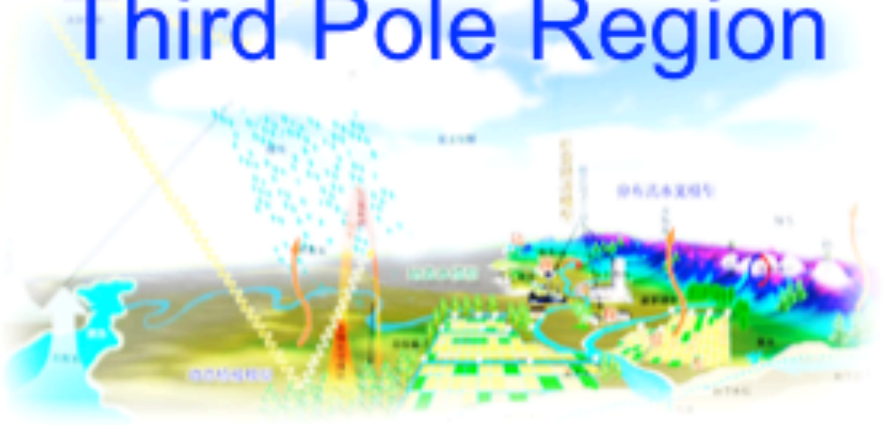
Closing water balance at basin scale in an endorheic river basin in the Pan Third Pole Region



Xin Li

Institute of Tibetan Plateau Research,

Chinese Academy of Sciences

May 6-11 2018, Canmore, Canada
2018 GEWEX Open Science Conference

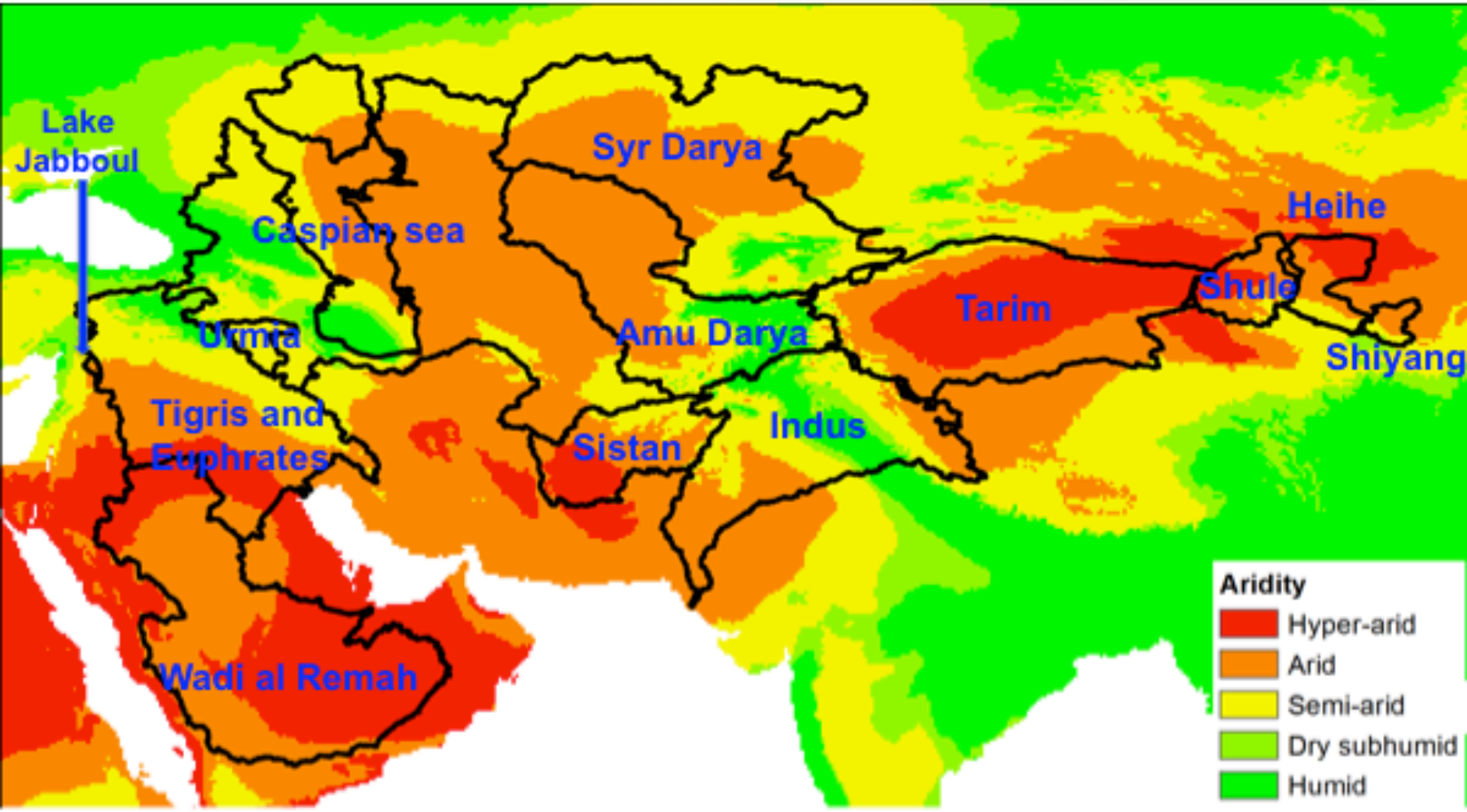
Outline

- Endorheic river basins along the silk road in the Pan Third Pole region and their water use crisis
- Integrated watershed study in the Heihe River Basin
- Closing water cycle in the Heihe River Basin and its Implication for water resource management in arid regions

1. Endorheic river basins along the silk road in the Pan Third Pole region and their water use crisis

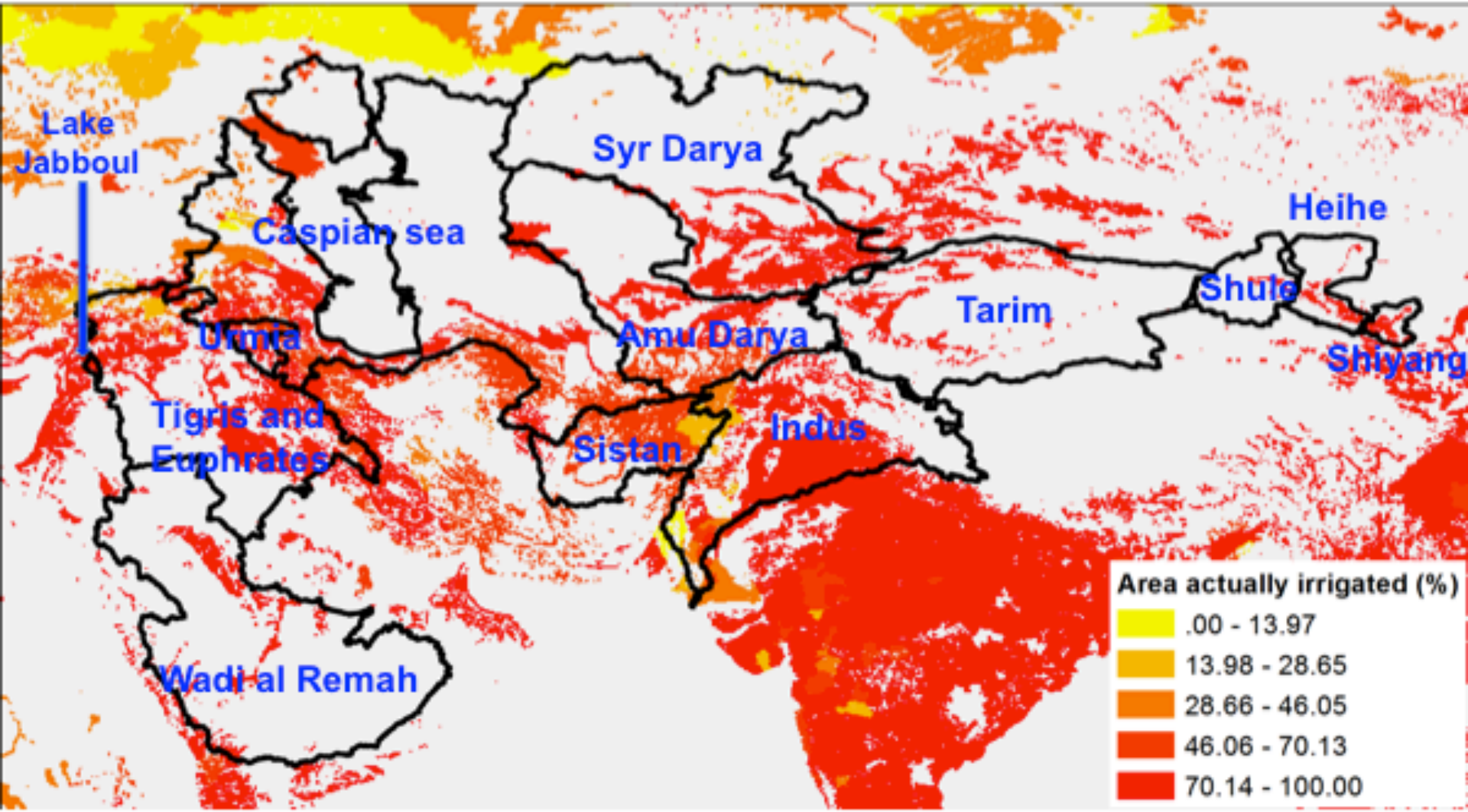
River basins along the silk road in the Pan Third Pole region

Arid environments



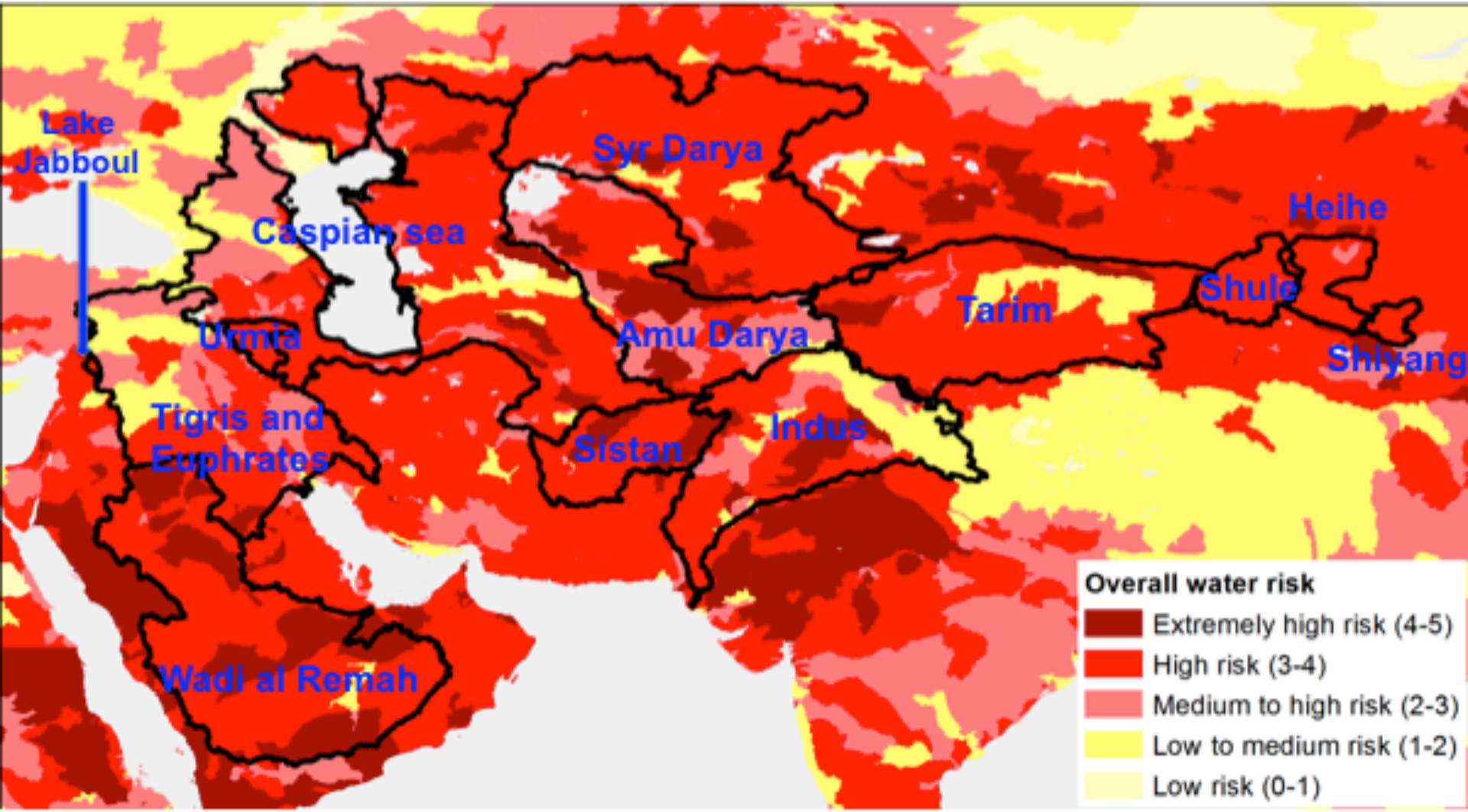
Food and Agriculture Organization of the United Nations. FAO GEONETWORK. Global map of aridity - 10 arc minutes (GeoLayer). (Latest update: 04 Jun 2015) Accessed (6 Mar 2018). URI: http://data.fao.org/ref/221072ae-2090-48a1-be6f-5a88f061431a.html?version=1.0

Overexploitation of water resources for irrigation



Stefan Siebert, et al., 2013. Global Map of Irrigation Areas version 5. Rheinische Friedrich-Wilhelms-University, Bonn, Germany / FAO, Rome, Italy

Water security in high risk

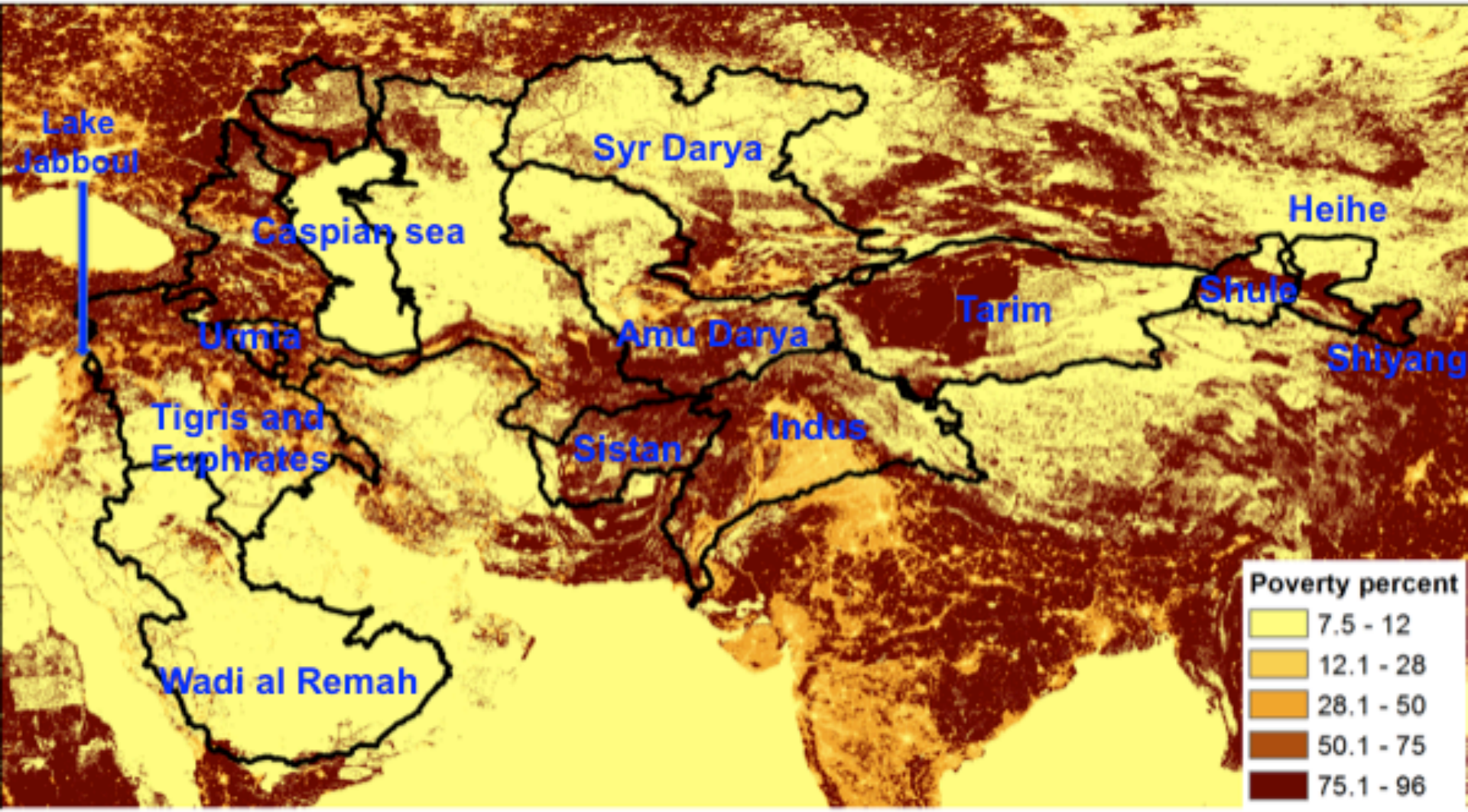


Gassert, F., M. Landis, M. Luck, P. Reig, and T. Shiao. 2014. Aqueduct Global Maps 2.1. Working Paper. Washington, DC: World Resources Institute.

Culture diversity: UNESCO world heritage sites

http://whc.unesco.org/en/interactive-map/

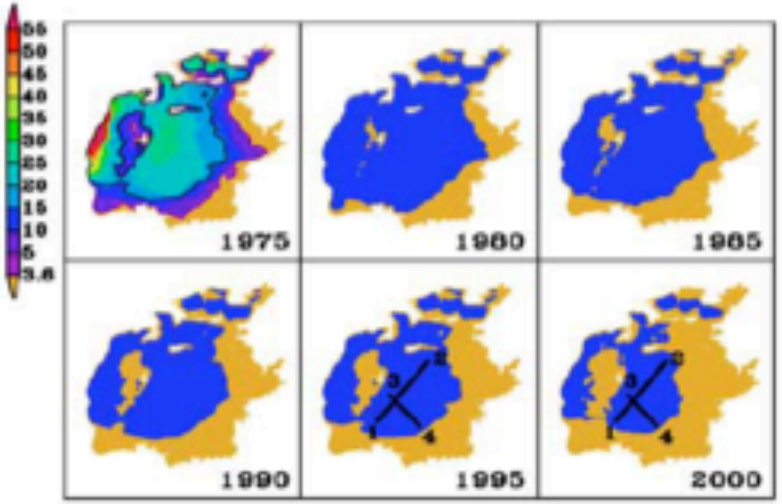
Poverty is a problem



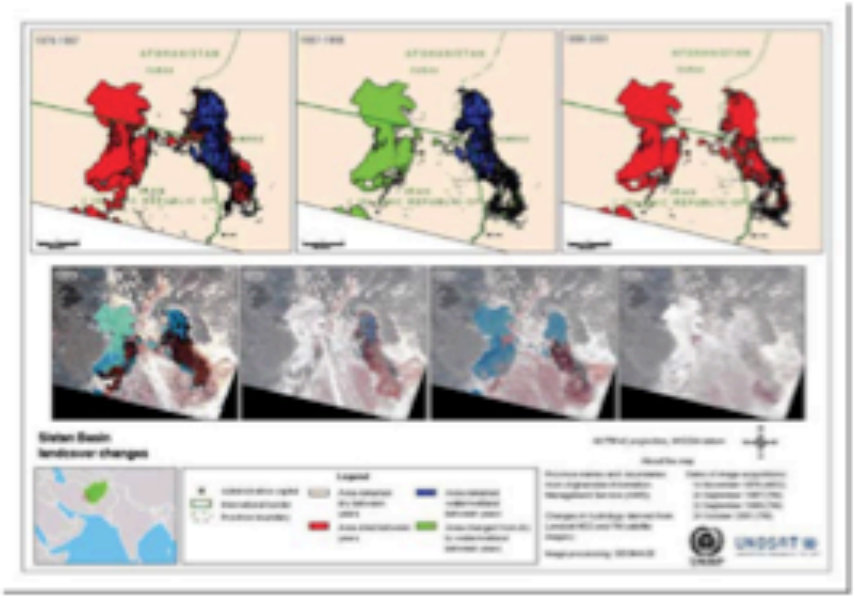
Elvidge C D, Sutton P C, Ghosh T, et al. A global poverty map derived from satellite data. Computers & Geosciences, 2009, 35(8): 1652-1660. *https://www.ngdc.noaa.gov/eog/dmsp/download_poverty.html*

Tragedy of the Commons

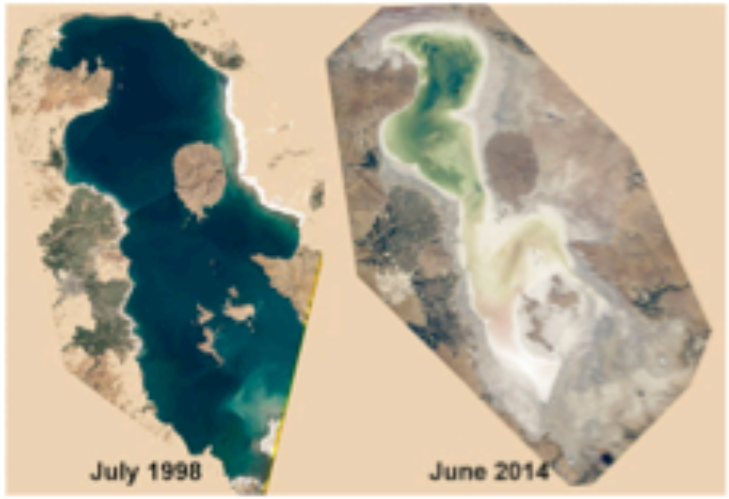
Overuse of shared and unregulated resources



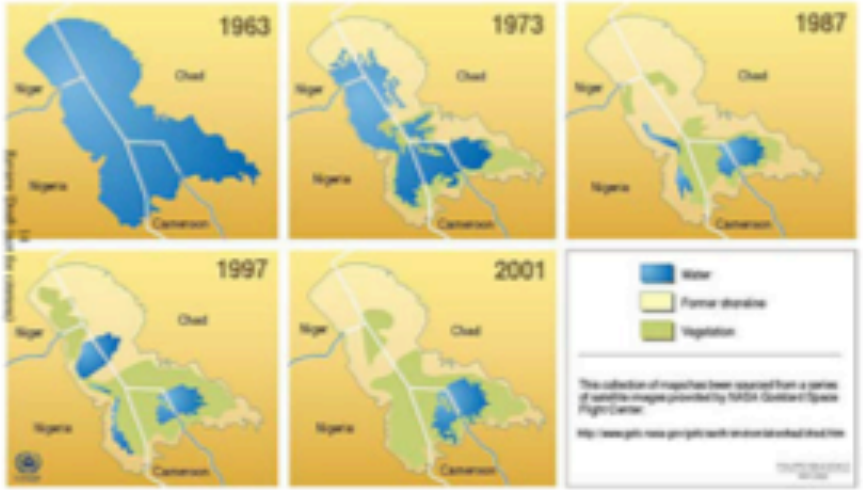
Aral sea ecological tragedy (Klein et al., 2014)



Hamoon lakes, Sistan Basin
(Najafi and Vatanfada, 2011)

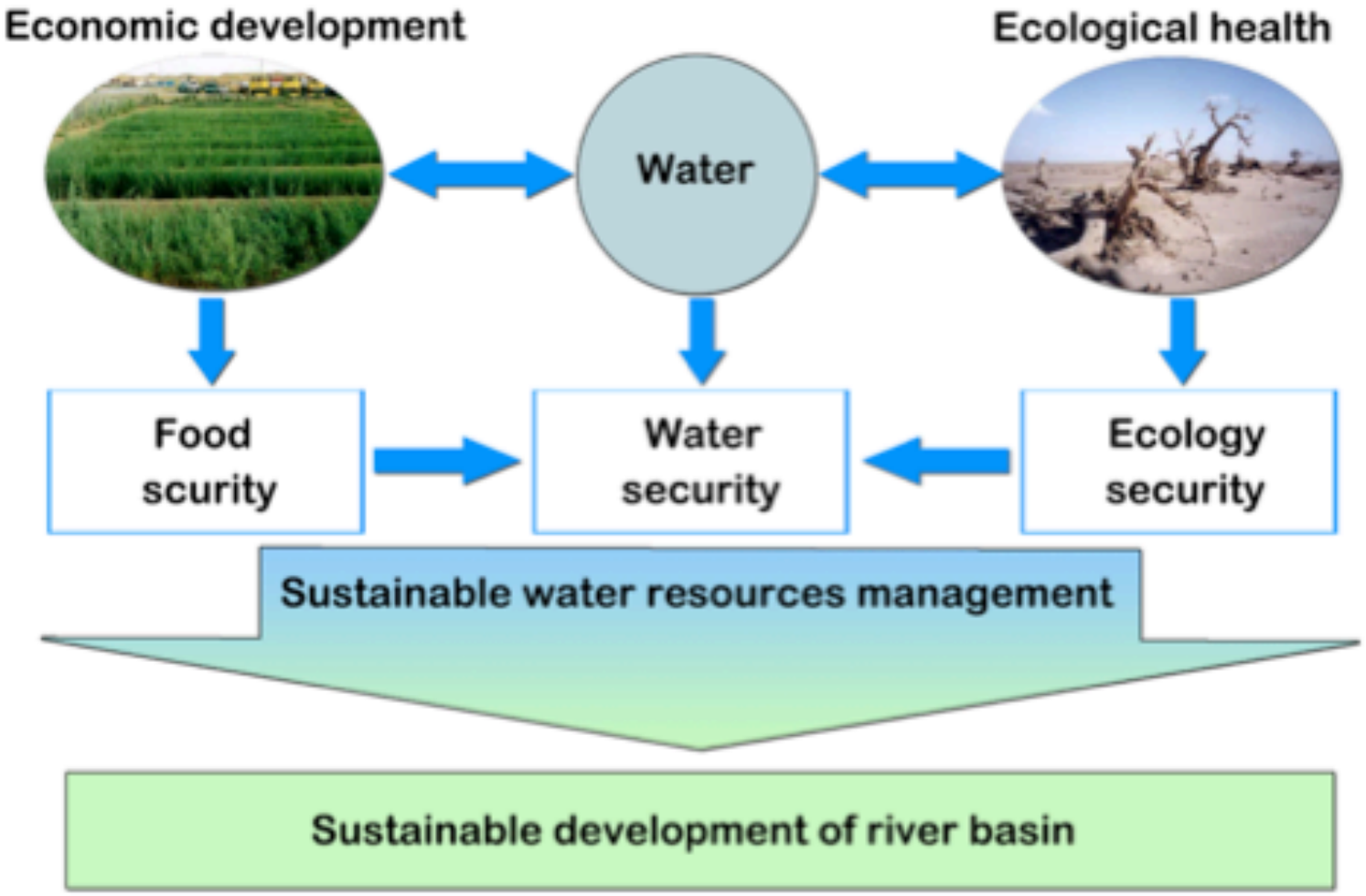


Lake Urmia (Stone, 2015)

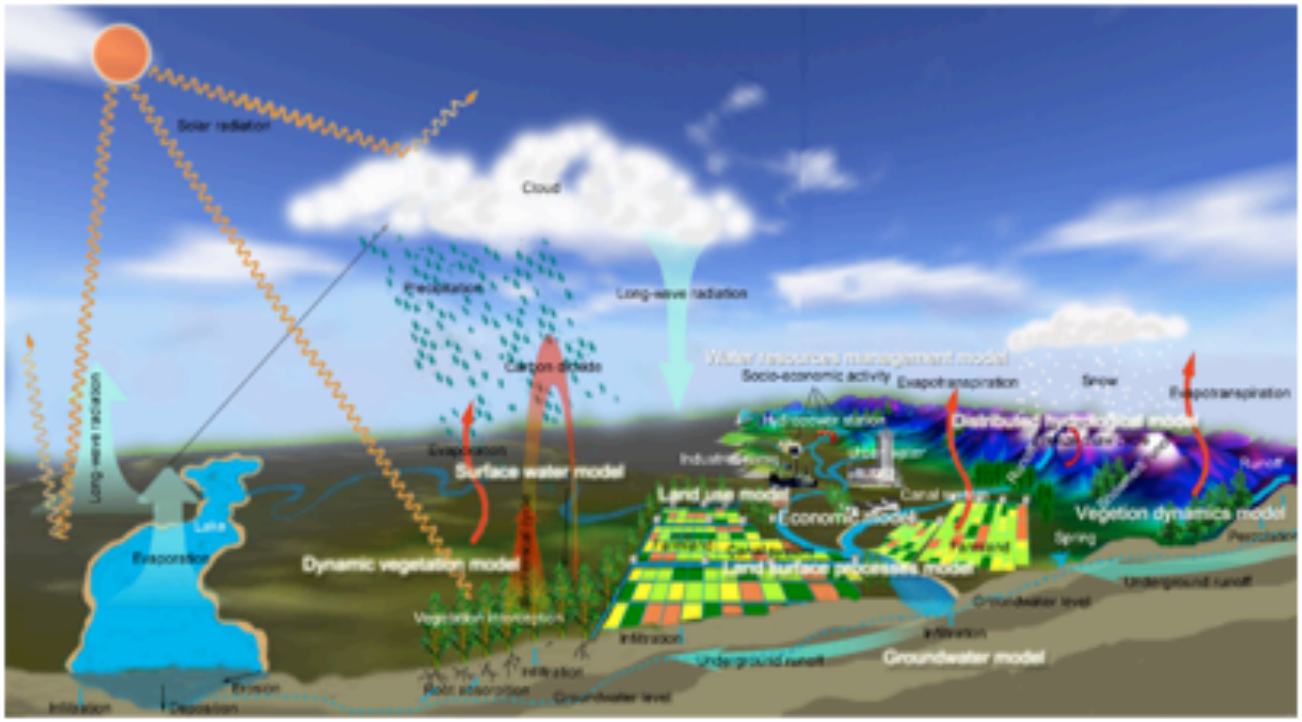


Shrinkage of the Chad Lake (Lemoalle et al., 2012)

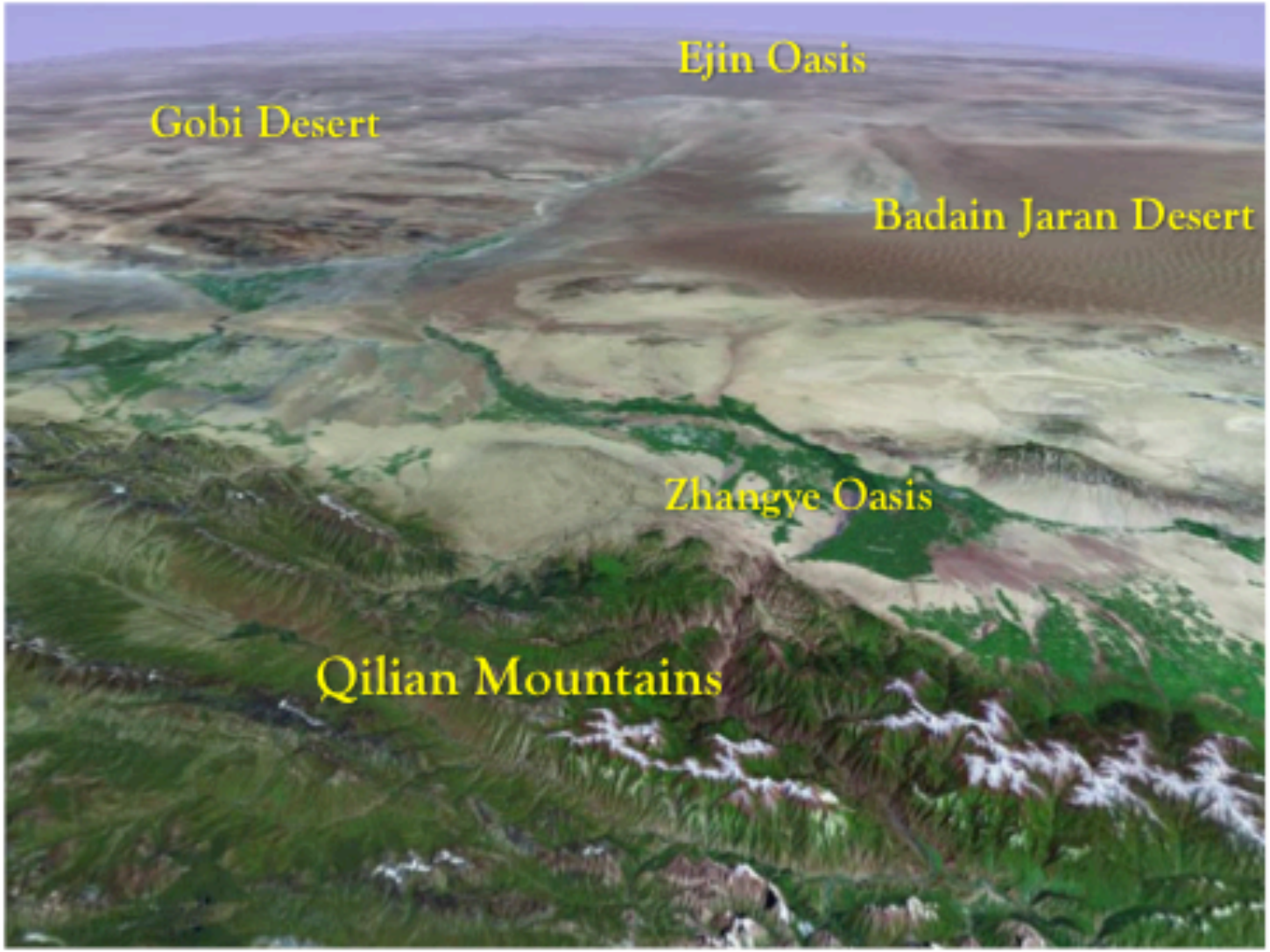
How to achieve “Our Common Future” and avoid the “Tragedy of the Commons” on the Silk Road



2. Integrated watershed study in the Heihe River Basin

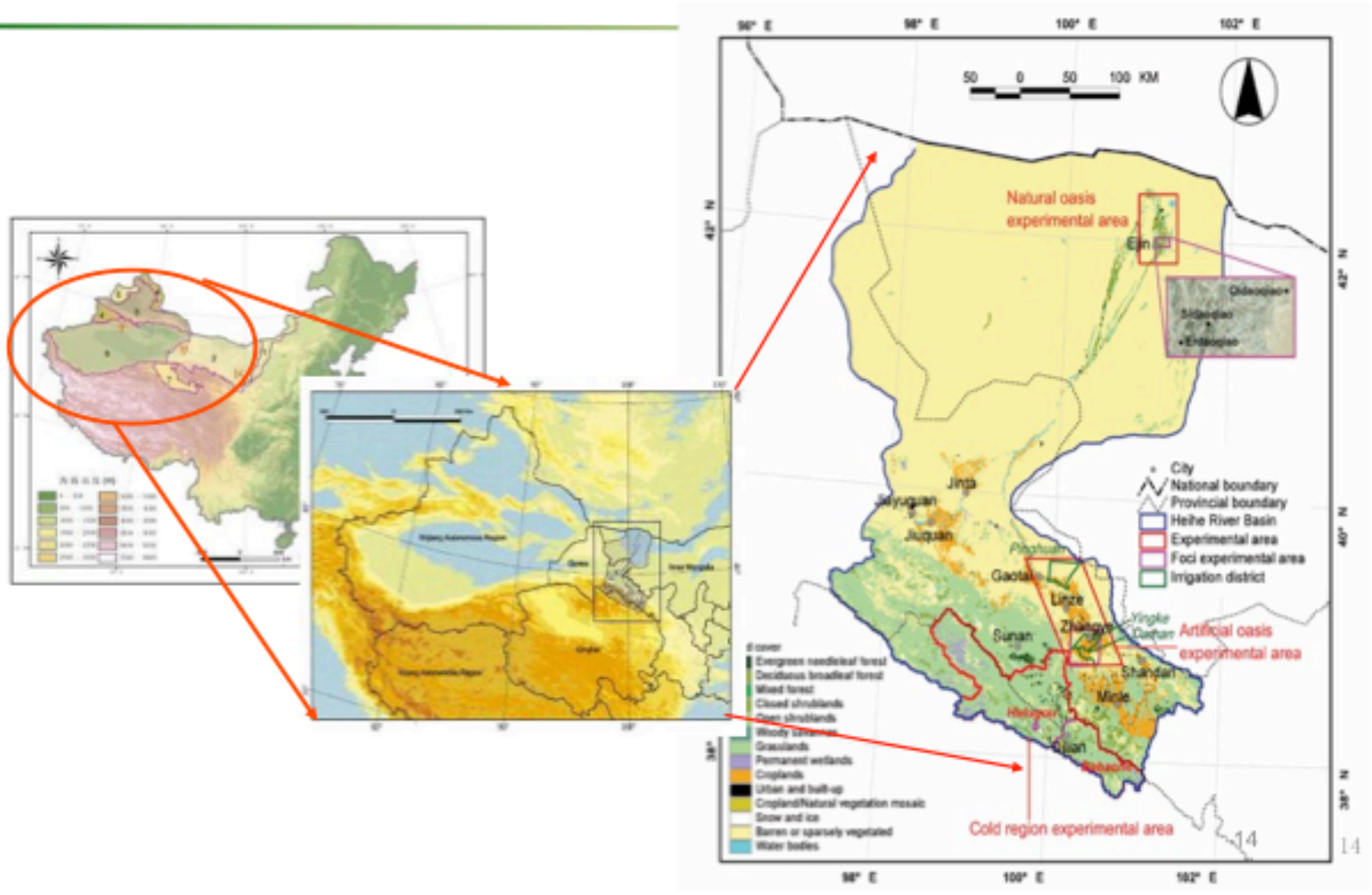


Geographic context of the Heihe River Basin: Mountain cryosphere, oases and deserts



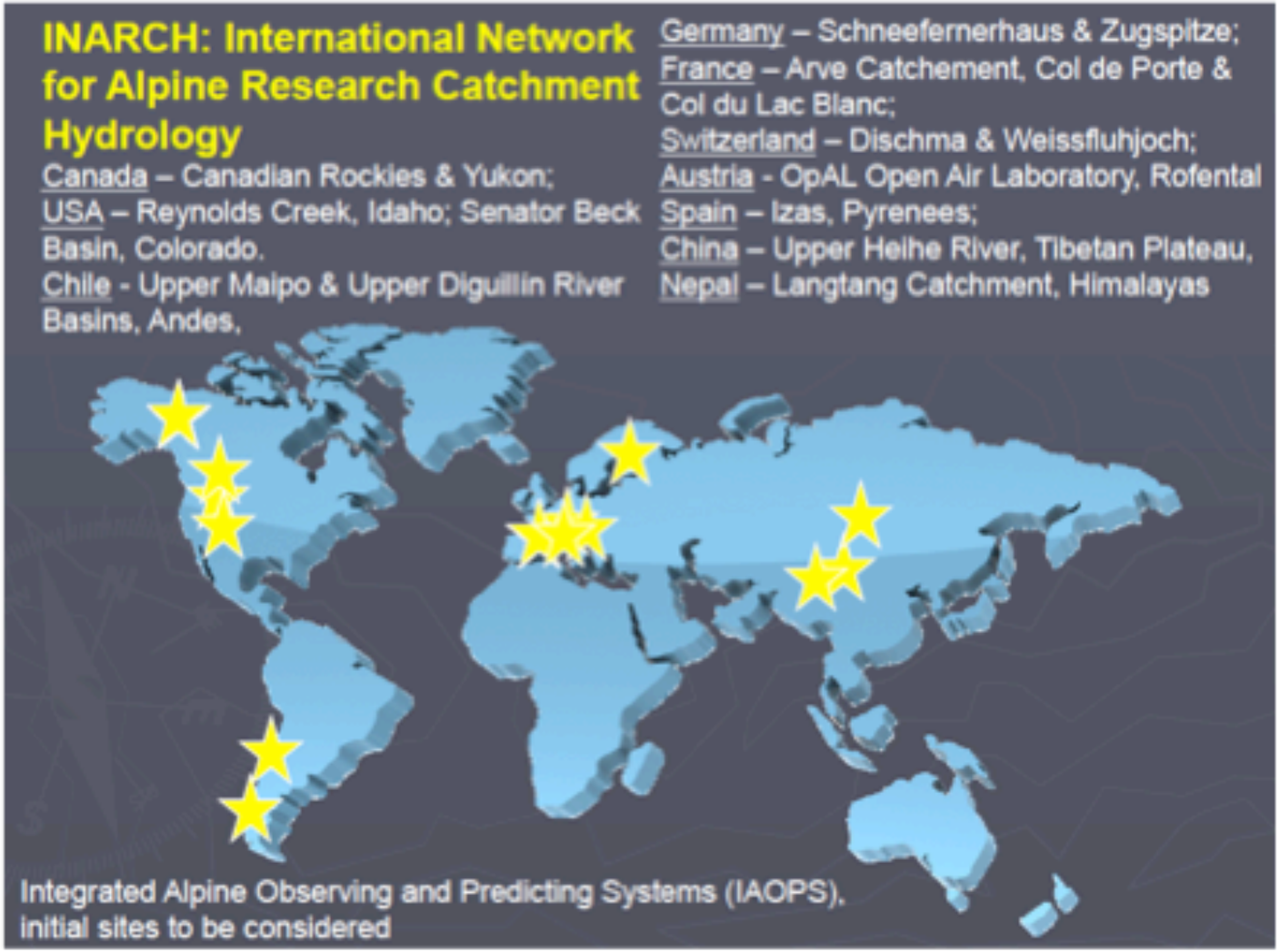
Cheng, Li, Zhao, Xu, Feng, Xiao, Xiao, National Science Review, 2014

Heihe River Basin: Extremes meet



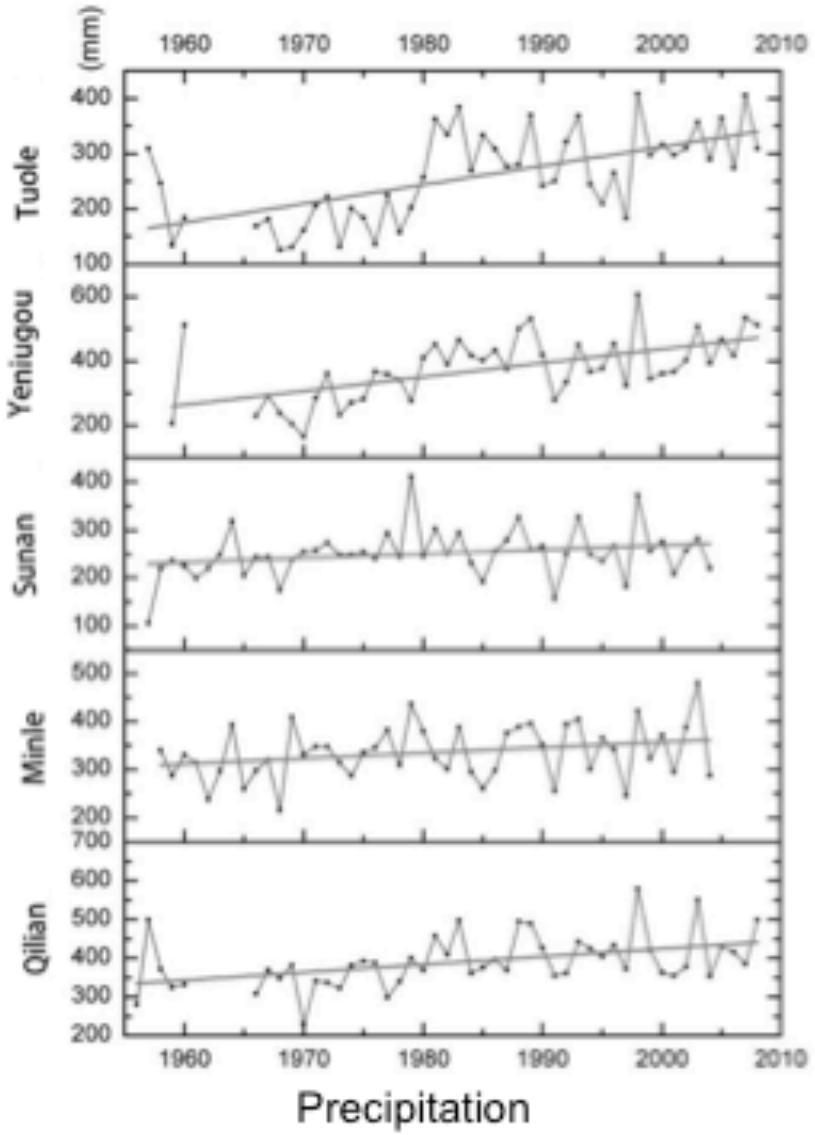
14

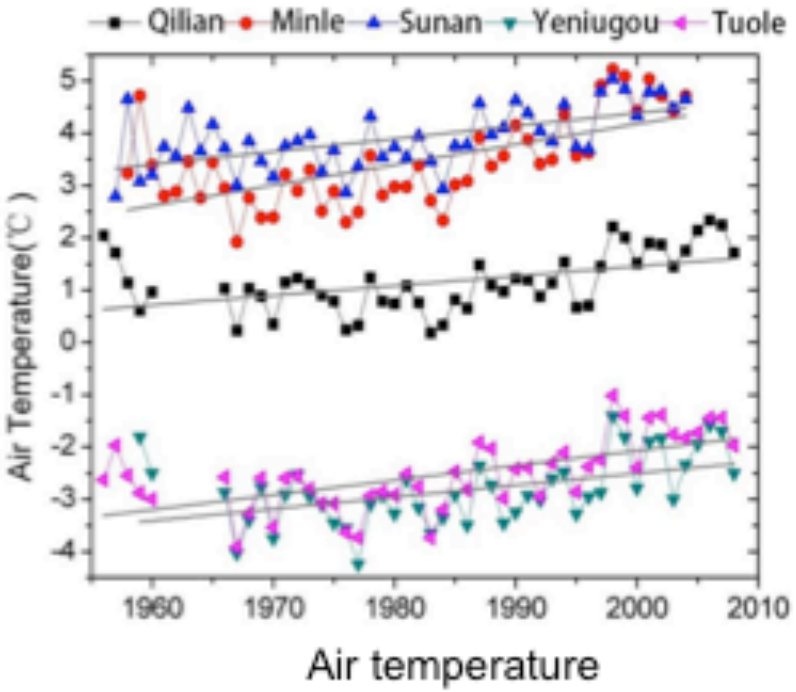
HRB as an INARCH site

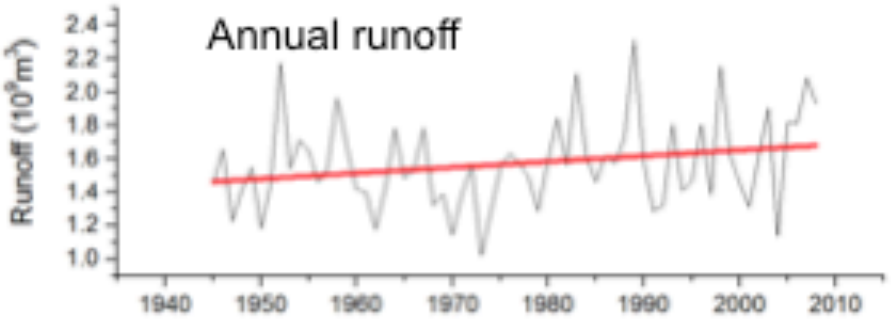


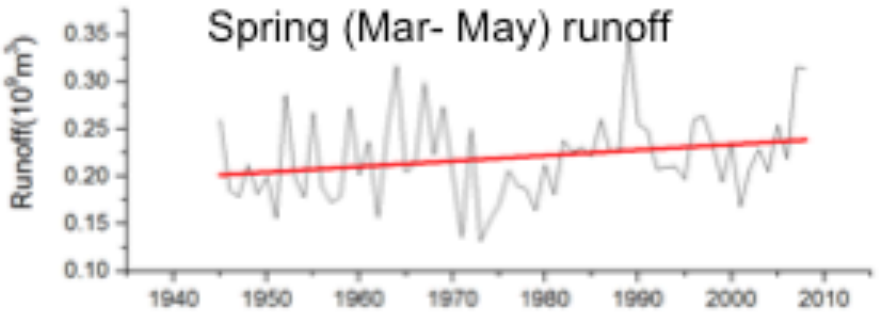
From Prof. John Pomeroy

Climate change

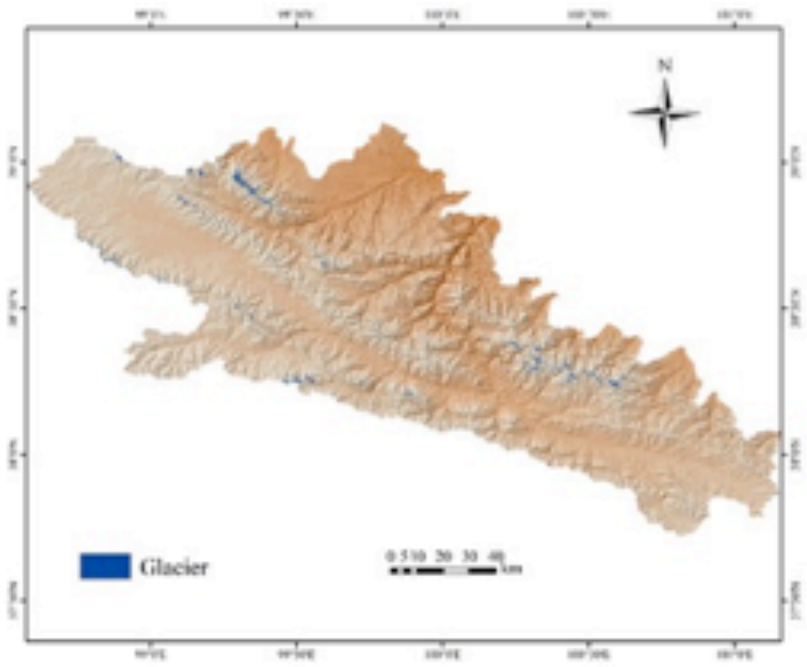


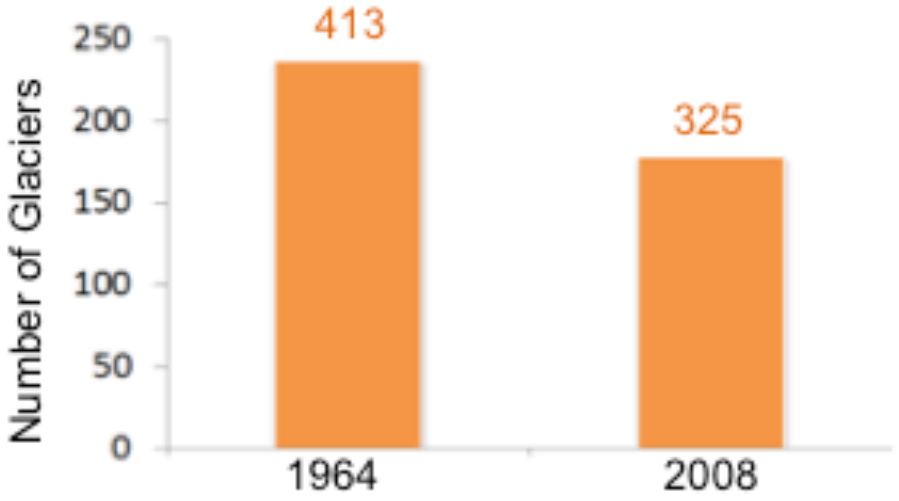


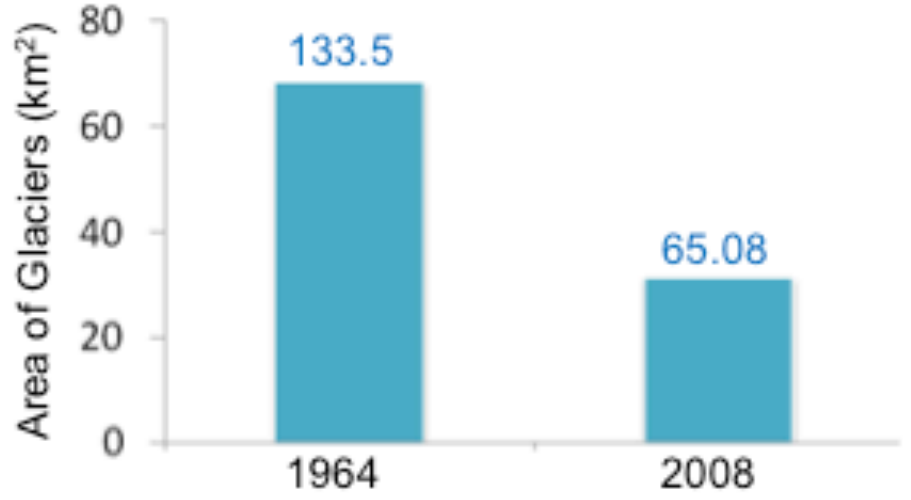




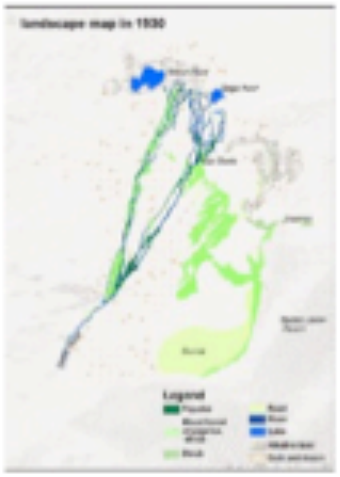
Observed cryospheric change: e.g., glaciers



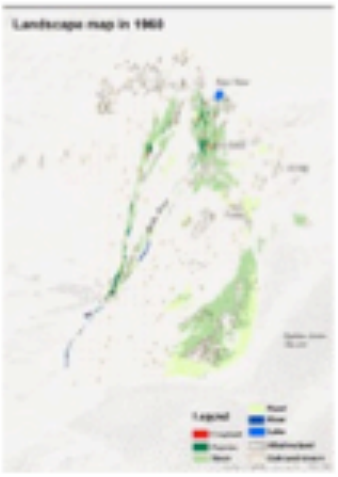




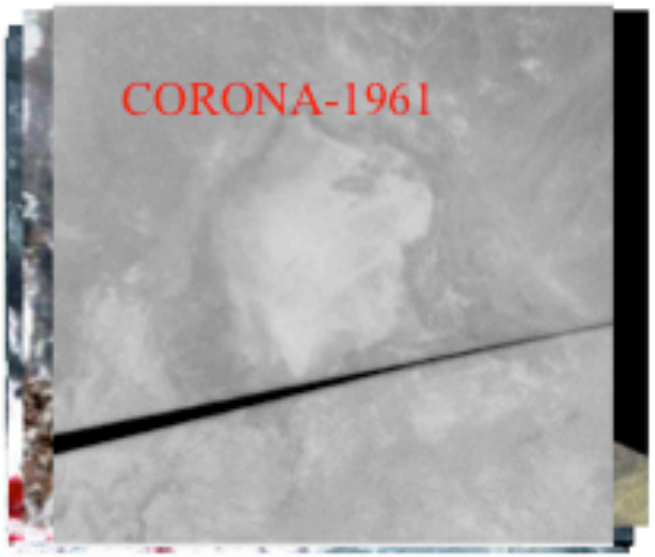
Ecological deterioration in the Heihe River Basin before 2000



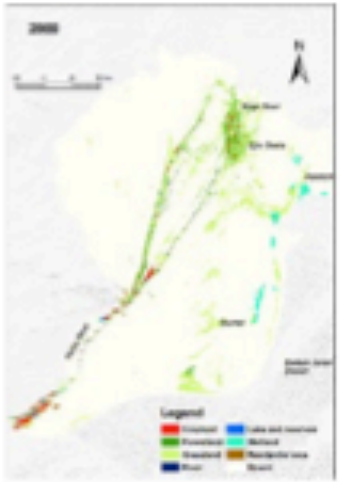
1930s



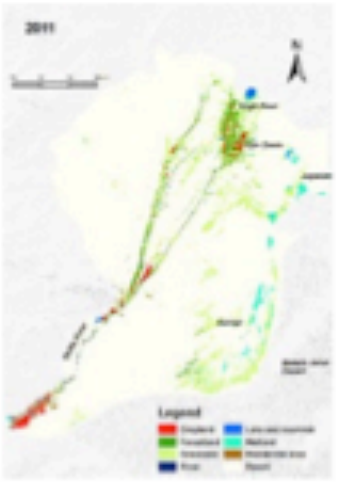
1960s



Drying up of the lake



2000



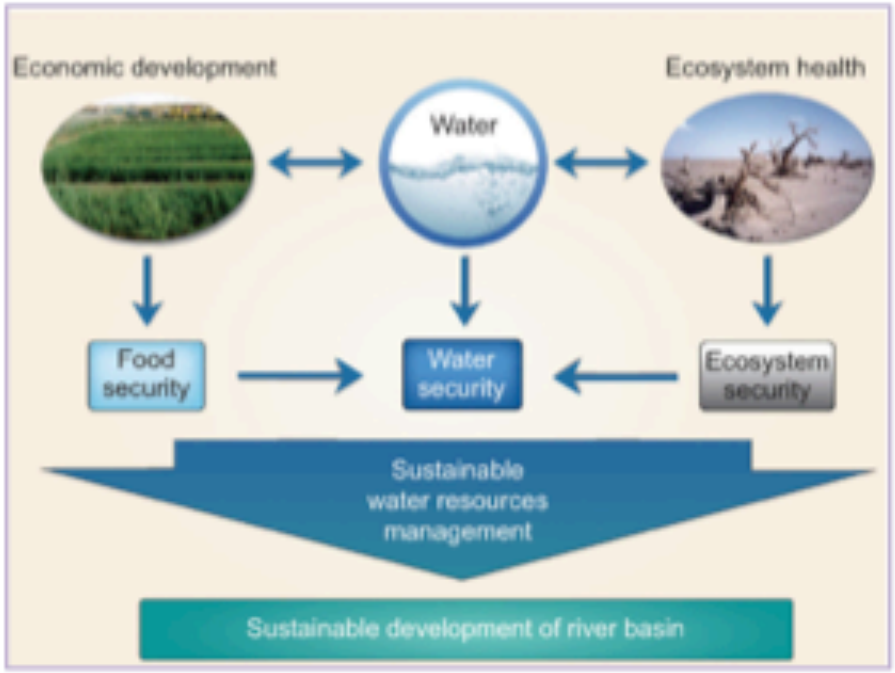
2011

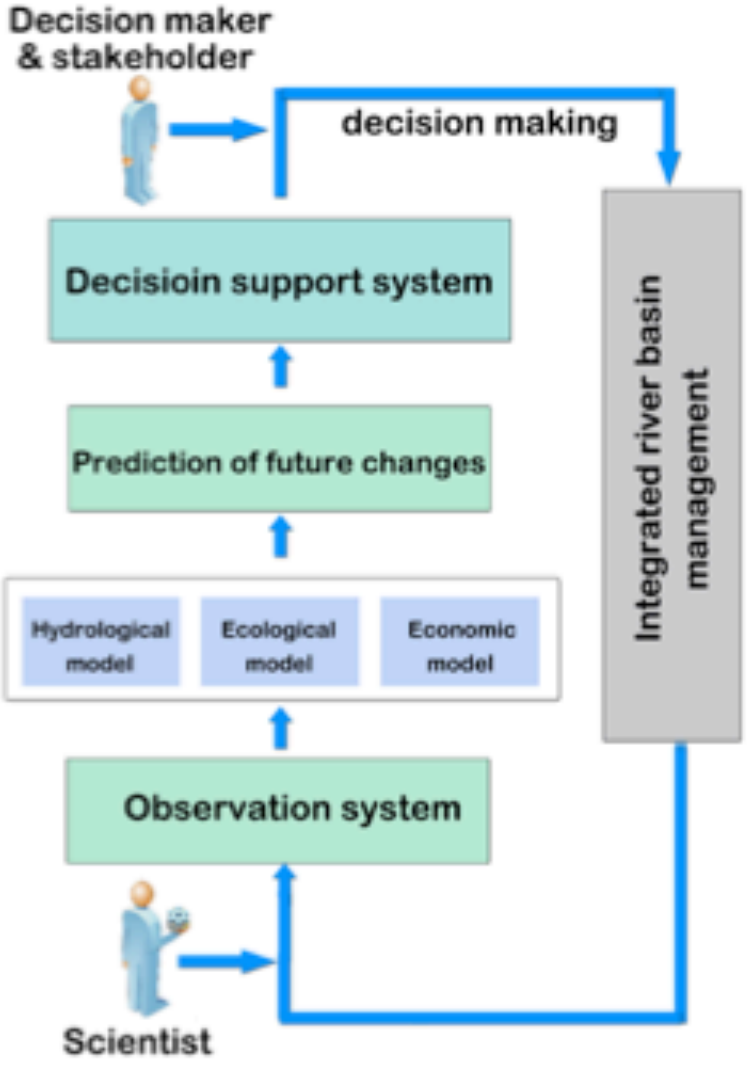
Dying *Populus euphratica Oliv*

Sandstorms prevailed

NSFC: Integrated Research on the Eco-Hydrological Process of the Heihe River Basin (2010-2018)

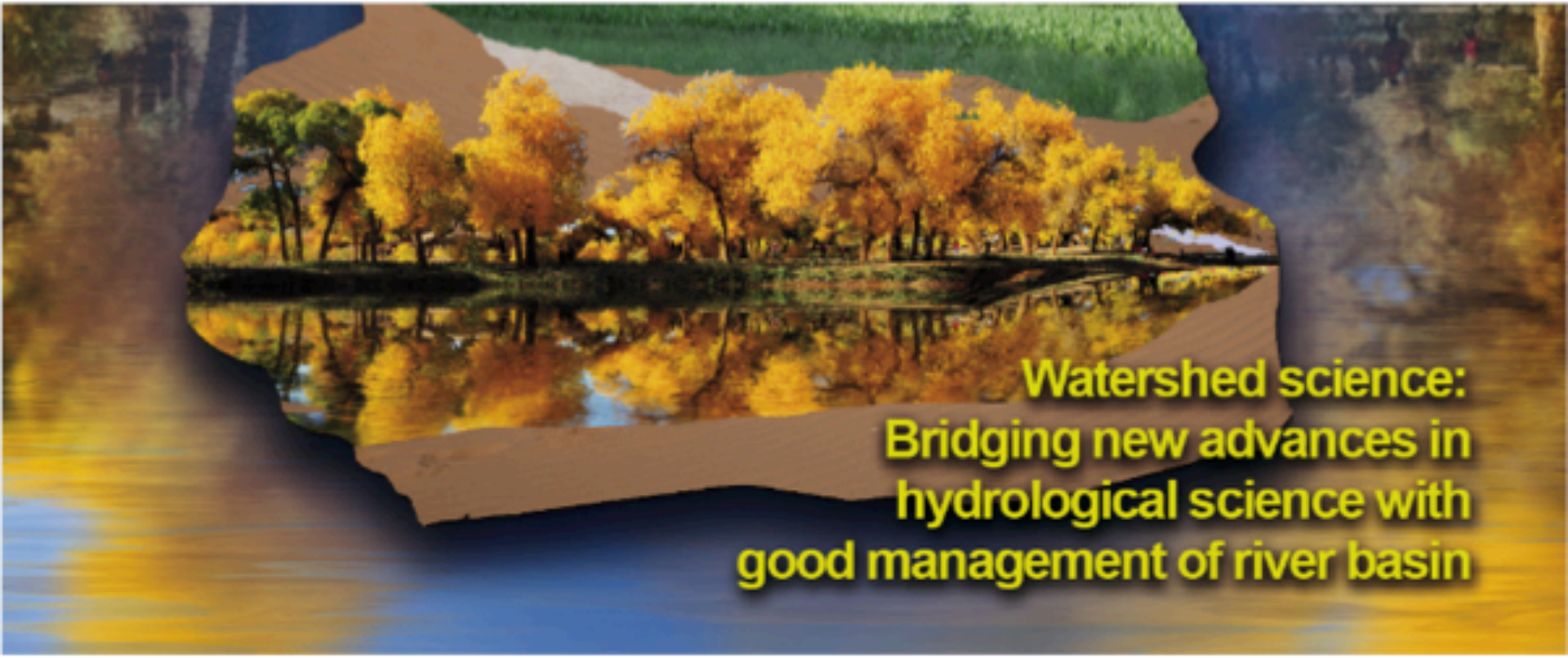
… and to provide fundamental theory and technical support for water security, ecological security, and sustainable development in inland river basins.



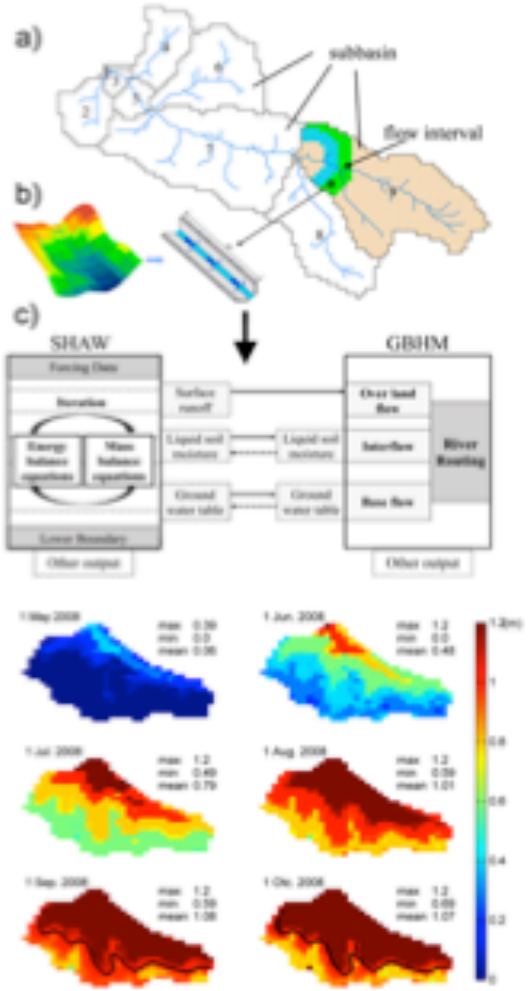


Cheng et al., 2014, NSR

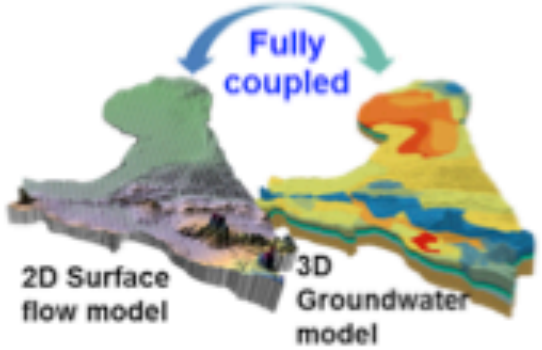
3. Closing water cycle in the Heihe River Basin and its Implication for water resource management in arid regions

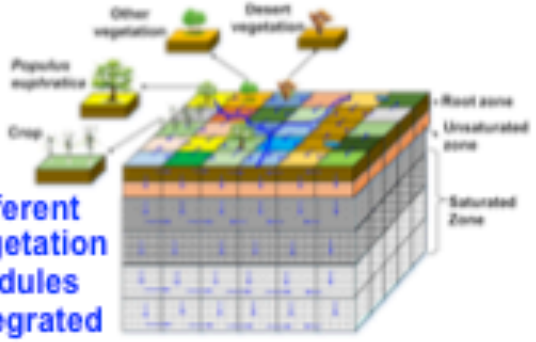


Methods: Integrated watershed system model

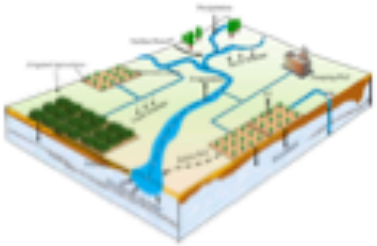


A distributed eco-hydrological model that integrates the glacier, snow, and frozen soil processes (Yang et al., 2015, SCES)



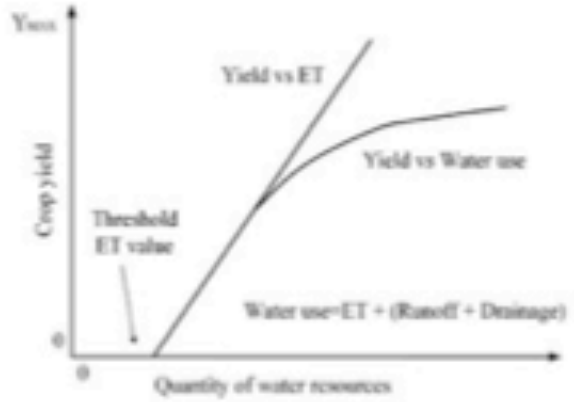


Different vegetation modules integrated

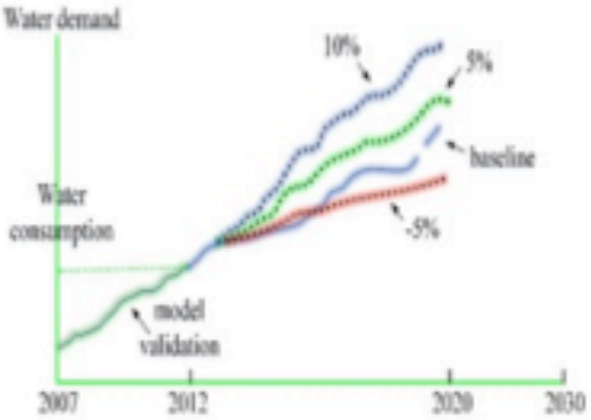


Agricultural water management explicitly represented

Hydrological-Ecological Integrated watershed-scale FLOW model (HEIFLOW) (Tian et al., 2015 WRR, Yao et al., 2015)

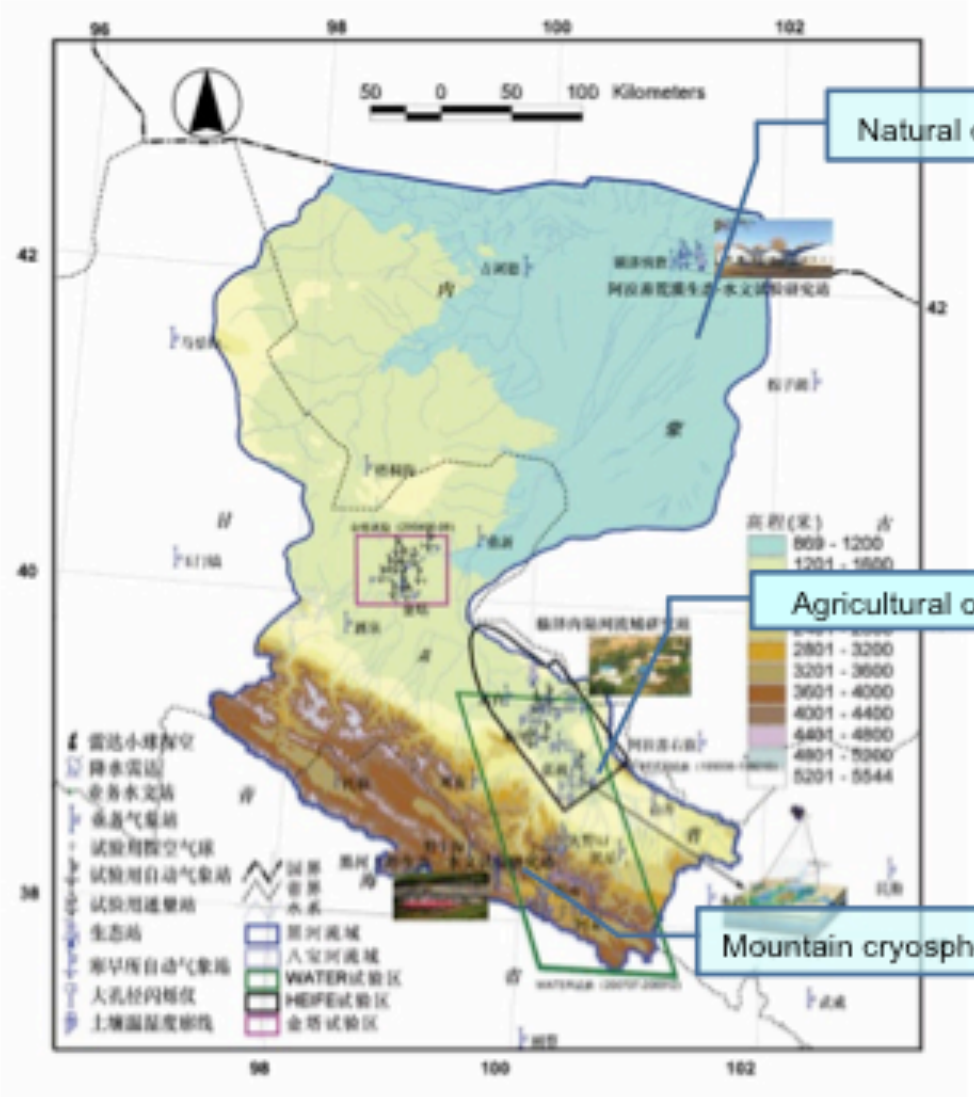


Production function model

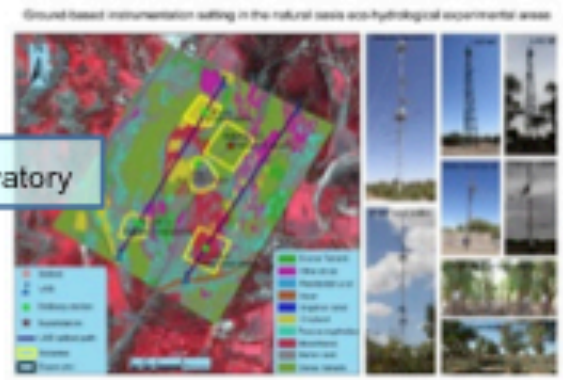


Water Economic System Model (WESM) (Wu et al., 2015, Ecological Modeling)

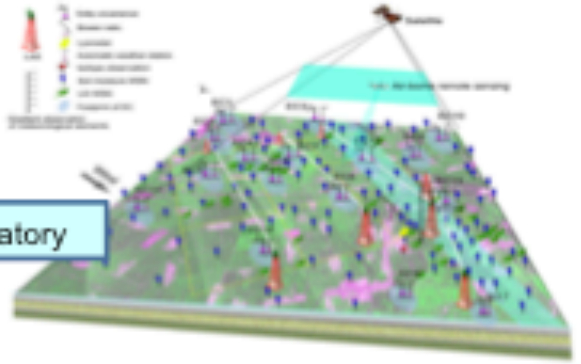
Watershed observation system in the HRB



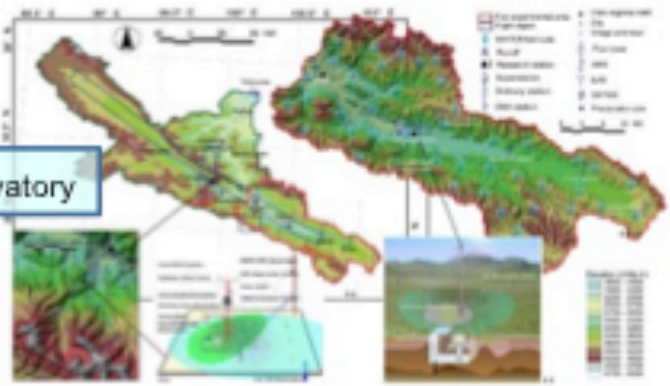
Natural oasis observatory



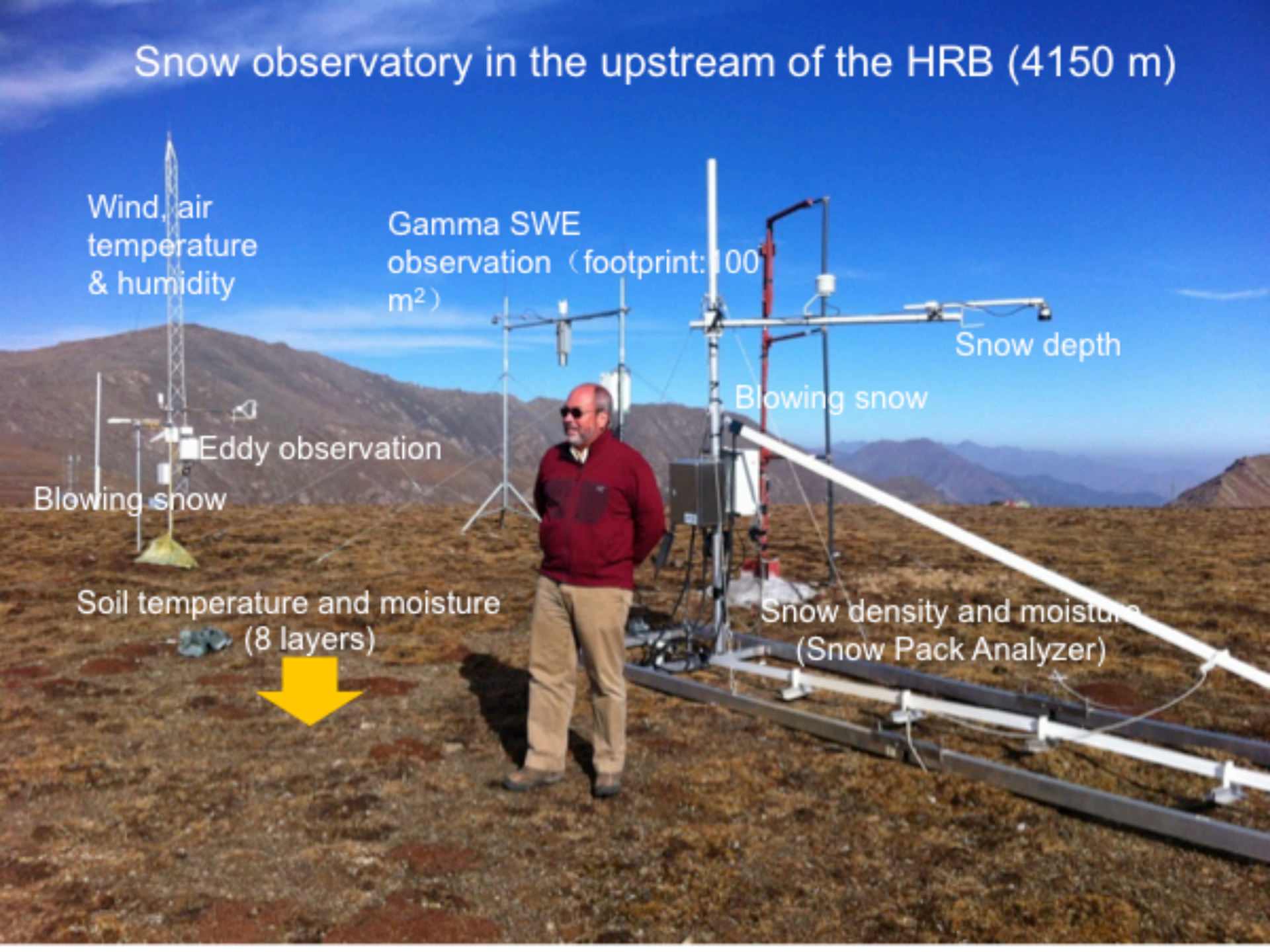
Agricultural oasis observatory



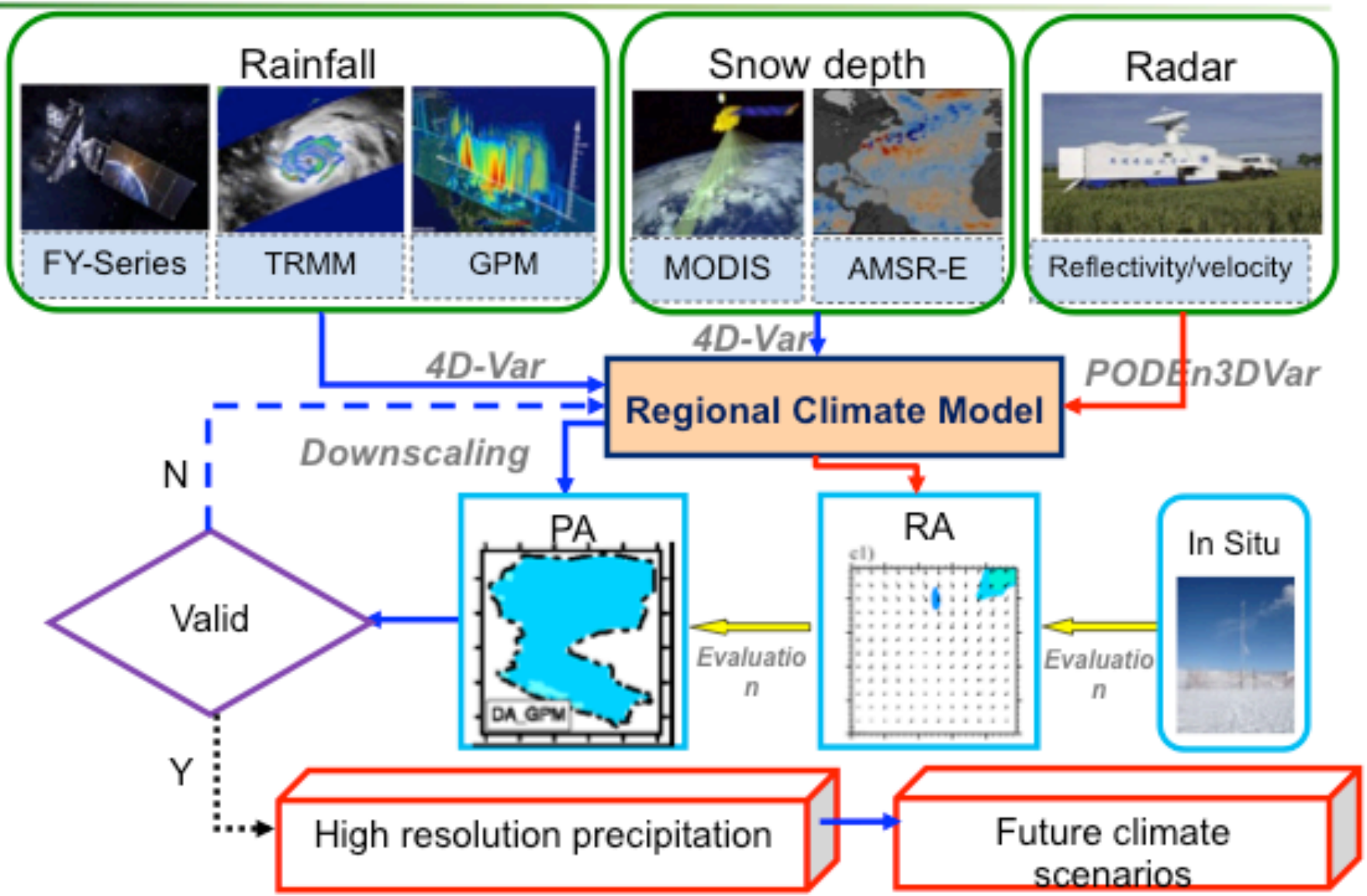
Mountain cryosphere observatory



Li et al., 2013, BAMS

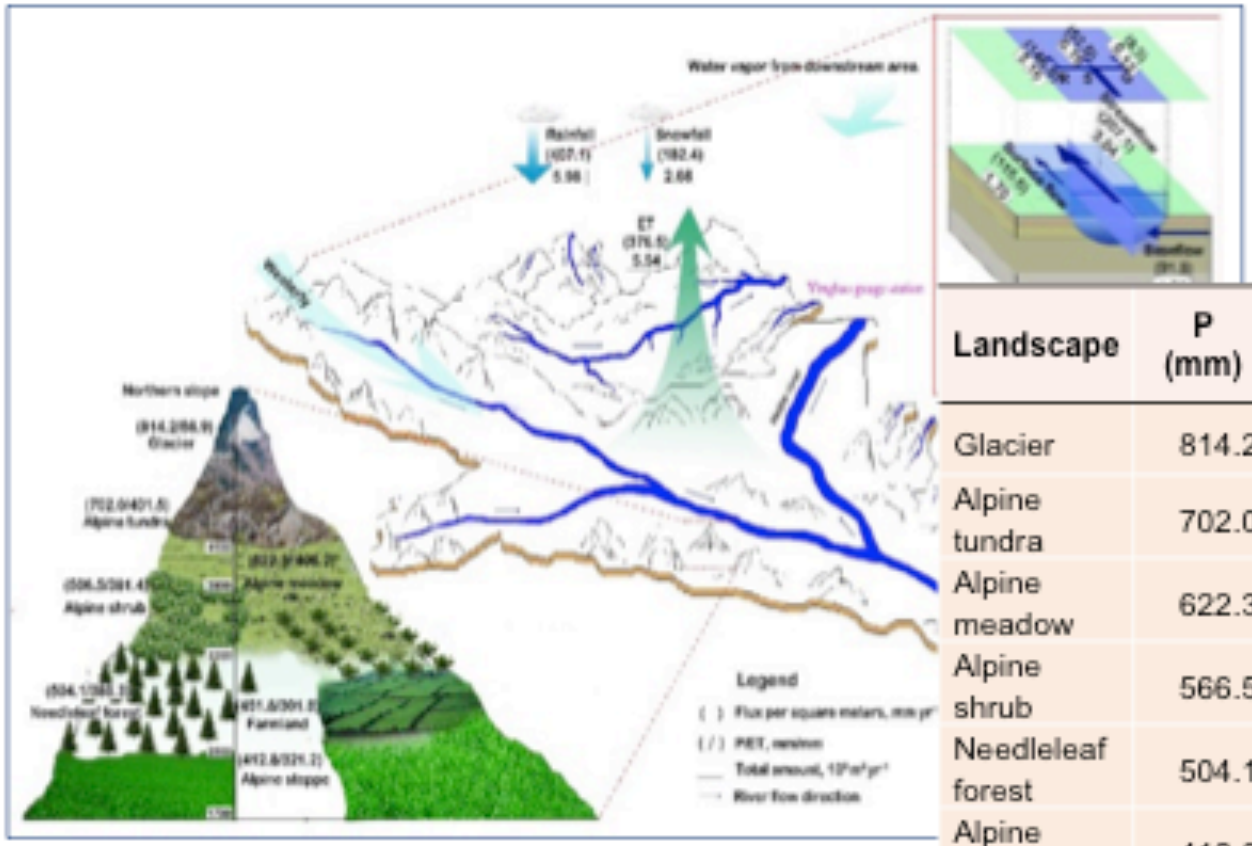

Snow observatory in the upstream of the HRB (4150 m)
Wind, air temperature & humidity
Gamma SWE observation（footprint: 100 m²）
Snow depth
Blowing snow
Eddy observation
Blowing snow
Soil temperature and moisture (8 layers)
(Snow Pack Analyzer)

Remote Sensing Precipitation Assimilation: High resolution precipitation products



Pan et al., 2012, JGR; Pan et al., 2014, JHM; Pan et al., 2015, RS; Pan et al., 2017, RS

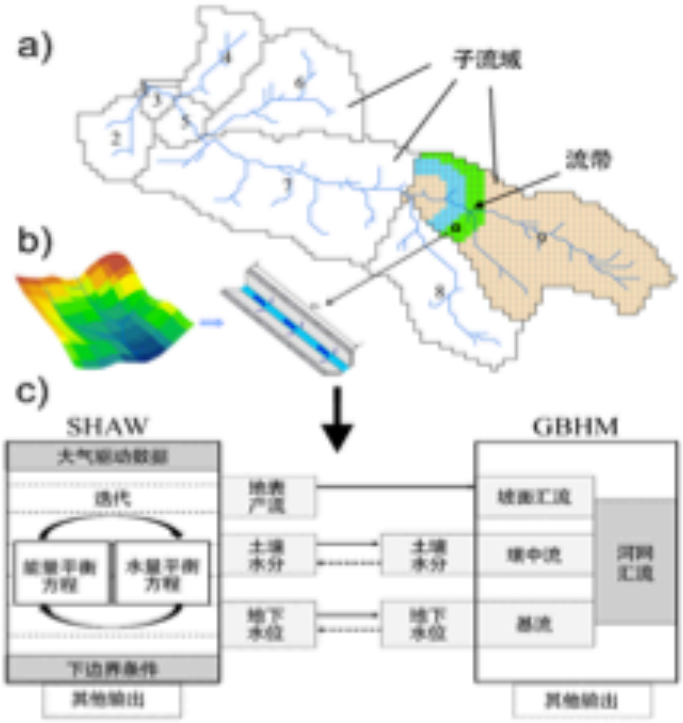
Upstream mountainous area

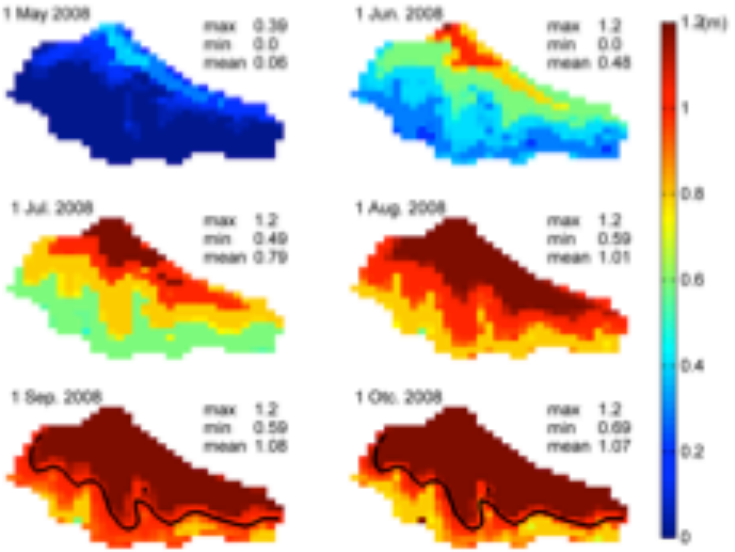


Landscape	P (mm)	ET (mm)	Runoff (mm)	Runoff coefficient	Storage change (mm)
Glacier	814.2	88.9	976.9	1.20	-251.6
Alpine tundra	702.0	401.5	297.7	0.42	2.8
Alpine meadow	622.3	406.2	204.4	0.33	11.7
Alpine shrub	566.5	381.4	179.0	0.32	6.1
Needleleaf forest	504.1	386.3	117.8	0.23	0.0
Alpine steppe	412.8	321.2	88.2	0.21	3.3
Farmland	451.8	301.8	122.6	0.27	27.4
Desert	425.4	257.6	164.6	0.39	3.2
Total	589.5	407.1	207.1	0.35	6.1

Li et al., 2018, JGR

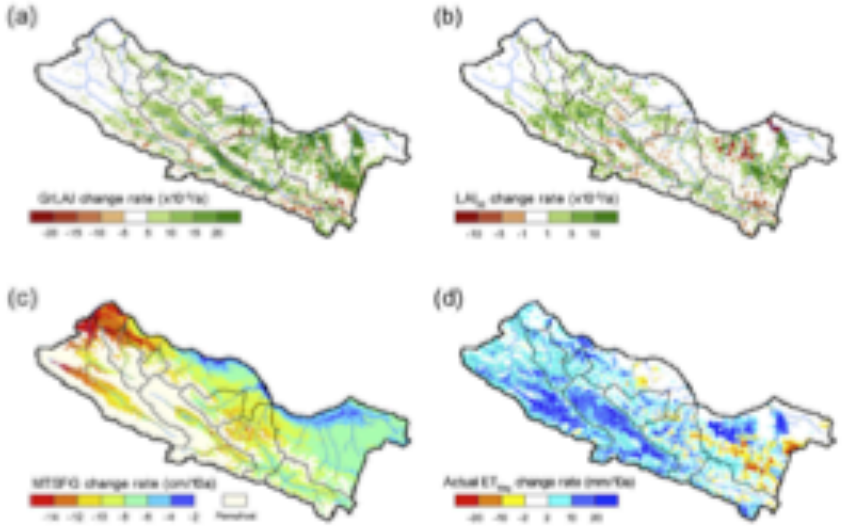
Coupling the frozen soil processes into an ecohydrological model



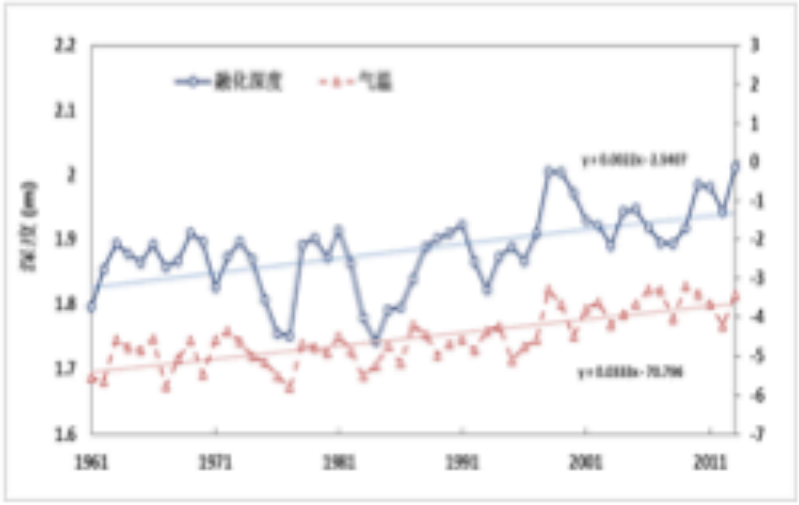


Spatial and temporal variation of frozen depth

Zhang et al., 2013, HP; Zhang et al., 2017, PPP



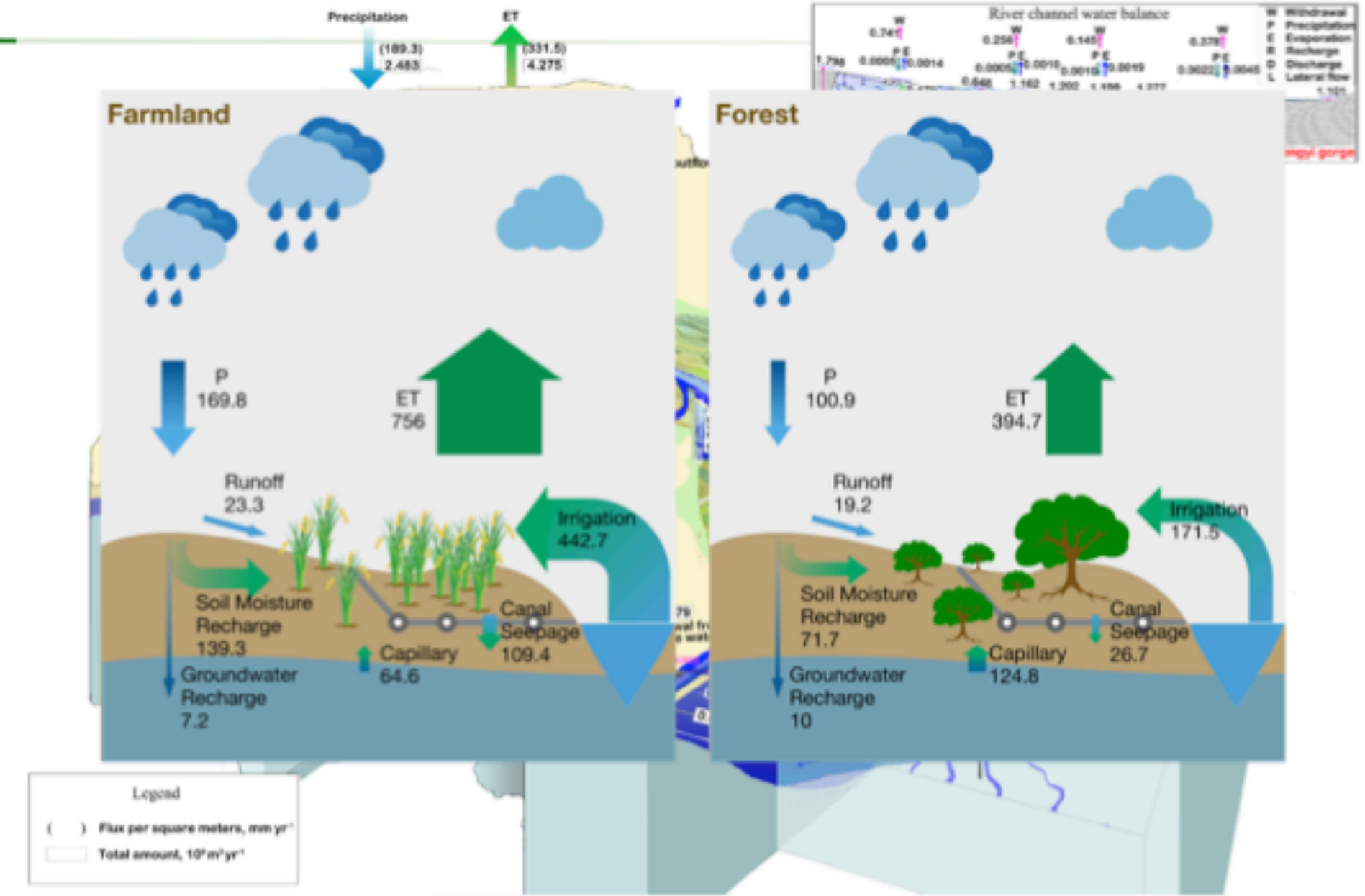
Ecohydrological model: simulation of LAI, maximum frozen depth, and ET



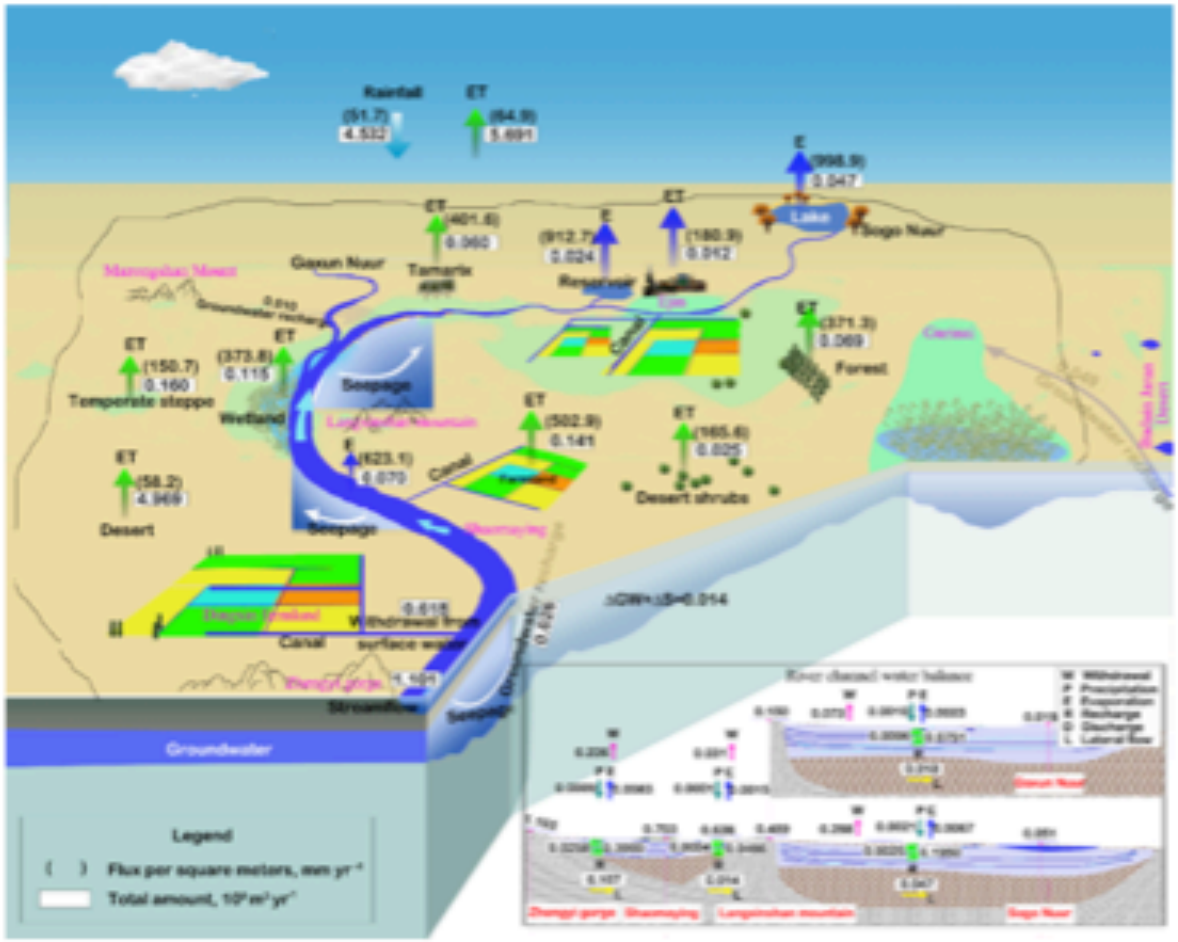
Prediction of the active layer of permafrost

Yang et al., 2015, SCES; Qin et al., 2016, JH

Midstream area



Downstream areas



In terms of the available water, approximately

- 39% is used to sustain the natural oases,
- 4% is used to sustain a terminal lake,
- 9% is used to maintain the streamflow and reservoirs,
- 13% is used for irrigation to support rapidly expanding cropland, and approximately
- 35% of water is lost via ET in the desert.

Policy suggestions: Ecological restoration by the year of 2011

- Policy suggestion on rescuing the Ejin oasis
- Eco-economic development path for the Heihe River Basin
- Virtual water: A new approach for water security in NW China
- Happiness oriented water resources management in Zhangye city

Revival of *Populus euphratica* in the Ejin oasis

Replenished Juyan lake

References


AGU PUBLICATIONS

JGR

Journal of Geophysical Research: Atmospheres

RESEARCH ARTICLE

Hydrological Cycle in the Heihe River Basin and Its Implication for Water Resource Management in Endorheic Basins


AGU PUBLICATIONS

JGR

Journal of Geophysical Research: Atmospheres

COMMENTARY

Watershed System Model: The Essentials to Model Complex Human-Nature System at the River Basin Scale

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Summary

- Climate warming, resulting in greater precipitation, snowmelt, glacier melt, and runoff, alleviates water scarcity in Heihe River Basin.
- Water resource management in the region should be adjusted to adapt to a changing hydrological cycle and economic water use should be reduced. To foster long-term benefits, water conflicts should be handled from a broad socioeconomic perspective.
- Endorheic basins in arid regions are similar in natural geography, climatology, hydrological cycle, and water resource problems. The results in this study could contribute to the understanding of the hydrological cycle in endorheic basins and also provide a useful reference for sustainably exploiting water resources in endorheic basins around the world.