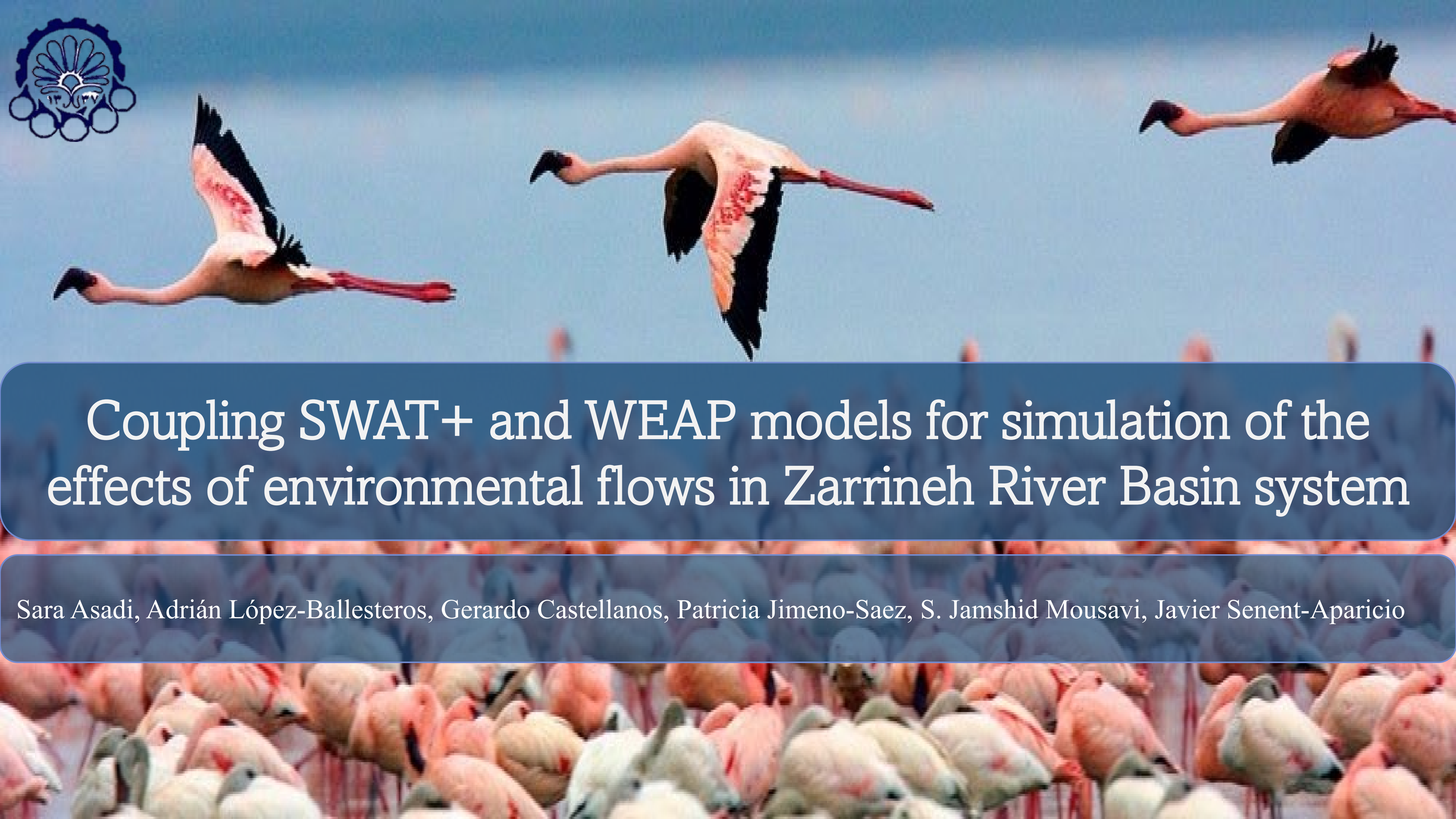


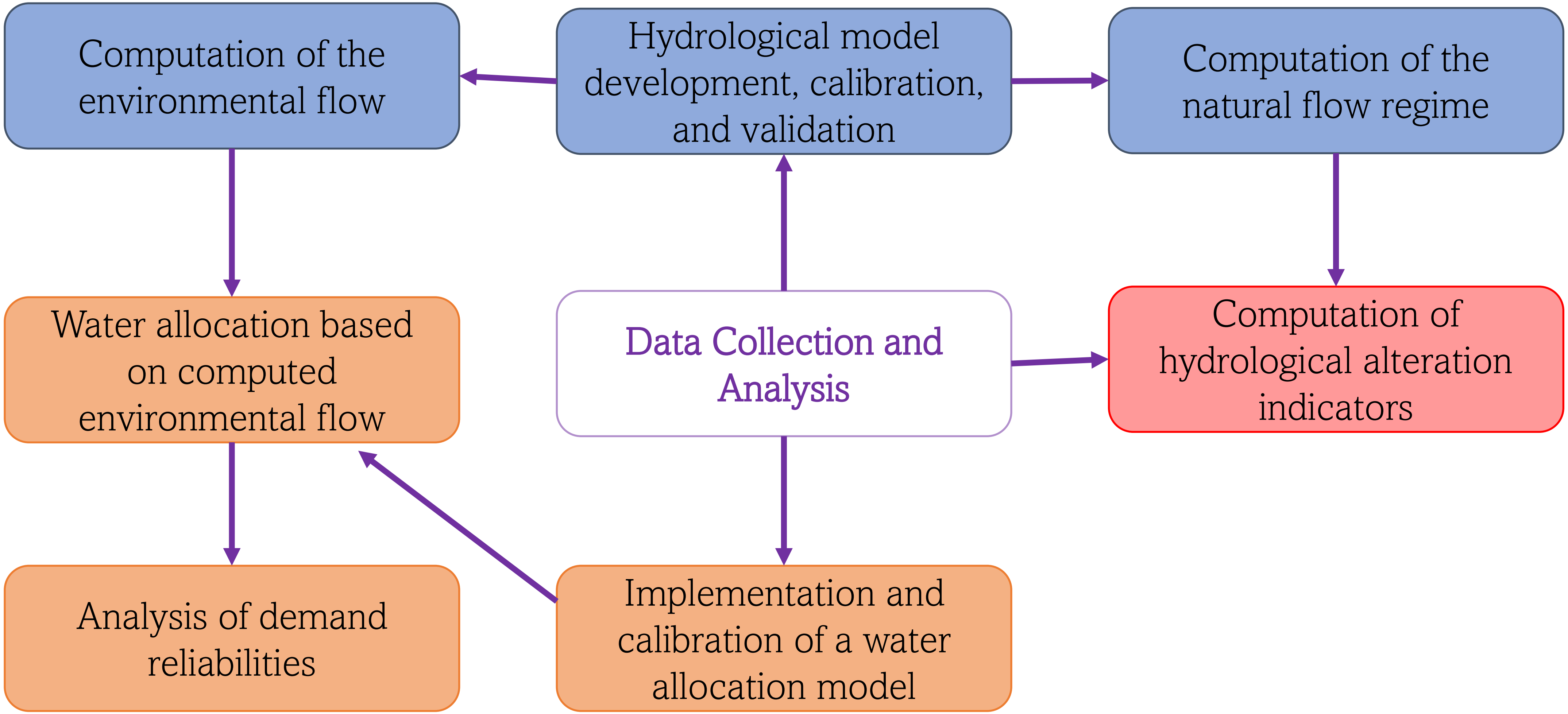
Coupling SWAT+ and WEAP models for simulation of the effects of environmental flows in Zarrineh River Basin system

Sara Asadi, Adrián López-Ballesteros, Gerardo Castellanos, Patricia Jimeno-Saez, S. Jamshid Mousavi, Javier Senent-Aparicio

OBJETIVE

Assessment of the impacts of dam construction on hydrologic alterations in the Zarineh River Basin

Assessment the effects of environmental flows on the reliability of water demands in the Zarrineh River Basin



Computation of the environmental flow

Hydrological model development, calibration, and validation

Computation of the natural flow regime

Water allocation based on computed environmental flow

Data Collection and Analysis

Computation of hydrological alteration indicators

Analysis of demand reliabilities

Implementation and calibration of a water allocation model

Case study: Zarineh River Basin

Zarrineh river base channel length: 300 km

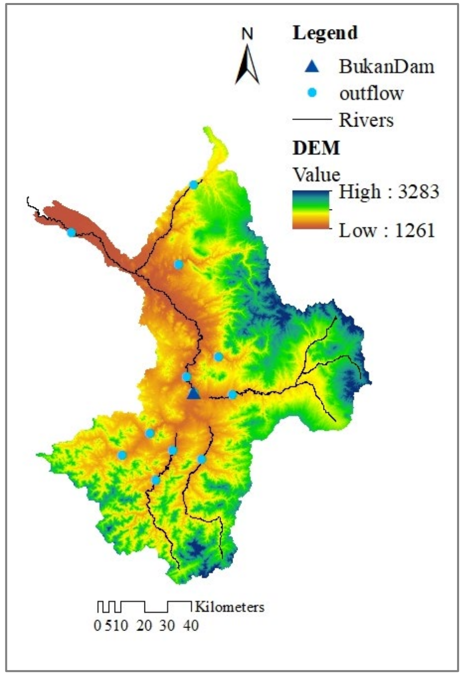
Zarrineh River Basin area: 12000 km2

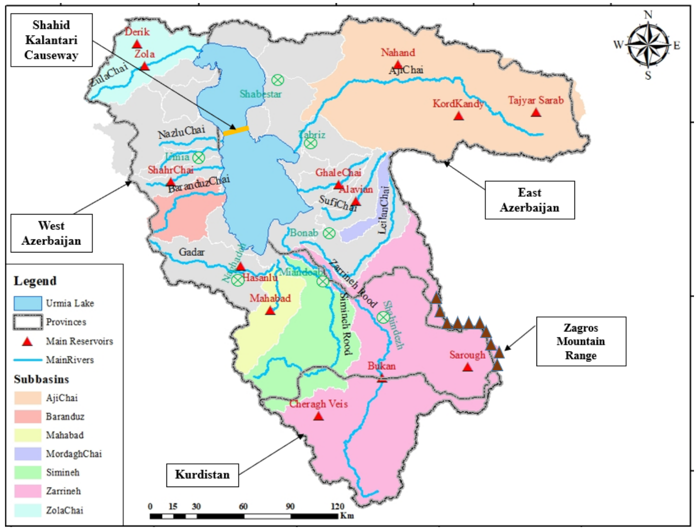
Boukan Dam

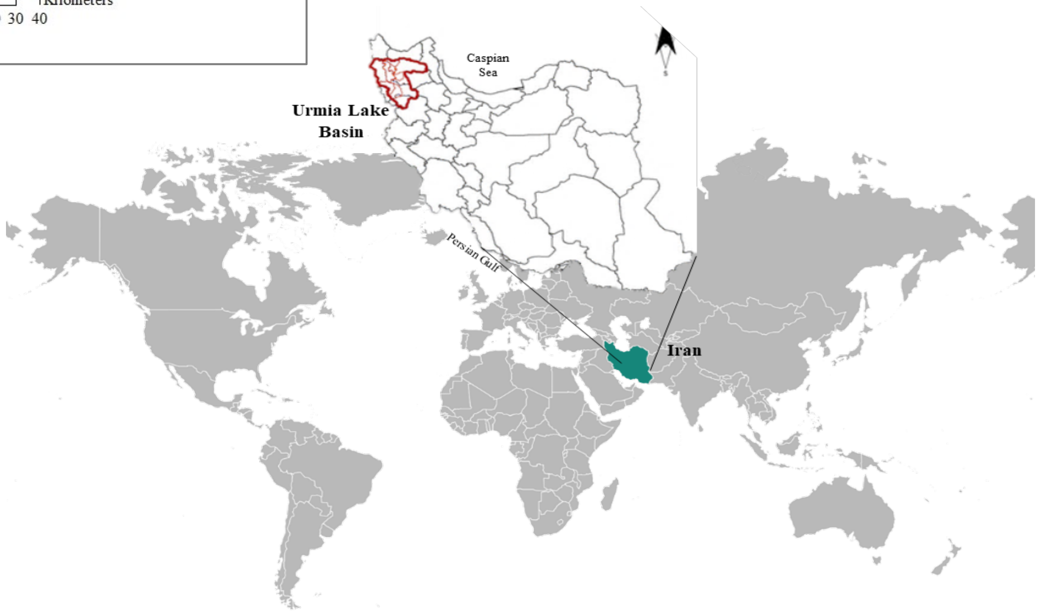
The biggest dam in Urmia Lake Basin
(vol.: 825 MCM)

Dam construction purpose:

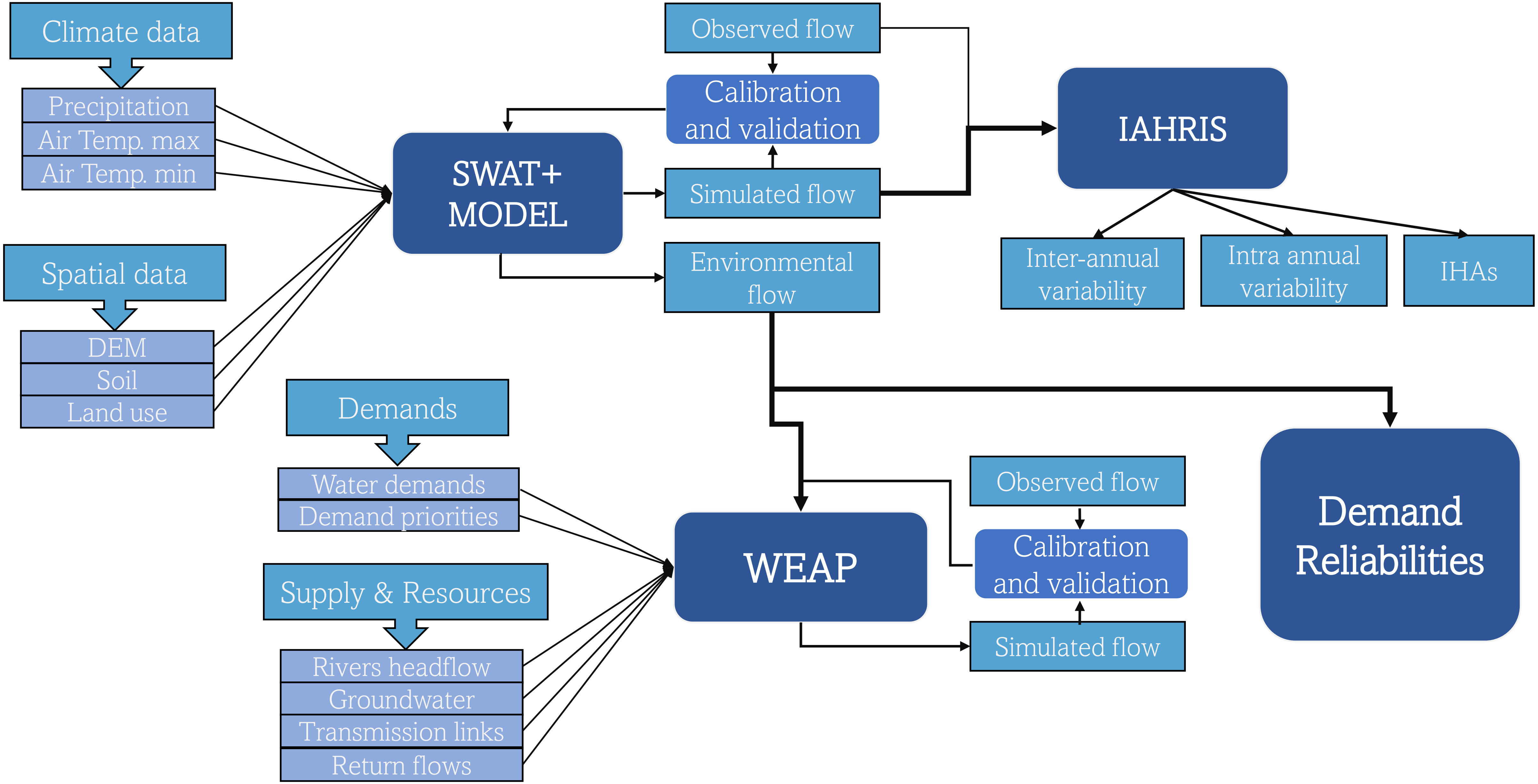
- Irrigating 65,000 ha irrigation lands of the Zarrineh Basin
- Flood Control
- Regulation of Zarrineh River inflow
- Municipal water supply for upstream and downstream cities







SWAT+	IAHRIS	WEAP
Soil and Water Assessment Tool	Indicators of Hydrologic Alteration in RIverS	Water Evaluation And Planning system
time continuous, semi-distributed hydrological model	Calculating IHAs using natural (simulated) and altered (observed) flow regimes	Simulating the allocation of the available water resources among competing users considering their priorities, in an optimal way



Climate data

Precipitation

Air Temp. max

Air Temp. min

Spatial data

DEM

Soil

Land use

SWAT+ MODEL

Observed flow

Calibration and validation

Simulated flow

Environmental flow

IAHRIS

Inter-annual variability

Intra annual variability

IHAs

Demands

Water demands

Demand priorities

Supply & Resources

Rivers headflow

Groundwater

Transmission links

Return flows

WEAP

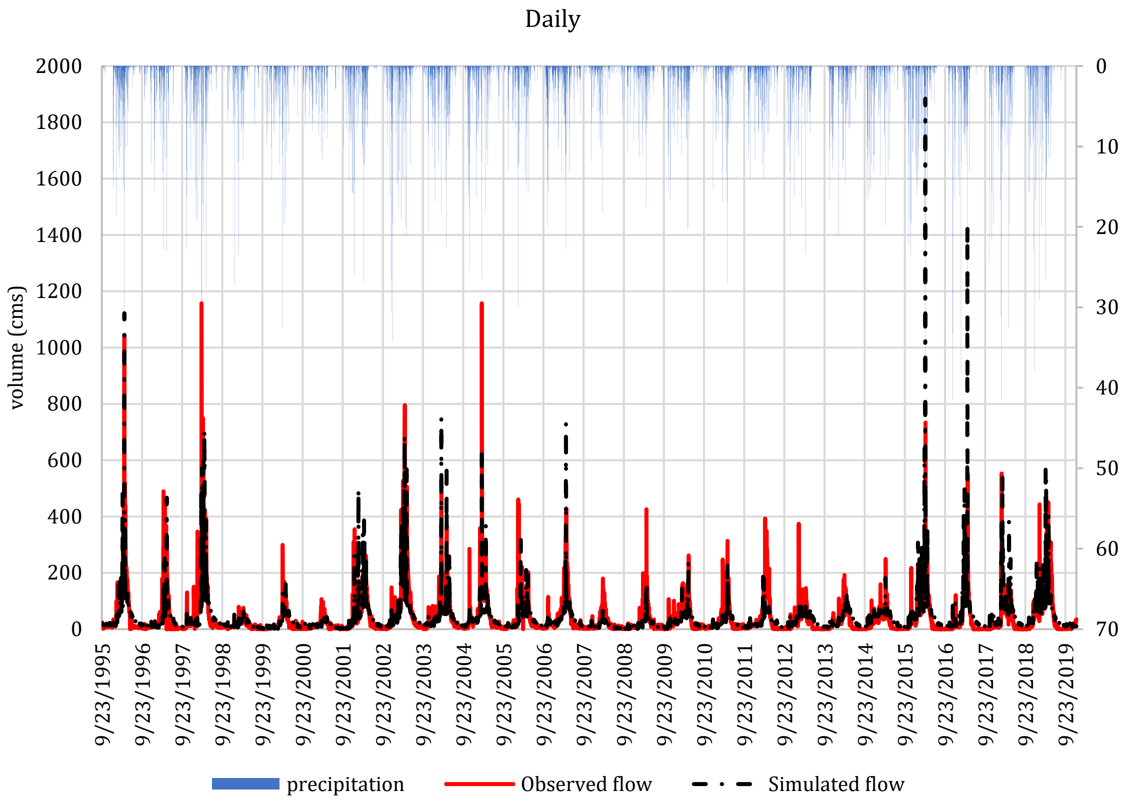
Observed flow

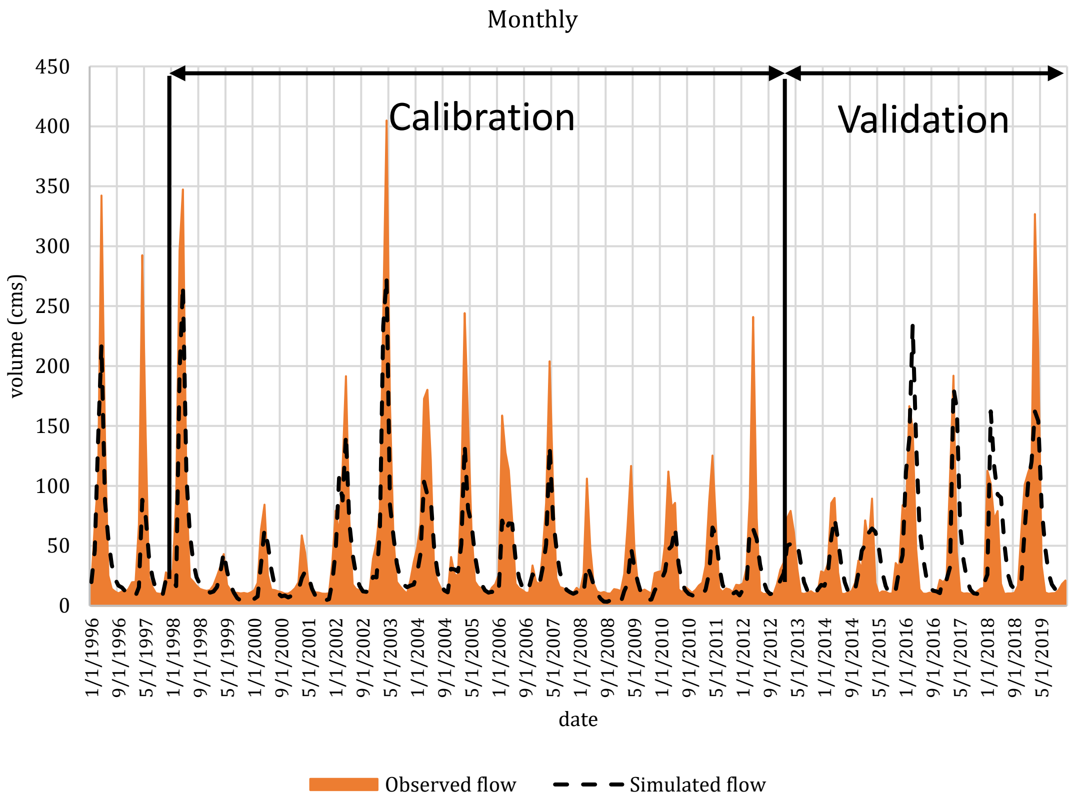
Calibration and validation

Simulated flow

Demand Reliabilities

SWAT+ MODEL



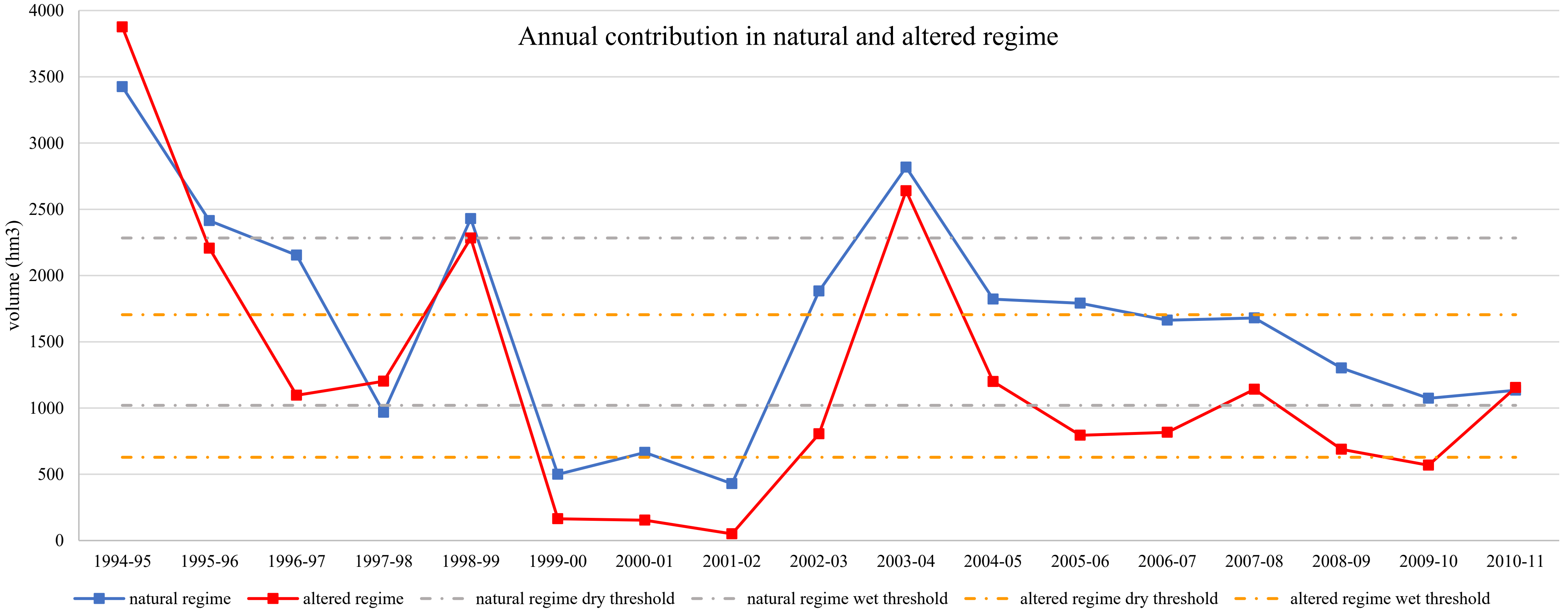


KGE
Calibration period: 0.55
Validation period: 0.48

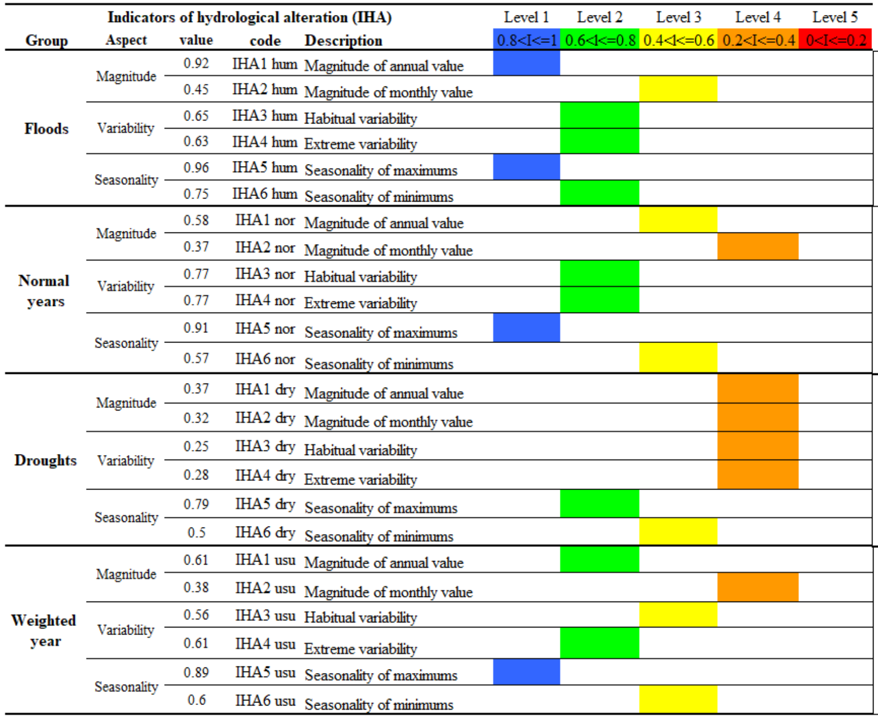
	NSE	PBIAS	R^2	KGE
Calibration period (1998-2012)	0.74	18.7%	0.82	0.59
Validation period (2013-2019)	0.67	-20.6%	0.69	0.68

IAHRIS

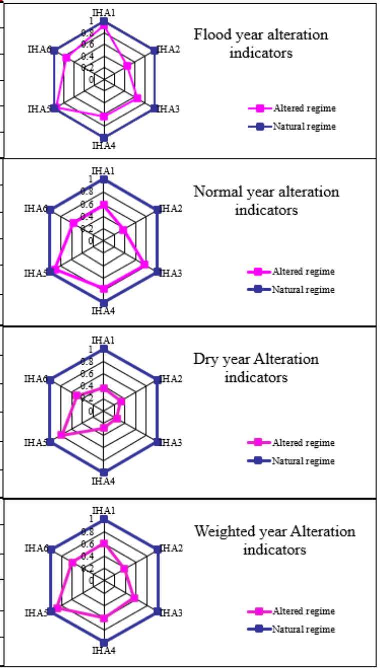
Inter-annual variations

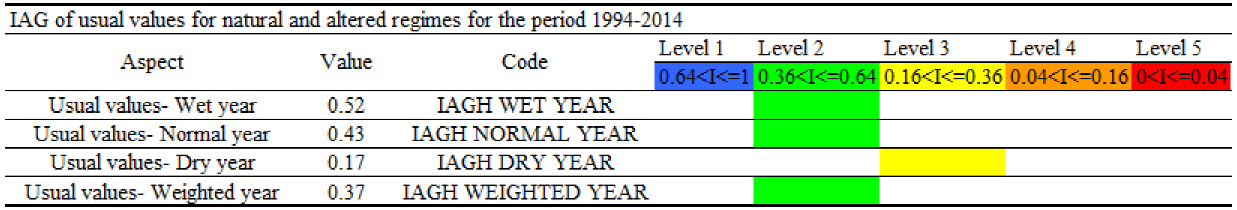


IAHRIS



	Indicators of hydrological alteration (IHA)				Level 1	Level 2	Level 3	Level 4	Level 5
Group	**Aspect**	**value**	**code**	**Description**	0.8<I<=1	0.6<I<=0.8	0.4<I<=0.6	0.2<I<=0.4	0<I<=0.2
Floods	Magnitude	0.92	IHA1 hum	Magnitude of annual value	🟦				
		0.45	IHA2 hum	Magnitude of monthly value			🟨		
	Variability	0.65	IHA3 hum	Habitual variability		🟩			
		0.63	IHA4 hum	Extreme variability		🟩			
	Seasonality	0.96	IHA5 hum	Seasonality of maximums	🟦				
		0.75	IHA6 hum	Seasonality of minimums		🟩			
Normal years	Magnitude	0.58	IHA1 nor	Magnitude of annual value			🟨		
		0.37	IHA2 nor	Magnitude of monthly value				🟧	
	Variability	0.77	IHA3 nor	Habitual variability		🟩			
		0.77	IHA4 nor	Extreme variability		🟩			
	Seasonality	0.91	IHA5 nor	Seasonality of maximums	🟦				
		0.57	IHA6 nor	Seasonality of minimums			🟨		
Droughts	Magnitude	0.37	IHA1 dry	Magnitude of annual value				🟧	
		0.32	IHA2 dry	Magnitude of monthly value				🟧	
	Variability	0.25	IHA3 dry	Habitual variability				🟧	
		0.28	IHA4 dry	Extreme variability				🟧	
	Seasonality	0.79	IHA5 dry	Seasonality of maximums		🟩			
		0.5	IHA6 dry	Seasonality of minimums			🟨		
Weighted year	Magnitude	0.61	IHA1 usu	Magnitude of annual value		🟩			
		0.38	IHA2 usu	Magnitude of monthly value				🟧	
	Variability	0.56	IHA3 usu	Habitual variability			🟨		
		0.61	IHA4 usu	Extreme variability		🟩			
	Seasonality	0.89	IHA5 usu	Seasonality of maximums	🟦				
		0.6	IHA6 usu	Seasonality of minimums			🟨		

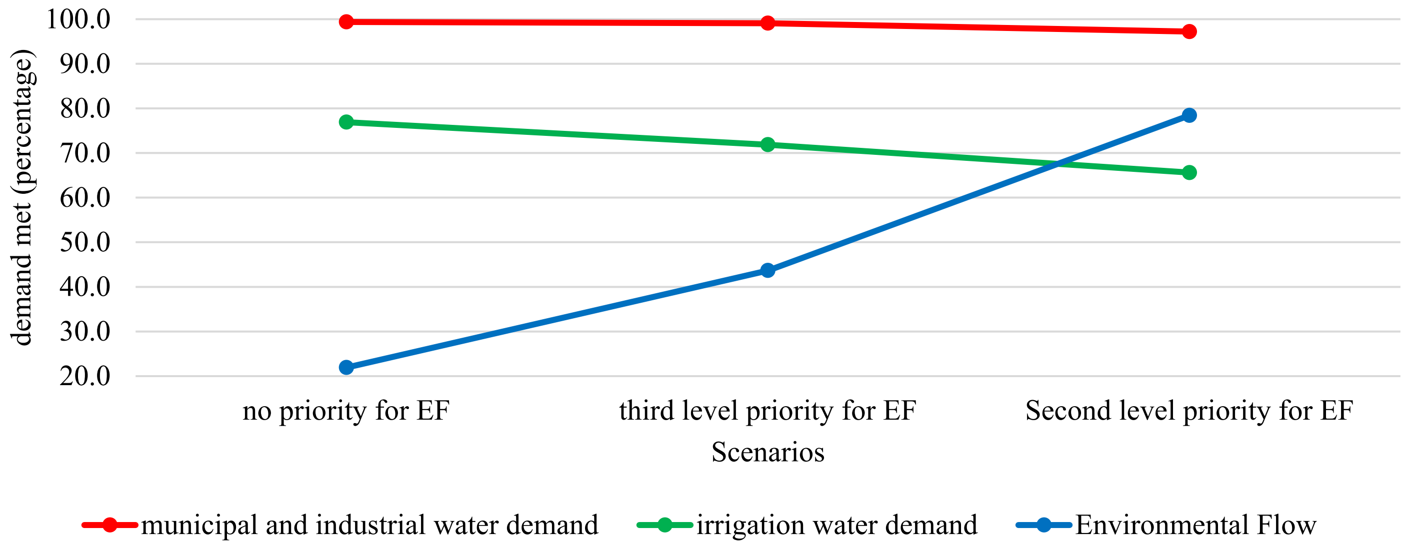




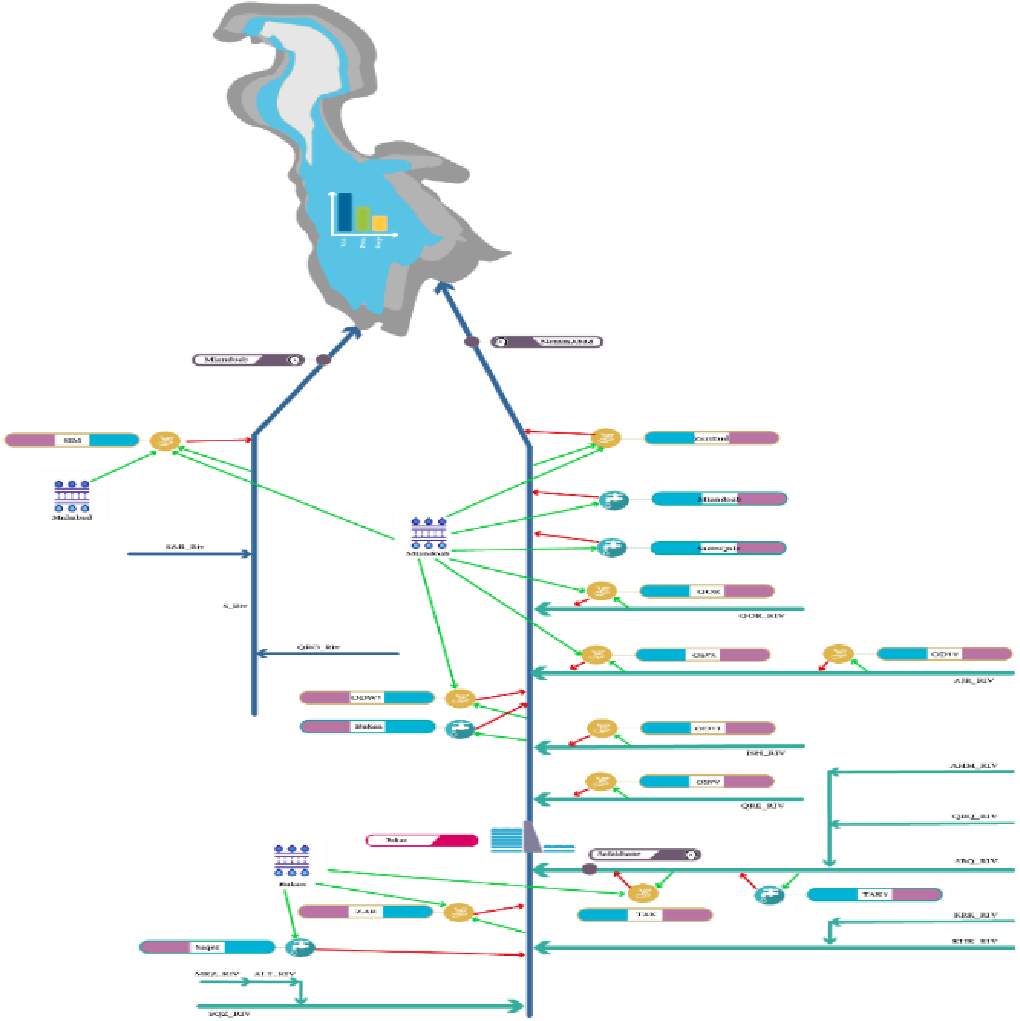
IAG of usual values for natural and altered regimes for the period 1994-2014

Aspect	Value	Code	Level 1	Level 2	Level 3	Level 4	Level 5
			0.64<I<=1	0.36<I<=0.64	0.16<I<=0.36	0.04<I<=0.16	0<I<=0.04
Usual values- Wet year	0.52	IAGH WET YEAR		🟩			
Usual values- Normal year	0.43	IAGH NORMAL YEAR		🟩			
Usual values- Dry year	0.17	IAGH DRY YEAR			🟨		
Usual values- Weighted year	0.37	IAGH WEIGHTED YEAR		🟩			

WEAP



demands / scenarios	municipal and industrial water demand	irrigation water demand	Environmental Flow
no priority for EF	99.4	76.9	21.9
third level priority for EF	99.1	71.8	43.7
Second level priority for EF	97.2	65.6	78.4

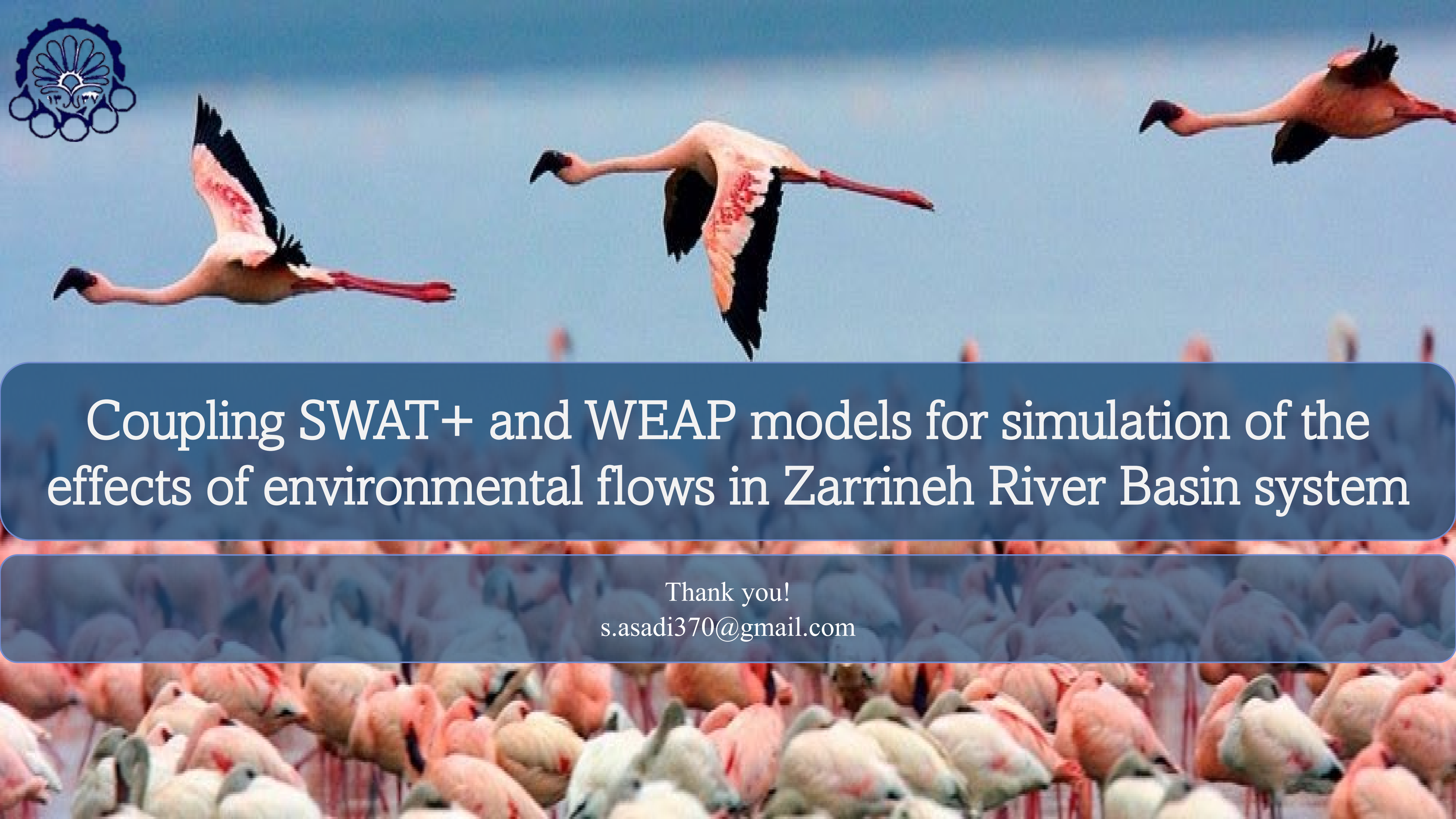


1. Regarding inter-annual variations, the trends of altered and natural regimes were similar, although 14 years out of 17 years volume were higher in a natural regime than in a regulated regime. The inter-annual water balance from 1994 to 2011 resulted in a decrease in volume in the altered regime that was 25.97% under that of the modelled natural regime.

2. Dry years usual (0.17) and extreme (0.12) IAG values indicated serious problems that could affect the riverine ecosystem or hydraulic conditions.

3. Our results show that 77% of agricultural demands would be met when we do not consider environmental flows. However, considering environmental flows would decrease meeting agricultural demands by 11%.

4. The findings of this study could assist policymakers in designing environmental flows that account for both the reliability of water demands and the hydrological changes within the basin.



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Thank you!

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