



Water Scarcity and Its Mitigation in China

Junguo Liu

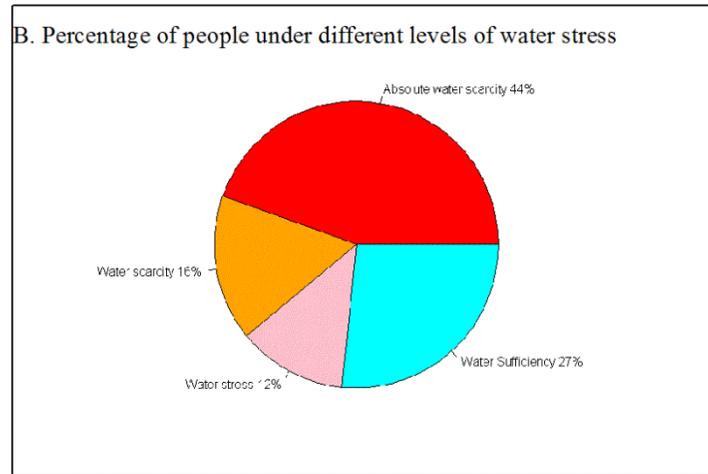
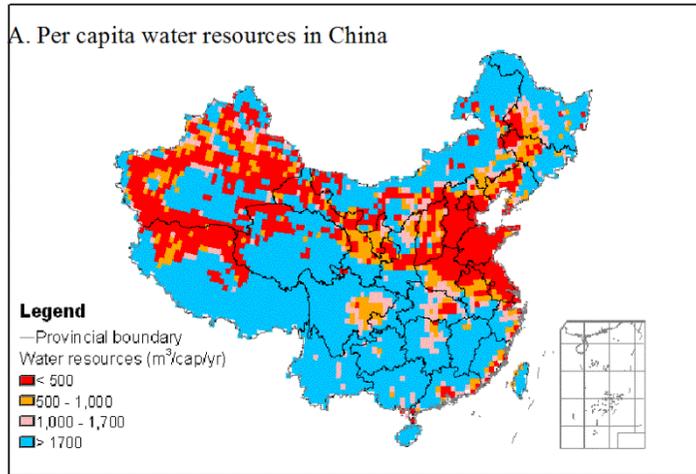
Professor, South University of Science and Technology of China (SUSTech)

President, Society for Ecological Rehabilitation of Beijing (SERB)

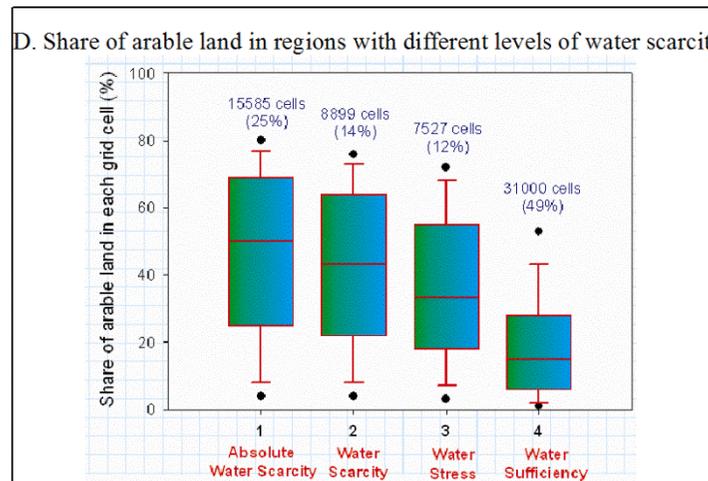
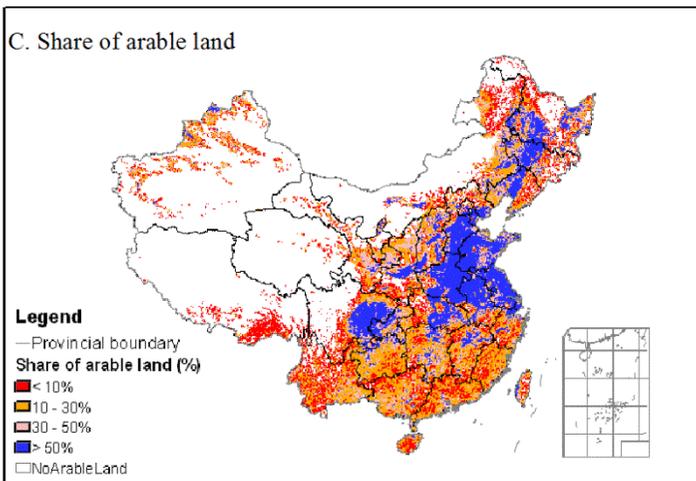
Chair, Union for Ecological Restoration and Environmental Protection in Beijing (USEREP)



Water Scarcity in China

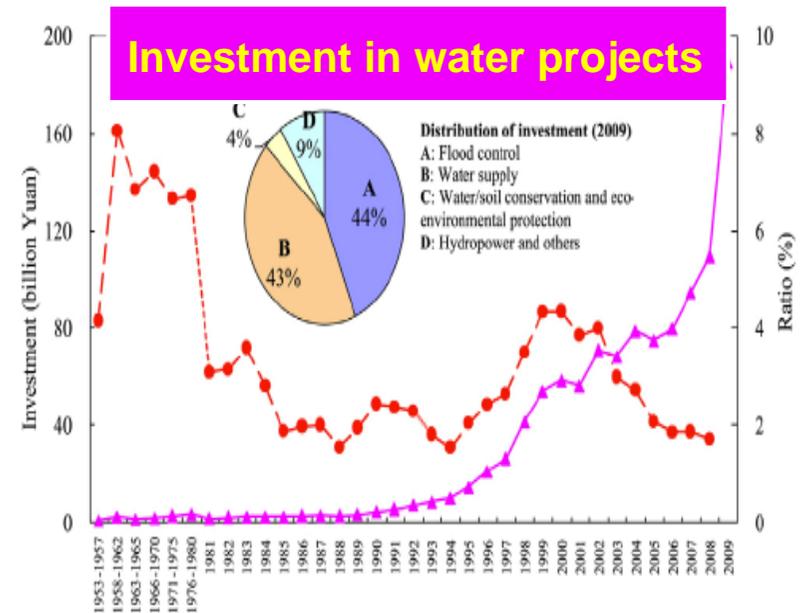
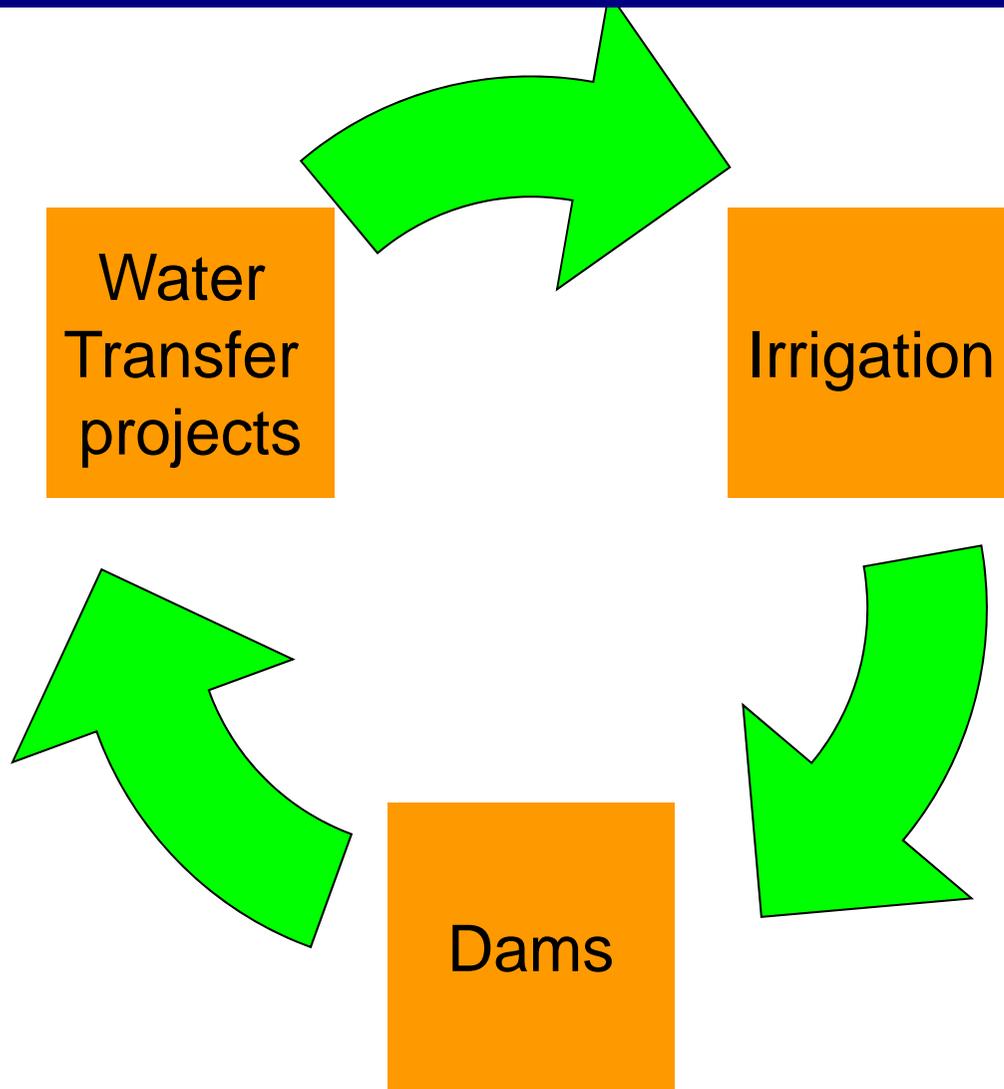


72% people with water scarcity



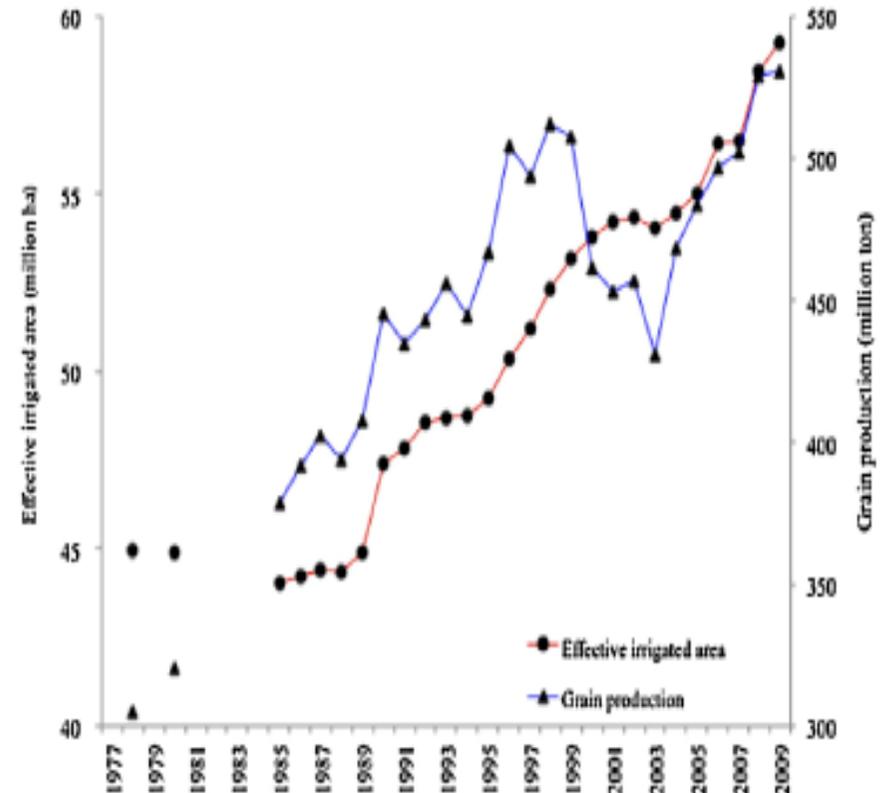
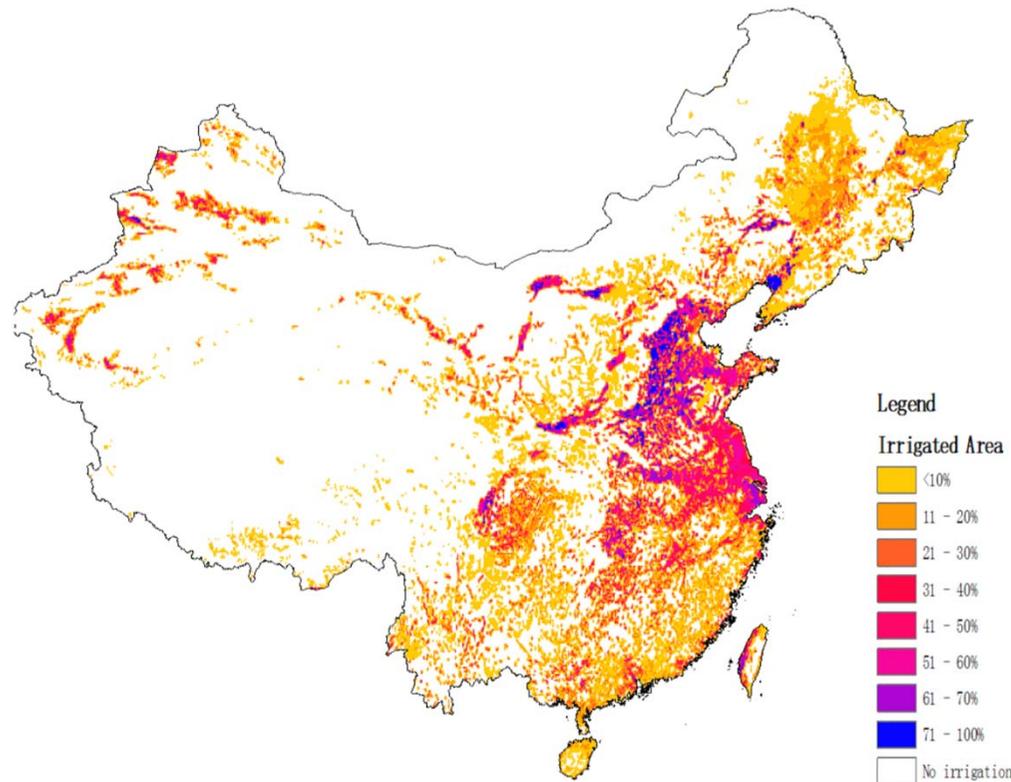
Water-land imbalance

Gray infrastructure, or hydro-engineering projects for mitigating water scarcity



China has the largest number of dams, largest amount of hydropower generation, largest irrigated area, hydropower project and water transfer project of the world.

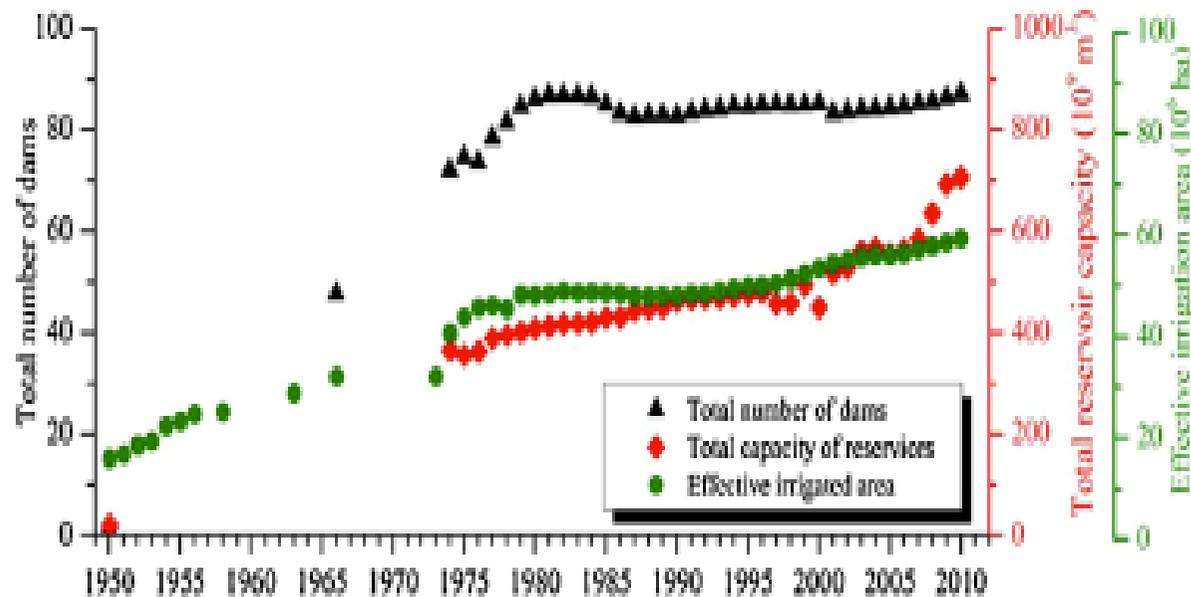
Gray infrastructure: irrigation



- ❑ China has irrigated area of 60 million ha (world's largest; 21% of the world's total)
- ❑ Accounting for about 45% of the arable land, irrigated land produces about 70% of the total grain, 80% of the cotton, and 90% of the vegetables and fruits in China
- ❑ Irrigation is a main cause for unsustainable water use and environmental degradation

Liu J.* et al., 2013. *Global Environmental Change* 23(3): 633-643.

Dams and Reservoirs

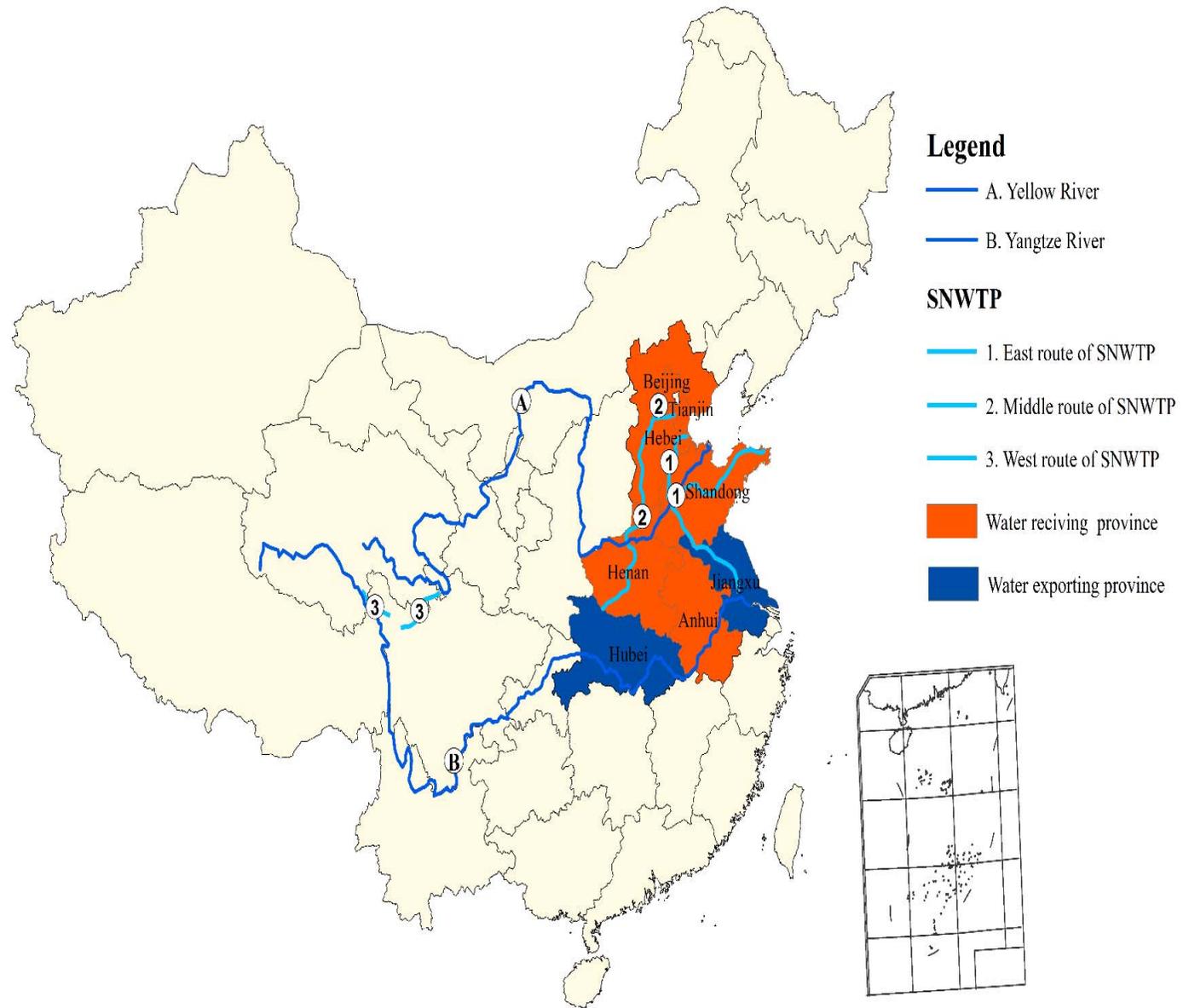


- ❑ China has 87,873 dams, accounting for over 50% of total world dams
- ❑ The flood control systems protect 46.8 million hectares of farm land and 598.5 million people (MWR, 2011a).
- ❑ The ecological effects are a global concern.

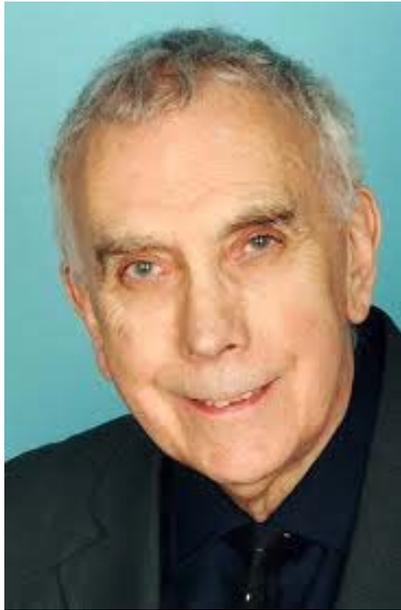
Liu J.* et al., 2013. *Global Environmental Change* 23 (3): 633-643.

Liu J.* et al., 2015. *Scientific Reports* 5: 11446.

China has been developing over twenty major physical water transfer projects with a total length of over 7200 km (Liu et al., 2013).

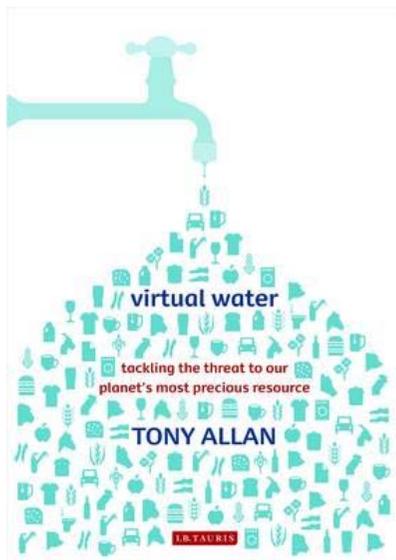


Virtual water



Water scarce regions import water-intensive foods to alleviate their water scarcity. This trade is termed as “**virtual water trade**”.

Since this water flow is invisible



Each year, more water is now imported into the Middle East and North Africa in virtual form than physically flows into Egypt via the Nile

Can water transfer mitigate water scarcity?

An important question is if the water redistributions through virtual and physical forms can be effective in **mitigating regional water stress** in China.

To answer this question:

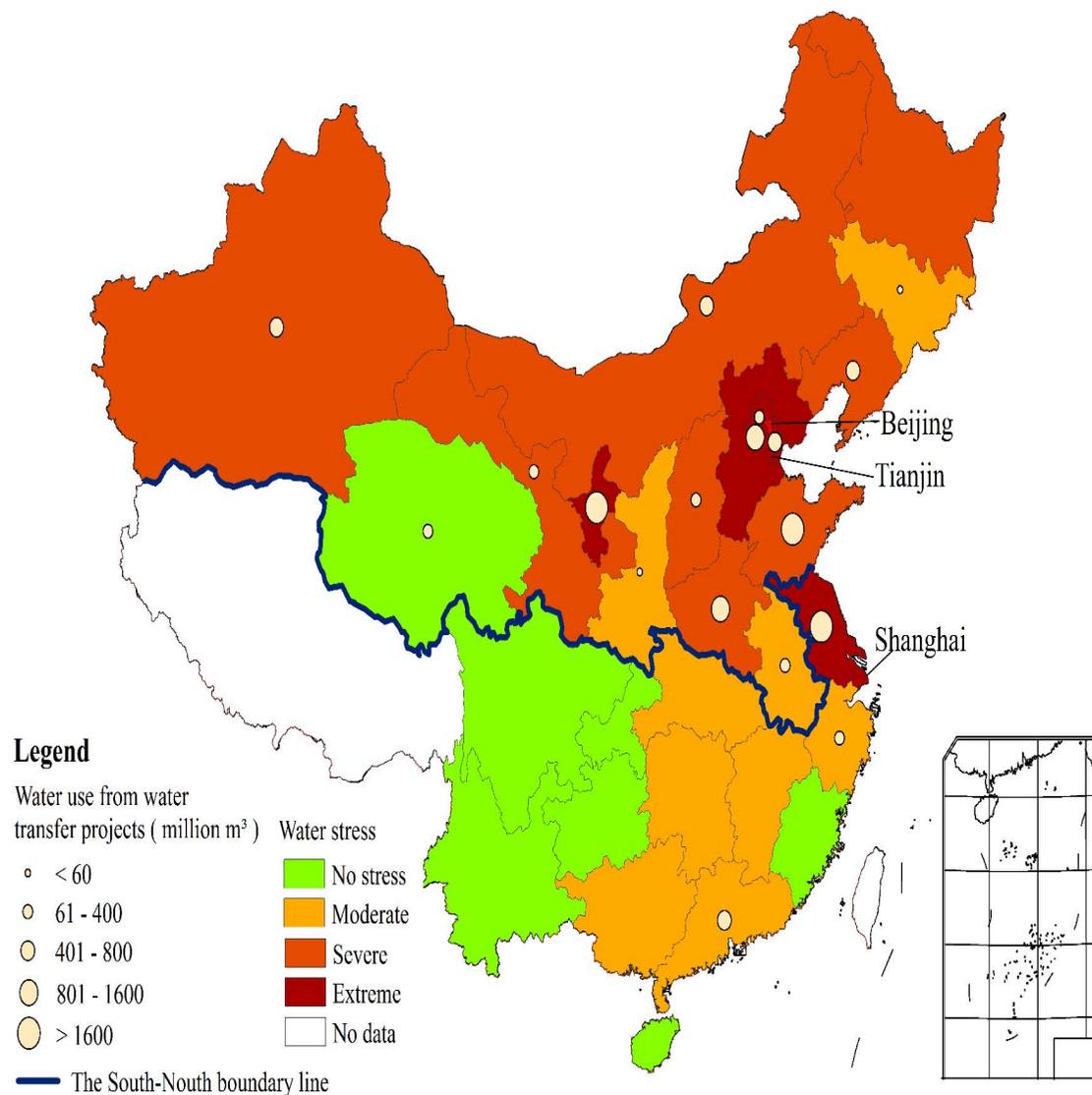
We report on our quantification of China's physical and virtual water flows at the provincial level for the year 2007, and a scenario analysis in 2030.

Water stress index

23 of the 30 Chinese provinces had at least moderate water stress (WSI>0.2)

Physical water flows

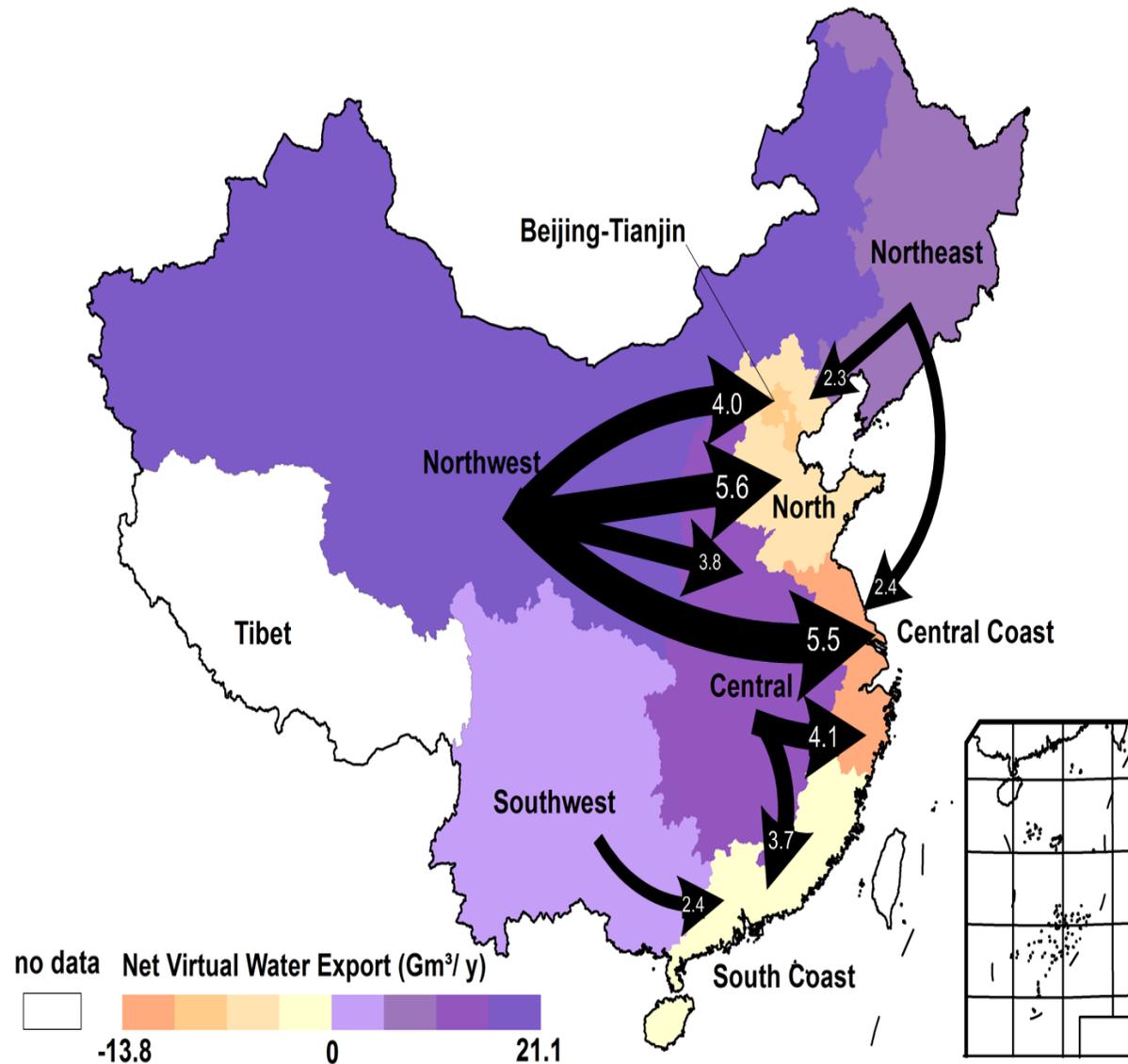
In 2007, physical water flows by water transfer projects amounted to 26.3 Gm³, accounting for 4.5% of national water supply and occurring in 18 provinces in China.



Zhao, Liu* et al., 2015. PNAS 112(4): 1031-1035.

Virtual water flows

The total volume of virtual water flows was 201 Gm³ in 2007, i.e. 35% of the national water supply was used for inter-provincial virtual water trade.

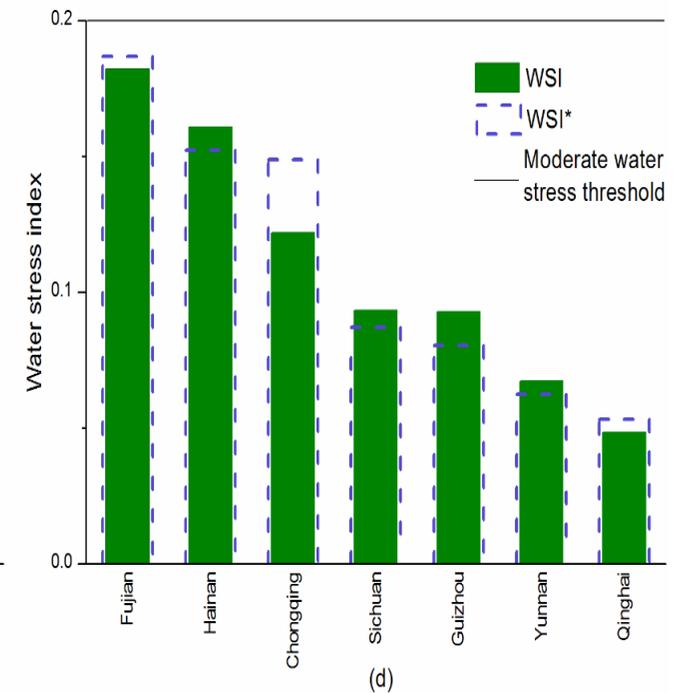
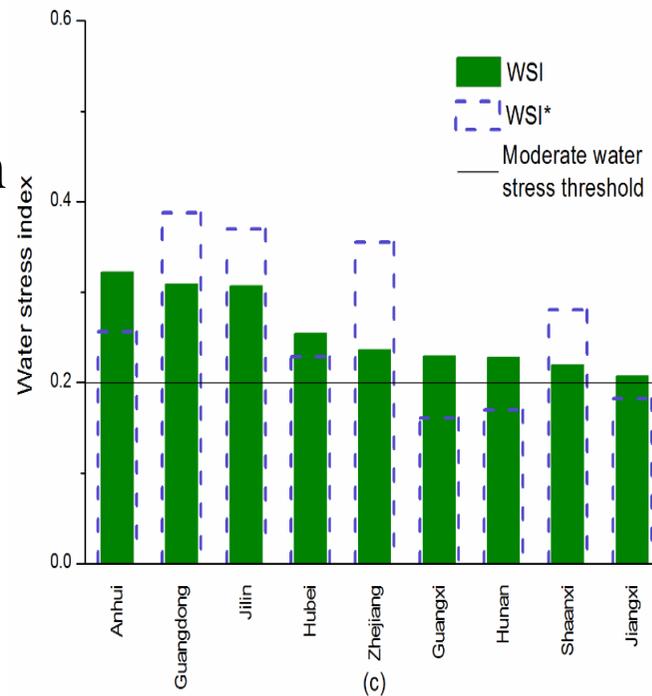
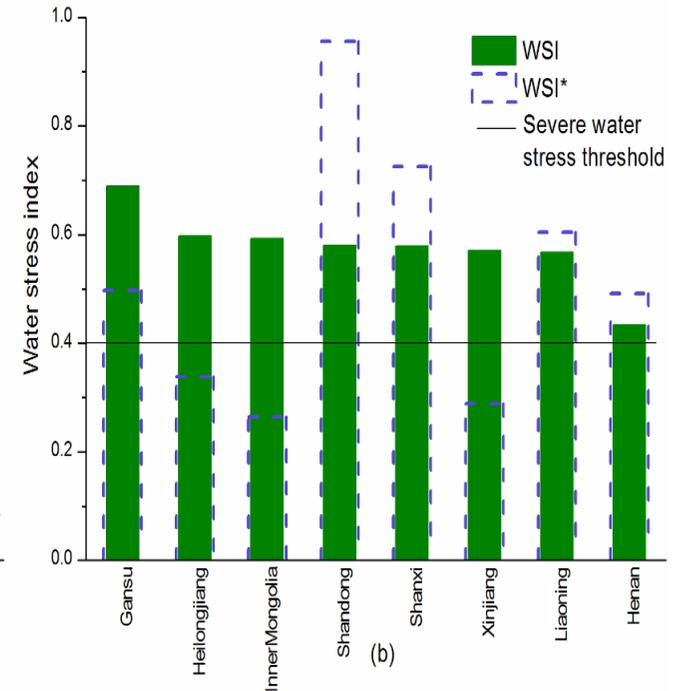
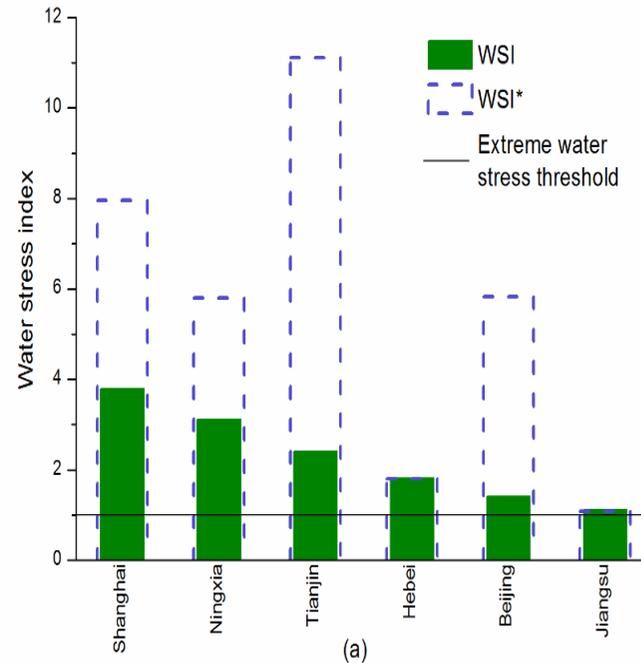


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12 water stressed provinces benefited from net virtual and physical water imports ($WSI^* > WSI$).

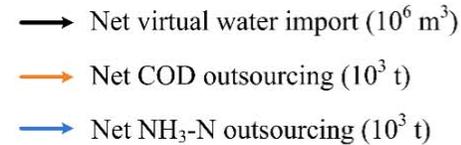
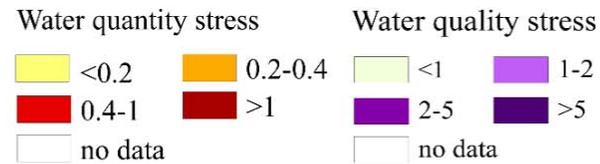
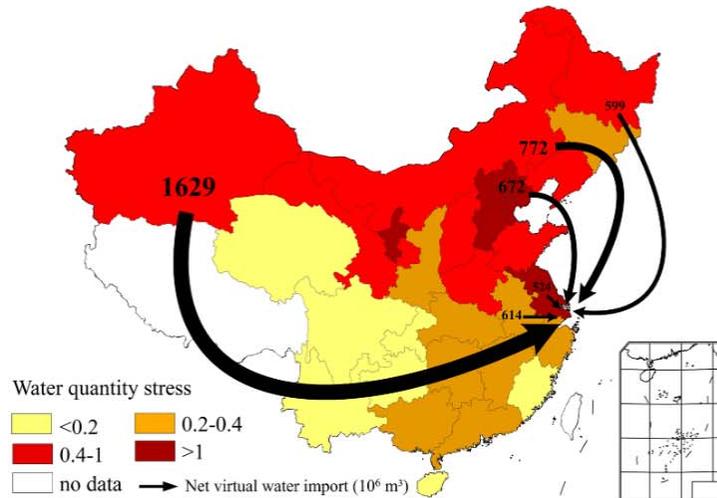
11 water stressed provinces the situation was further compounded through net virtual and physical water exports ($WSI^* < WSI$).

Zhao, Liu* et al., 2015. PNAS 112(4): 1031-1035.

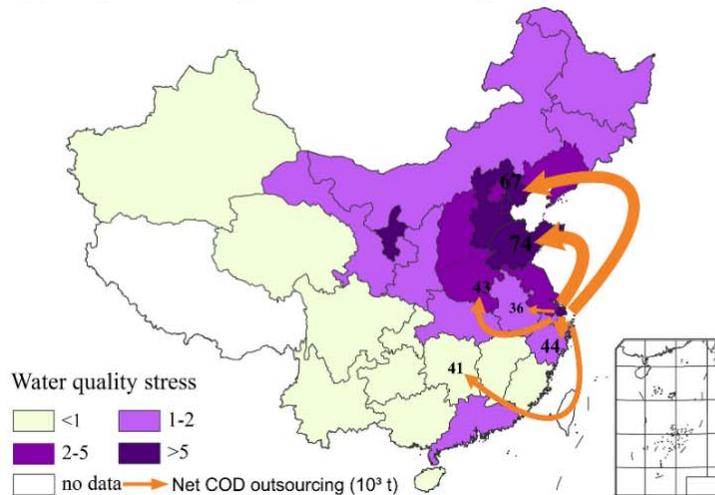


Transfer virtual water, shift real problems

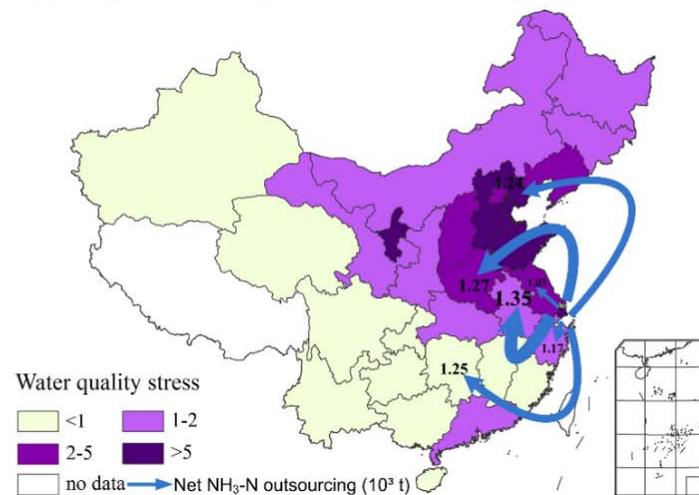
(a) Shanghai's net virtual water import from China's other provinces



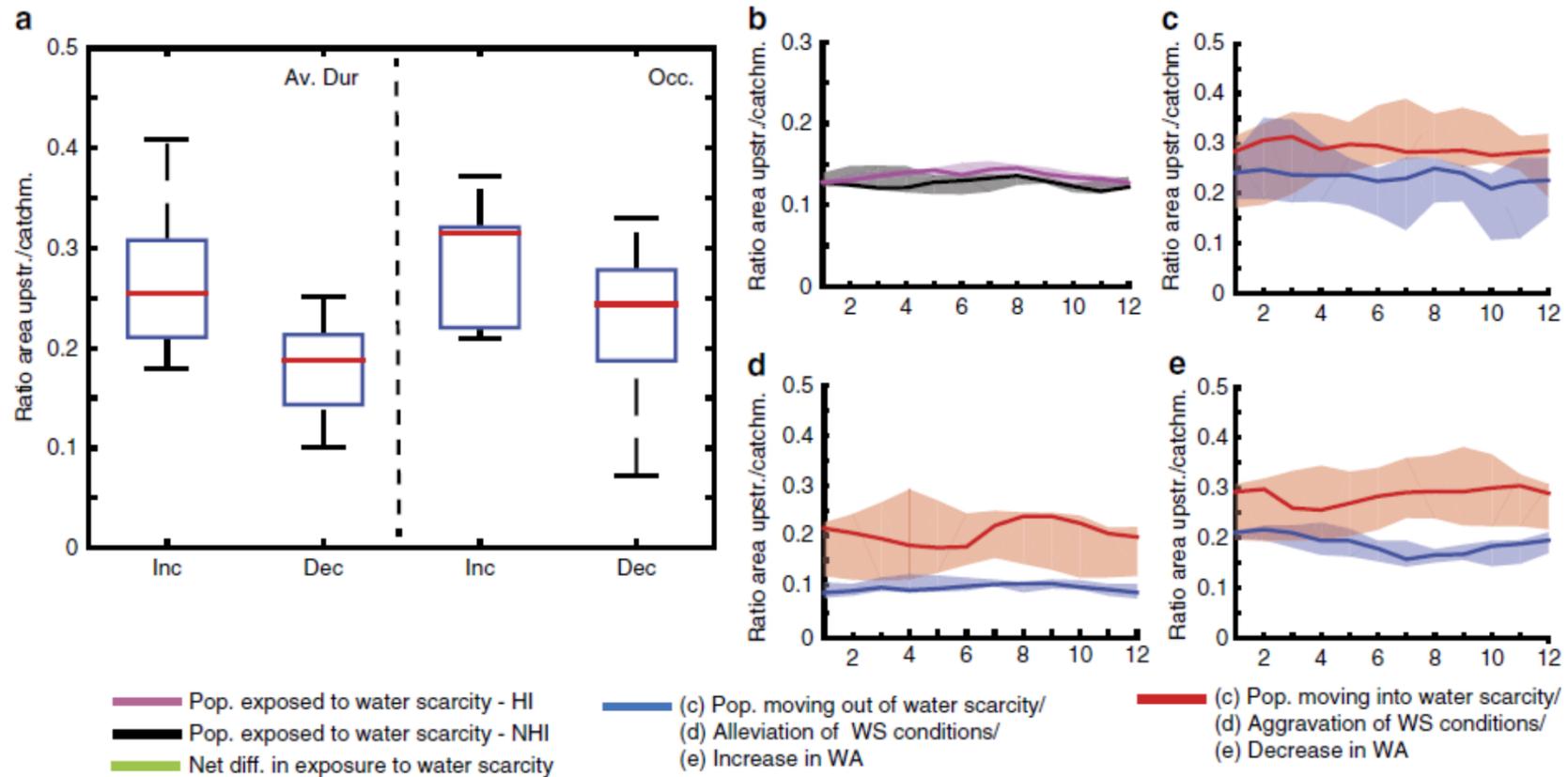
(b) Shanghai's outsourcing COD from China's other provinces



(c) Shanghai's Outsourcing NH₃-N from China's other provinces



Water scarcity problems transfer to downstream



- Human interventions (HI) aggravate water scarcity for 8.8% (7.4–16.5%) of global population, but alleviate it for another 8.3% (6.4–15.8%).
- Positive impacts mostly occur upstream, whereas HI aggravate water scarcity downstream; **HI cause water scarcity to travel downstream.**

Veldkamp et al., 2017, Nature Communications 8:15697

Mitigating water stress through efficiency improvement

Agricultural irrigation efficiency

-Agricultural irrigation efficiency will increase by 23% from 0.48 in 2007 to 0.59 in 2030

-Such efficiency gains will help

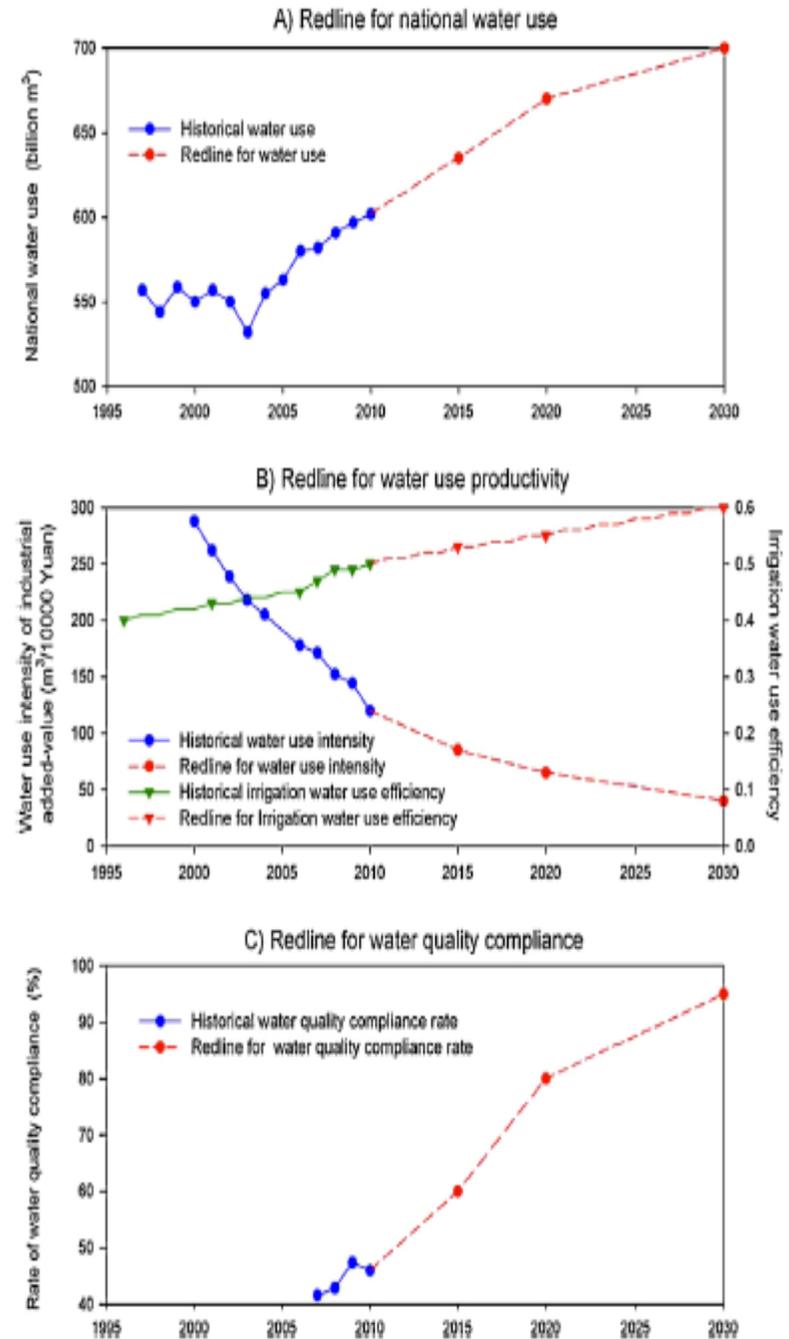
reduce irrigation water demand by 26%

Industrial water intensity

-Industrial water intensity will decrease by 81% from 2.54 m³/thousand CNY in 2007 to 0.48 m³/thousand CNY in 2030

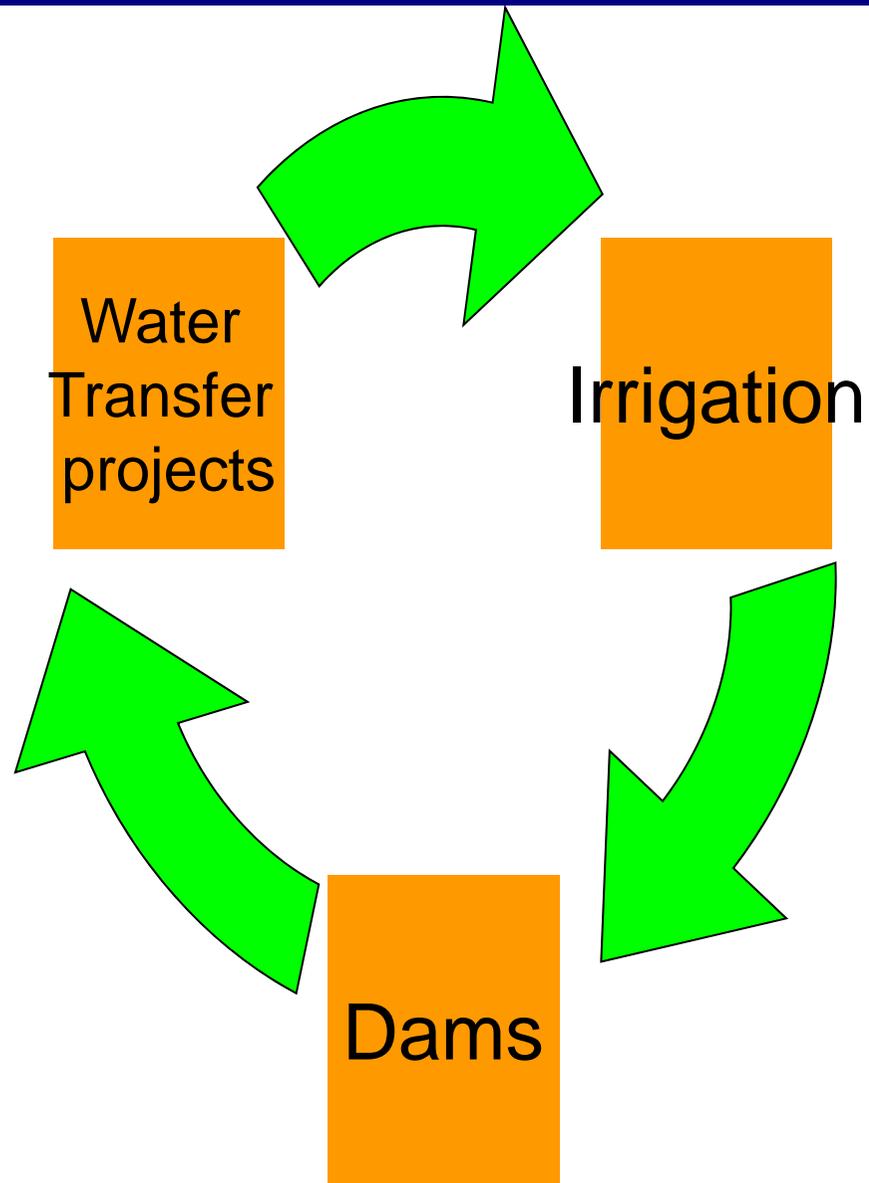
-Efficiency gains in industry would help to **reduce 80% of industrial water demand**

Liu J.* et al., 2013. *Global Environmental Change* 23(3): 633-643.

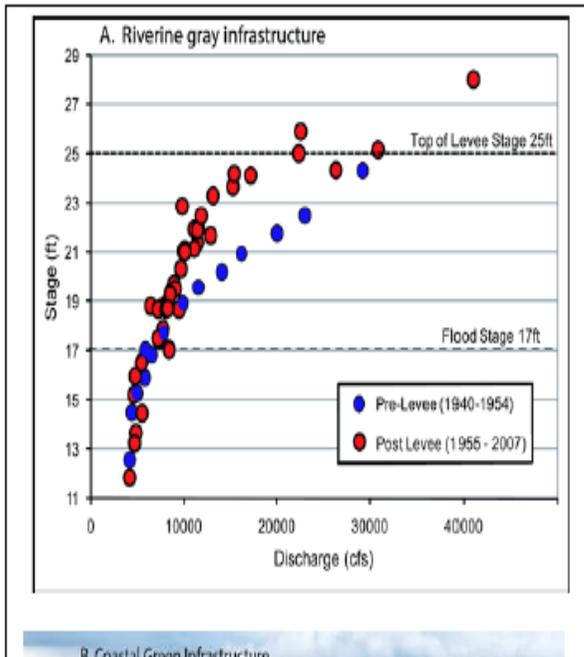


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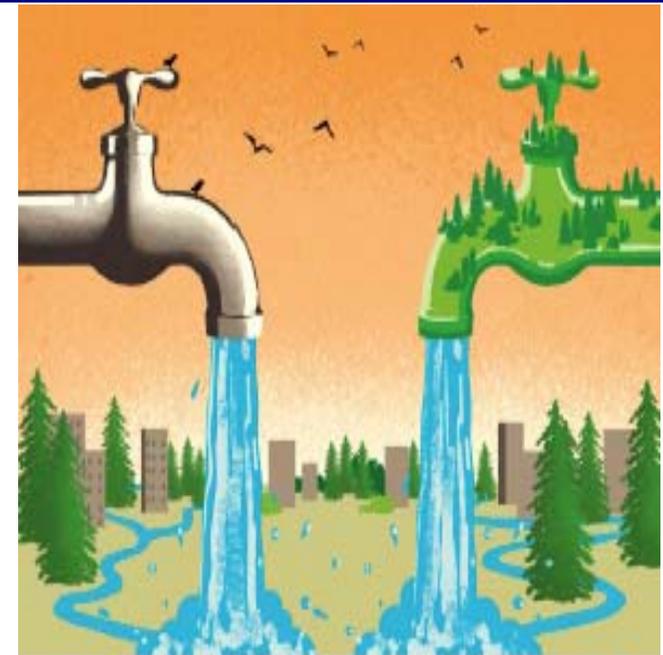
Large-scale hydro-engineering projects for mitigating water scarcity



Building Water Security: the role of natural ecosystems



- Green infrastructure
- Grain to Green Program
- Reforestation/Afforestation
- Ecological restoration
- Wetland protection
- Green roofs
- Low-impact development



WATER

Water security: Gray or green?

Building engineered structures, such as dams and dikes, has been the conventional approach to water management. Some suggest that such “gray” infrastructure make way for “green” ecosystem-based approaches. In this second of three debates, *Science* invited arguments for how these approaches can address the challenge of building the water security of rapidly growing societies worldwide.

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Manage water in a green way

By Margaret A. Palmer,^{1*} Junguo Liu,^{2,3*} John H. Matthews,⁴ Musonda Mumba,⁵ Paolo D’Odorico^{1,6}

conserving coastal sand dunes, coral and/or oyster reefs. Although versatile and has led to wide use of ecological restoration, and combining used (5). In the Netherlands, geomorphological processes that

“Green” infrastructure is more flexible and cost-effective for providing multiple benefits. Supplementing or integrating gray infrastructure with biophysical systems is critical to meeting current and future water needs.

Palmer*, Liu*, et al. 2015. Science 349 (6248):584-585

Take-home Messages

- ❑ Physical water transfer projects are important gray infrastructure, but do not play the most important role in mitigating China's water scarcity
- ❑ Virtual water transfer may shift water problems from one region to other regions
- ❑ Water problems cannot be solved by gray infrastructure alone
- ❑ Integrating gray infrastructure with ecosystem-based green infrastructure is a key to future water security

*“Anybody who can solve the problems of water will be worthy of **two Nobel Prizes**, one for peace and one for science”*

- President J.F. Kennedy



Special Thanks

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*Grey Water Footprint and Water Scarcity Assessment***

Thank you!

Junguo Liu

liu_junguo@163.com.com