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China's water resources vulnerability:
A spatio-temporal analysis during 2003-2013

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Background

Table 1 Composite index approach for VAWR in China

Index Name	Weighing scheme	Component	Indicator Name	Equation	Data	Value interpretation
Water resources vulnerability index (WRVI)	$WRVI = \frac{WSc + \frac{WSt + SDWA}{2} + WPo + \frac{W\,\mathrm{Pr} + ISA}{2}}{4}$	Resources stress	Water scarcity (WSc)	$\begin{cases} WSc = \frac{1700 - WRP}{1700} (WRP \le 1700) \\ WSc = 0 (WRP > 1700) \end{cases}$	*	0-1 [0, 0.2) : Low [0.2, 0.4) : Moderate [0.4, 0.7) : High [0.7, 1] : Severe
			Water stress (WSt)	$WSt = \frac{WSu}{WR}$	*	
		Development pressure	Safe drinking water accessibility (SDWA)	$SDWA = 1 - \frac{P_\alpha}{P}$	**	
		Ecosystem health	Water pollution (WPo)	$\begin{cases} WPo = \frac{\frac{WW}{WR}}{0.1} (WW < 0.1 \times WR) \\ WPo = 1 (WW \ge 0.1 \times WR) \end{cases}$	*	
		Management capacity	Water productivity (WPr)	$\begin{cases} W\,\mathrm{Pr} = \frac{40 - GDPWW}{40} (GDPWW \le 40) \\ W\,\mathrm{Pr} = 0 (GDPWW > 40) \end{cases}$	*	
			Improved sanitation accessibility (ISA)	$ISA = 1 - \frac{P_\beta}{P}$	**	

Acronym interpretation: WRP – annual per capita water resources (m^3/person); WSu –annual total water supply (m^3); WR – annual total water resources (m^3); P – annual total population (person); P_α – annual total population with access to improved water sources or water supply (person); WW – annual total wastewater discharge (m^3); GDPWW - annual gross domestic product (GDP) in constant prices divided by annual total water withdrawal (US dollars/m^3); $GDPWW_G$ - the global average WP (US dollars/m^3); P_β - annual total population with access to improved sanitation facility (person); * – National Bureau of Statistics of China (2004; 2005; 2006; 2007; 2008; 2009; 2010; 2011; 2012; 2013; 2014); ** – Ministry of Public Health of China (2004; 2005; 2006; 2007; 2008; 2009; 2010; 2011; 2012) and National Health and Family Planning Commission of China (2013; 2014).

Challenges

➢Due to the grave situation of China's water environment and aquatic ecosystems, it is of prime importance to understand the present situation of China's water resources vulnerability, and how this situation has evolved on the basis of the historical changes of its dynamic socioeconomic development.

➢There is a pressing need for an analysis of vulnerability assessment of water resources (VAWR) in China with a sufficiently high spatio-temporal resolution.

Objective

➢To conduct a comprehensive, multidisciplinary, and comparable spatio-temporal analysis of VAWR in China during 2003-2013, using a composite index approach with a broad array of aspects highlighting key challenges to China's water resources system.

Methodology

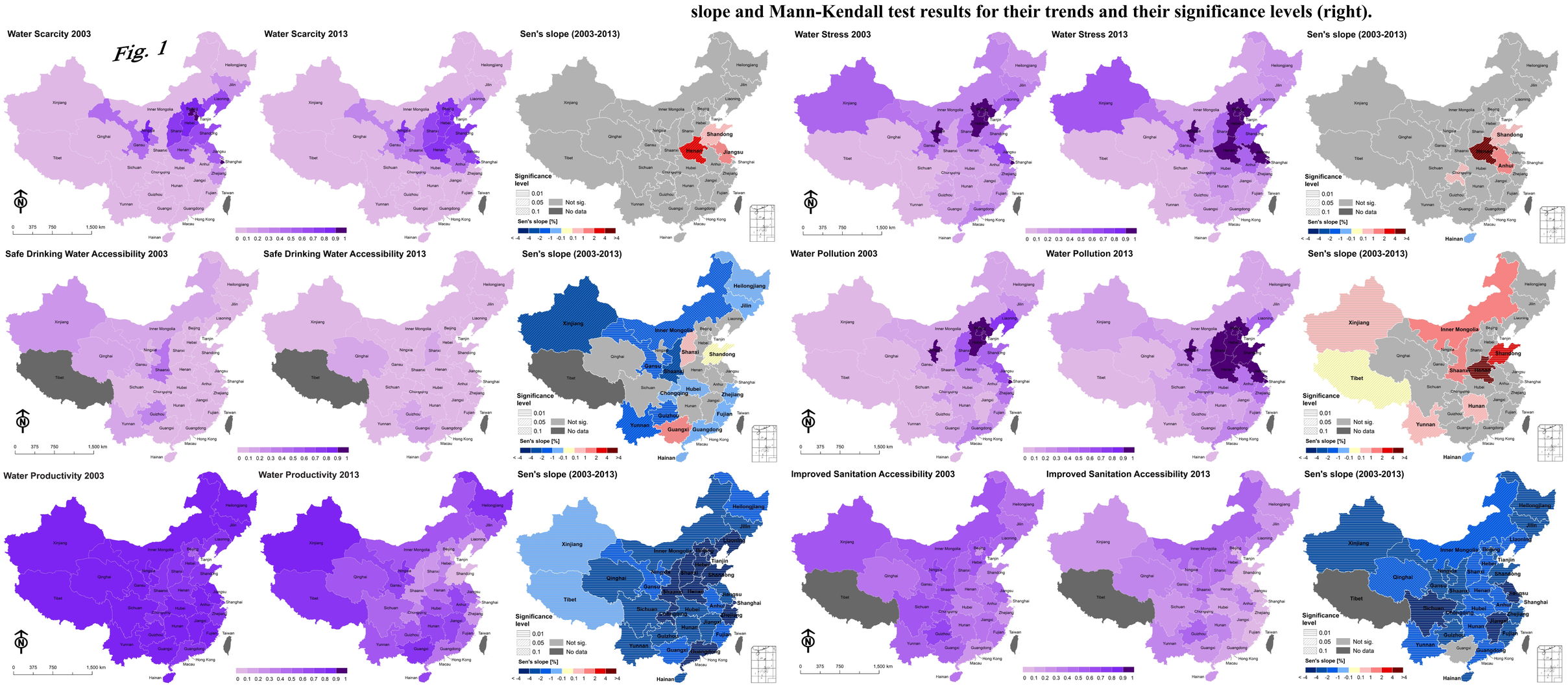
➢The methodology of VAWR developed by Huang & Cai (2009) prioritized the key issues of IWRM and was designed to use Millennium-Development-Goals-relevant indicators for quantifying water resources vulnerability to environmental change at different scales (Table 1).

➢It has been widely used in Asia to evaluate the interactions between socioeconomic and administrative challenges as well as correspondingly the coping capacity of its water resources system.

Results

Fig. 1

Figures Indicator (1) and index (2) results for China's provinces in 2003 (left) and 2013 (middle) as well as Sen's slope and Mann-Kendall test results for their trends and their significance levels (right).



Spatial analysis

➢The water resources system in the North and Central Coasts was more vulnerable than that in Western China.

Temporal analysis

➢Water scarcity and water stress have kept worsening in some of the most stressed areas, Henan having the most alarming development. In most of other parts of China, not much change has taken place.

➢A very positive development can be observed in the development of sanitation coverage almost invariably throughout China. Large parts of the country also exhibit positive development of water supply coverage, particularly in less advanced parts of China where there has been more space for improvement.

➢Water pollution has still been worsening in around half of the surface area of China. The negative trend can be observed in many water-stressed areas.

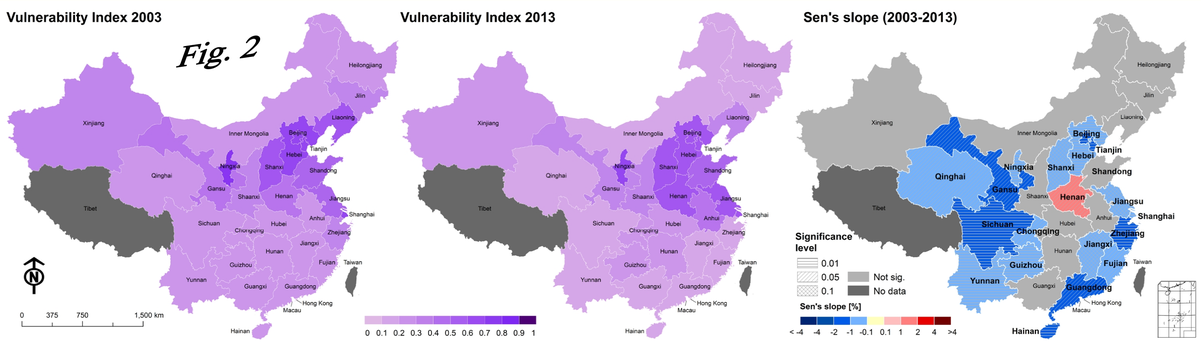
➢Water productivity has undergone an improvement across China. Particularly notable is the development in most of the economically advanced areas. This is obviously partly due to changing economic structure with rapidly developing tertiary industries and the diminishing role of water-thirsty primary industries. The development is thus partly a consequence of the evolution of the China's economy to be less dependent on water and may be only to a limited extent due to water sector-related factors.

Conclusion

➢The key challenges to China's water resources system are not only rooted in the geographical mismatch between socioeconomic development (e.g. water demand) and water resources endowments (e.g. water resources availability), but also stem from the intertwining of socioeconomic development and national strategic policy making.

➢This would require all the efforts from central and local governments, non-government investors, enterprises, universities and research institutions, as well as the public to overcome the contemporary socioeconomic and administrative challenges.

Fig. 2



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