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Viewpoint

Economic Transformation, Technological Innovation, and Policy and Institutional Reforms Hold Keys to Relieving China's Water Shortages

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Although China ranks sixth in total water resources (2.8 trillion m^3) in the world, with a population of 1.3 billion the country's annual per capita renewable freshwater availability (less than 2200 m^3) is only a quarter of the world's average. The spatial distribution of water resources shows a significant mismatch with that of water demand, while large intra- and interannual variability makes effective utilization of water resources difficult, particularly in the more arid north China (*1*). The increasing water demand brought by fast industrial and economic development, population growth, and rapid urbanization, combined with deteriorating water quality, have significantly intensified the water shortages in China.

Balancing the limited supply of freshwater resources among various uses supporting agricultural activities, industrial production, and domestic consumption, as well as protecting the natural environment and ecosystems is a daunting challenge. The constraint of water resources on China's future development and sustainability is further exacerbated by global climate change, which is expected to significantly impact the availability, and the quality and quantity of the accessible water (*2*). Figure 1 shows the water consumption per capita as a function of gross domestic product (GDP) per capita in China since 1949. With the rise in per capita GDP, agricultural water use first increased and then declined after reaching a plateau. Such relationship, known as the Kuznets curve, is not observed for industrial and domestic water uses yet, although total water consumption per capita has stabilized in recent years.

The current water abstraction per capita is less than a quarter of the renewable freshwater availability in China, but further water abstraction is increasingly more difficult and expensive (*3*). Furthermore, irreversible environmental damage may result if the water abstraction exceeds the ecological threshold. China's population will peak at 1.6 billion by 2030, lowering the annual per capita renewable freshwater availability to only 1760 m^3 (*1*). It is clear that water demand brought by increasing population and productivity will not be met if the current practices and levels of water use efficiency were to continue. We believe that the long-run relief to China's water shortages comes from the transformation from extensive to intensive economic growth, innovation in water-saving and treatment technologies, and reforms of policy and institutional framework toward sustainable water resources management. In addition, public

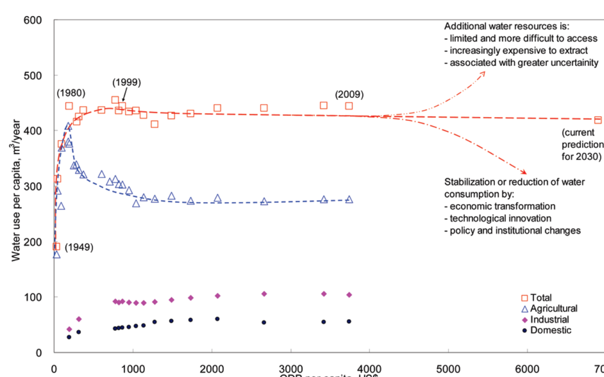

FIGURE 1. Water use Kuznets curve for China: 1949–2009. Driven by the competition from increasing demands from industrial and domestic uses, irrigation water consumption has declined without compromising agricultural output over the last three decades. Industrial and domestic water uses can also decrease with proper economic, technological, and policy drivers.

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awareness and activism can help better conserve water resources and increase water use efficiency.

Despite the increased water demand over the past three decades, continued economic growth, particularly transformation from extensive to intensive growth, could actually reduce abstraction of water resources. Some developed countries have stabilized or even reduced per capita (and total) water abstractions since the late 1980s while gross national product (GNP) rose (*4*). China has built a strong manufacturing economy based largely on an extensive growth model, yet the enormous and rapid industrialization was achieved at the expenses of resource depletion and environmental degradation. China is stepping up the efforts to develop a high-value-added and service-based economy, with the ultimate goal of building a knowledge economy. Such transformation enables China to increase productivity while reducing the stress on the environment and natural resources, including water. In addition, continued economic growth provides the economic wherewithal to develop and implement water-saving and treatment technologies, and to afford policy and institutional changes.

Innovation in technologies can help agricultural, industrial, and municipal sectors cut their water demands. Technological improvements in irrigation methods reduce agricultural water use; new technologies can lower the water requirement of industrial production; and water-saving devices can cut domestic water use. More effective, lower-cost, less energy-consuming water and wastewater treatment technologies can improve the quality of water supply, and promote water reuse and recycling as well. Technological innovation driven by the increasing water demand and open market competition can lead to better use of the water resources through conservation, reuse, and recycling, and more water efficiency services (*1*).

China's water resources policies and management practices have been primarily supply driven and engineering based (*3*), with intensive efforts placed on capturing a greater percentage of available surface water and increasing total water storage (*1*). They largely ignored the economic nature of water resources and aggravated the natural water shortages (*3*). An integrated and efficient institutional system and an effective administrative mechanism can greatly improve water resources management and water pollution control nationwide. Reforming the water pricing policy and developing the institutional capacity to implement full cost accounting and pricing can reshape future water demands through encouraging water conservation and water use efficiency (*5*). Improved legal and policy framework of water rights and better institutional arrangements on water rights trade are expected to lead to effective and efficient allocation of water resources (*3*), and to boost innovation, diffusion, and adoption of water-saving technologies as well (*5*). Overall, switching from supply management to demand management, primarily through controlling water use, reducing wasteful water consumption, and increasing use efficiency, will allow China to meet the water demands from agricultural, industrial, and domestic uses without exhausting the supply capacity.

Each individual can take part in the national effort of protecting and conserving water resources in China. Enhanced awareness of the water shortages by the general public can facilitate the adoption of water-saving devices in homes, factories, businesses, and commercial premises, and increase the acceptance of water reuse and recycling. Environmental education and activism in China can help to reduce water consumption across all sectors.

Restrained by the availability of water resources, China's economic growth is already decoupled from water consumption to a certain degree (Figure 1). The future water demand is set by water resources availability, economic transformation, technological innovation, and policy and institutional changes. The current GDP per capita in China is very low compared to that of developed countries (less than one-tenth that of the United States), and there is a long way for China's economy to catch up. The pressure on water resources will continue to mount from productivity and population increases. The combination of economic, technological, and policy drivers holds the key to coping with water shortages while maintaining socio-economic development in the long-run.

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