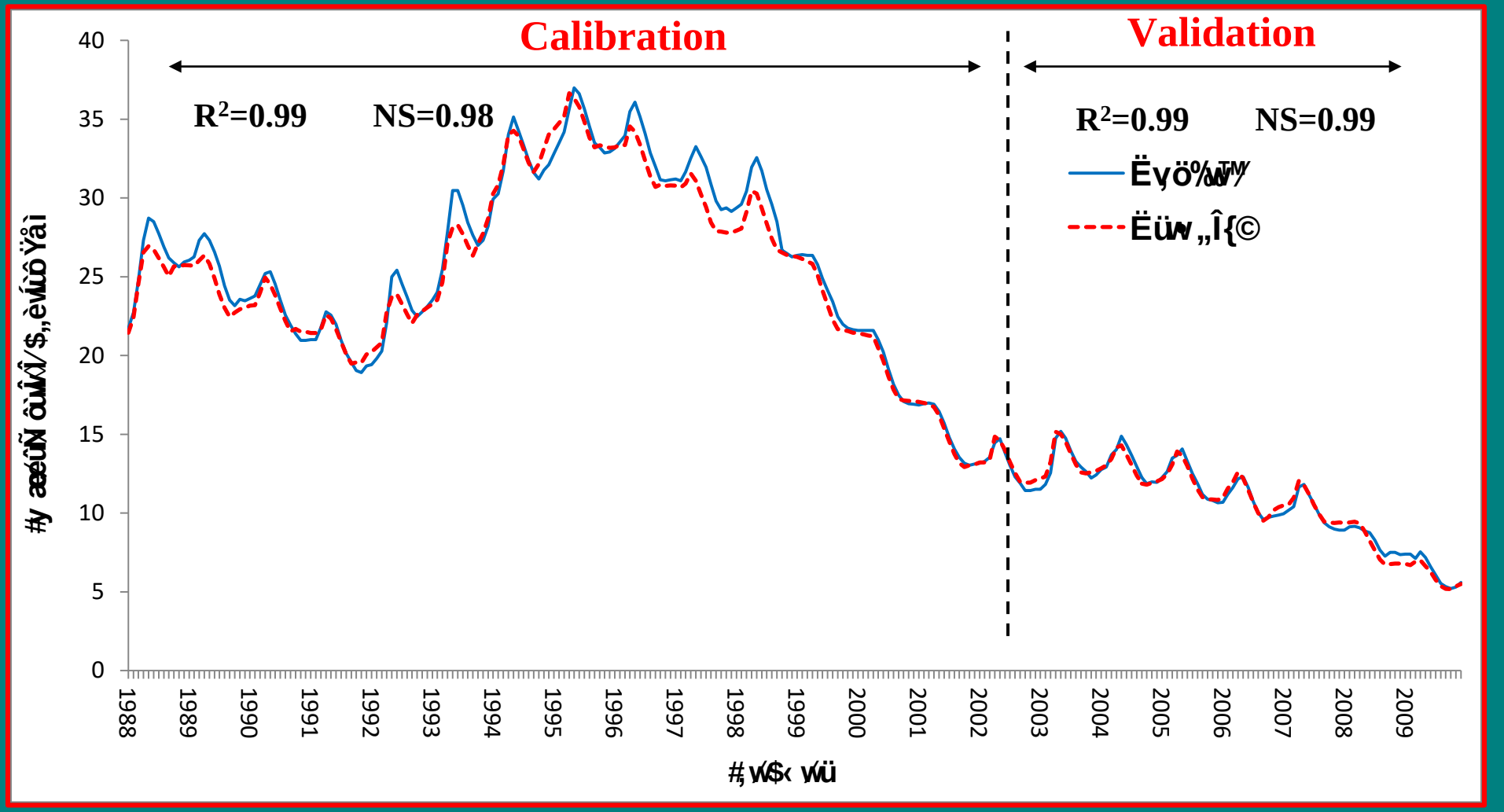


Calibration/validation of actual evapotranspiration and change in groundwater



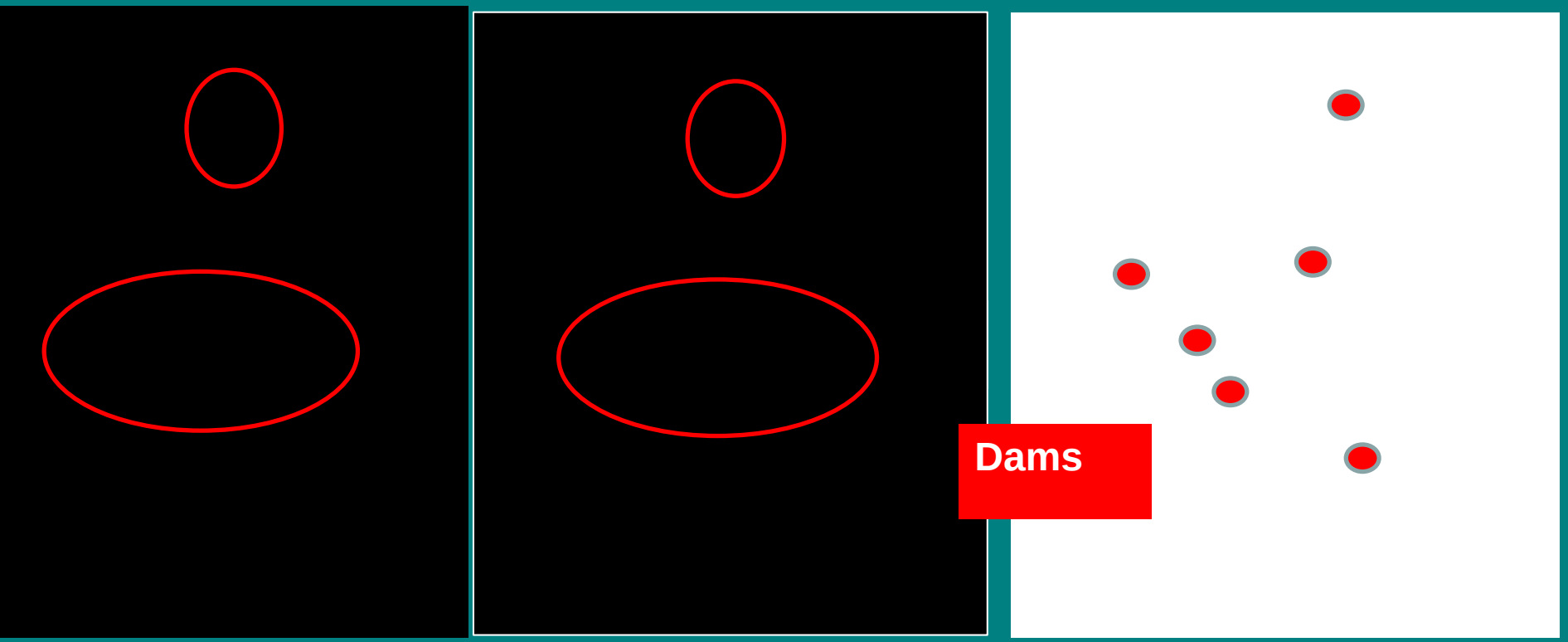


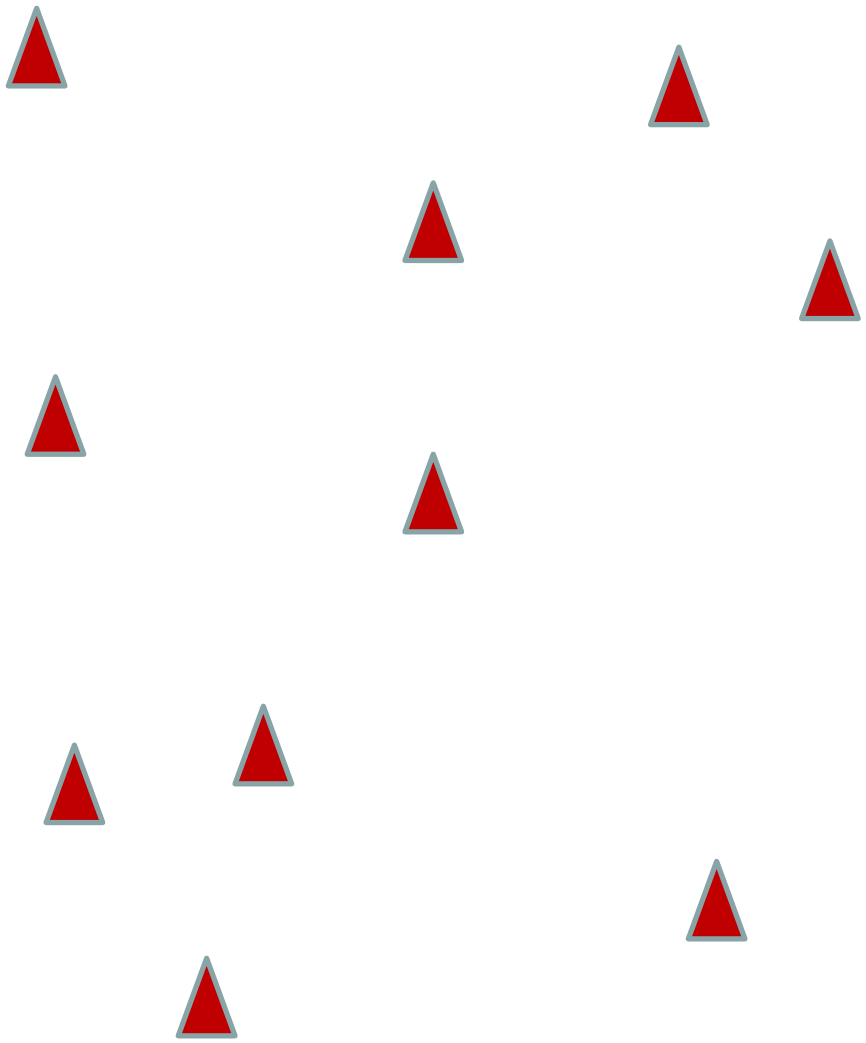
Calibration/validation of Lake Urmia's level using SWAT-LU



Producing Land Use Map the basin 1988 and 2007

Land use change including construction of the dams representing the role human activities of the basin





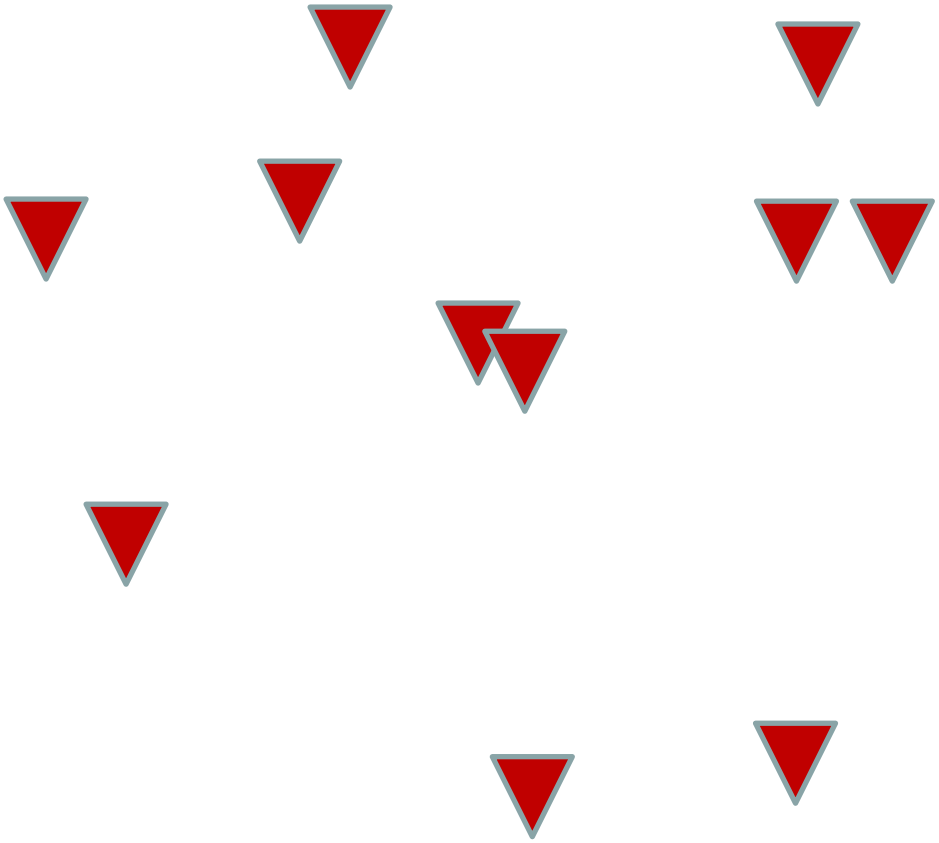
Trend analysis of temperature

▲ Significant positive trend

Positive trend but not significant

1980-2009
Mann-Kendal
Spearman

Trend analysis of rainfall



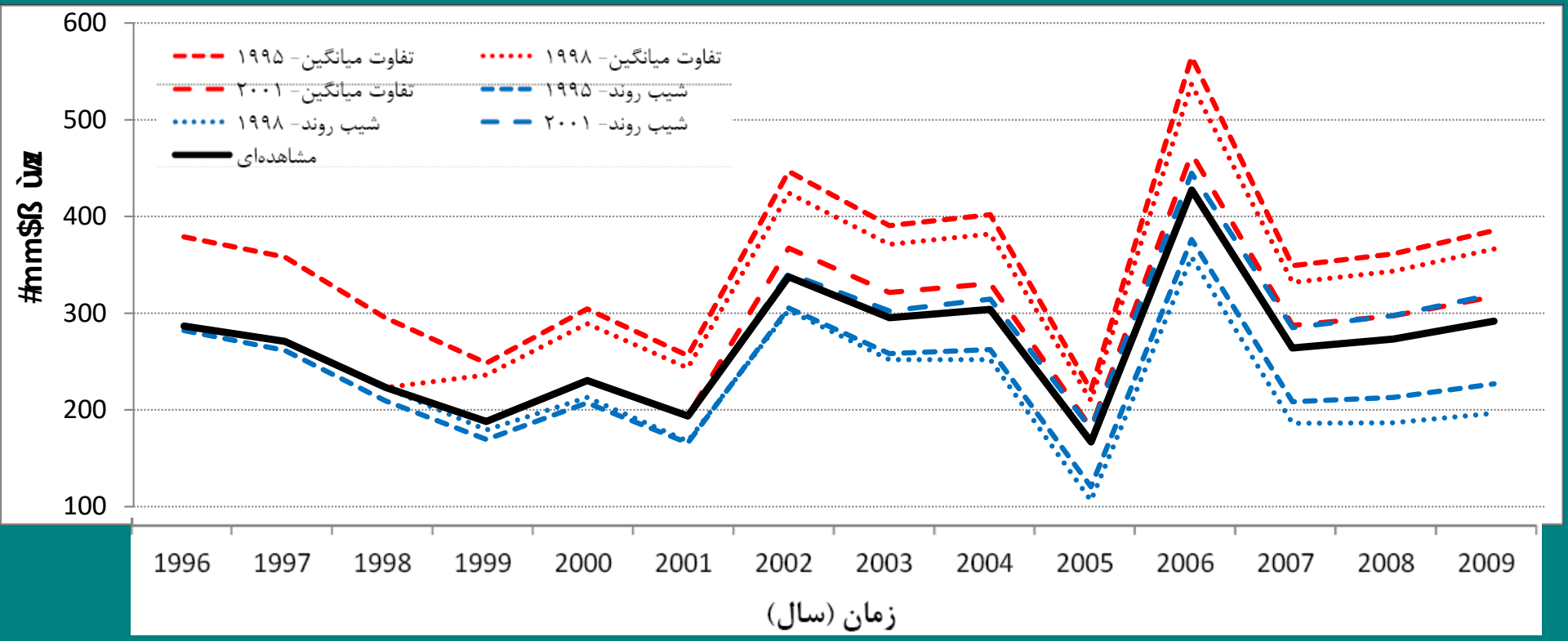
▼ Significant negative trend

Negative trend but not significant

No trend

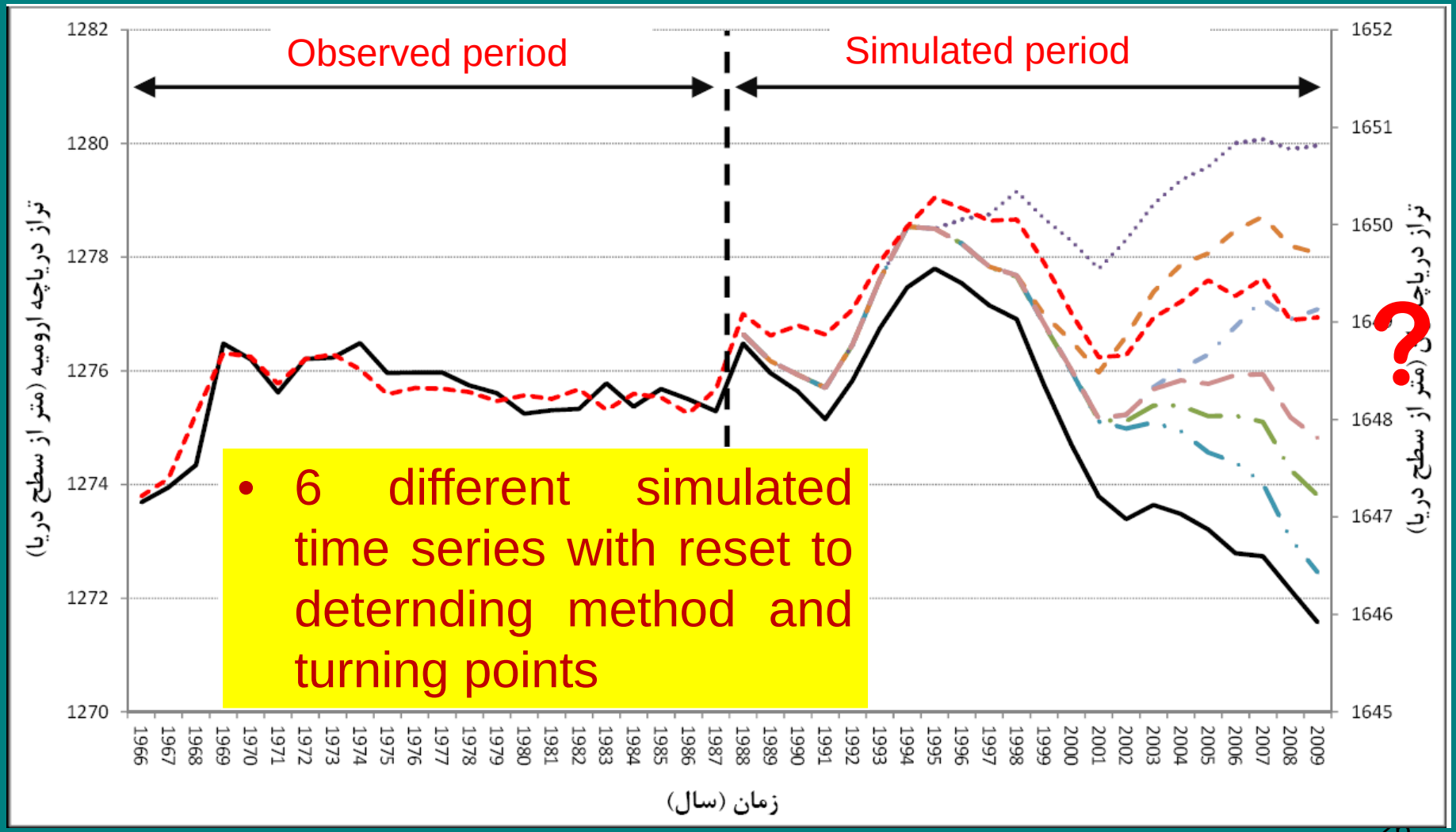
1980-2009
Mann-Kendal
Spearman

Deternded time series of temperature and rainfall after the lake's drawdown (1995 onward)



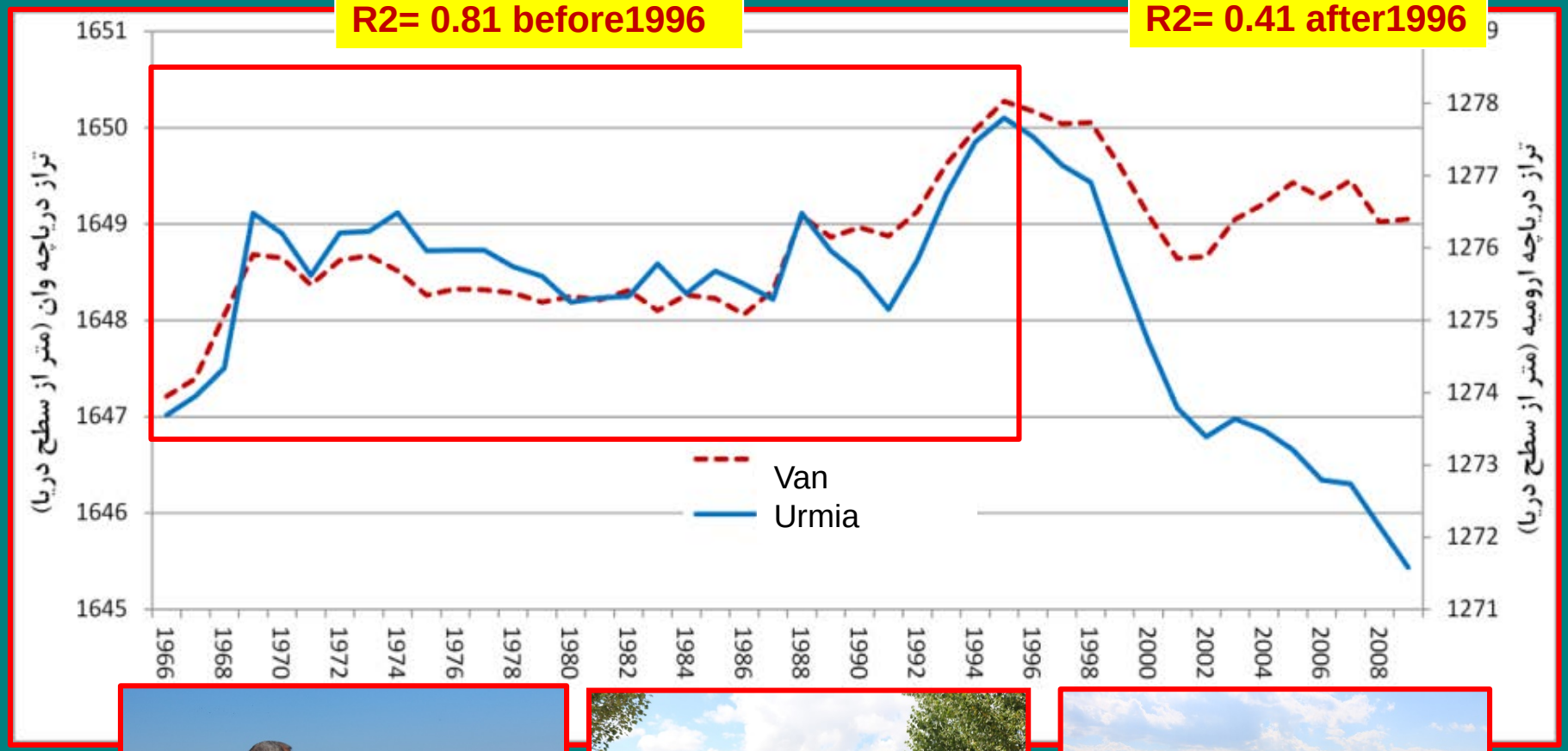
- **Problem: Getting different time series using different deternding methods (linear/average differences) and turning points (1995, 1998, 2002)**

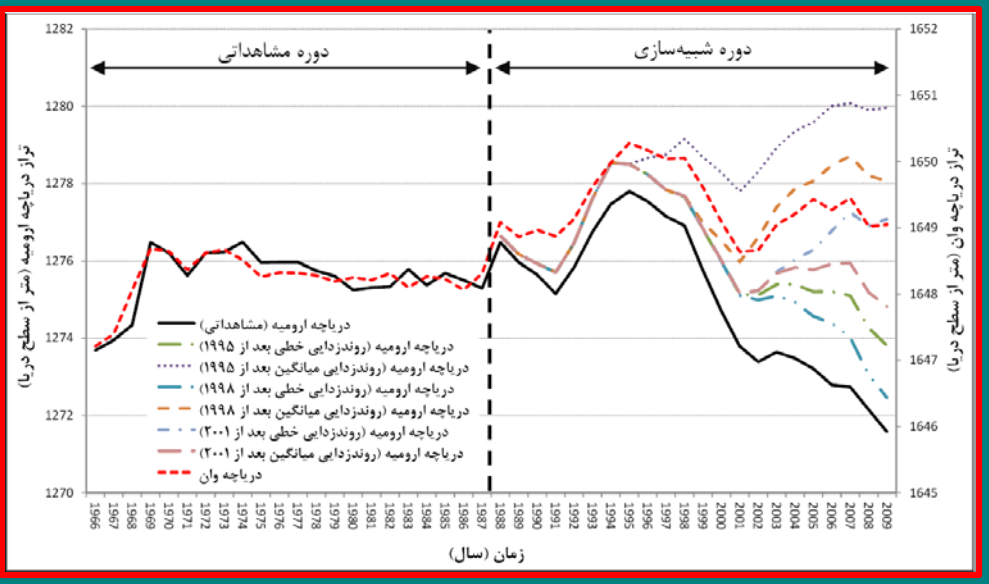
Simulation of Lake Urmia's level using different deterndig methods and turning points



Lake Van vs Lake Urmia

Lake Van's level vs Lake Urmia level

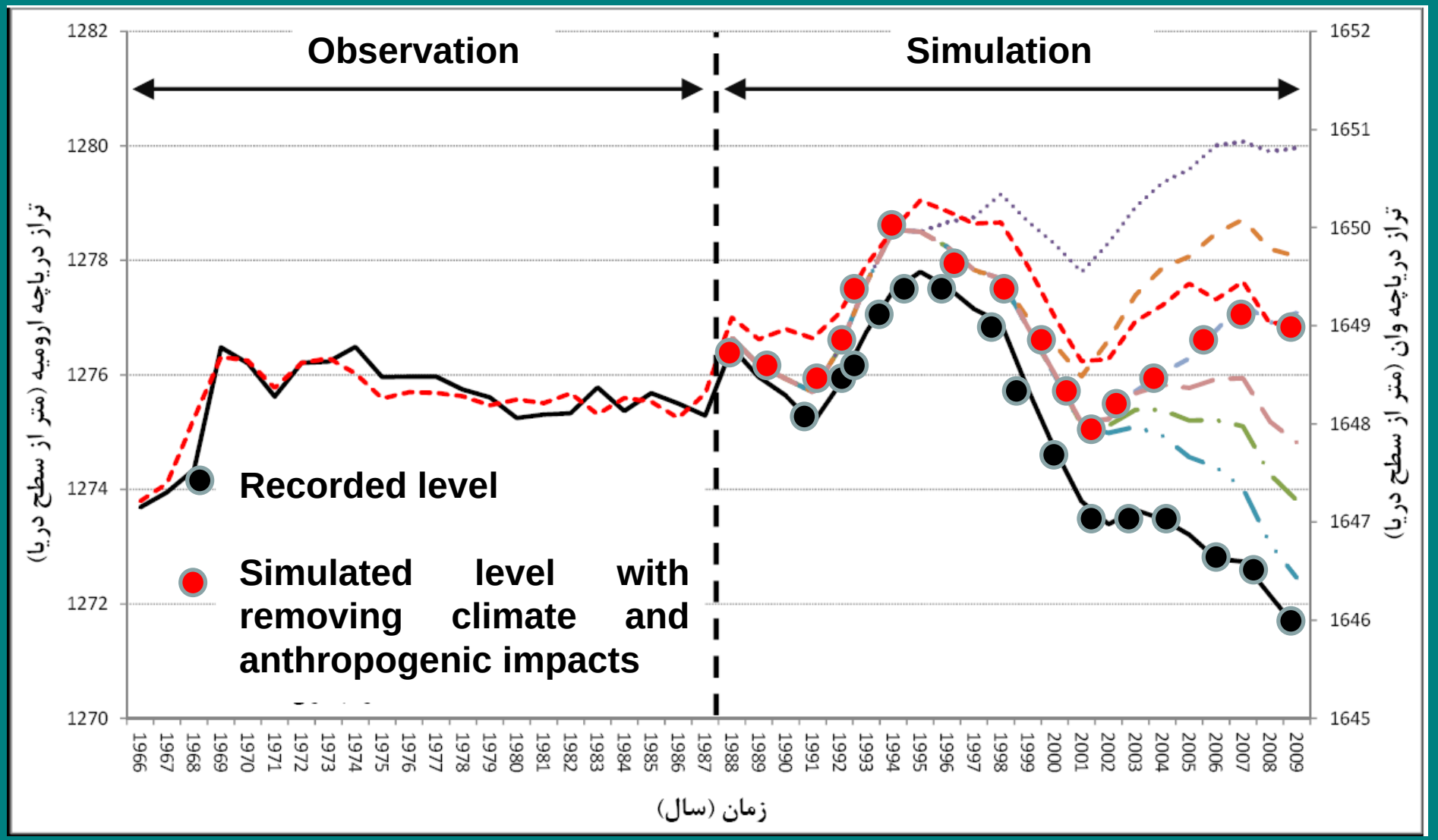




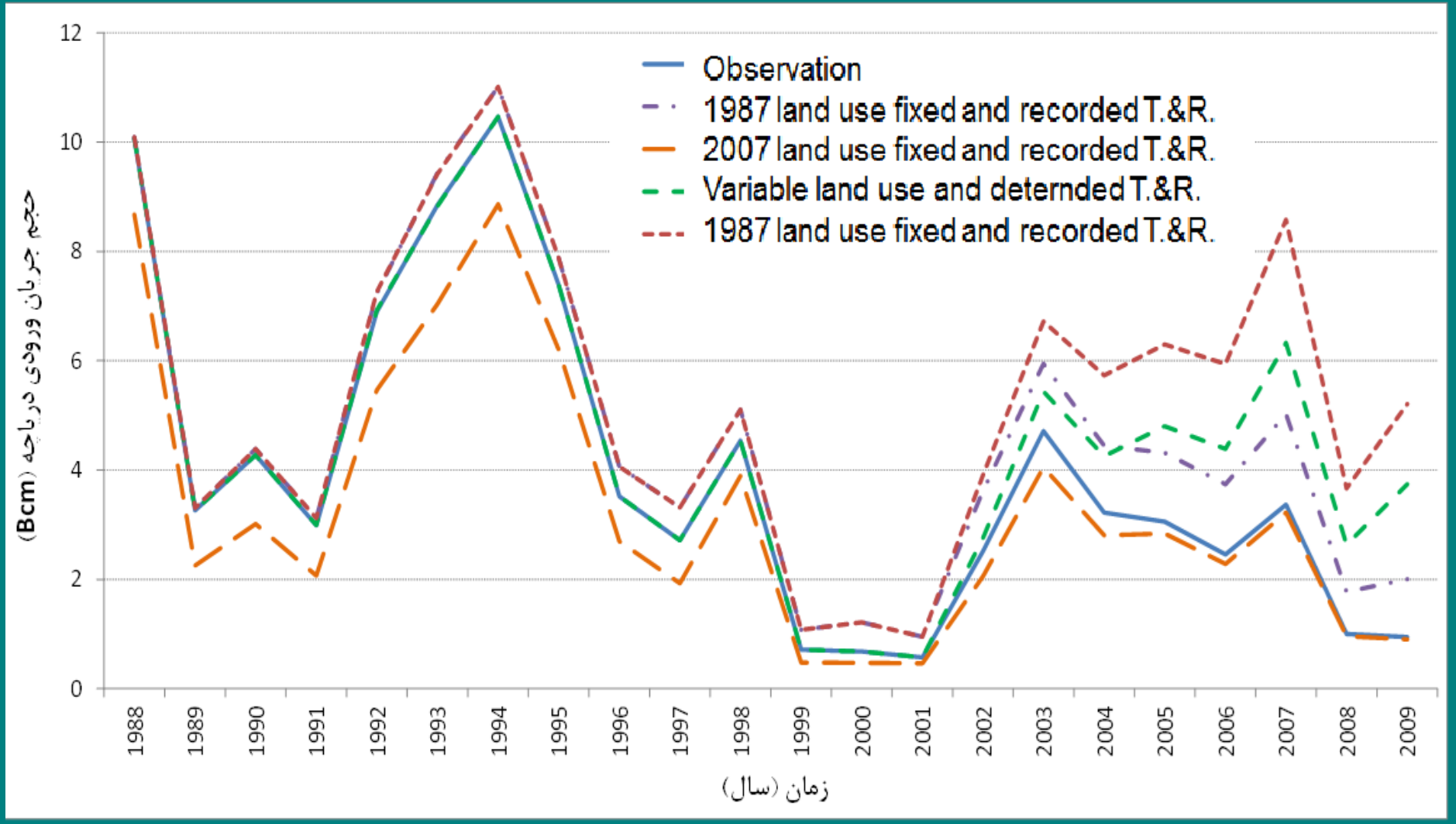
Correlation between lake's levels of Van and Urmia using different methods and turning points

R2	Turning point	Deternding method	Data type	Period
0.81	--	--	Observed	1966-1987
0.41	--	--	Observed	1988-2009
0.54	1996	Linear	Simulated	1988-2009
0.17	1996	Average	Simulated	1988-2009
0.41	1999	Linear	Simulated	1988-2009
0.52	1999	Average	Simulated	1988-2009
0.82	**2002**	**Linear**	**Simulated**	**1988-2009**
0.76	2002	Average	Simulated	1988-2009

Simulation of Lake Urmia's level using different deterndig methods



Simulated inflows to Lake Urmia under different climate and anthropogenic impacts based on the average differences deternding method and 2002 turning point



Relative impacts of anthropogenic and climate variability impacts on Lake Urmia drawdown

1999-2009		1988-2009		Simulation Sc.		Scenario
Change (△) comparing with base condition (BCM)	Inflows to lake (BCM)	Change (△) comparing with base condition (BCM)	Inflows to lake (BCM)	Climate data	Land use	
---	2.11	---	4.01	Observed	Variable	**Base** ($Q(Irr)_B$)
-0.99 **(%41.8)**	3.10	-0.67 **(%49.3)**	4.68	Observed	1987 fixed	**Rem. Human I.** ($Q(Irr)_H$)
-19.1 **(%50.2)**	3.30	0.59 **(%43.4)**	4.60	Deternded	Variable	**Rem. Climate I.** ($Q(Irr)_C$)
-2.37 (%100)	4.48	-1.36 (%100)	5.37	Deternded	1987 fixed	**Rem. both** ($Q(Irr)$)
-0.19 **(%8.0)**	---	0.10- **(%7.3)**	---	**Interaction of human & Climae** ($Q(Irr)_{C,H}$)		

Conclusion and remarks

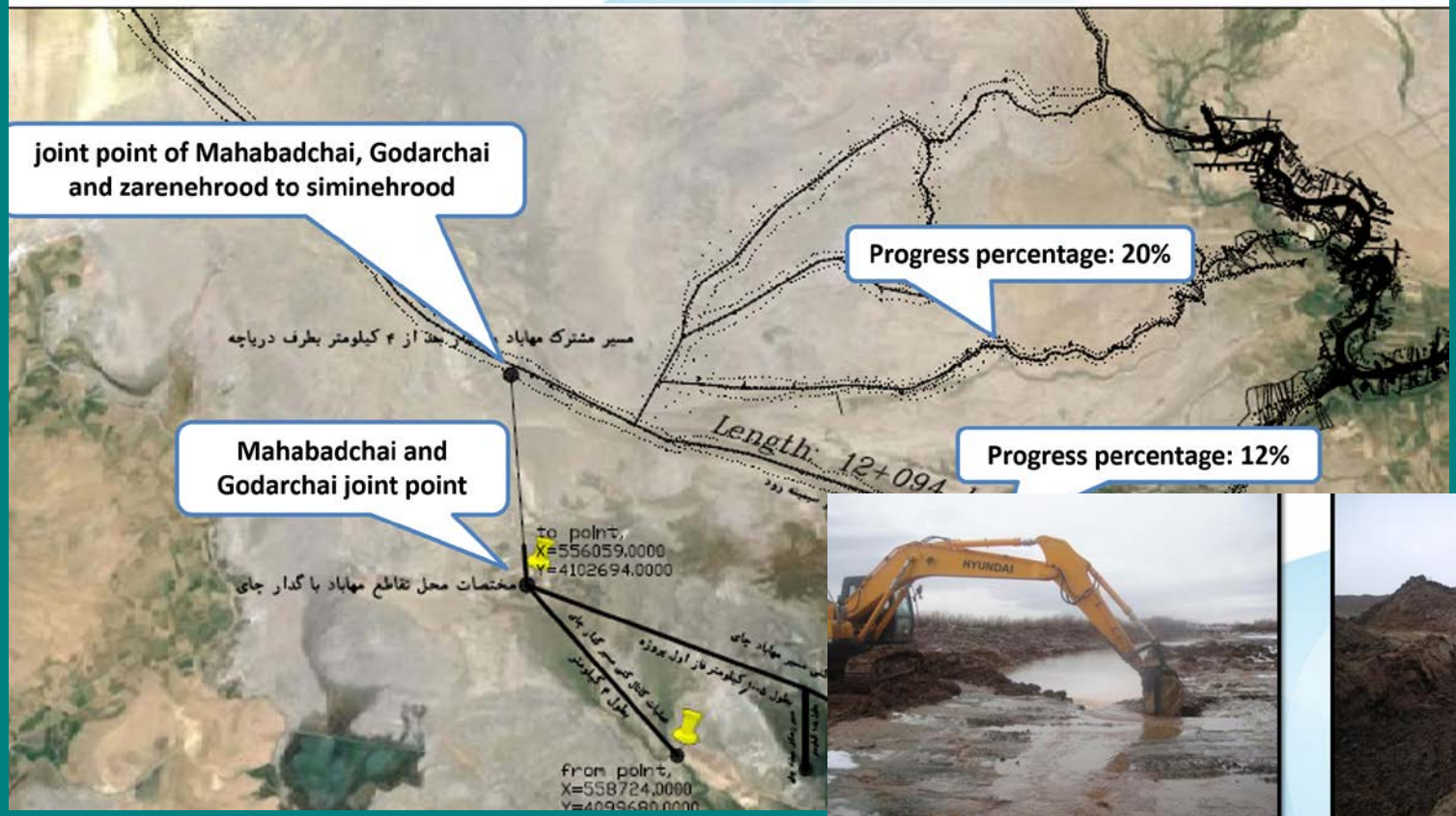
- **The results showed that inspite of many subjective analyses that introduce human activities (miss management as the main resean for the drawdown of hLake Urmia; climate viability of the basin has also seriously had affected the lake.**

- **Having in mind the finding, face us with a new hot question which is:**
- **Can be bring back the lake to its historical level or it is essential to accept this reality and work on partial restoration of the lake. As it was also considered in restoration of Aral Sea (Central Asia) and Mono lake (California).**

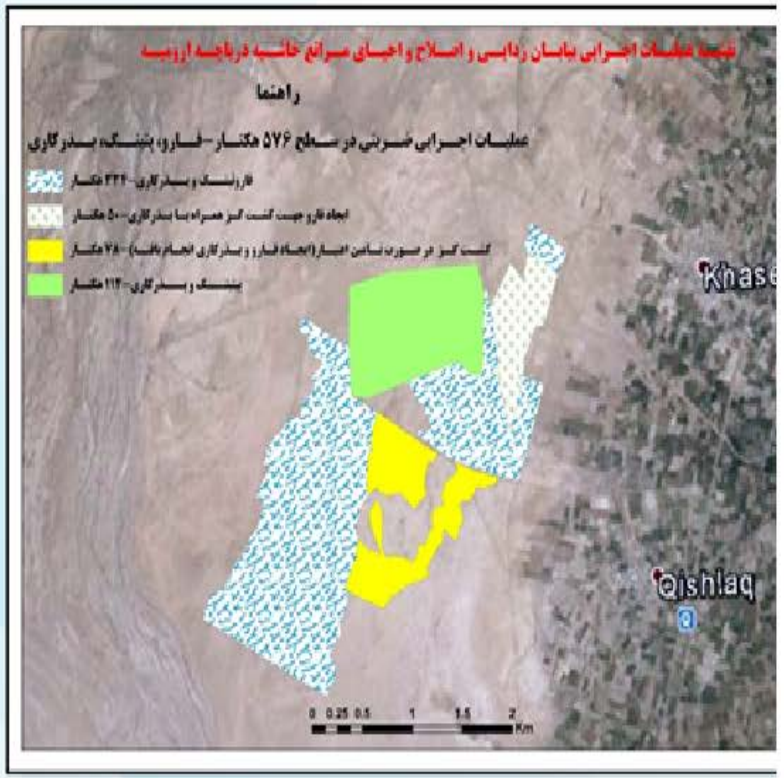
- **SWAT-LU can be accounted as a suitable tool for supporting the related policies and decisions to restore the lake.**

Thanks for your attention

The map of Dredging rivers poured into the south of Lake Urmia



Implemented actions for dust control



Water transfer from Sylveh Dam to Urmia Lake in order to supply 190 million cubic meters annually

Recent progress of Sylveh building process