Policies and Programmes related to Water-Energy-Food Nexus in China

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Content

1. Importance of water-energy-food nexus

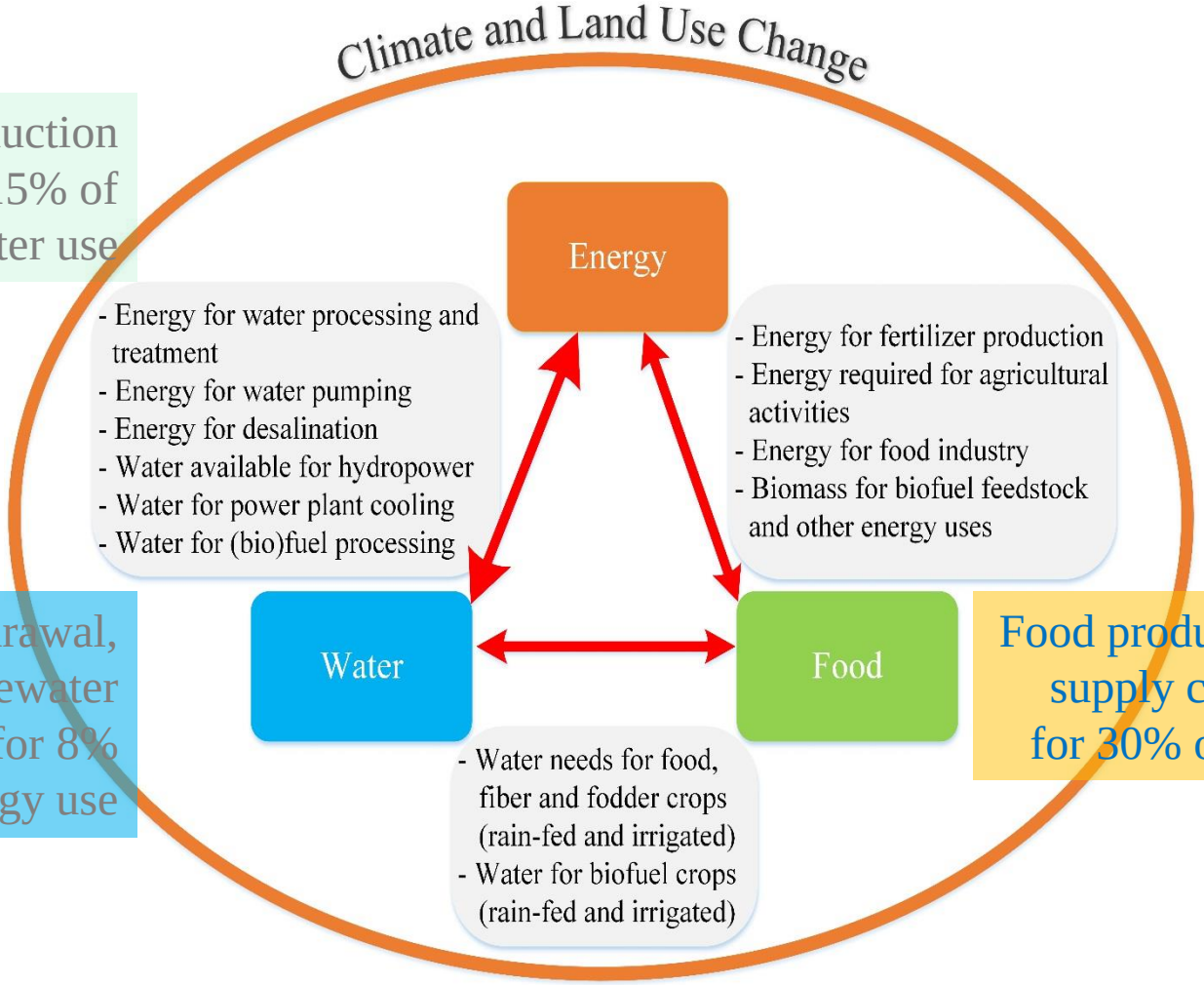
2. Research on China’s water-energy-food nexus

3. Policies and programmes of the WEF nexus

4. Take-home messages

Energy production accounts for 15% of world water use

Water withdrawal, distribution & wastewater treatment account for 8% of world energy use

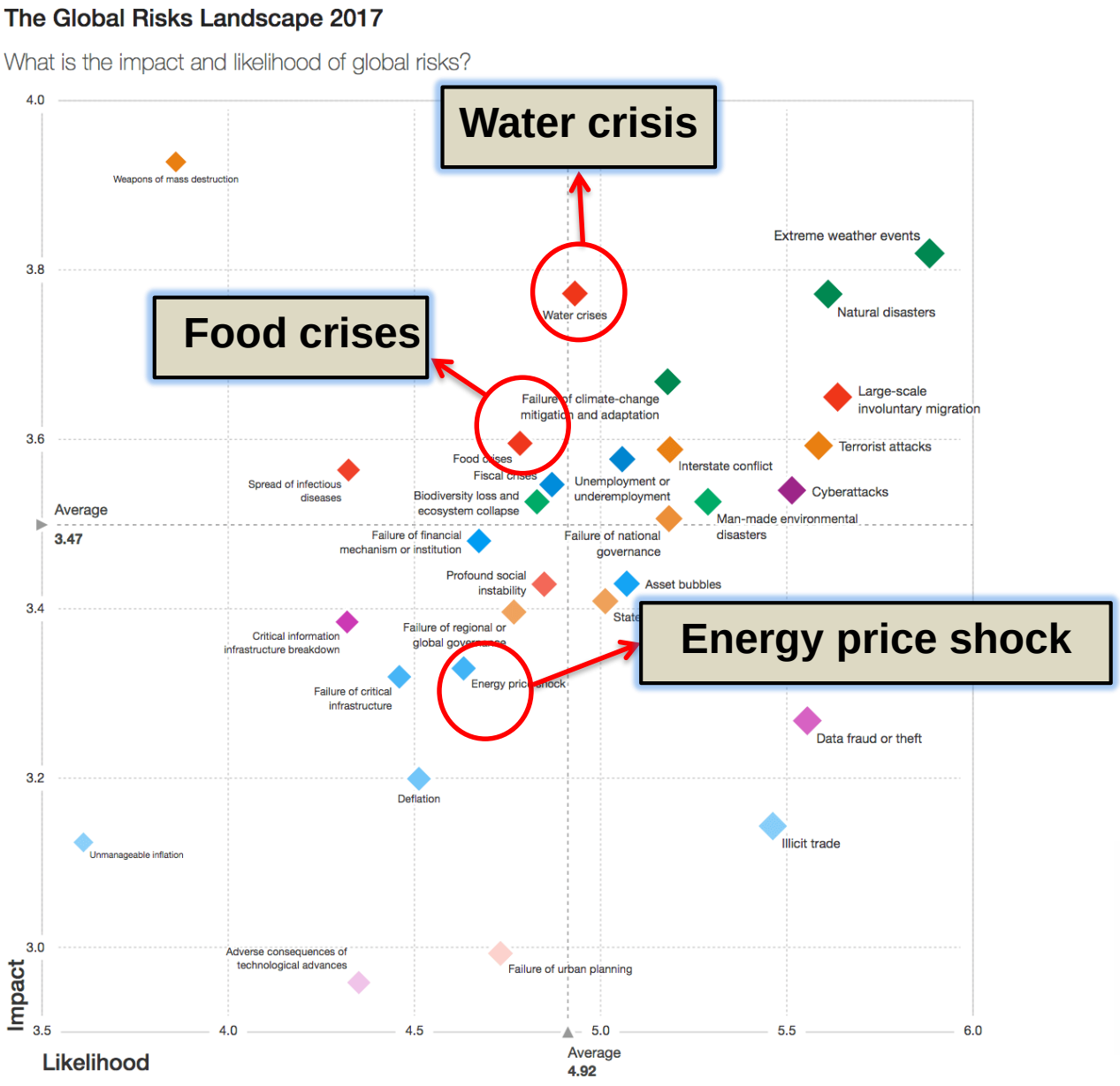


Food production and its supply chain account for 30% of energy use

Agriculture accounts for 70% of water use and 90% of water consumption

Liu J.*, et al.., 2017. *Challenges in Operationalizing the Water-Energy-Food Nexus*, *Hydrological Sciences Journal.*

Global Nexus Risks



Water, Food and Energy

Water security:

- 1.2 billion people live in areas affected by physical water scarcity
- 1.6 billion people live in areas affected by economic water scarcity
- 884 million people lack access to clean water
- Poor quality water in Middle East and North Africa costs from 0.5% to 2.5% of GDP.

Food security:

- 925 million people go hungry
- Around 1 billion people suffer from the 'hidden hunger'
- World population is increasing by 6 million per month
- An extra billion tonnes of cereals will be needed by 2030 (FAO)

Energy security:

- Currently, 1.4 billion people do not have sufficient electricity.
- It is estimated that in 2030 1.2 billion people will still lack access to electricity

Source: FAO (2010) / WEO 2010/UNICEF 2010

2050 – The Challenge

9 Billion People

60% More Food

55% More Water

80% More Energy

Research on China's Water-Energy-Food Nexus

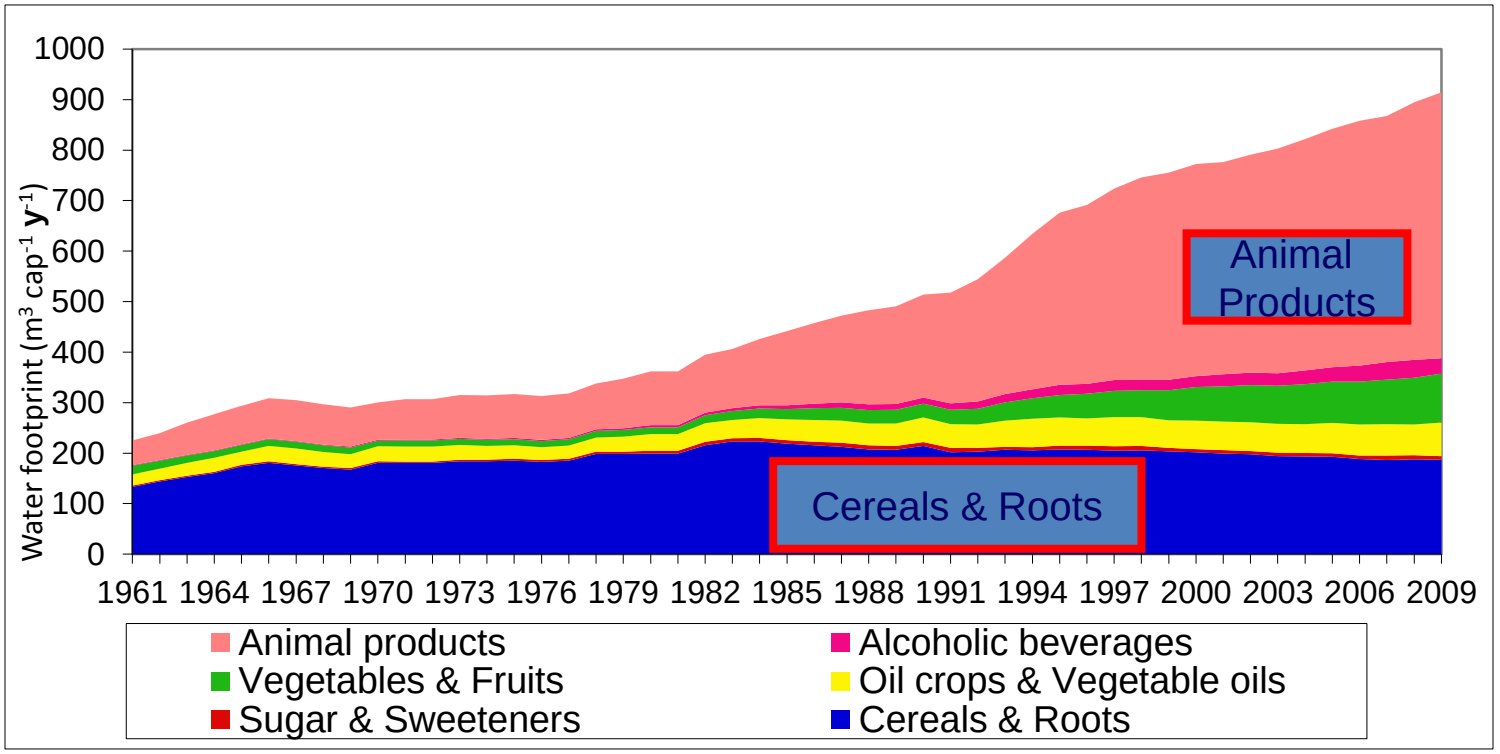
1. Food-induced water (and land) footprint in China

2. Biofuel-induced water (and land) footprint in China

3. Hydropower-induced water footprint in China

4. Coal-induced water footprint in China

Per Capita Water Footprint in China



Changing food-consumption patterns are the main cause of the worsening water scarcity in China (*Liu et al., 2008. Nature*)

Source: Liu and Savenije, 2008. *Hydrology and Earth System Sciences* 12(3): 887-898.

Liu J.*, Yang H., Savenije H.H.G., 2008. *Nature* 454 (7203): 397.

Food losses from field to folk

Food losses and waste in China

19 %
grains lost and wasted in supply chain from field to fork

135 billion
m^3 of water used to produce food not eaten

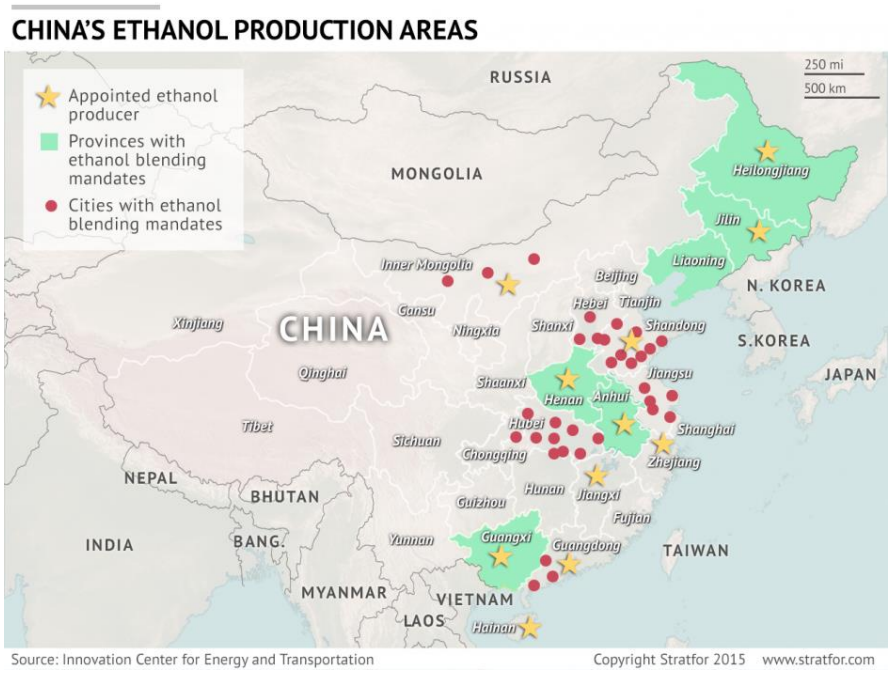
WF of Canada

26 million
hectares of crop-land used in vain

Arable area of Mexico

Liu et al., 2013. *Environmental Science & Technology*. 47(18): 10137-10144

Water and land footprint of biofuel production



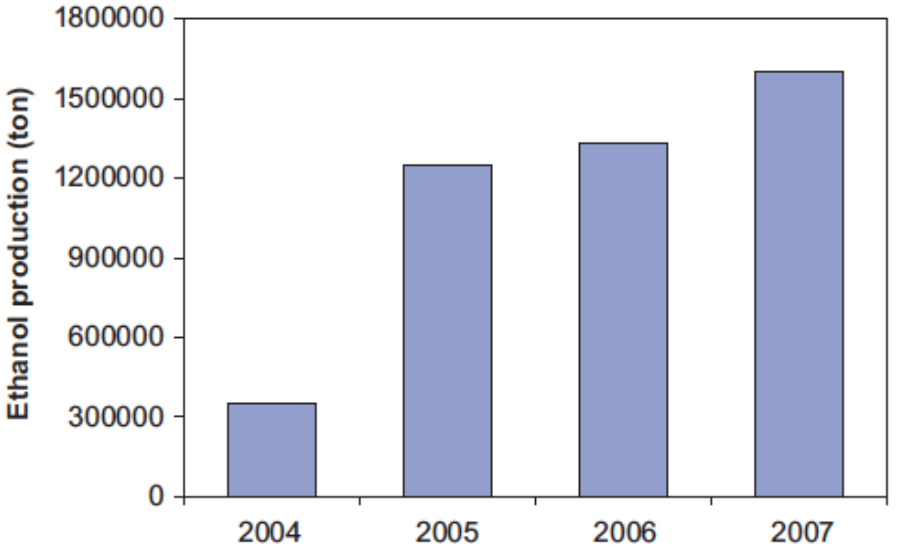


Fig. 1. Bioethanol production in China, 2004–2007. *Source*: Cheng (2007) and Ad Hoc News (2008).

Biofuel type	Feedstock	Feedstock biofuel conversion ratio (kg/kg) (ton/ton)	Crop yield (kg/ha)	CWR (m^3/kg)	Water footprint of biofuel (m^3/L)	Land footprint of biofuel (m^2/L)
Bioethanol	Maize	3	5001	0.84	2.01	4.75
Bioethanol	Cassava	6	16,226	0.55	2.64	2.93
Bioethanol	Sugarcane	15	62,563	0.12	1.47	1.9
Bioethanol	Sugarbeets	14	20,196	0.20	2.24	5.49
Bioethanol	Sweet potato	10	20,968	0.23	1.83	3.78
Biodiesel	Rapeseeds	3.3	1836	2.02	5.82	15.67
Biodiesel	Soybean	5.6	1720	3.20	15.63	28.40

Yang, Zhou and Liu, 2009. *Energy Policy*. 37: 1876-1885

Water and land footprint of biofuel produced in future

Land and water requirements for the production of the targeted biofuel.

Year	Biofuel target	Feedstock crop	Feedstock use (million tons)	Area for biofuel crops (1000 ha)	% of total crop area	Total water requirement (km^3)
2010	2 million tons of ethanol	Maize	6	1112	0.72	5.1
		Cassava	12	735	0.47	6.7
		Sugarcane	30	477	0.31	3.7
		Sugarbeet	28	979	0.63	5.7
	0.2 million ton Biodiesel	Soybean	1.2	686	0.44	3.8
		Rapeseed	0.66	361	0.23	1.3
2020	10 million tons of ethanol	Maize	30	5562	3.59	25.3
		Cassava	60	3676	2.37	33.3
		Sugarcane	150	2387	1.54	18.6
		Sugarbeet	140	4897	3.16	28.3
	2 million tons of biodiesel	Soybean	12	6857	4.42	38.4
		Rapeseed	6.6	3607	2.33	13.3

The projection on land and water requirements of biofuel suggests that to meet the biofuel targets for 2020, between 5% and 10% of the total cultivated land and between 32 and 72 km^3/year of water would be needed, depending on the feedstocks used. Given the extremely small per capita arable land in China, it is very difficult to spare this amount of land from currently cultivated land for feedstocks. The associated water requirement further lowers the possibility because much of the northern land already endures serious water shortage.

Yang, Zhou and Liu, 2009. *Energy Policy*. 37: 1876-1885

We were the very few scholars that first question the sustainability of first-generation biofuel development.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生物燃料乙醇生产与消费面临重要机遇

——国家乙醇汽油推广领导小组特邀顾问乔映宾教授访谈

本报记者 傅玥雯

《中国能源报》（2014年12月08日 第14版）

编者按

生物燃料乙醇产业，并非新鲜事物，因提倡消化陈化粮而起，并随着推广被赋予新的方向。2002年6月，八部委制定下发了《车用乙醇汽油推广试点方案》和《车用乙醇汽油使用试点工作实施细则》，在河南郑州、洛阳、南阳和黑龙江哈尔滨、肇东等5个城市开展了为期一年的车用乙醇汽油使用试点工作。自2004年国家决定进一步扩大乙醇汽油推广试点起，目前我国已是继美国、巴西之后世界第三大乙醇汽油生产和使用国。

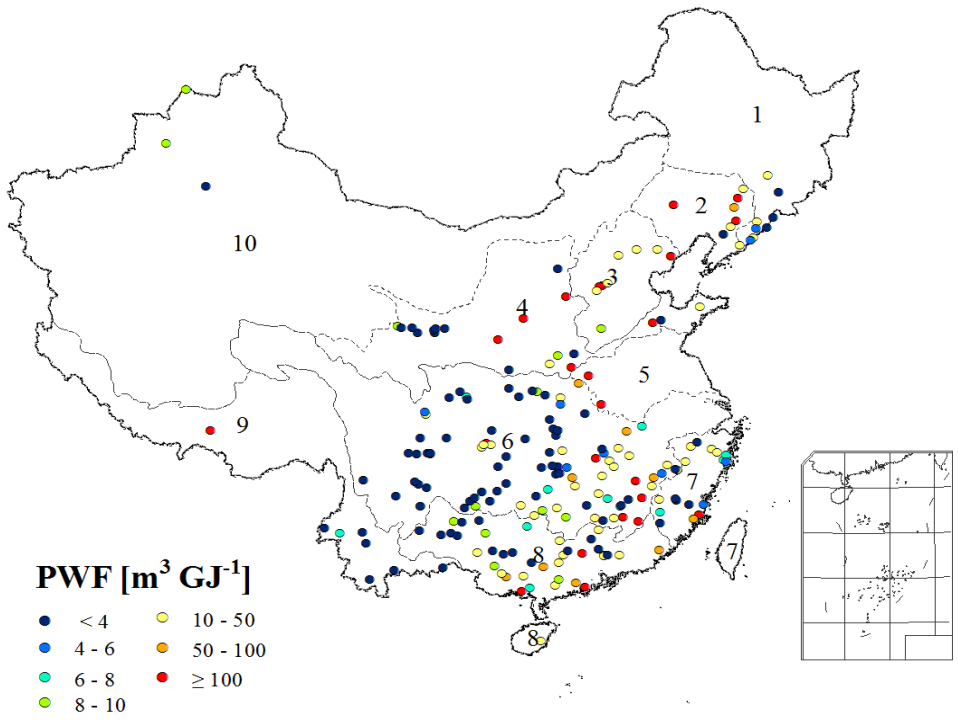
随着燃料乙醇汽油的推广，我国提出了“限制一代（粮食原料）、鼓励1.5代（甜高粱茎秆、木薯非粮原料）、推进二代（纤维素原料）”的生物燃料乙醇产业发展路线，对此，本报记者专访国家乙醇汽油推广领导小组特邀顾问乔映宾教授，介绍我国生物燃料乙醇的推广的现状以及生物燃料乙醇产业面临重要的发展机遇。

大气污染防治重点区域应大力发展、

封闭推广乙醇汽油

中国能源报：据了解，国家正在研究制定《生物燃料乙醇产业发展政策》中可能会进一步明确继续坚持“核准生产、定向流通、封闭运行、有序发展”的基本原则，将鼓励京津冀等大气污染防治重点区域推广使用乙醇汽油。对此你如何看待？

Water footprint of hydropower



209 hydropower plants

- China's hydroelectric WF totaled 6.6 Gm^3 yr^{-1} in 2010. This was about 24% of the reservoir WF
- Average hydroelectric product water footprint (PWF) of 3.6 m^3 GJ^{-1}
- Hydropower resources are concentrated in western regions, where PWF is low; but energy demand is dominant in eastern regions with a high PWF.

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

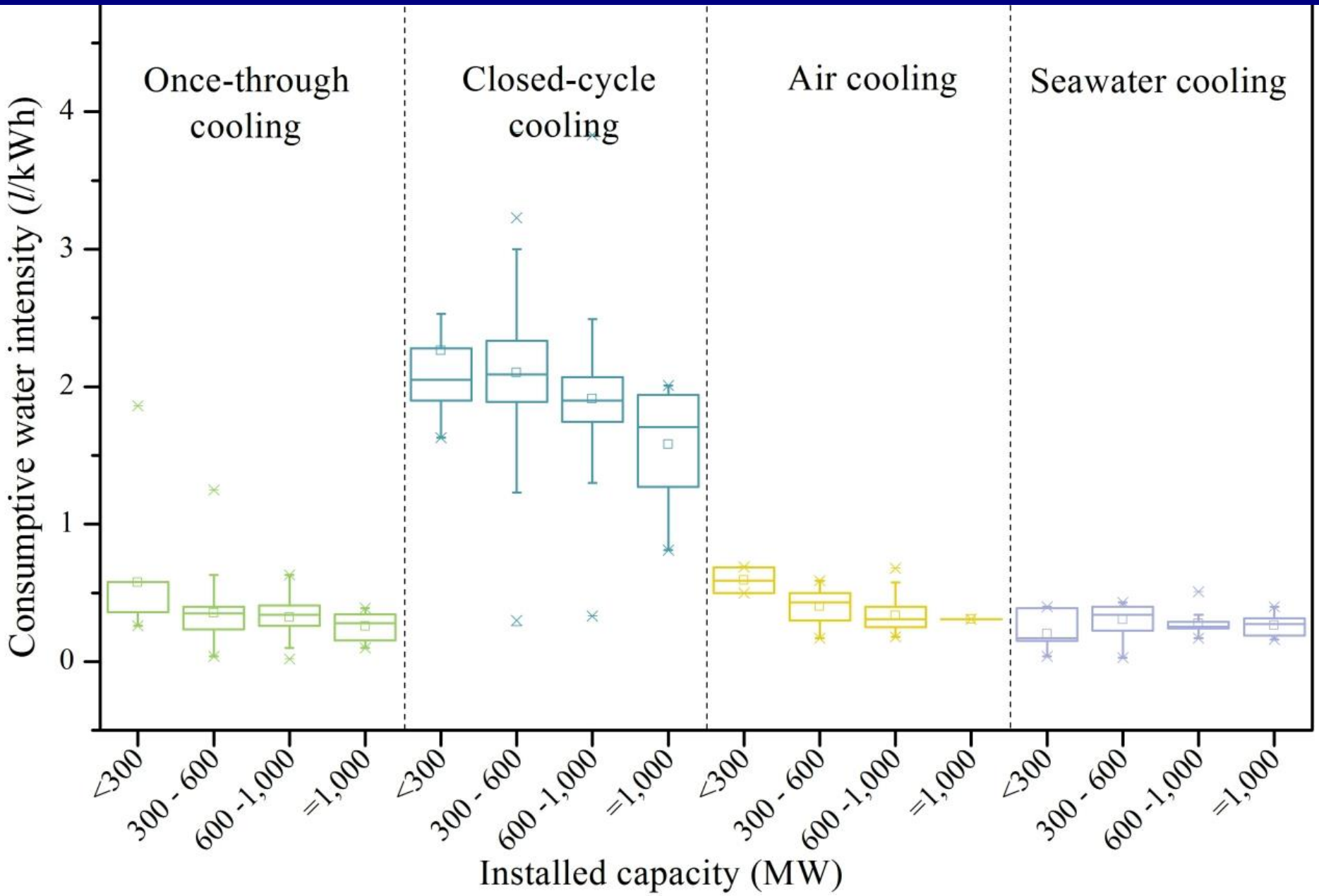
Water footprint of energy carrier

Energy carrier	Process	Blue water footprint ($m^3/10^{12}$ J)
Wind energy	Construction, erection and operation of the turbines	0.0[a]
Coal	Surface mining	2-5[a]
	Deep mining	3-20[a]
	Benefication	4[b]
	Slurry pipeline	40-85[b]
	Other plant operation	90[b]
	Mining, benefication, slurry pipeline and other plant operations	*136-199*
Oil	Onshore oil extraction and production	3-8[a]
	Oil refining	25-65[a]
	Other plant operations	70[a]
	Onshore oil extraction and production, oil refining and other plant operations	*98-143*
Natural gas	Processing	6[a]
	Pipeline operation	3[a]
	Plant operation	100[a]

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

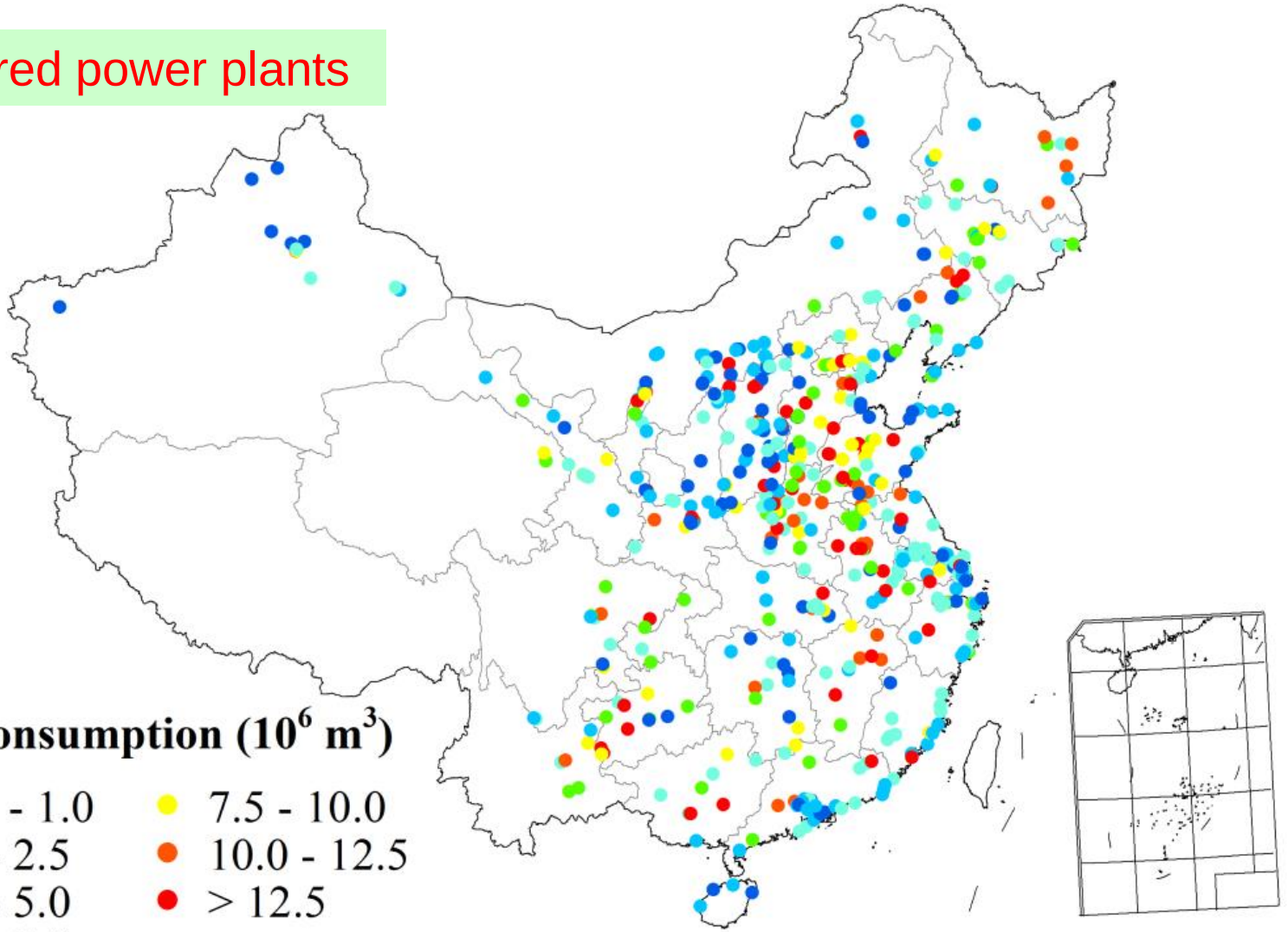
- The Chinese national average hydroelectric PWF of 3.6 $m^3\ GJ^{-1}$ (3600 $m^3/10^{12}$ J) is higher than that of most other technologies
- PWF of wind energy and underground uranium mining is negligible
- Water footprint of electricity from solar energy, coal-fired and nuclear thermal energy is generally far below 1.0 $m^3\ GJ^{-1}$
- Hydropower is not an efficient solution to energy supply from a water consumption perspective

Water Footprint of China's Coal-fired Power Plants



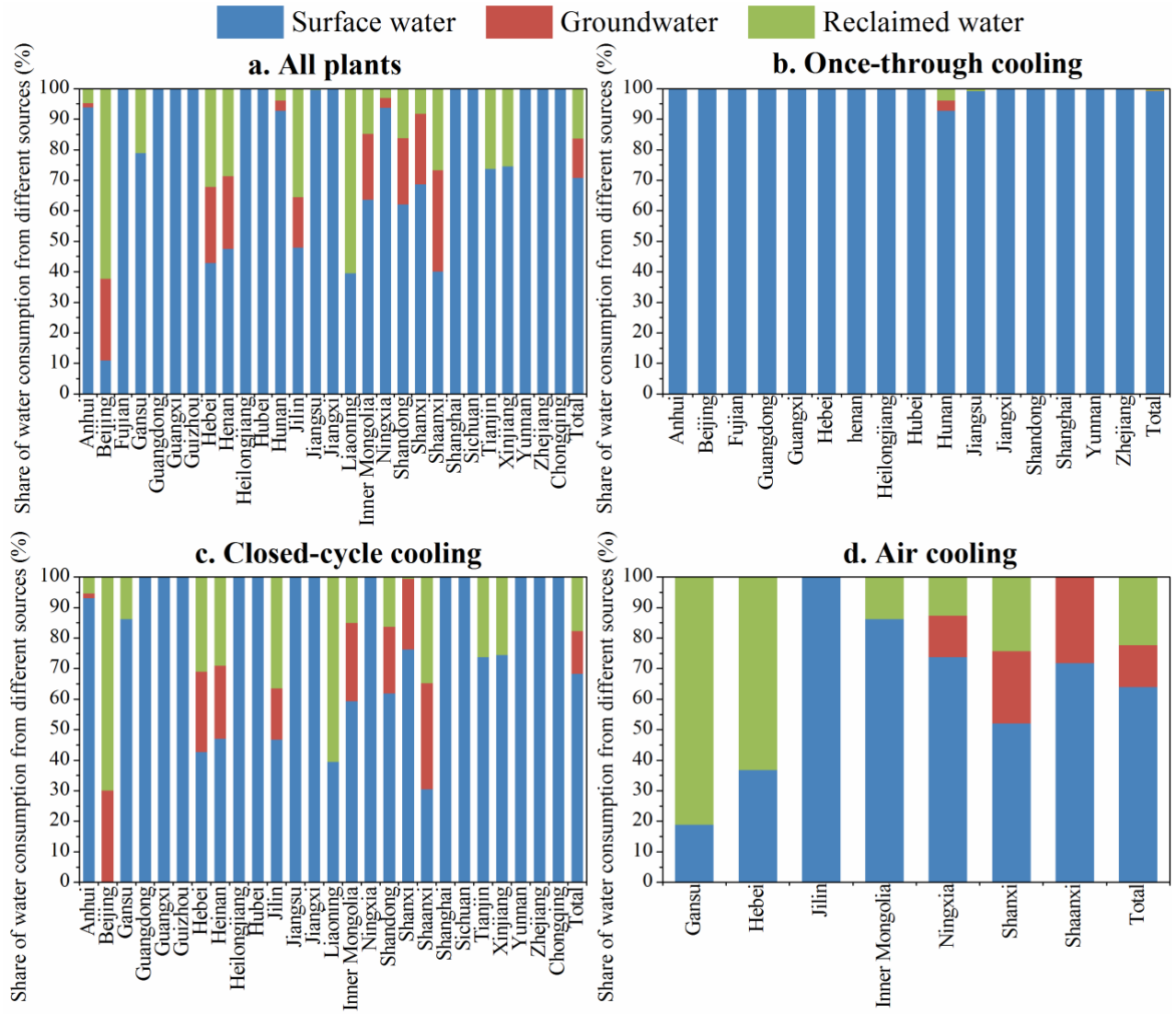
Water Footprint of China's Coal-fired Power Plants

621 coal-fired power plants



Zhang, Liu* et al., 2017. *Journal of Cleaner Production* 10.1016/j.jclepro.2017.04.040

Water Footprint of China's Coal-fired Power Plants



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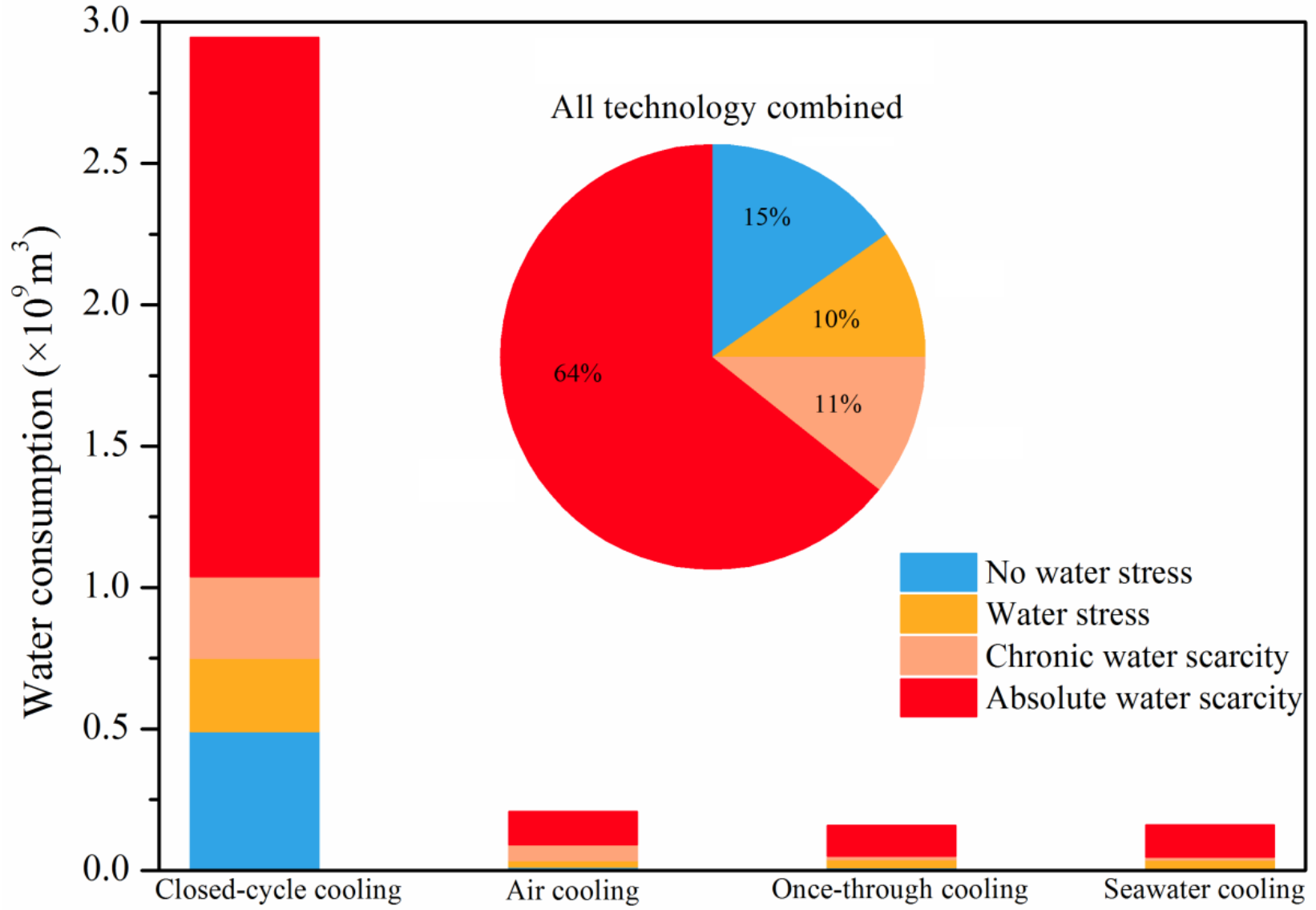
Water Footprint of China's Coal-fired Power Plants



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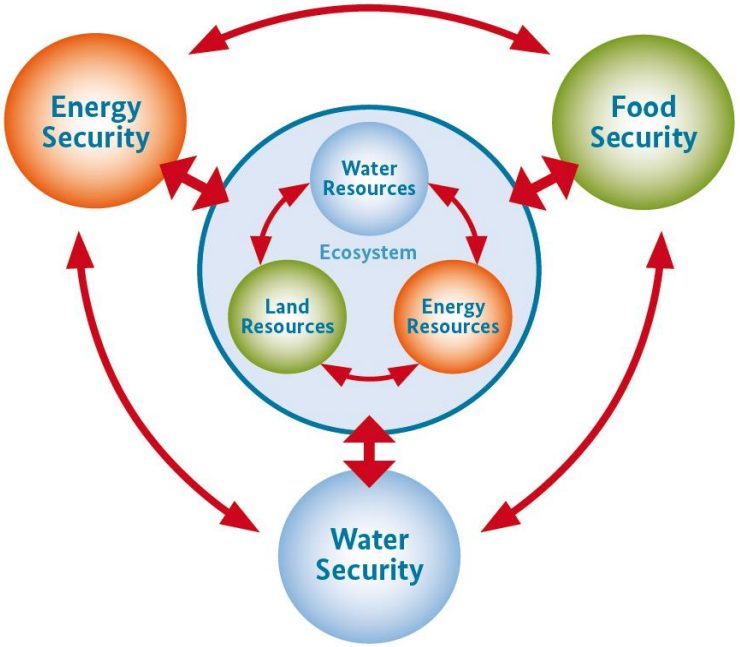
Policies and Programs related to WEF Nexus in China



Water Policies

Policy	Issuing Org/Year	Main content	Relation with energy and agriculture
Decision on Accelerating Water Conservancy Reform and Development (2011 *No.1 Document*)	State Council/ 2011	- Three ‘‘redlines’’ to control national water use, water use efficiency and water pollution	- Setting quantitative goals for agricultural & industrial sectors
Opinions on Implementing the most Stringent Water Resources Management	State Council/ 2012	Setting quantitative goals of three ‘‘redlines’’ for 2020 and 2030.	- Setting quantitative goals for agricultural & industrial sectors
Water Pollution Prevention and Control Action Plan (“Water Ten”)	State Council/ 2015	10 general measures for water pollution prevention and control	- Strict regulations for oil refineries; electro-plating; agriculture food production & sing
The 13th Five-Ye on Building a Water-Saving Society	MWR, MHURD/ 2017	water-saving society in the 13th five-year plan period (2016–2020)	targets for agriculture, coal sector and coal-fired electricity

Water policies are closely relevant to water uses in agriculture and energy sectors

Energy Policies

Policy	Issuing Org/Year	Main content	Relation with water and agriculture
The 13th Five-Year Plan for Electricity Power Development (2016-2030)	NDRC, NEA/ 2016	Setting quantitative development goals for different types of electricity for 2016-2020	Hydropower increased from 2.97 * 10^8 kW in 2015 to 3.4 * 10^8 kW in 2020
The 13th Five-Year Plan on energy development	NEA/ 2017	A set of 2020 targets covering everything related to energy development	Targets for hydro energy installed capacity
Energy production and consumption transition strategy (2016	NDRC, NEA/	Set quantitative goals for energy	- Water use efficiency reaching global advanced level in y 2020 on and nsidering carrying capacity of water - Hydropower development

Energy policies are closely relevant to hydropower development and water use efficiency

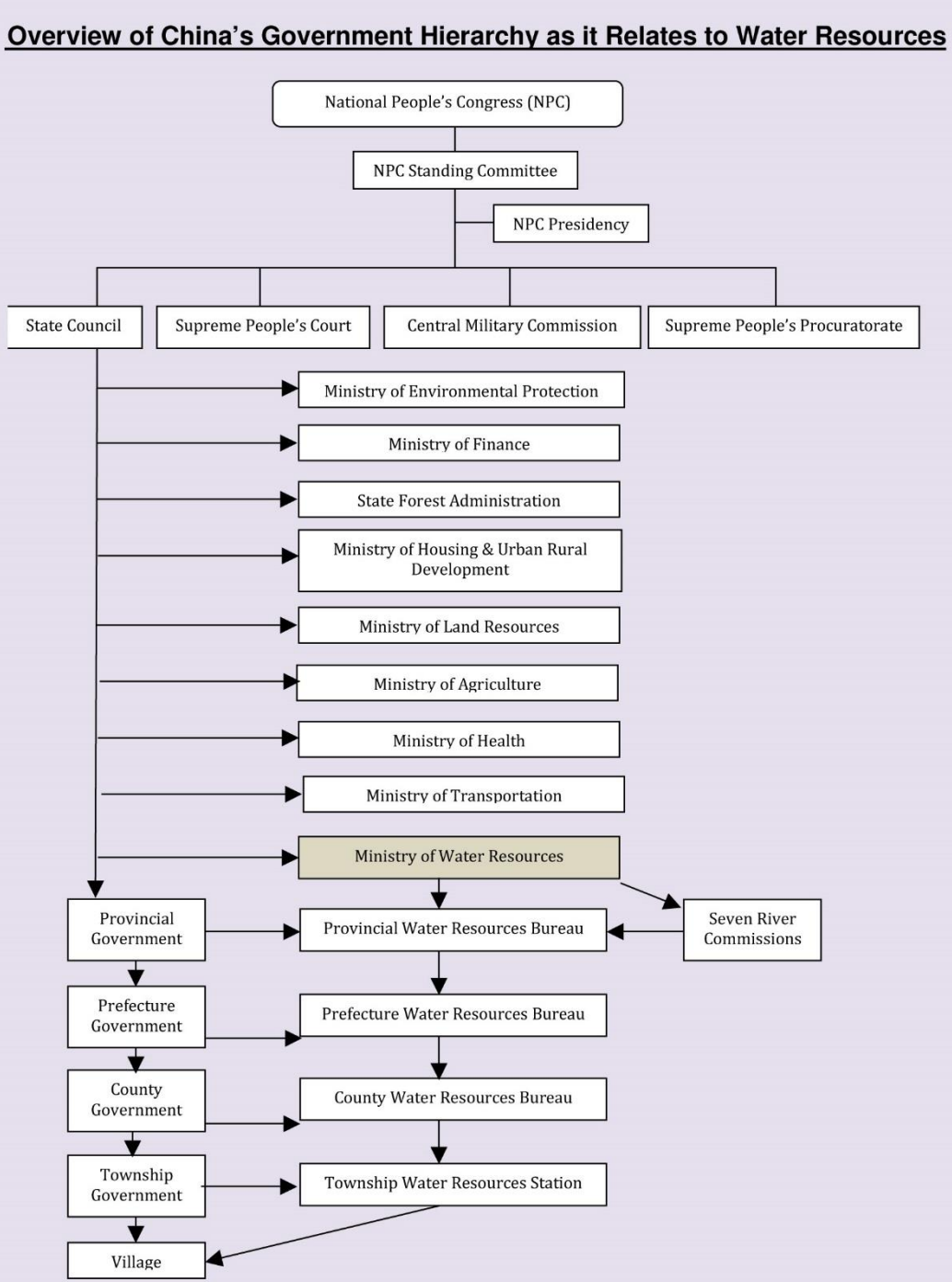
Agriculture Policies

Policy	Issuing Org/Year	Main content	Relation with water and energy
National Sustainable Agricultural Development Plan (2015- 2030)	MoA, NDRC, MOST, MOF, MLR, et./2015	Guide for sustainable agricultural development in the future	Quantitative targets for irrigation water use, water-saving irrigation
No.1 Central Document 2016	State Council /2016	Apply new concept of development to agricultural modernization	- Advancing agricultural irrigation system. - Tackling the priority environmental problems.
National Plan for Agricultural Modernization (2016-2020).	State Council /2016	By 2020, make notable progress in agricultural modernization	Coordinated development of regional agriculture by considering water resources; Save water and use it efficiently
The 13th Five-Year for Agricultural and Rural Economic Development		rural economic development plan	rigation water use

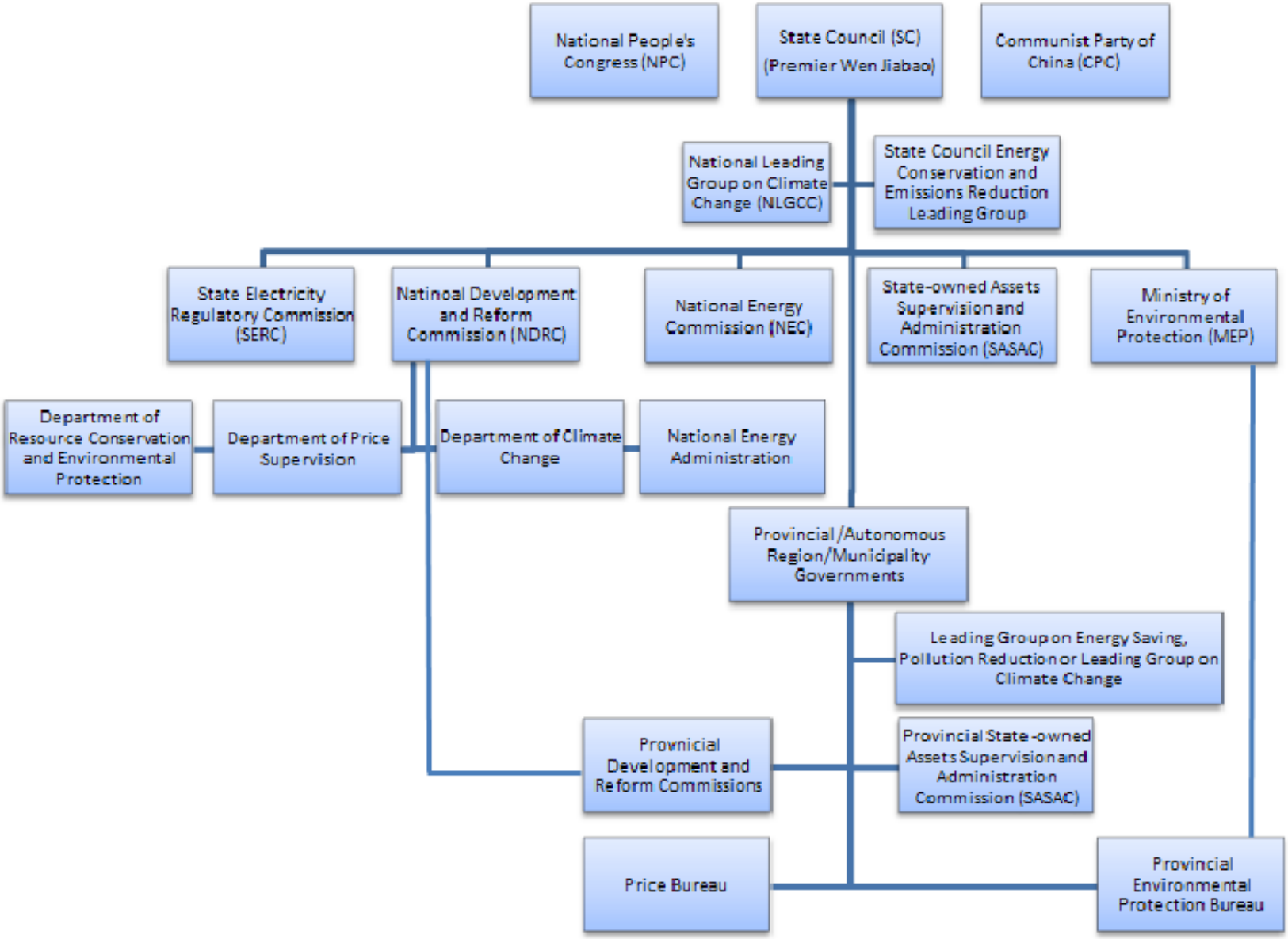
Agricultural policies are closely relevant to Irrigation and water use

Nine Dragons Manage Water

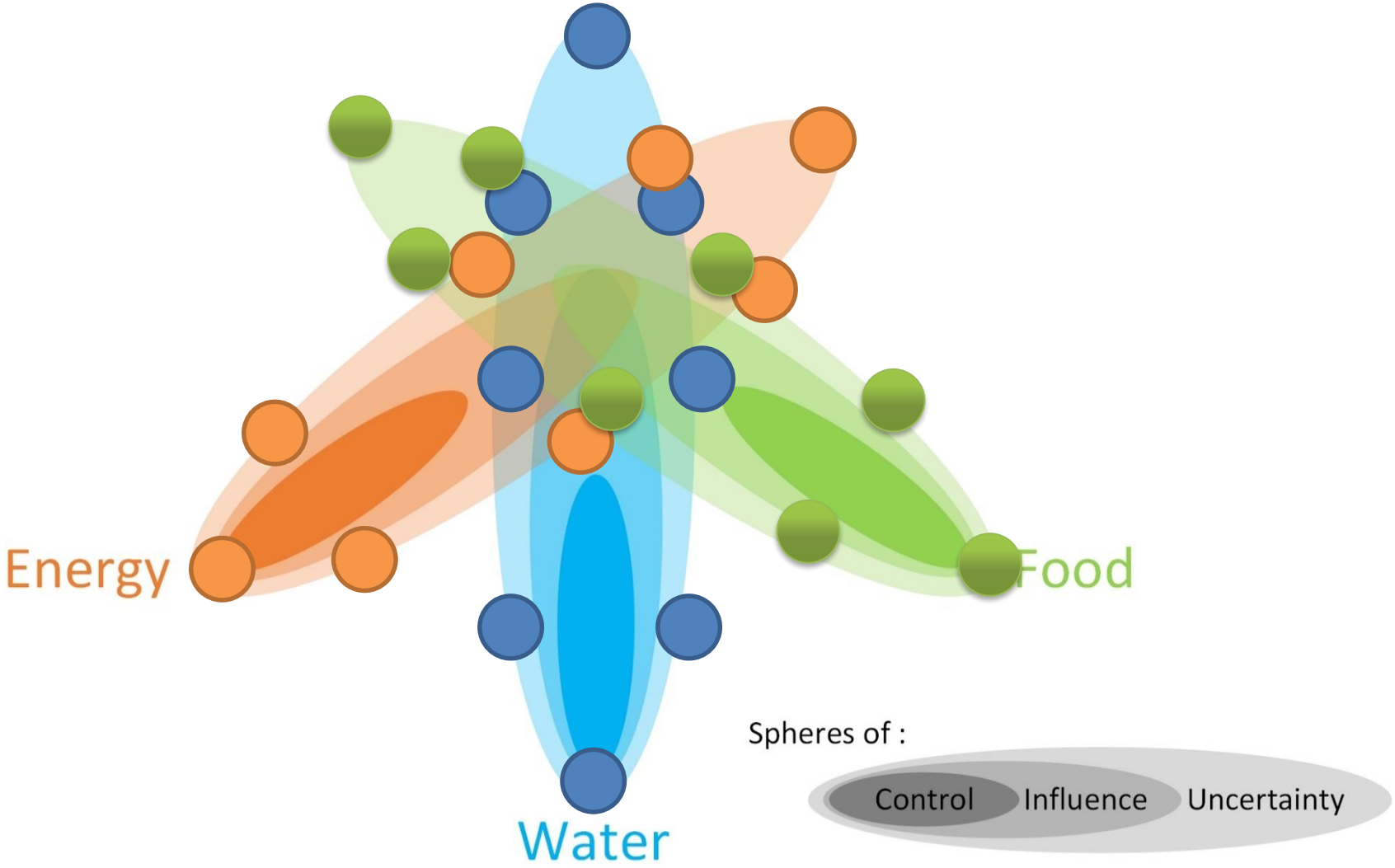
http://chinawaterrisk.org/wp-content/uploads/2011/04/DiagramA21.jpg



Multiple Sectors Manage Energy



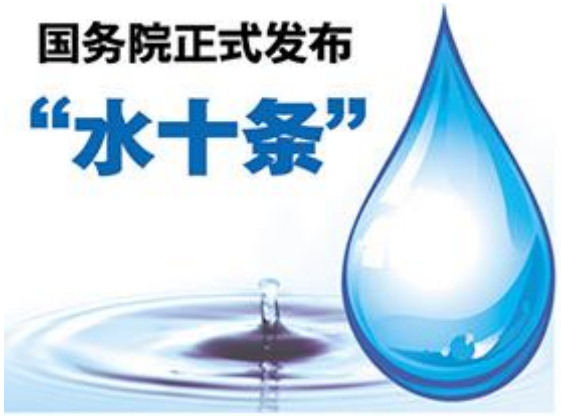
Tsang and Kolk, 2010. Environmental Policy and Governance



Water, energy and food are all managed by multiple sectors; which sectors will mange the nexus, and how?

Towards coordination among sectors

- *Water Ten Plan* is result of **coordination & inputs from over 12 ministries and government departments**, including Ministry of Environment Protection, National Development & Reform Commission, Ministry of Water Resources, and Ministry of Agriculture.
- The plan sets out 10 general measures which can be broken down to 38 sub-measures with **deadlines with responsible government departments** identified for each action.



WEF Programmes in China (Cont)

Year	Organization	Programmes	Highlights
2011	National Energy Administration (NEA)	Research on the main factors of energy development	Water resource is regarded as an important factor of both energy production and consumption
2012-2013	Greenpeace; CAS	Joint research on assessing water consumption of coal-fired electricity	Water demand for coal-fired power generation in west of China would exceed supply capacity by 2015
2013	Beijing Forestry University	Food losses and waste and their implication for water and land	Total water footprint related to food losses in China was equivalent to WF of Canada. Such losses imply land area equivalent to arable land of Mexico were used in vain
2013 - 2014	U.S.- China Framework for the Ten-Year Cooperation on Energy and Environment	China and U.S. sign an eco-partnership agreement	Cooperation in clean water field; Learn lessons for water pollution control and treatment to promote groundwater conservation and sustainable environment

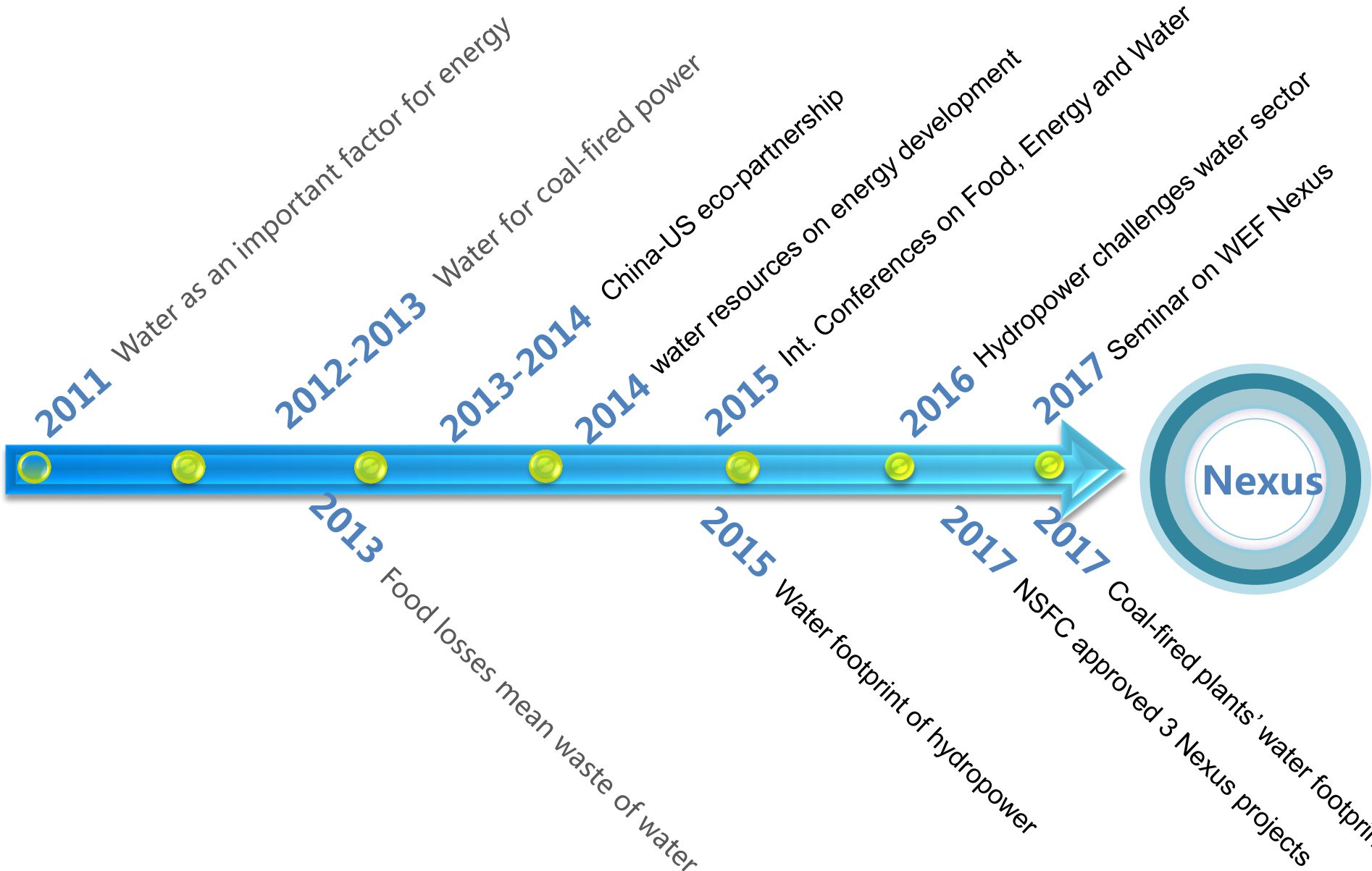
WEF Programmes in China (Cont)

Year	Organization	Programmes	Highlights
2014	China Institute of Water Resources and Hydropower Research	Investigating the influences of water resources on energy exploitation and use	- Assess the water resources capability of China's major energy basements - Water use and supply is a priority for energy industry
2015	Peking University and New York Institute of Technology	Int. Conferences on Sustainable Megacities: Food, Energy, Water, and the Built Environment	Focus on deepening understanding of relationship between water and energy
2015	Beijing Forestry University	Water footprint of hydroelectric power for Three Gorges Reservoirs	A new approach to quantify WF of hydropower by separating it from reservoir WF using an allocation coefficient

WEF Programmes in China (Cont)

Year	Organization	Programmes	Highlights
2016	Southern University of Science and Technology	China's rising hydropower demand challenges water sector	The WF of hydroelectricity was quantified based on data of 209 power plants. Energy policy imposes pressure on freshwater resources.
2017	Shandong University etc.	Seminar on Energy-Food-Water Nexus Security and China's Mitigation	Make efforts in synergy mitigation towards the WEF resource crisis from the nexus perspective
2017	Southern University of Science and Technology	China's fired power plants impose pressure on water resources	Water consumption of coal-fired power plants (CPPs) is 11% of total industrial water consumption. ~75% of water consumption of CPPs was from regions with absolute or chronic water scarcity.
2017	National Natural Science Foundation of China (NSFC)	Approve 3 China-US Network Projects on Water-Energy-Food Nexus	Scientists collaboration on WEF Nexus

WEF Programmes in China (Cont)



Challenges in operationalizing the water-energy-food nexus

by **J. Liu**, H. Yang, C. Cudennec, A.K. Gain, H. Hoff, R. Lawford, J. Qi, L. de Strasser, P.T. Yillia, C. Zheng

Main Points:

- There remain many challenges in scientific research on the water-energy-food (WEF) nexus, while implementation as a management tool is just beginning;
- The scientific challenges are primarily related to data, information and knowledge gaps in our understanding of the WEF interlinkages.
- Our ability to untangle the WEF nexus is also limited by the lack of systematic tools that could address all the trade-offs involved in the nexus.
- Future research needs to strengthen the pool of information. It is also important to develop integrated software platforms and tools for systematic analysis of the WEF nexus.

IAHS Scientific Decade opinion paper series

Liu* et al., 2017. *Hydrological Research Journal* In press

Nexus Initiative: Special Issue

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Call for Papers: Special Issue on "Energy-Water-Food Nexus"

With continuous population increase and economic growth, challenges on securing sufficient energy, water, and food supplies to meet the demand are also amplifying. The close linkages of the three sectors give rise to the need for tackling the challenges with a nexus approach. Information shared and interpreted jointly between these three sectors is important for better understanding the complicity of the energy-water-food (E-W-F) nexus and taking integrated approaches for their management. Studies and discussions on the issues relating to concept, research framework, technology innovations, and policy implementation of the nexus are needed to facilitate this understanding. In addition, governance and climate change can guide the development of innovations and policies in the energy, water and food sectors, hence, are important aspects in the

Special issue on "Energy-Water-Food Nexus"

Editor(s): Liu J., Hoekstra A.J., Wang H., Wang J., Zheng C., van Vliet M.T.H. Wu M.

China-US Nexus Network

NSFC-NSF Approved 3 Proposals on Food-Energy-Water Nexus Research Network

2017年度国家自然科学基金委员会与美国国家科学基金会 “食品、能源、水”系统关联合作网络项目指南

This project aims to build up a research network of Food-Energy-Water (FEW) nexus between China and the United States (U.S.), and integrate an array of systems analyses and modeling approaches from domains such as hydrology, agriculture, energy, climate and environmental science.

- University of Texas at Austin (UTA)
- University of Maryland (UM)
- Harvard University (Harvard)
- University of California, Irvine (UCI)
- Sandia National Laboratories (SNL)

- SUSTech
- Peking University (PKU)
- China Institute of Water Resources and Hydropower Research (IWHR)
- IGSNRR, CAS

Take-home Messages

- Water, energy and food are **closely linked and interacted**. A nexus approach is needed for research and management
- China has implemented many policies on water, energy and food, and **water is always an important issue** for each sector
- The **triangle water-energy-food nexus** has not been widely studies
- The nexus approach is **difficult to implement** due to lack of close coordination among sectors
- A **dynamic and systematic resource management** is expected to avoid “solos” in policies. **Stakeholder dialogue** across sectors helps implement nexus approach

Thank You

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