缓解缺水对流域水文过程的影响

Impact of Alleviating Water Scarcity on River Hydrological Process in China Inland Rivers (CIR)

---- A Case study in Heihe river basin (HB)

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Human impact on……

1. *Hydrology can be used to regulate biota;*
2. *Shaping biota can be a tool to regulate hydrological processes;*

- *The two types of above regulations can be integrated at the basin …….*

From: UNESCO IHP-Ecohydrology Demonstration Project

Outline

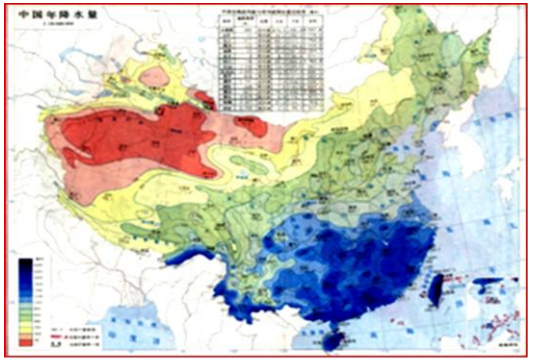
1. Water issues in CIR;
2. General of HB;
3. Reform **water process**;
4. Reform ecosystem;
5. Water process in soci-econ system
6. Result of Water Issues
7. HB Major program of NSFC.

1. Water Issues in CIR

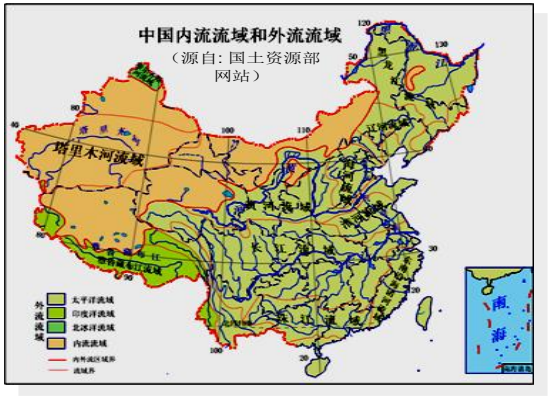
Natural Condition:

Water Scarcity in CIR

- China north is one of 13 countries of water scarcity (UN).
- CIR occupied **1/3** of China.
- Annual rainfall <200 mm.
- Water resource only **5%** of state's.



Annual precipitation in China



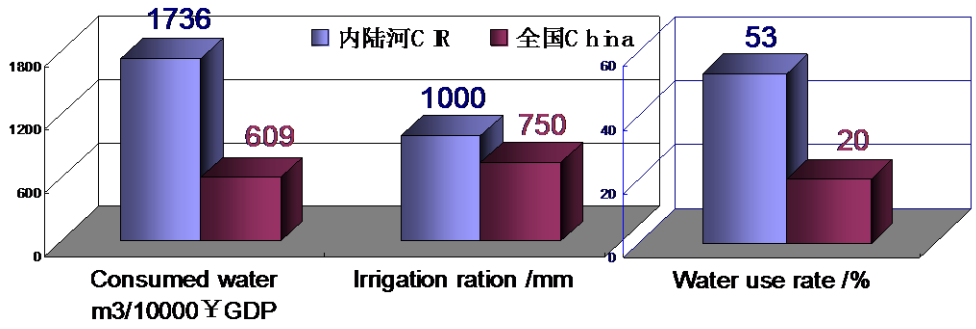
内陆河流区占国土面积的34.7%；

太平洋流区58.3%，印度洋流区6.4%，北冰洋流区0.6%。

1. Water Issues in CIR

Human Impact:

Low Water Benefit in CIR



- Water over-development, overuse;
- Irrational management;
- Rebuild / disturb water cycle;
- Desertification.

1. Water Issues in CIR

目标：在流域尺度提高水效益

Goal: Higher water benefit at a basin scale

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1. Water issues in CIR;
2. **General of HB**;
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2. General of HB

Typicality

Centre of arid region of East Asia;

International river basin. Mongolia;

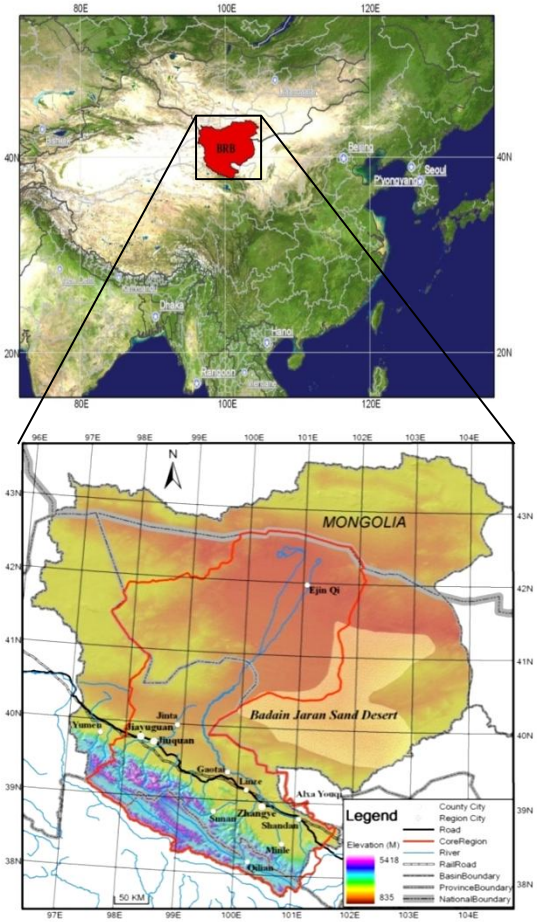
Qinghai, Gansu, Inner-mongolia;

2th-largest inland river in China;

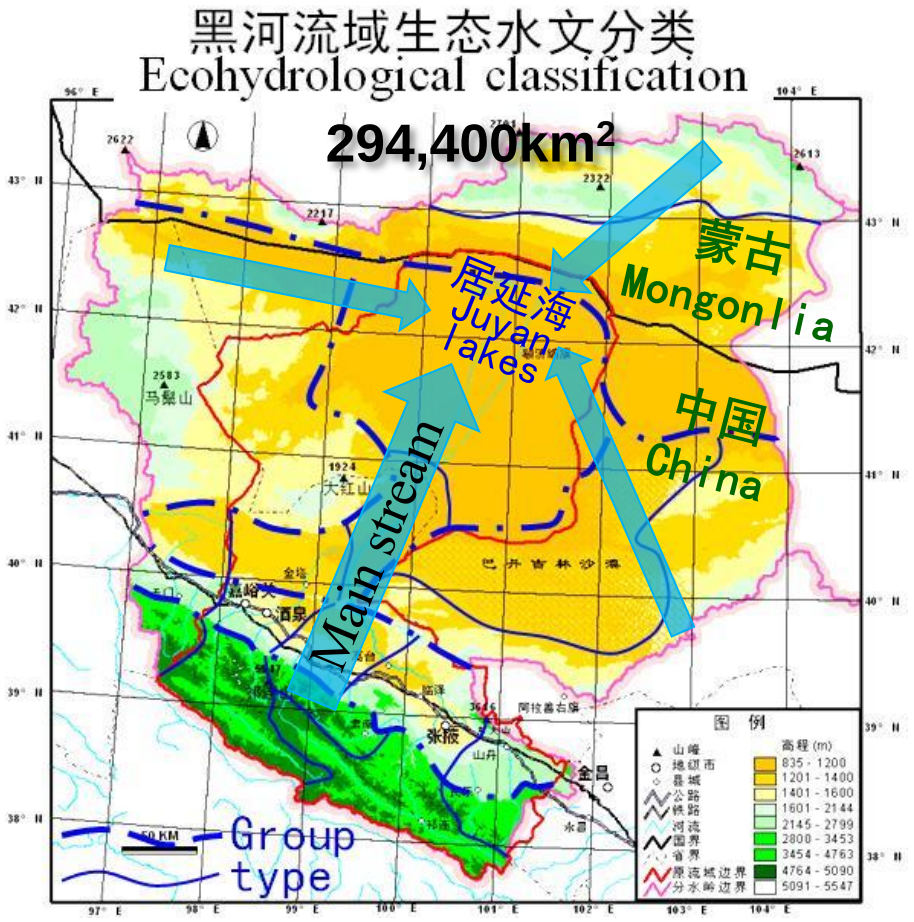
Earliest irrigation agri. 2000a ago;

Typical problems on water,

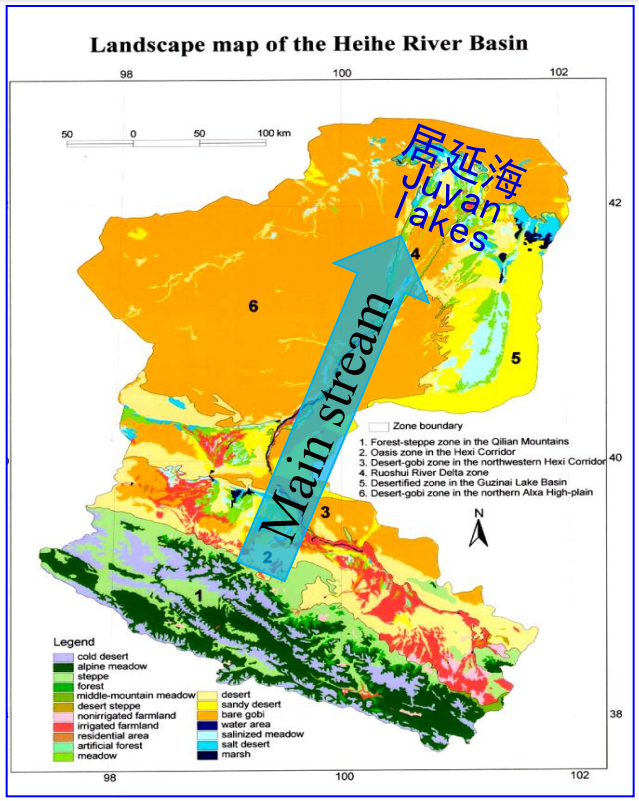
eco, envir.



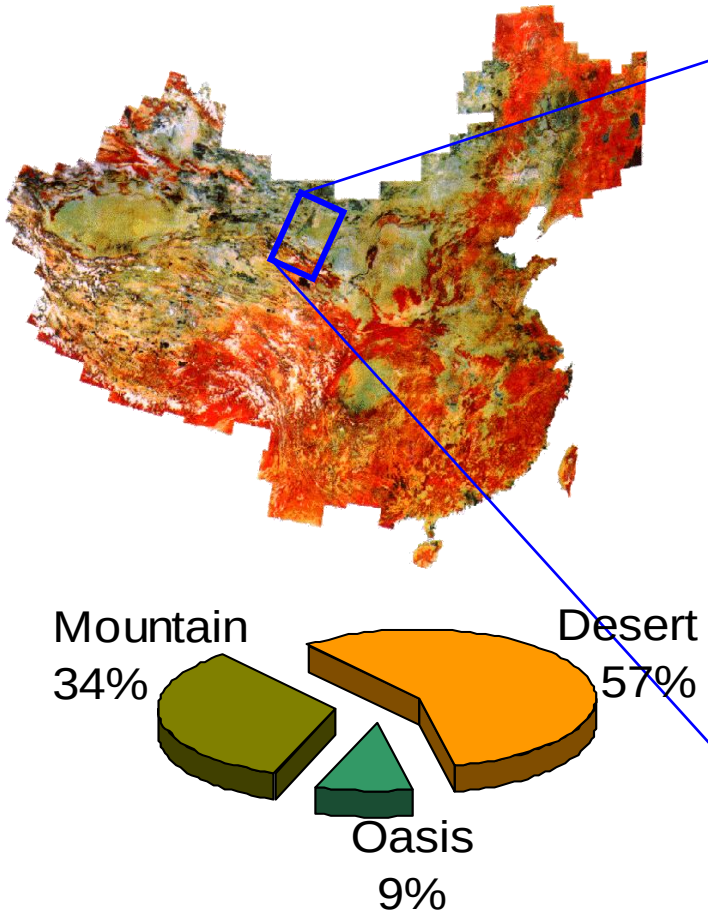
2. General of HB



Study area:130,000 km²

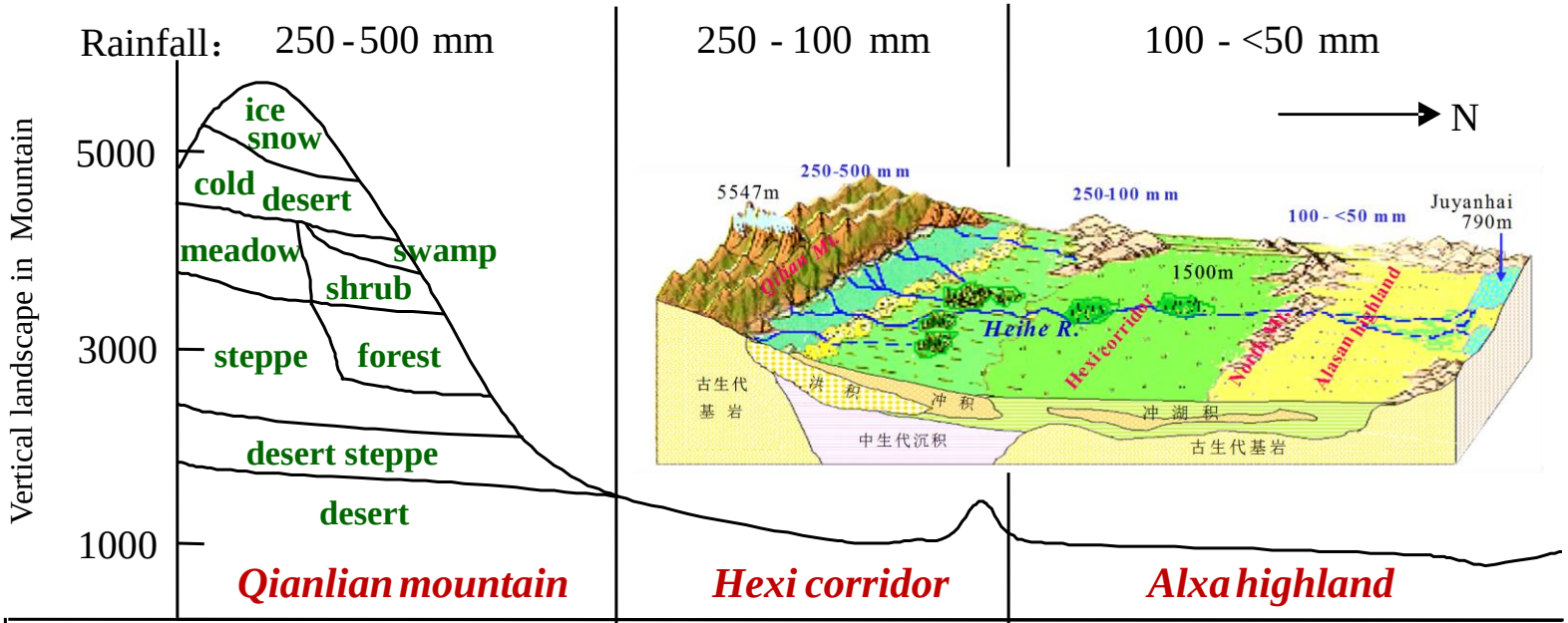


2. General of HB



2. General of HB

Typical landscape



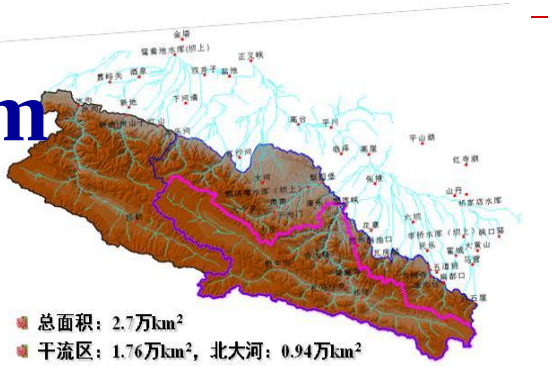
Agri/forest/livestock(%): 9/**59**/47	**76**/32/21	15/9/**32**
Oasis / desert (%)	8.5%	3.3%

Special river eco-hydrological system: snowfield-forest-grassland-oasis-desert.

2. General of HB

Water balance in Upper stream

- >90% runoff，$3.333\times10^9m^3$，forms above 3300m during Jun -Sept；
- Not runoff in forest zone。

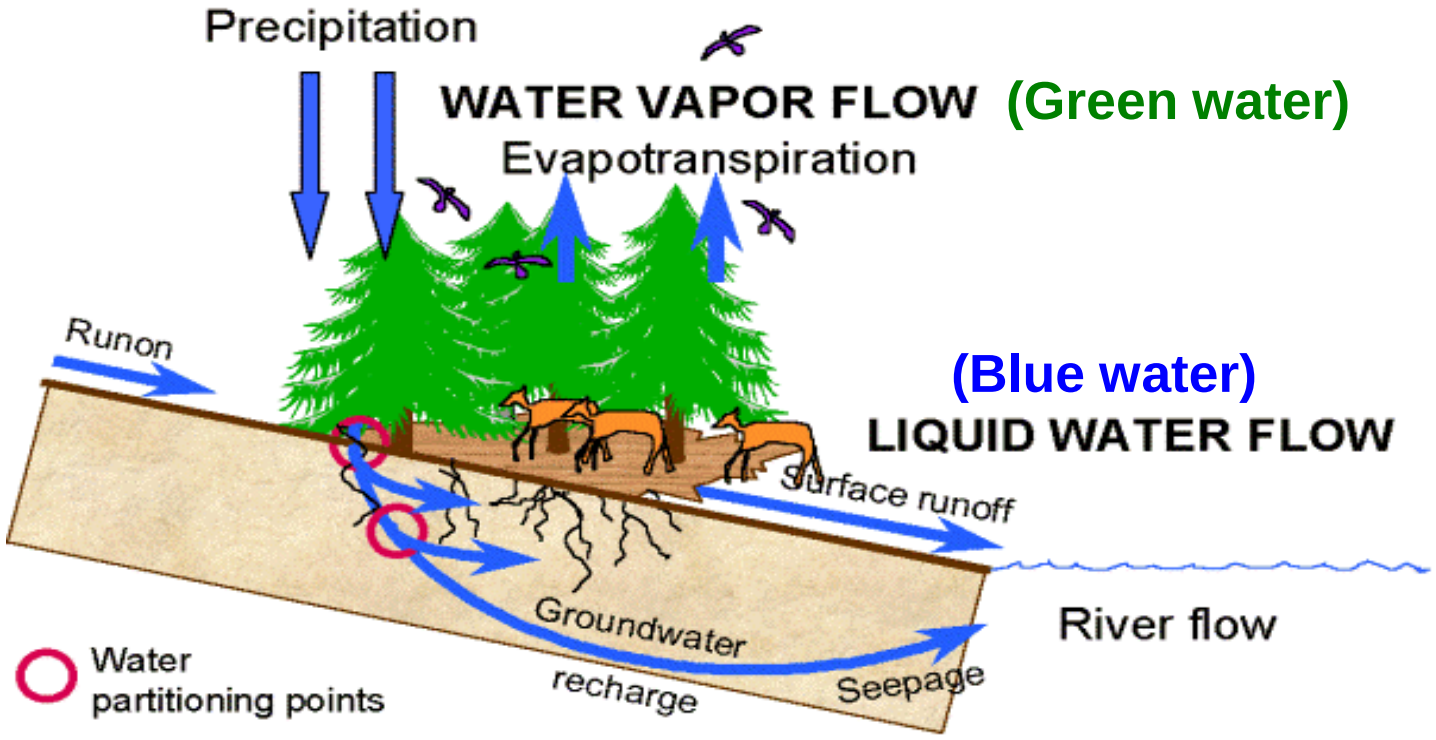


土地类型 Land type	海拔Altitude /m	面积Area /%	/km²	降水Precipitation /mm	/10⁸m³	蒸散ET /mm	/10⁸m³
冰雪Ice/Snow	4400-5500	0.2	475	650	3.09	289	1.30
高山寒漠 Alp cold desert	**3900-4400**	**27.5**	**6275**	**453**	**28.40**	**196**	**12.30**
高寒草甸 Alp meadow	**3300-3900**	**36.1**	**10425**	**380**	**39.64**	**232**	**24.20**
森林Forest-steppe	**2700-3300**	**16.8**	**747**	**332**	**2.46**	**449**	**3.35**
山地草原Steppe	2200-2700	9.4	8803	310	27.30	258	22.70
荒漠 Desert	1600-2200	2.8	7506	200	15.01	141	10.50
合计			34231		115.90		74.35

2. General of HB

黑河流域上、中、下游蓝、绿水平衡与循环

Water balance in upper, middle, lower reaches



Modified from *Johan Rockström et al. 1999*.

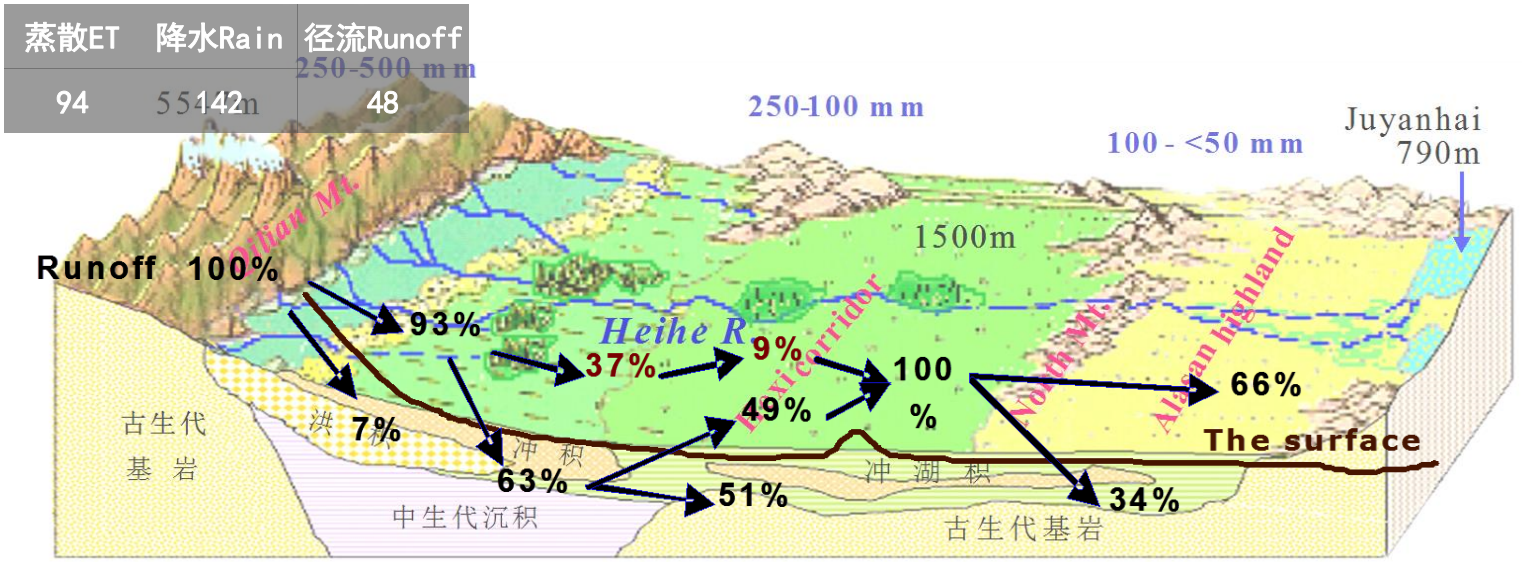
2. General of HB

Water balance at basin scale

大气水 Atmosphere water：$28\times10^9\ m^3$，核心区。

地表水 Surface water: Irrig. cropland 380 mm，Oasis191 mm。

虚拟水Virtual water：export $5.58\times10^8 m^3$，in which farming $5.16\times10^8 m^3$，livestock $1.17\times10^8 m^3$。



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3. Reform water process

At 1000a scale: 5000-3000 a BP

Long-term dry with **damp only once**
in the sediment of the end-lake, Juyanhai

年代 Date /cal ka BP	气候条件 Climate	沉积环境 Sediment environment	植被孢粉
2.98-2.7	非常干旱 Very dry	湖相，沙丘 Lake, wet, dune	沙漠 Desert
3.05-2.98	干旱 Dry	浅湖相，侵蚀 Shallow lake, erosion	旱生
3.1-3.05	非常干旱 Very dry	风成沙沙丘 Dune	
3.135-3.1	干旱 Dry	河流/浅湖相 River, shallow lake	
3.15-3.135	非常干旱 Very dry	风成沙丘 Dune	
3.5-3.15	湿到干旱 Damp-Dry	河/湖相 River, lake, erosion	河岸 River bank
5.25-3.5.	干旱 Dry	湖相，无脊椎动物增加 Lake,	湿生植物

3. Reform water process

At 1000a scale

居延海衰退史：自然+人

Juyan lake drying-up: nature +man

- **汉领河西前 No faring (121 BC)**

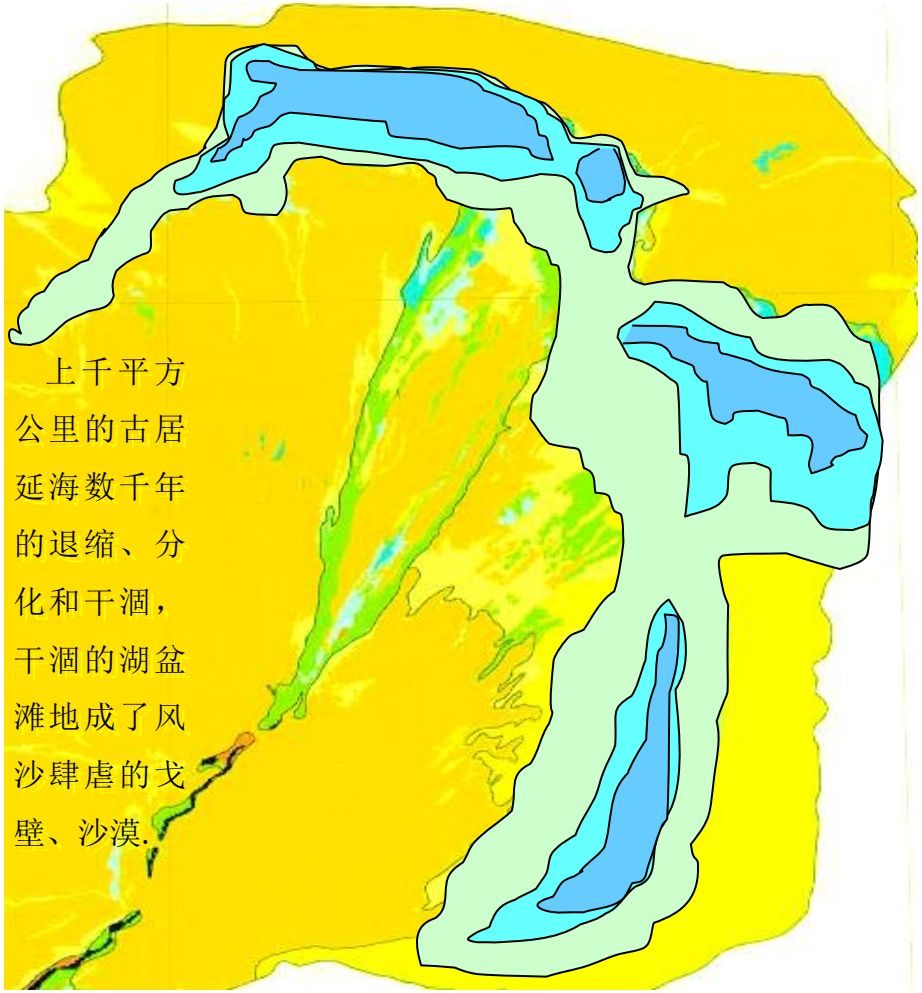
逐水草而迁徙，无城郭常居耕田之业。水丰草美，湖泽广布，可耕可渔。

- **汉唐开垦 Reclaim (121BC-55AD)**

汉代流域首次大规模农垦；西晋八王之乱,东晋五梁纷并；唐代屯垦向高阶地发展。

- **清朝农业发展 Agro-develop in Qing Dynasty**

河西最盛时（1808）张掖人口53万；雍、乾之时河西耕地约为今日的一半，”一切边疆隙地莫不广垦”。



3. Reform water process

At 100a scale: change of land use

人水关系变化

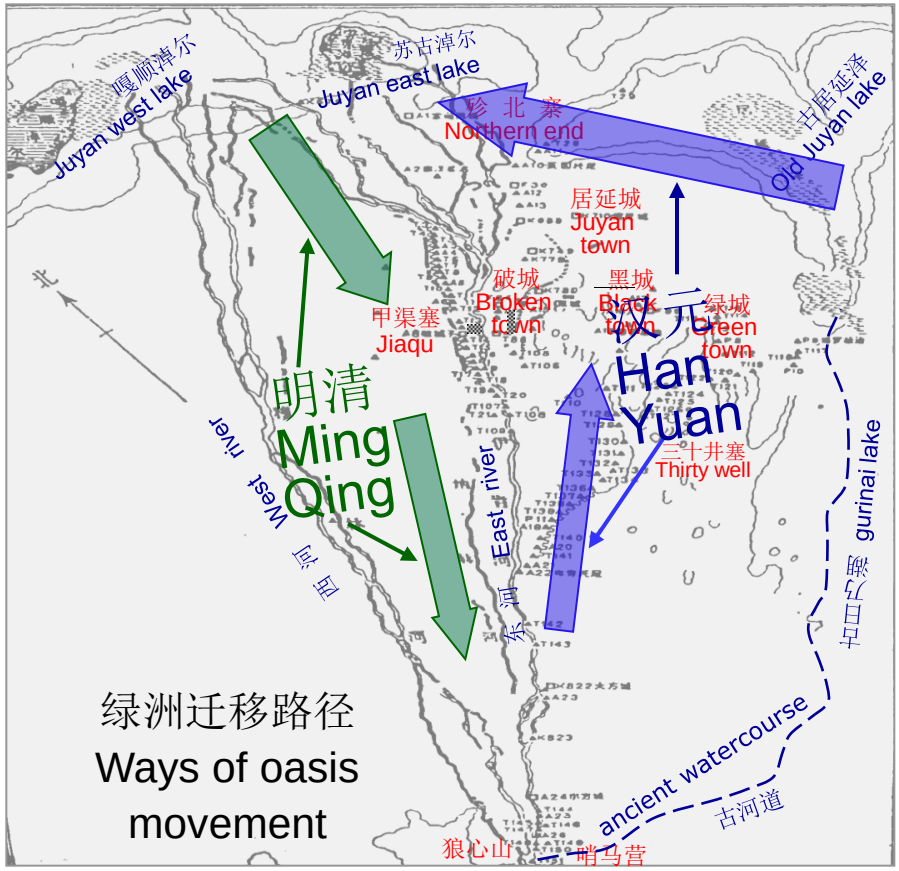
Change of relationship between people and water

- 汉、元时期，人从水；

  In AD. 2000-1000, Human follows water, oasis moved from S to N, E to W;

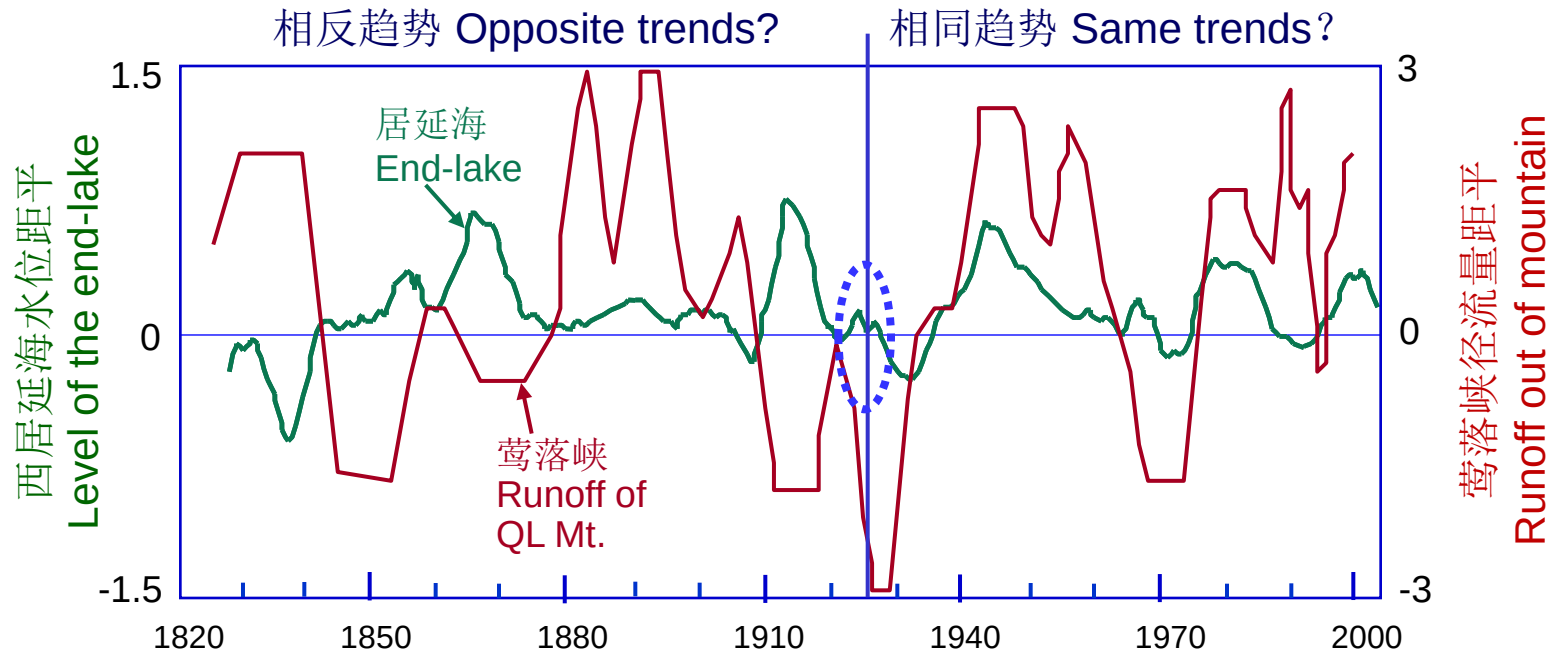
- 明清以来，水从人；

  After AD. 1000, water follows human, oasis move from lower to upper reaches。



3. Reform water process

At 100a scale: an un-known driving force

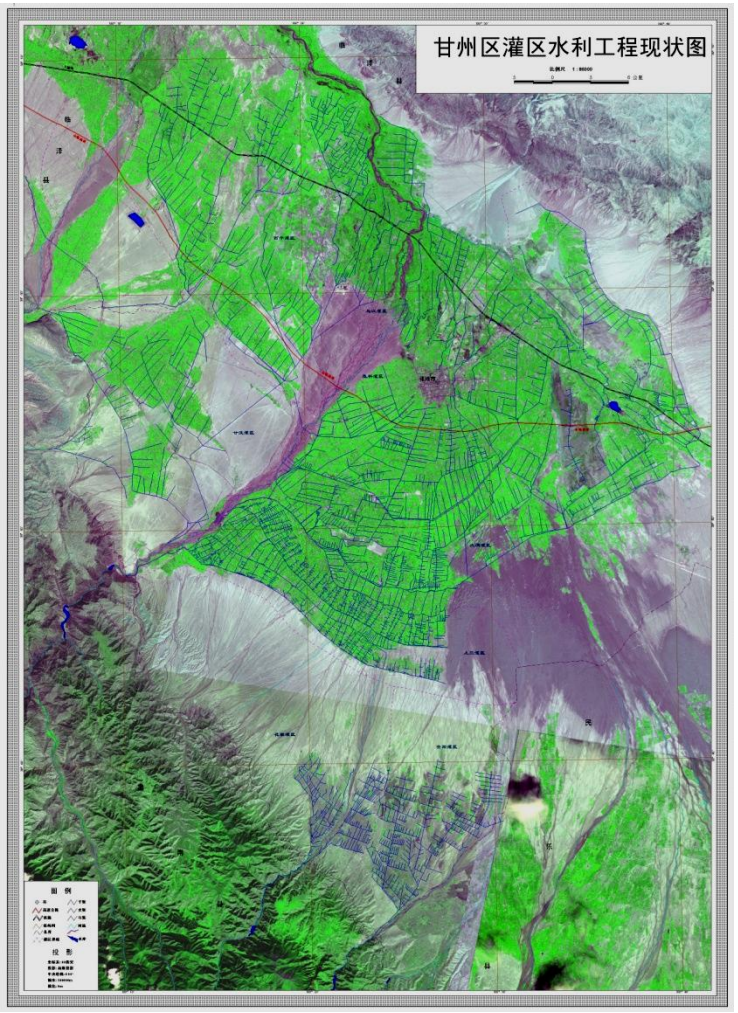


清嘉庆25年（1820）中游人口28.25万，耕地10万公顷；In 1820, 0.28 million people,0.1 hectare farmland；
到1996年，人口123.28万,耕地20多万公顷，水库100座。In 1996, 1.23 million people,0.2 hectare farmland,100 reservoir。

3. Reform water process

At 10a scale:

Artifical water system replace natural one

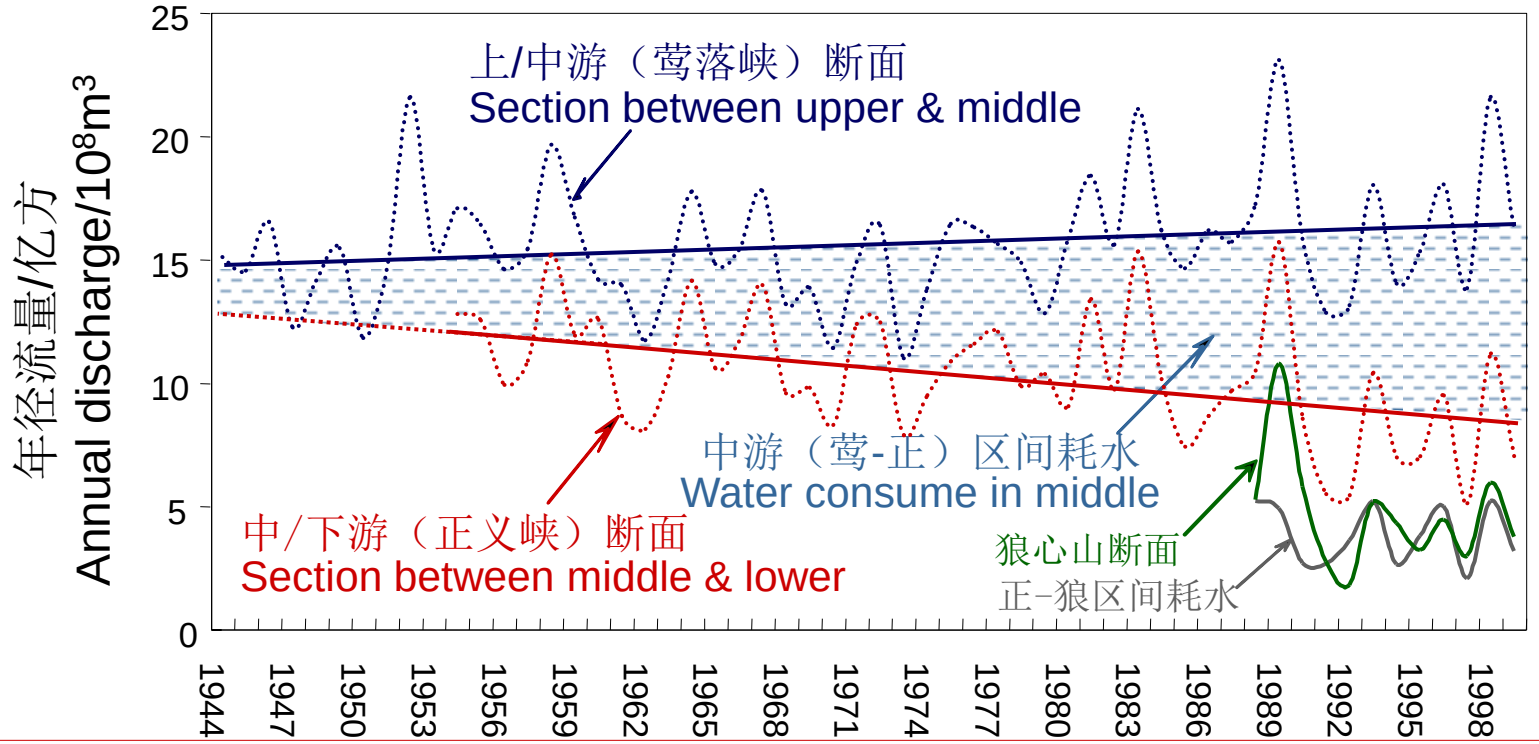


3. Reform water process

At 10a scale: a man-made change

干扰流域水循环：中游灌面从200增到600万亩，下游用水从80%减少到30%。

Rebuilding water cycle unprecedentedly

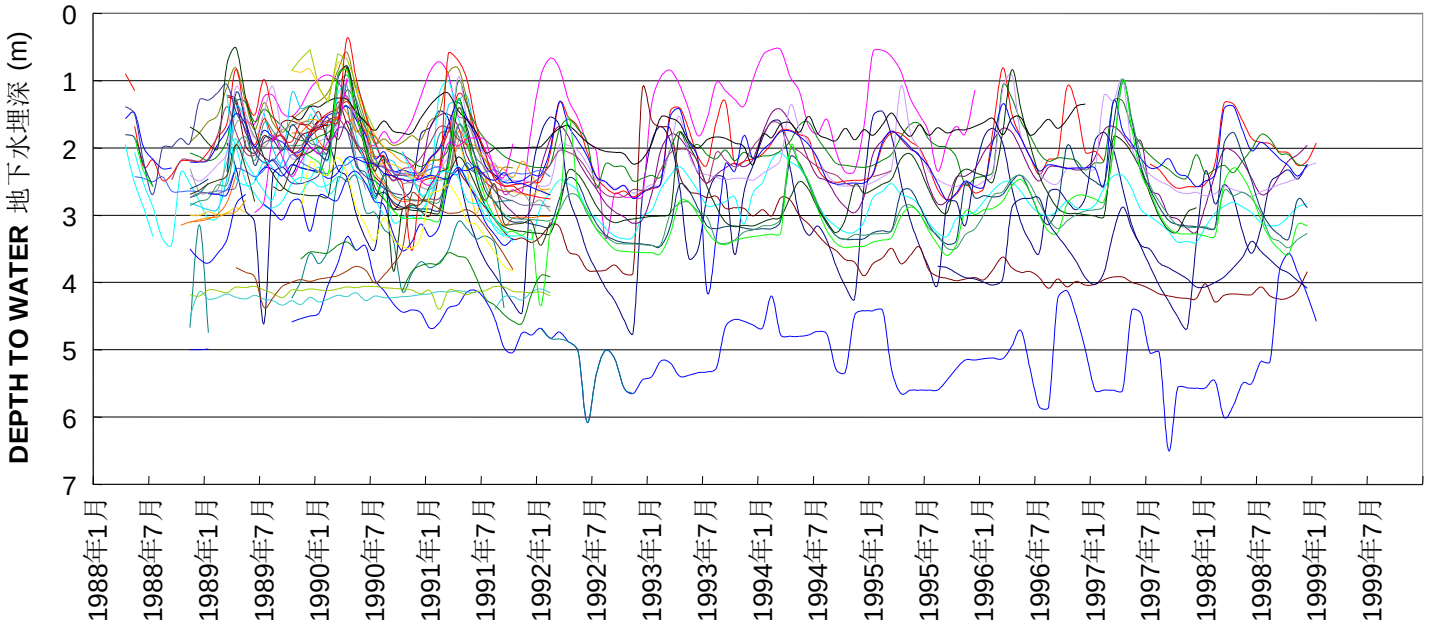


3. Reform water process

At 10a scale: an un-hope result

地表水减少3亿方/年导致的下游地下水位下降

Fall of groundwater level because runoff lessens 3×10^9 m^3 in 1990s in lower reaches.



Groundwater levels Change in Ejina banner 下游额济纳旗地下水变化

3. Reform water process

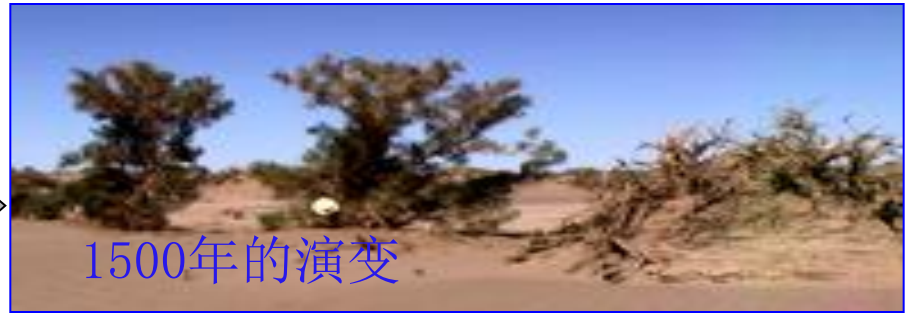
Ecosystem impacted by hydro-change at 10a scale

地下水位下降导致的植被演替

Vegetation succession with fall of groundwater level

柽柳取代胡杨

Tamarix replaced populus in 20 years



梭梭取代柽柳

Haloxylon replaced Tamarix in 1000 years

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4. Reform eco-system

Development above 3000m at small scale

Over-grazing, runoff 10-15%+

Over-cutting, runoff 20%+

Farming doesn't runoff

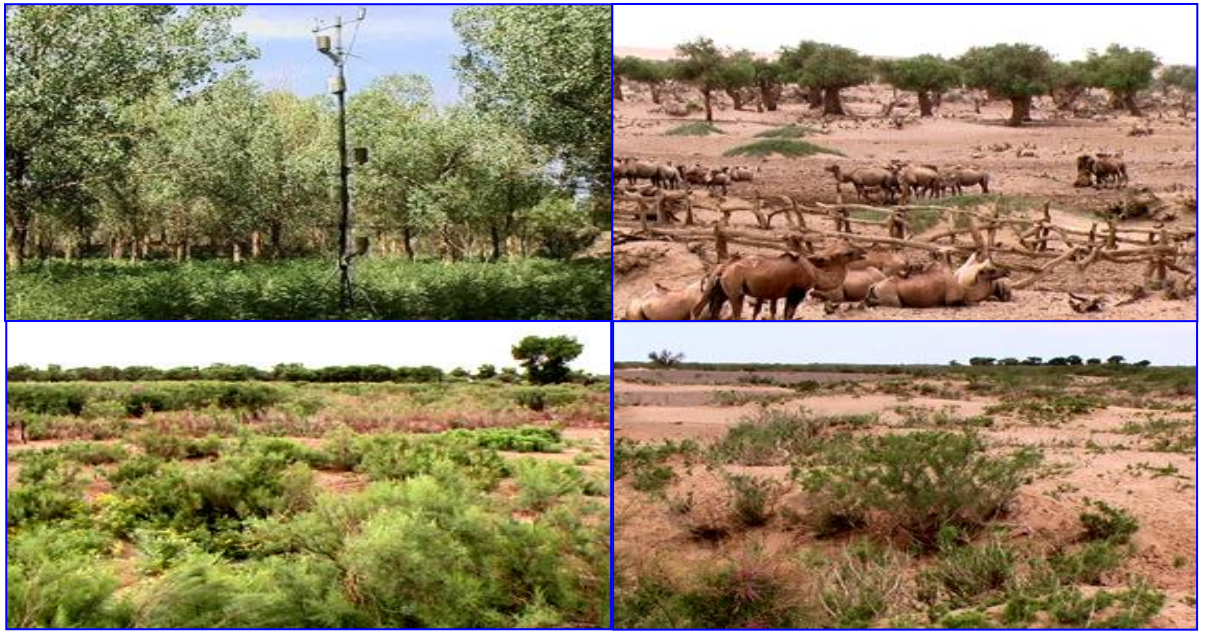
4. Reform eco-system

土地利用与沙漠化的关系
Land use and desertification

封育 Closed　　过牧 Over-grazing

乔木林（*胡杨*）
Forest
(Populus euphratica Oliv)

灌木林（*柽柳*）
Shrubbery
(Tamarix chinensis)

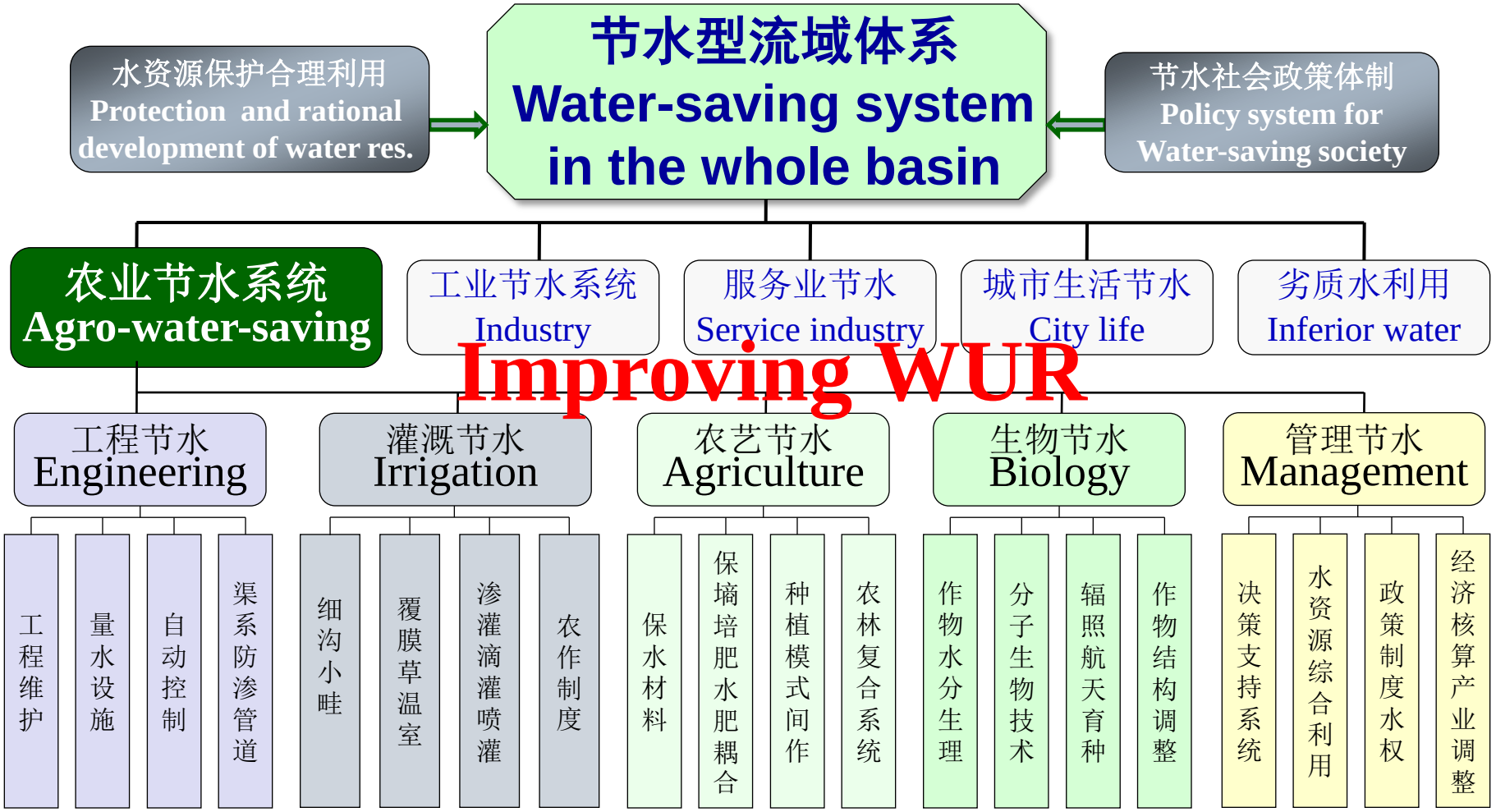


4. Reform eco-system

Sand desert into oasis

1970s' around Linze station

4. Reform eco-system



4. Reform eco-system

Improving WUR 25%-33%

coupling water with temperature

Fertilization, water-saving on the need of crops

免耕、垄作
No-till and ridge cultivatio

地膜覆盖
Film cover

间作试验
Intercropping

秸秆覆盖
Straw mulch

Farming technology

农民培训
Training farmer

春麦–枣树
Wheat-jujube

玉米–枣树间作
Maize-jujube

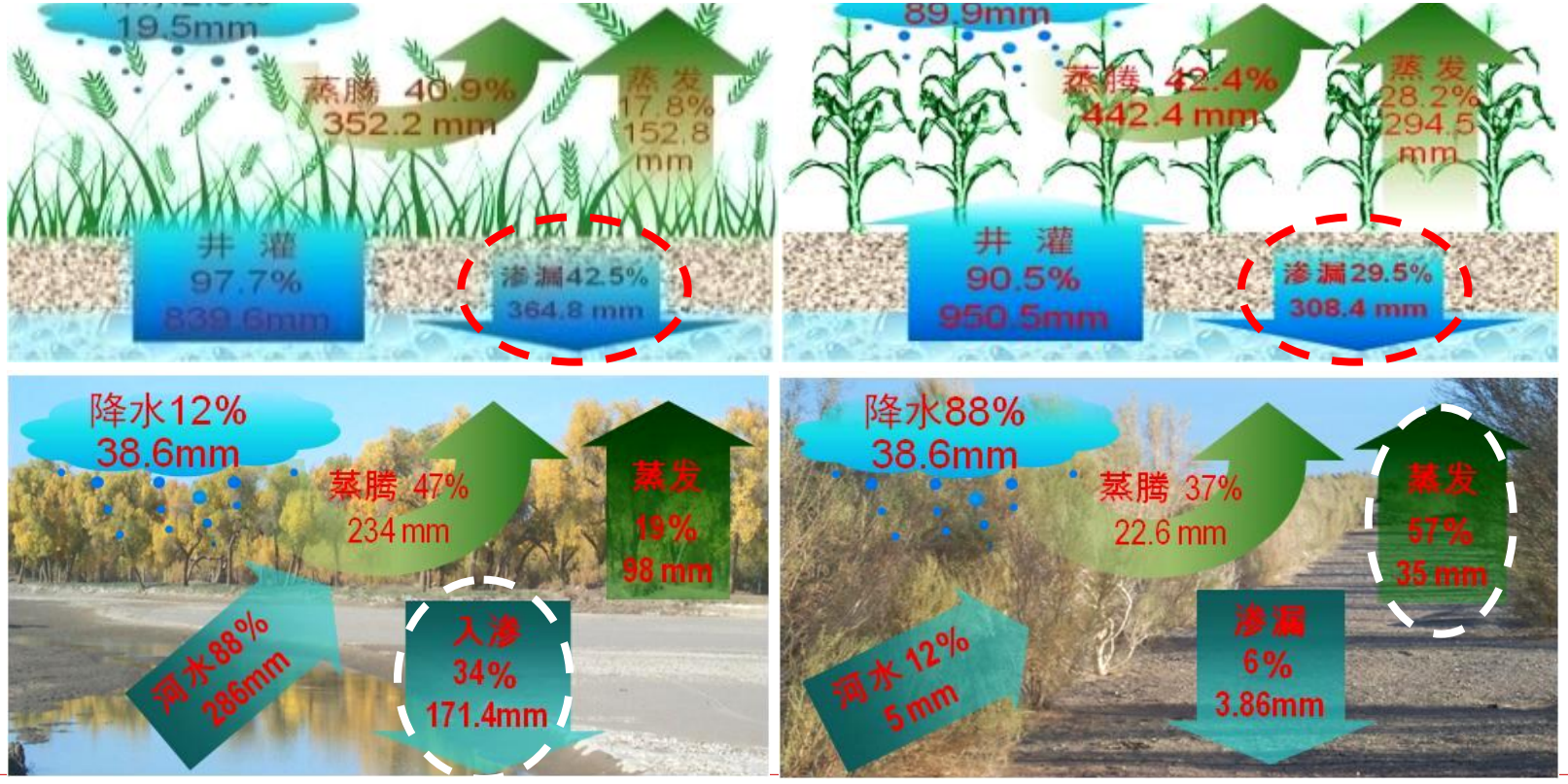
杨树–苜蓿
Poplar-clover

Agro-forest system

4. Reform eco-system

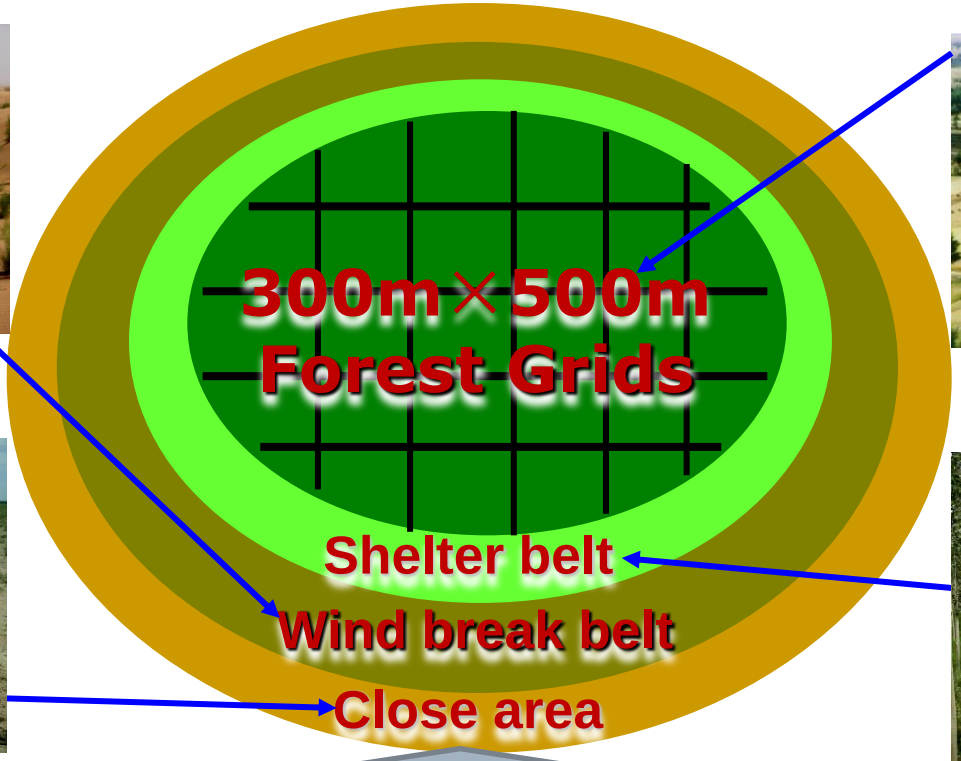
Water balance at cropland and community

Wheat, corn, trees and shrubs



4. Reform eco-system

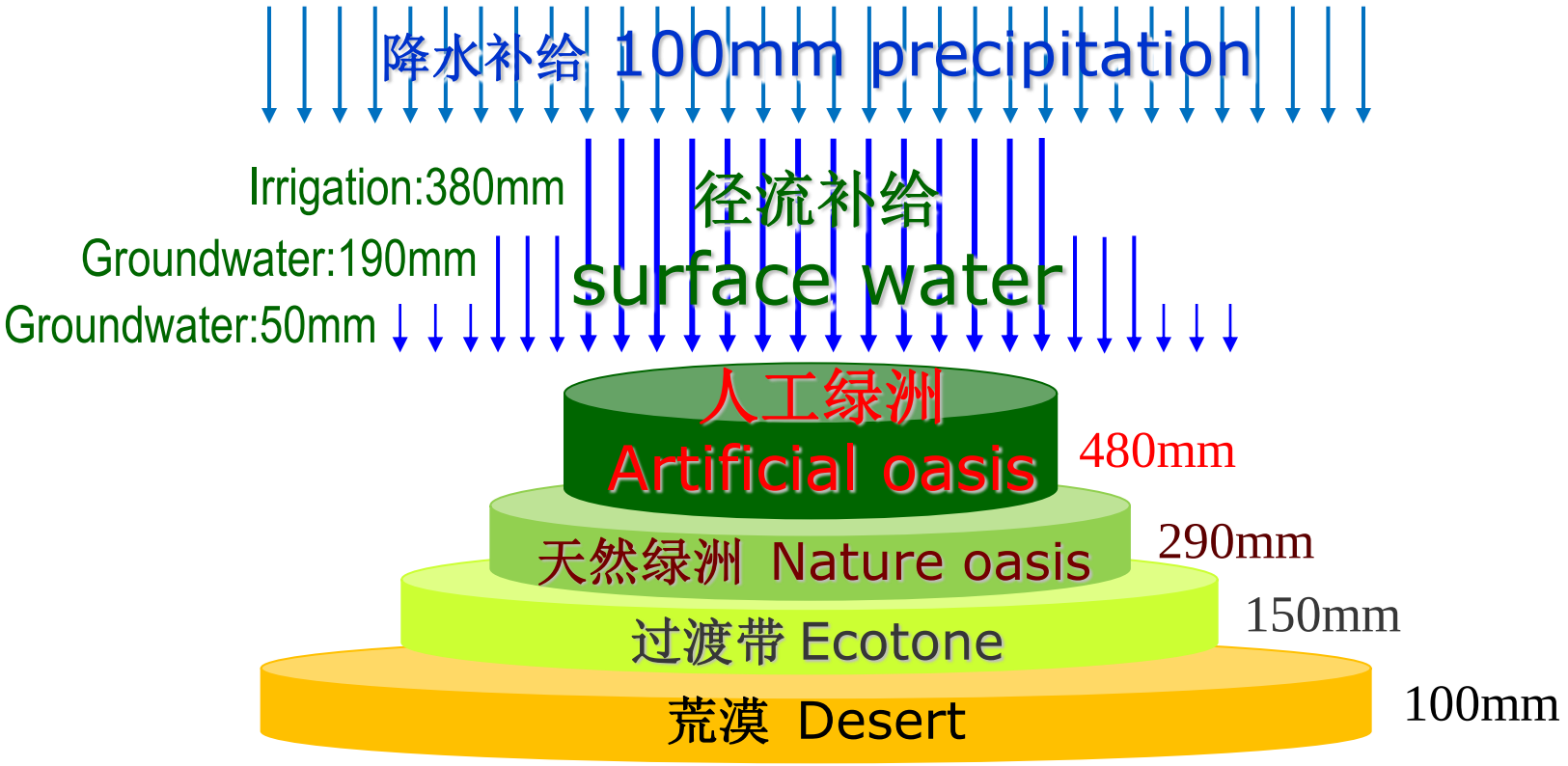
Pattern of oasis system : 1+3



4. Reform eco-system

Water balance at oasis scale

with surface water irrigation



4. Reform eco-system

Water balance at oasis scale

with ground water irrigation

Stable artificial oasis consumes water 750-900mm/a, in which non-agriculture ecosystem uses up 25%.

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5. Water process in soci-econ system

虚拟水流 Virtual water cycle

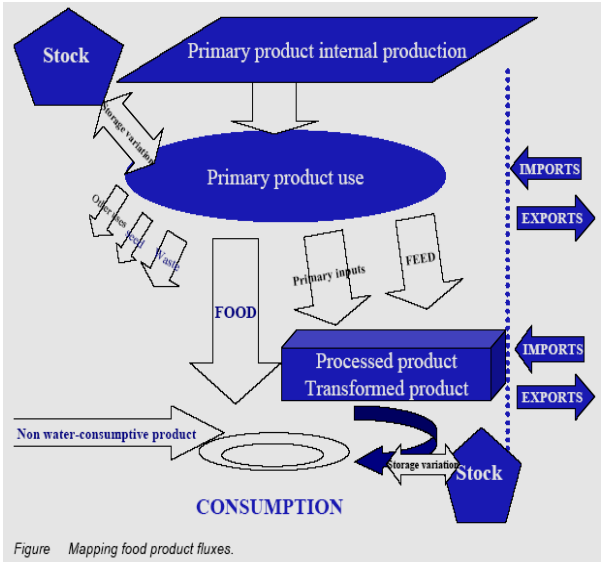
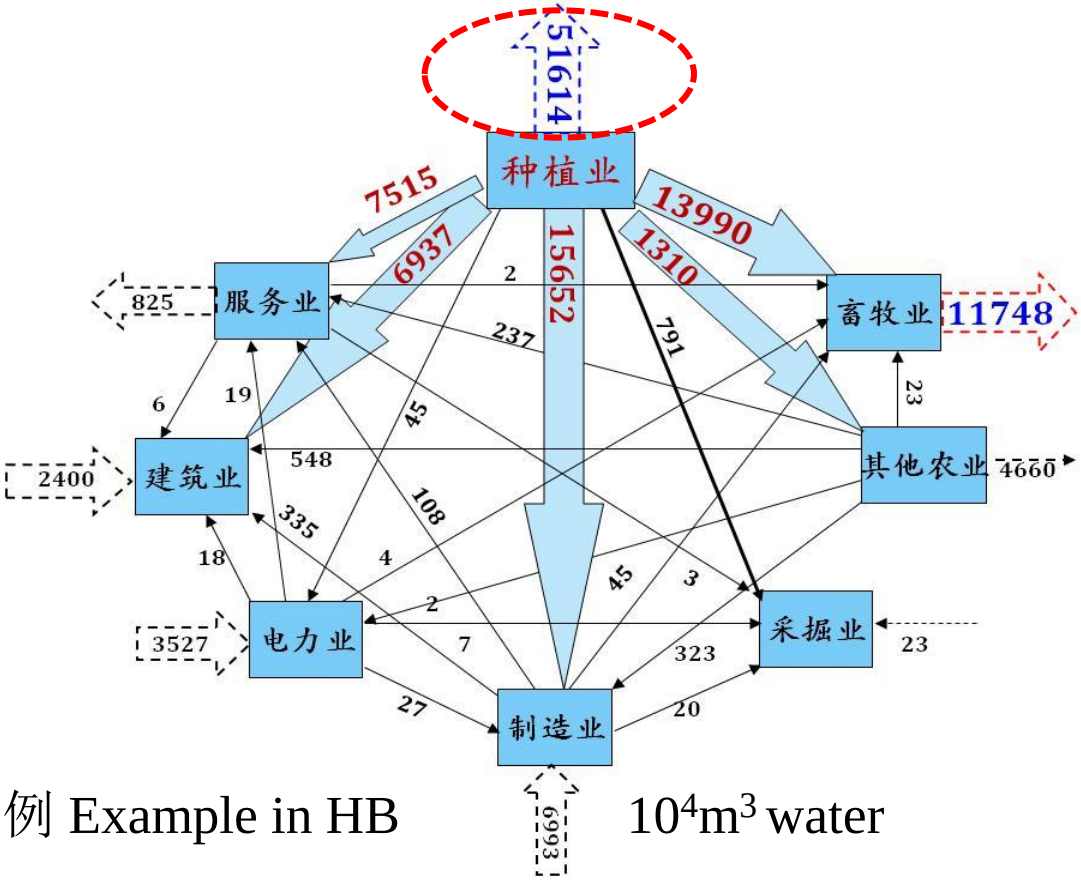


Figure Mapping food product fluxes.

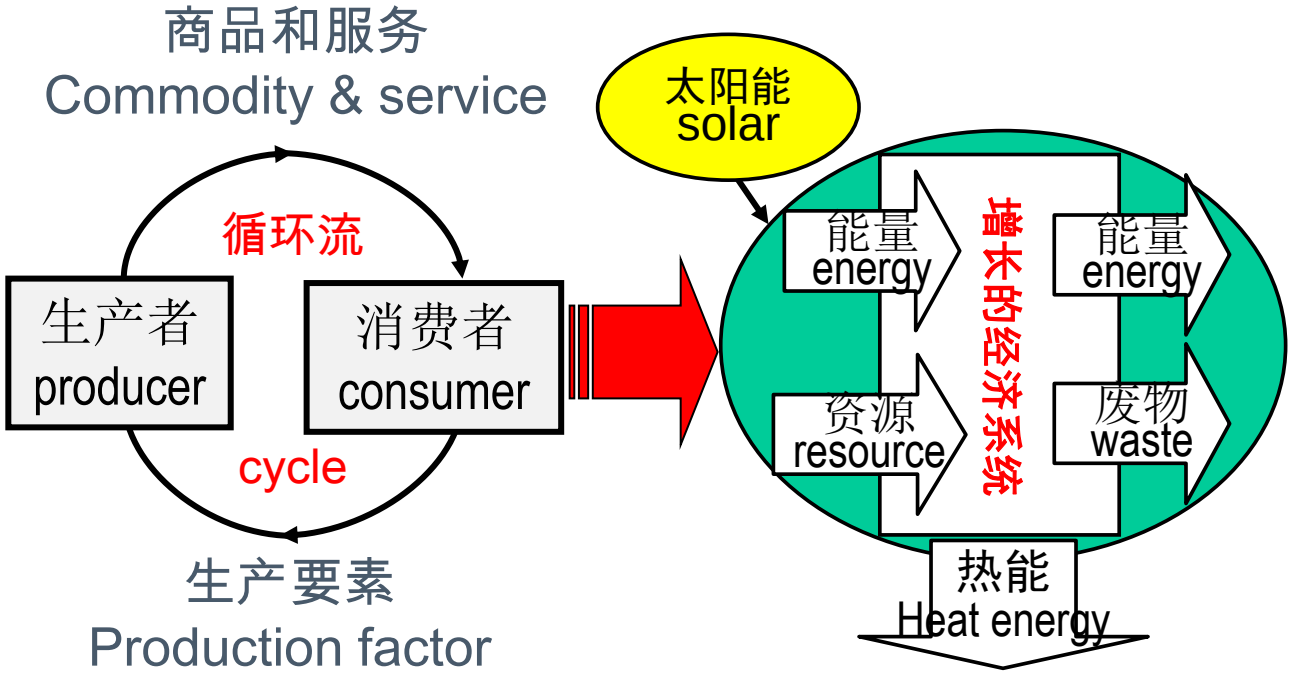


实例 Example in HB $10^4 m^3$ water

5. Water process in soci-econ system

把经济系统交换价值推演到物–能循环的度量

Value exchange transforms cycle of matter and energy



正确定位:

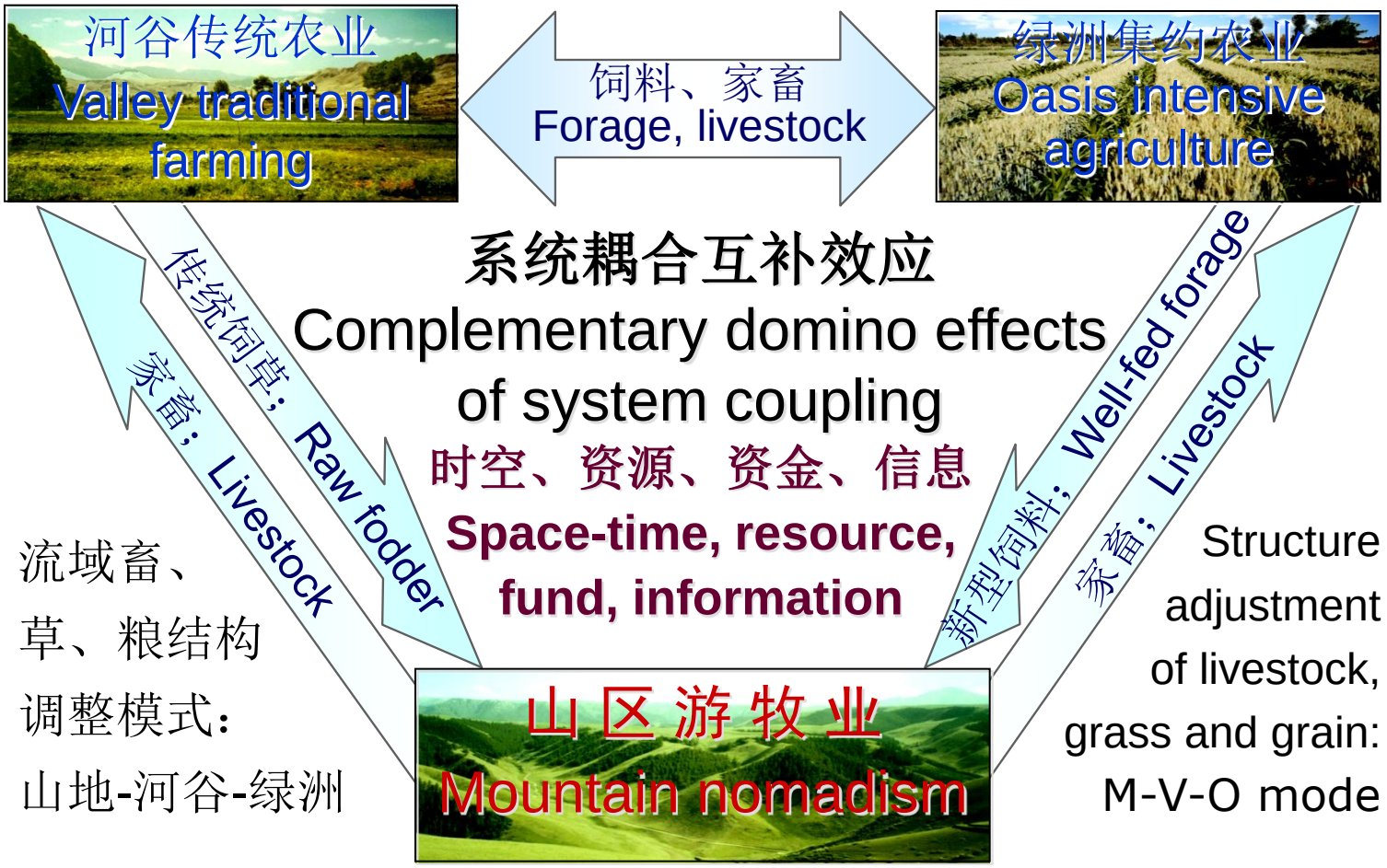
人是子生态系统

依托定位观测试验

Confirm people as a sub-ecosystem to link up observation and experiment

常规：孤立经济系统　　经济系统：生态系统的开放子系统

5. Water process in soci-econ system



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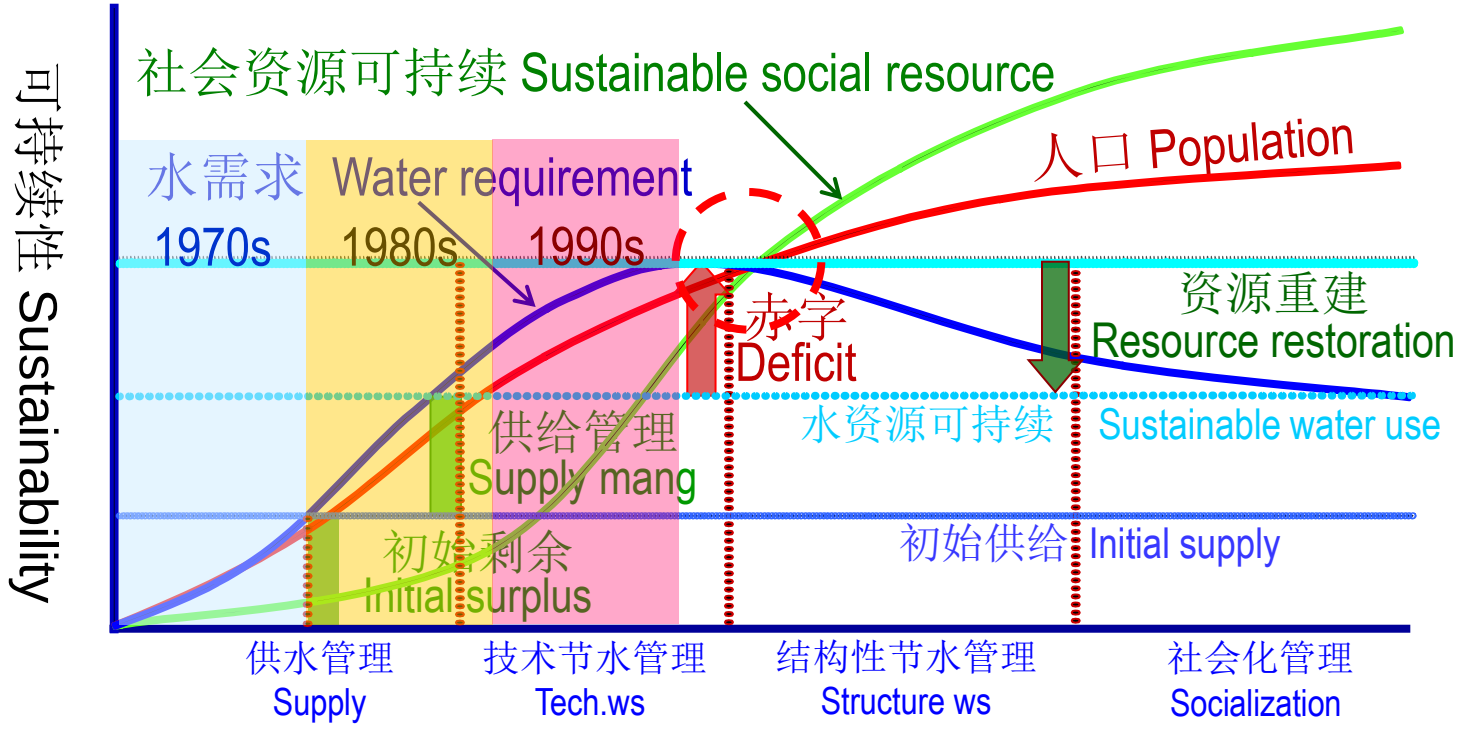
6. Results of Water Issues

开源 ⇒节流 ⇒ 结整结构⇒ 社会化管理

Source⇒Save ⇒ Adjust structure ⇒ Socialization



继续改变水过程 **Reforming water process**

6. Result of Water Issues

How to change ?

What Hydro-prodiction should answer !

♦ **Rational water allocation at basin-scale**

- Couple water, ecology, society and market;
- Allocation among upper, middle, lower, and industries.

♦ **Improve water benefit in irrigation district scale**

- Couple water with soil, light and temperature；
- Use rate: irrigation water-soil water-biowater – benefit.

♦ **Social manag. of water res. in/among river basins**

- Virtual water strategy in the world；
- Water-saving society----institutional, water right, laws/regulations.

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7. HB Major program of NSFC

Name： **Integrated Research on the Eco-Hydrological Process of Heihe Basin;**

budget： **150 million** RMB￥;

Time： **8-year;**

Projects： **60 General Program and 30 Key Program**。

Webset: www.nsfc.gov.cn/english/06gp/index.html

国家自然科学基金委员会
National Natural Science Foundation of China

7. HB Major program of NSFC

General targets :

Establish research platform which integrates observation and experiment with simulation

- 揭示植物个体、群落、生态系统、景观、流域尺度生态-水文过程相互作用规律；
  Reveal eco-hydrological processes on individual plant, community, ecosystem, landscape and watershed scale;
- 刻画气候变化和人类活动影响下内陆河流域生态-水文过程机理；
  Describe the principal of eco-hydrological process in inland River Basin under the impact of climate change and human activity;
- 发展生态-水文过程尺度转换方法
  Develop method of scale transform of eco-hydrological processes
- 建立耦合生态、水文和社会经济的流域集成模型
  Establish integrated model that coupled ecological, hydrological and socio-economic processes.

7. HB Major program of NSFC

Key scientific issues

1. Vegetation water use efficiency and its adaptation mechanisms under water stress in arid environment
2. Interaction mechanism and its eco-hydrologic effect between surface water and groundwater
3. Eco-hydrological processes mechanism and scale conversion method at different-scale
4. Response mechanisms of watershed eco-hydrological process under the influence of climate change and human activity
5. Methodological and technological synthesis of experimental observation and data simulation.

7. HB Major program of NSFC

Research contents

1、 冰冻土演化雪、与水文、水资源变化过程

Evolution of snow and frozen soil, and change of hydrology and water resources

2、 地表水与地下水转换过程及其生态效应

Transform processes of surface water and ground water and their eco-effect

3 、 不同尺度植被水分利用与耗水的生物学机制

Biological mechanism of water use and consumption of vegetation on multi-scales

4、 典型植被格局生态-水文过程的相互作用机制

Interaction mechanism of eco-hydrology process under typical vegetation pattern

5、 流域经济-生态-水系统演变过程

Evolution processes of water-ecology-economy system at basin scale

6 、 流域生态-水文集成模型与决策支持系统

Integrated model of watershed eco-hydrology and decision support system

7. HB Major program of NSFC

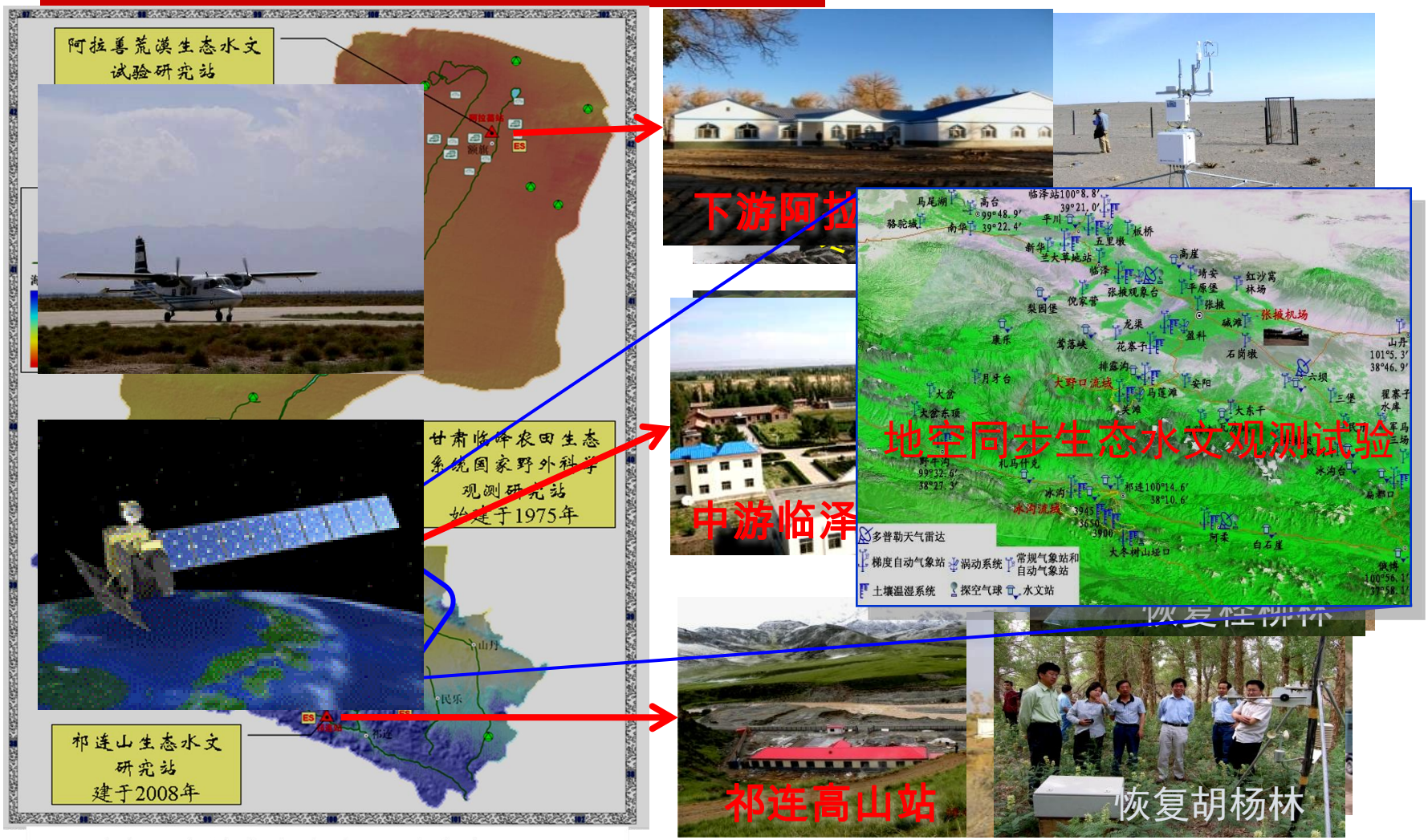


图 1 流域生态水文观测试验站网

7. HB Major program of NSFC

国家黑河工程
State Heihe Eco-engineering since 2002

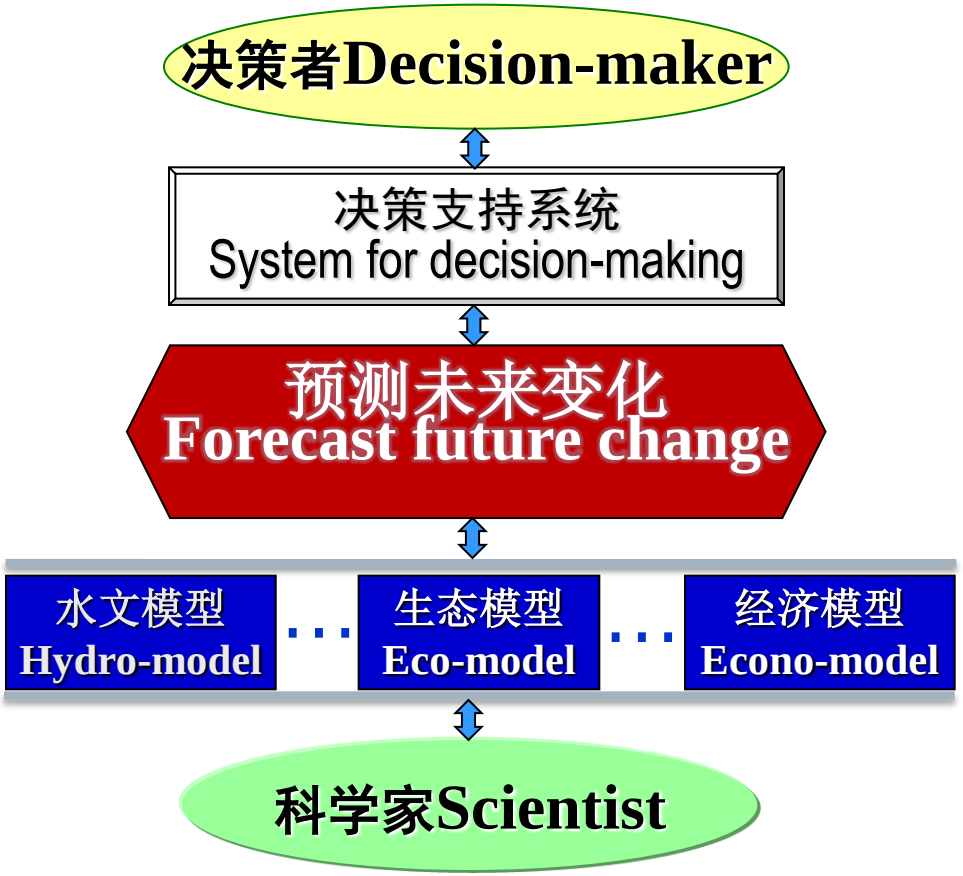
- 近5年，国家“黑河生态工程”，居延海再现碧波荡漾；

In recent 5 years，2.5×10^9 RMB, 2Juyan lake，terminal lake recovered during the state eco-engineering。

居延海再现碧波荡漾，Juyan lake revives

Conclusion

Build a bridge between science and decision-making



科学之所以能成为真正的科学是因为能预测未来的变化;

决策之所以被称为科学的决策是因为能洞察变化的未来;

科学与决策之间的桥梁就是对未来变化的预见

提高预测能力应该是科学界追求的最高目标

谢谢！

Thanks !