www.water-alternatives.org Volume 13 | Issue 1
Chen, D.; Luo, Z.; Webber, M.; Rogers, S.; Rutherfurd, I.; Wang, M.; Finlayson, B.; Jiang, M.; Shi, C. and Zhang, W. 2020. Project and region: The challenges of managing water in Shandong after the South-North Water Transfer Project. Water Alternatives 13(1): 49-69

Between Project and Region: The Challenges of Managing Water in Shandong Province After the South-North Water Transfer Project

Dan Chen
College of Agricultural Engineering, Hohai University, Nanjing, China; cherrydew@hhu.edu.cn

Zhaohui Luo
College of Resources and Environmental Sciences, Nanjing Agricultural University, Nanjing, China; lzhui@njau.edu.cn

Michael Webber
School of Geography, The University of Melbourne, Melbourne, Victoria, Australia; michaeljwebber@gmail.com

Sarah Rogers
School of Geography, The University of Melbourne, Melbourne, Victoria, Australia; rogerssm@unimelb.edu.au

Ian Rutherfurd
School of Geography, The University of Melbourne, Melbourne, Victoria, Australia; idruth@unimelb.edu.au

Mark Wang
School of Geography, The University of Melbourne, Melbourne, Victoria, Australia; myw@unimelb.edu.au

Brian Finlayson
School of Geography, The University of Melbourne, Melbourne, Victoria, Australia; brianlf01@gmail.com

Min Jiang
School of Geography, The University of Melbourne, Melbourne, Victoria, Australia; min.jiang@unimelb.edu.au

Chenchen Shi
School of Geography, The University of Melbourne, Melbourne, Victoria, Australia; chenchens1@student.unimelb.edu.au

Wenjing Zhang
School of Geography, The University of Melbourne, Melbourne, Victoria, Australia; wenjingz8@student.unimelb.edu.au

ABSTRACT: This paper examines the challenges that a region of China is facing as it seeks to integrate a centrally planned, hierarchically determined water transfer project into its own water supply systems. Water from China's South-North Water Transfer Project (SNWTP) has been available in Shandong since 2013. How has this province been managing the integration of SNWTP water into its water supply plans, and what challenges is it facing in the process? This paper demonstrates that Shandong's planners consistently overestimated future demand for water; this, together with the threats posed by reduced flows in the Yellow River, encouraged the Shandong government to support the building of the SNWTP. However, between the genesis of the plans for the SNWTP and its construction, the supply from the Yellow River became more reliable and the engineering systems and the efficiency of water use in Shandong Province itself has improved. As a result, by the time the SNWTP water became available, the province had little pressing need for it. Besides this reduced demand for SNWTP water, there have been difficulties in managing delivery of, and payment for, water within the province. These difficulties include unfinished local auxiliary projects that connect cities to the main canal, high water prices, conflict and lack of coordination among stakeholders, and ambiguous management policies. The result is that in 2016, on average, cities used less than 10% of their allocated quota of SNWTP water, while seven cities used none of their quota. The story of the SNWTP in Shandong is that of a centralised, hierarchically planned, fixed infrastructure with its deterministic projections coming into conflict with the fluidity of water demand and local political circumstances.

KEYWORDS: South-North Water Transfer Project (SNWTP), water demand, politics, planning, Shandong, China

INTRODUCTION

Interbasin water transfer has been promoted worldwide as an effective and increasingly popular management tool for providing flexibility in the allocation and use of water, but its contributions and consequences have also been widely argued (Wilson et al., 2017). Studies of interbasin water transfers have accelerated in the last 20 years; they have investigated topics that range from planning, design, procurement, construction and operational management, to social, economic and environmental impacts. Massive water transfer projects around the world are under construction or awaiting approval (Shumilova et al., 2018), but they are complex and difficult (Shourian et al., 2017) and have become one of the most controversial topics in water resources planning (Zhang et al., 2015).

China has launched massive interbasin water transfer projects in the last 50 years, delivering about 100 billion cubic metres (Bm^3) of water per year (Yu et al., 2018), of which about one-quarter is from the South-North Water Transfer Project (SNWTP). The SNWTP began operating its Eastern and Middle Routes in 2013 and 2014, respectively (Liu et al., 2013). Official media in China have widely reported the achievements of the SNWTP, including the transfer of more than 10 Bm^3 of water from South to North China, safe and steady operation of the engineering systems, meeting of water quality goals, more than 100 million human beneficiaries, and contributions to water supply, ecological protection and environmental improvement; these achievements, however, need further long-term scientific evaluation. This project has also caused population resettlement (Yan et al., 2016) and had environmental impacts (Yan et al., 2012).

Many studies have investigated the impacts of water diversion projects in China, especially of the SNWTP (Barnett et al., 2015; Liu and Yang, 2012; Yu et al., 2018). Most of them have focused on specific topics such as water pollution control and water quality (Ma et al., 2015; Yang et al., 2015), hydrological and ecological responses (Chen et al., 2013; Webber et al., 2015), population resettlement (Yan et al., 2016), project construction and operation (Gu et al., 2017), water supply alternatives (Li et al., 2016), policy dimensions of water infrastructure development (Liu et al., 2013; Tortajada, 2016), regional water security (Zhang, 2009b), ecosystem services and compensation (Sheng and Webber, 2018; Li et al., 2016; Liu et al., 2013; Tortajada, 2016; Yang et al., 2015; Zhang, 2009b). There are also studies from technopolitical and hydropolitical perspectives concerning water governance (Rogers et al., 2016), institutional change (Webber and Han, 2017), political economy (Pohlner, 2016), political legitimacy and authoritarian environmentalism (Moore, 2014), technocratic administration (Crow-Miller et al., 2017a, 2017b), and persuasive and coercive governance strategies (Crow-Miller, 2015; Crow-Miller and Webber, 2017; Sheng et al., 2018).

The more politically inflected studies recognise that the politics of water needs to be analysed at various scales, since place, territory and society are materially, socially and politically constructed. Common scales of analysis are basin level (such as found in Webber et al.'s 2015 study of the implications of the SNWTP for water security in Shanghai), regional (such as in Rogers et al.'s 2016 work on the Middle Route), national (Crow-Miller, 2015; Crow-Miller and Webber, 2017; Crow-Miller et al., 2017b), and international (Hofstedt, 2010; Moore, 2018), although it is understood that processes and actors at one scale affect outcomes at other scales. Such work reveals the divergent interests of actors at the different levels, which often take the form of conflicts between regional and national interests (Gorostiza et al., 2018; Linton and Delay, 2018). Local actors, such as NGOs or political movements, must then find an appropriate scale at which to mount their support for, or opposition to, proposed actions (Akbulut et al., 2018; Sneddon, 2002; Swyngedouw, 2004).

From the point of view of supplying water to users, water transfer projects such as the SNWTP do not exist in isolation, but rather must be integrated into an overall water management plan; in a hierarchical governance system, this requires a regional overview of the total water supply system rather than a project-level view of one source of water. In other words, rather than only studying the characteristics of the SNWTP, we must understand how this project fits into an overall plan to supply water. In China this must include 1) the role of the central government, which sets policies and targets for the country as a whole as well as organising national-scale projects such as the SNWTP; 2) river basin commissions, which are responsible for integrated water resources management including allocating river water to provinces, flood control, drought relief, and hydraulic projects; and 3) provincial governments, which are responsible for implementing central government policies and providing water to users and which, in turn, delegate some of their responsibilities to cities. The task of integrating the SNWTP into an overall plan to supply water to users is thus largely the responsibility of the provinces. The operators of the SNWTP have only to extract water from sources and deliver it along canals; the provincial government must combine SNWTP water with water from other sources to supply the demands of users. In this way, regions have different goals than do project managers.

This paper thus presents a regionally focused analysis of the manner in which SNWTP water is integrated into an overall plan to supply water, and of the challenges of achieving this integration. We do not survey the social and environmental impacts of the SNWTP such as water pollution control, population resettlement, or hydrological and ecological responses, and we also do not examine its governance; rather, we ask: what are the challenges that a province faces in integrating SNWTP water into a provincial plan to supply water, and how is it meeting those challenges? Answers to these questions reveal some of the hydropolitical implications of regional water management under interbasin water transfer regimes.

Shandong Province was selected as a case study. Shandong is a key water-receiving area of the Eastern Route of the SNWTP (ER-SNWTP); it was one of the provinces most enthusiastic in its support when the SNWTP was first proposed (Shandong Provincial Government, 2001). As it was designed, water supply to Shandong accounts for one-third of the Eastern Route total water diversion. Shandong is identified as one of provinces in which water is chronically scarce (Yang and Zehnder, 2001), so the provision of water has been a key factor in regional economic growth. (We focus here exclusively on Shandong Province since our aim is to illustrate how a specific region manages a system of water supply in the face of a water transfer megaproject.)

After briefly describing the SNWTP and its Eastern Route and our methods of collecting information, the paper describes the quantities of water supplied to, and demanded by, the residents of Shandong; this section also demonstrates how the planners consistently overestimated the future demand for water. We then examine the sources of water on which Shandong draws, both transfers and local sources. The predicted shortfalls in supply and the threats posed by the decreasing flow of the Yellow River as it reaches Shandong Province combined to provoke the Shandong government into strong support for the plan to build the SNWTP. However, between the genesis of the plans for the SNWTP and its construction, the supply from the Yellow River became more reliable because of stronger controls over the use of its water upstream of Shandong, and there has been an increase in the efficiency with which water is used within the province. By the time SNWTP water became available in Shandong, the province had little pressing need for it. As demonstrated in the next section, the decreasing demand in Shandong for SNWTP water has led to difficulties in completing and paying for water delivery systems within the province; this has resulted in unfinished local auxiliary projects connecting cities to the main canal, high water prices, conflict and lack of coordination among stakeholders, and ambiguous management policies.

In the final section of the paper, three conclusions are drawn which are applicable outside of Shandong and even of China. The first conclusion is that the story of the SNWTP in Shandong is that of a centralised, hierarchically planned, fixed infrastructure whose deterministic projections come into conflict with the fluidity of water demand and local political circumstances, and that hierarchical, technocratic water management does not efficiently adjust to locally specific particularities. Second, predicted catastrophic water shortages in Shandong were grossly overestimated for two reasons: because the bureaucracy and its associated commercial enterprises have an interest in advertising the need for large-scale infrastructure, and because investments in efficient use of water proved sufficient to avoid shortages. Third, there is a direct conflict of interest between project planners and managers, and the municipal authorities of Shandong's cities. Planners drew up projections of demand for which managers provided supply, but the fixed costs of providing supply means that the managers must force cities to buy water from the project even if those cities can satisfy their demand for water more cheaply by other means.

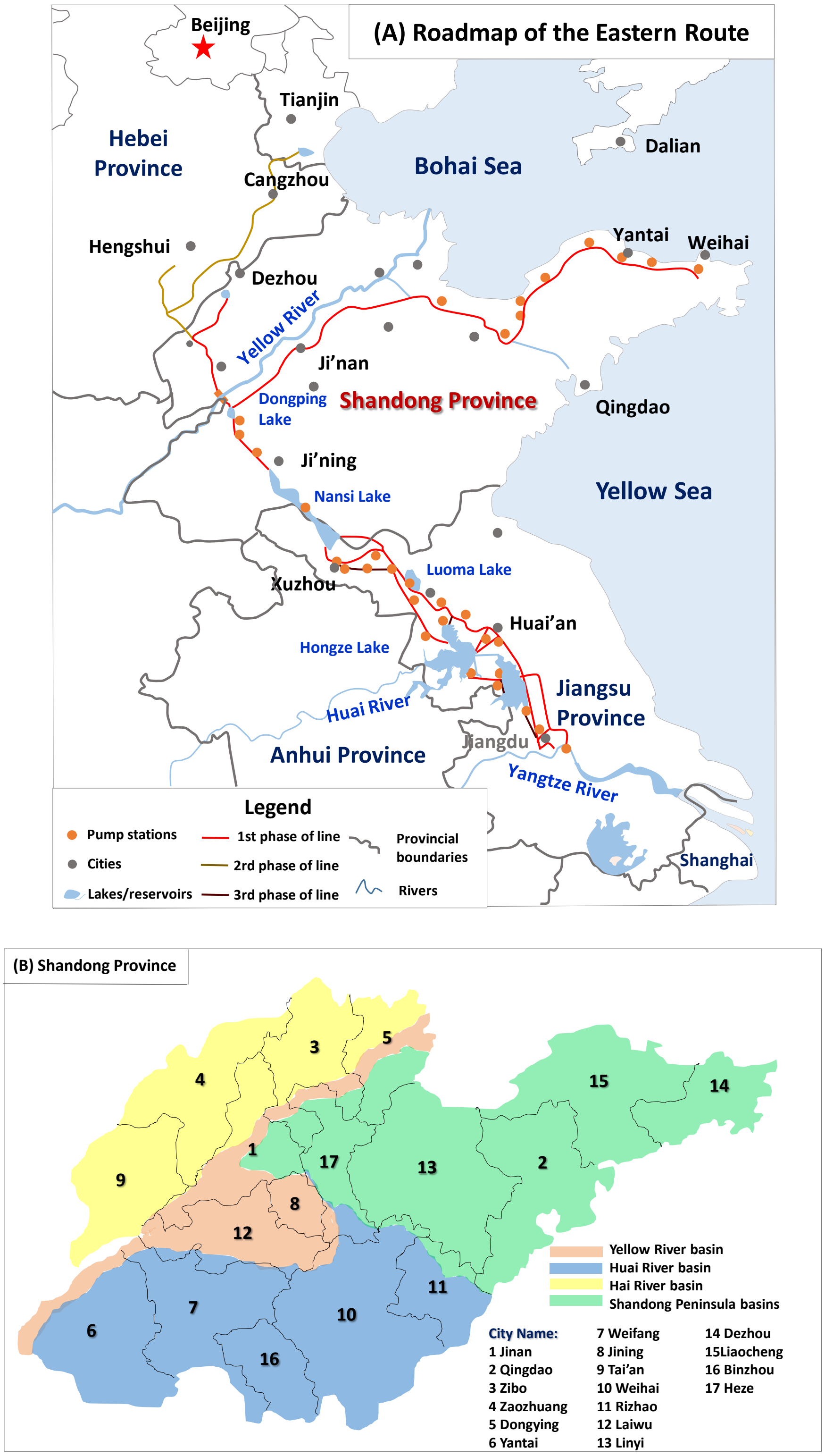
THE SNWTP'S EASTERN ROUTE AND SHANDONG

The Eastern Route has a planned capacity of 14.8 Bm^3 per year; this volume of water is to be supplied from the Yangtze River to Northern China through a system of pumps, rivers, lakes, reservoirs and canals. As shown in Figure 1(A), this includes the Grand Canal, which is itself more than 2500 years old (Webber et al., 2017). The Eastern Route uses Jiangsu Province's existing south-to-north project, expands its scale and extends it northwards. When the water from the Yangtze River is lifted by pumps and conveyed into Dongping Lake in Shandong, it is divided into two routes: the one to the north crosses the Yellow River via a tunnel and will in future flow to Tianjin; the other is connected eastward into the Shandong Peninsula via the existing Yellow River-to-Qingdao Water Diversion Project. The construction of the Eastern Route was planned in three stages: the first stage began operating in November, 2013, transferring water to the provinces of Jiangsu, Anhui and Shandong; the second and third stages are not yet operational, but are expected to supply cities in Hebei and the municipality of Tianjin.

Shandong Province is the current destination of the water supplied by the first stage of the Eastern Route. Shandong is located on the eastern coast of China and at the lower reaches of the Yellow River, as shown in Figure 1(A); it covers a land area of 157,900 km^2. It has mountainous areas (15.51%), hilly areas (13.19%), plains and basins (62.72%), coastal areas and tidal flats (5.34%), and the Yellow River Delta (3.24%). It contains parts of three major river basins – the Yellow, Huai and Hai – as well as the Shandong Peninsula, which is an area of small river basins, as shown in Figure 1(B). There are 17 prefecture-level cities in Shandong, of which 13 cities are water-receiving areas for the Eastern Route (Figure 1(B)). With 100 million inhabitants, Shandong is China's second most populous province (after Guangdong), and its GDP is third-highest in the country.

Shandong lies in a warm temperate zone with a semi-humid monsoon climate. Mean annual temperatures range from 11 to 14°C. Annual precipitation averages 680.5 mm, but its distribution is uneven over both place and time. Annual mean precipitation decreases from 850 mm on the south-eastern coast to 550 mm in the north-west. Between 1956 and 2016, the maximum annual precipitation was 1171 mm (1964), but in 1981 it was only 442 mm. The distribution of precipitation over the course of a year is highly seasonal, with 75% of annual precipitation and 80% of natural runoff occurring during the flood season, especially during the months of July and August; Shandong is thus often struck by the twin natural disasters of flooding and drought. The total annual amount of local water resources per capita in Shandong is only 315 m^3, less than one-sixth of the national average. Due to the uneven spatial and temporal distribution of water resources in relation to demand, between 2001 and 2016 Shandong transferred an average of 5.8 Bm^3 per year from the Yellow River.

Figure 1. Study area.



Source: (A) revised from Zhang (2009a); (B) revised from www.shandong.gov.cn/

DATA AND METHODS

We proceeded in several steps. First, the challenges that arose after the Eastern Route started operation in 2013 in Shandong were identified from various sources. Four main challenges were observed: 1) the planned water quotas allocated to Shandong; 2) construction of local auxiliary projects; 3) pricing of the transferred water; and 4) the charging of fees for Yangtze water by local cities. Second, we linked water supply and interbasin water transfers in Shandong by calculating three indices for quantifying the dependence of water supply on interbasin water transfers; in understanding this dependence, we considered changes in the water supply structures in Shandong. Third, the linkage between water demand and interbasin water transfers in Shandong was analysed according to four different aspects of the impact of two key events (cease-to-flow events in the Yellow River and an extreme water crisis in eastern Shandong); we examined the impact of these events 1) on the Shandong government's enthusiasm for the Eastern Route, 2) on water demand projections in different planning reports, 3) on changes in water consumption structures, and 4) on demand for groundwater replenishment and ecological water.

The three indices are as follows. The first index scales the actual degree of dependence of water supply in a region on interbasin water transfer from source *i* (A_i). A_i is computed as the percentage of the total annual water supply in a region (*TWS*) arising from the water transfer of source *i* (WST_i). WST_1 denotes water transferred from the Yellow River; WST_2 denotes water transferred from the Yangtze River; the total water transferred is $WST_3 = WST_1 + WST_2$. The higher the index, the more that regional development relies on water transfer:

$$A_i = WST_i / TWS \quad (1)$$

The second index, B_i, measures the degree to which interbasin water transfer from source *i* could in principle support water supply in a region. B_i compares the maximum allowable water supply by transferred water ($MWST_i$) to the total water supply in a region (*TWS*). A high value suggests that water transfers could play a greater role in supporting supply:

$$B_i = MWST_i / TWS \quad (2)$$

The third index (C_i) is the ratio of A_i to B_i. C_i scales the actual demand of the region for interbasin water from source *i* in relation to the maximum capacity of that source. According to Equation 3, C_i is the ratio of WST_i and $MWST_i$. The higher this ratio, the closer is the region to using all the available water from source *i*;

$$C_i = A_i / B_i = WST_i / MWST_i \quad (3)$$

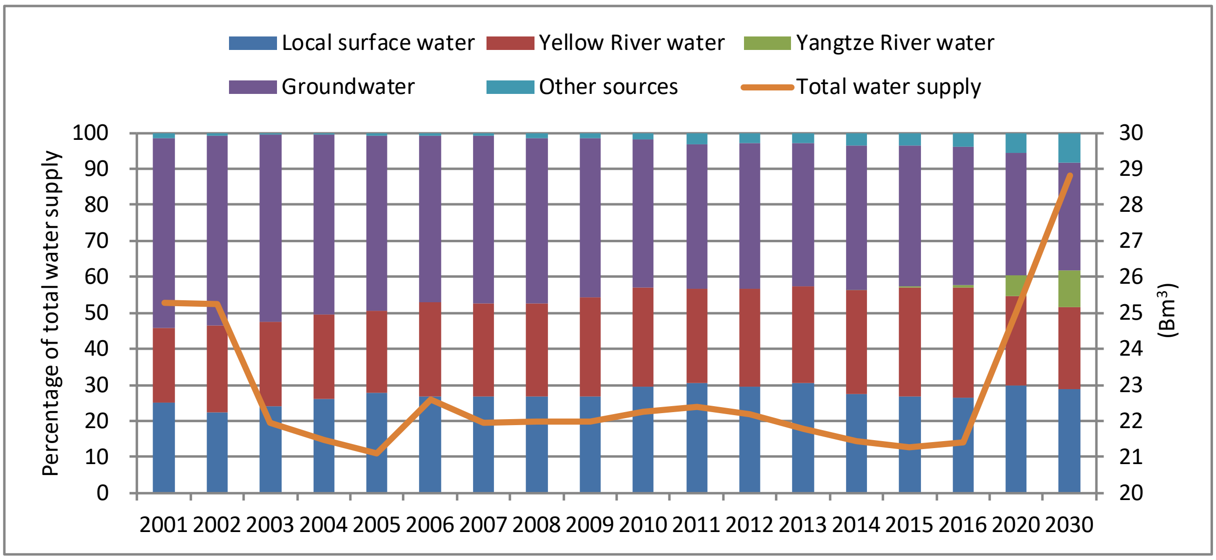
The data required consists of: (a) official planning reports and statistical data about the Eastern Route of the SNWTP and water resources development in Shandong; (b) various public data and information on official websites; (c) information collected from mainstream media in China and Shandong using the search keywords "South-to-North Water Transfer Project" and "Shandong"; (d) two field surveys along the Eastern Route in Shandong and Jiangsu in June and December 2017; and (e) communications with officials and managers in Shandong. Like all hydrologic data, the official data is subject to measurement error (Sauer and Meyer, 1992; Harmel et al., 2006). Evaluations of Chinese water data suggest that it can be useful provided that it is checked against other sources – such as central government and provincial data or data from different bureaus – and is compared to local, on-the-ground observations of third parties (Long, 2019). In this paper we use multiple sources of data and check it against information from local informants.

PREDICTED DEMAND FOR WATER IN SHANDONG

The SNWTP Eastern Route may have been built to satisfy national goals such as fuelling the growth of Northern China and maintaining domestic consumption, but the support of provincial governments was needed both politically (through their representation inside the National Development and Reform Commission and the State Council) and financially (provinces were required to pay some of the capital costs of the project) (Liu et al., 2013). Did provincial demand for water justify the project? Did provincial demand for water result in sufficient provincial financing to pay for the project?

By the late 1990s and early 2000s, Shandong's total water supply was either stable or shrinking (Figure 2). The principal sources were local surface water (about 25% of the total) and groundwater (over 50%), supplemented by transfers from the Yellow River (about 20%).

Figure 2. Main sources of water in Shandong Province and their proportions of the total (2001-2030).



Source: Data for 2001-2016 are from *Shandong Province water resources bulletins (2001-2016)* (Department of Water Resources in Shandong, 2017). Projections for 2020 and 2030 are for normal hydrologic years and are from the *Mid- and long-term planning report on comprehensive utilization of water resources in Shandong Province* (Shandong Provincial Government, 2016).

Note: Total water supply is indexed on the right-hand axis; percentage of total water supply is on the left.

The provincial government's problem was that upstream abstractions from the Yellow River after 1972 had become so large that periodically water was not sufficient to reach the sea (Cao et al., 2008). The Yellow River basin is home to 12% of the population of China and constitutes 15% of the country's farmland, much of it on the flat and fertile North China Plain; however, the basin accounts for only 2.2% of China's total runoff (Barnett et al., 2006). By 1997, there were 226 'no flow' days, when the river's water failed to reach the sea; the dry point started more than 600 km from the river mouth, at Kaifeng City in Henan Province (Webber et al., 2008). Since the Yellow River provided such a large share of Shandong's water, the river's cease-to-flow events were a grave threat to the province's supply. Between 1972 and 1999, the cease-to-flow events in the Yellow River occurred earlier and earlier in the year and lasted longer, causing serious problems to Shandong's water supply and ecosystems.

By the late 1990s and early 2000s, therefore, the Shandong government was eager for construction to start on the SNWTP Eastern Route; evidence of this enthusiasm can be found in the *Chronicle of Events of the SNWTP in Shandong in 2000* (Shandong Province South-North Water Transfer Memorabilia, 2000). On 28 June 2000, for instance, the provincial government officially submitted a report to the State Council, a *Request for early implementation of the ER-SNWTP* (Shandong Province South-North Water Transfer Memorabilia, 2000). In another report, submitted on 28 July 2000, *Request for help to solve the drought and water shortage in the Shandong Peninsula*, the provincial government asked the state to offer a special drought relief fund of 50 million yuan to undertake an emergency project to transfer water from the Yellow River to the peninsula and to implement the Eastern Route as soon as possible (Shandong Province South-North Water Transfer Memorabilia, 2000). According to the *Planning report on sustainable utilization of water resources in Shandong Province in the early 21st century* (Shandong Provincial Government, 2002), the prefectural governments of 14 cities in Shandong confirmed that their demand for Yangtze River water for industrial and urban domestic uses would be 0.671 Bm^3 in 2005, growing to 1.586 Bm^3 by 2010, and peaking at 3.463 Bm^3 by 2030. The *Planning report of the ER-SNWTP* was revised in 2001, recommending that 1.699 Bm^3 of water in 2010 and 3.734 Bm^3 in 2030 should be transferred from the Yangtze River for Shandong (Huaihe River Commission and Haihe River Commission of the Ministry of Water Resources, 2001). In December 2002, the State Council formally approved the *Overall plan of South-to-North Water Transfer Project*, and on 27 December 2002 construction of the ER-SNWTP in Shandong formally began (Shandong Province South-North Water Transfer Memorabilia, 2002). Eleven years later, the first stage of the Eastern Route began operating. The projections would prove to be substantial overestimates of the demand for transferred water (Table 1).

Predictions of future demands for water in water-receiving areas are supposed to be key indicators which determine the quantity of water to be diverted from the Yangtze River. Three key planning reports and data from Shandong's water resources bulletins provide predicted and actual quantities of water supply and demand; the relevant findings are in Table 1.

Table 1. Predictions and actual water supply and demand, Shandong 2005-2030 (Bm^3).

	Water supply	Water demand	Water shortage	Water transferred by SNWTP	Data sources
2005 Predicted	30.047	32.246	2.200	0.671	PWSD2002
2005 Actual	21.103	21.103	0	0	SDWRB 2010
2010 Predicted	–	–	–	1.699	PER2001
2010 Predicted	32.458	33.719	1.262	1.586	PWSD2002
2010 Actual	22.247	22.247	0	0	SDWRB 2010
2016 Actual	21.399	21.399	0	0.123	SDWRB 2016
2020 Predicted	24.998	26.410	1.412	1.467	PWSD2016
2030 Predicted	–	–	–	3.734	PER2001
2030 Predicted	37.277	37.477	0.199	3.463	PWSD2002
2030 Predicted	28.821	29.224	0.403	2.951	PWSD2016

Source: *Planning report on sustainable utilization of water resources in* Shandong Province *in the early 21st century* (PWSD2002)(Shandong Provincial Government, 2002); *Mid- and long-term planning report on comprehensive utilization of water resources in* Shandong Province (PWSD2016) (Shandong Provincial Government, 2016); *Planning report on the Eastern Route of SNWTP* (PER2001) (Huaihe River Commission and Haihe River Commission of the Ministry of Water Resources, 2001); Shandong Province *water resources bulletins (2001-2016)* (SDWRB) (Department of Water Resources in Shandong, 2017).

Note: PWSD2002 was released by the Shandong provincial government in 2002. It predicted the provincial water demand and the planned supply, including the quantity of water to be diverted from the Yangtze River in 2005, 2010 and 2030. PWSD2016 was released by the Shandong provincial government in 2016; it predicted demand and supply for 2020 and 2030. PER2001 was revised in 2001 by the Huai River Commission and Haihe River Commission of the Ministry of Water Resources; it predicted Shandong's demand for SNWTP water for 2010 and 2030, and planned the three stages of the Eastern Route and the corresponding water allocation schemes. SDWRB provided actual quantities of water supplied and consumed in Shandong. – = no data available.

Actual water demand was exactly met by supply in both 2010 and 2016. Throughout this period, actual demand grew much more slowly than planned, and the result was that there was much less demand for water than planners had predicted; specifically, by the time water from the SNWTP reached Shandong, demand was only about two-thirds of that predicted in 2010. If the recent rates of growth in demand continue, by 2020 much more SNWTP water will be delivered than is required.

Of course, in rapidly developing regions like Shandong, errors in predicting water supply and demand are to be expected. Many measures to improve the capacities of water supply and reduce water demand have been implemented in recent years; these include: the development of different water sources; enhancing the use of rainwater, recycled and desalinated water; the application of water-saving technology; and more stringent water resources management. It is notable, however, that the planning reports of the early 2000s consistently overestimated the demand for water in Shandong and especially the demand for water from the SNWTP. As elsewhere, such consistent overestimates help justify huge infrastructure projects like the SNWTP and, in the process, overestimate the jobs and profits that are expected to accompany them.

CHANGING CIRCUMSTANCES: BETTER MANAGEMENT, HIGHER EFFICIENCY

Between the initial support for the SNWTP and its concrete connection to Shandong, an important shift occurred: water from the Yellow River, since 2000, never ceased to reach the sea. The central government adopted several measures to tackle the crisis of no-flows in the Yellow River, including, from 1999, strengthening the Water Allocation Program by imposing strict water withdrawal quotas on provinces in the Yellow River basin, and regulating the river's discharge by storing water in the first phase of the Xiaolangdi Reservoir after its completion in 2000. Through taking these measures, the threat of cease-to-flow events in the Yellow River has been removed and Shandong has become more dependent on the Yellow River for water (as indicated in Figure 2 and Table 2). As a result, local projects have been constructed to abstract water from the Yellow River, including the Yellow River-to-Qingdao Water Diversion Project (the first stage of which was completed in December 2015), and the Yellow – Peninsula Water Diversion Project (the first and second stages of which were completed in August 2018 and May 2019, respectively). The Shandong government has also rebuilt diversion sluices, culverts and channels.

Table 2. Dependence of water supply in Shandong on interbasin water transfers.

	2011	2012	2013	2014	2015	2016	2020	2030
A_1 (%)	26.3	27.4	26.9	28.9	30.3	30.6	23.5	22.3
A_2(%)	–	–	–	0.1	0.4	0.6	5.6	10.1
A_3(%)	26.3	27.4	26.9	29.0	30.7	31.1	29.1	32.4
B_1(%)	29.0	29.3	29.8	30.3	30.6	30.4	24.6	22.3
B_2(%)	–	–	–	6.8	6.9	6.9	5.6	10.1
B_3(%)	29.0	29.3	29.8	37.2	37.5	37.2	30.2	32.4
C_1	0.90	0.94	0.90	0.95	0.99	1.01	0.96	1.00
C_2	–	–	–	0.01	0.05	0.08	1.00	1.00
C_3	0.90	0.94	0.90	0.78	0.82	0.84	0.96	1.00

Source: Data for 2001-2016 are from *Shandong Province water resources bulletins (2001-2016)* (Department of Water Resources in Shandong, 2017). Projections for 2020 and 2030 are for normal hydrologic years and are from the *Mid- and long-term planning report on comprehensive utilization of water resources in Shandong Province* (Shandong Provincial Government, 2016).

Note: A_i measures the degree to which regional development relies on water transfers; B_i measures the degree to which interbasin water transfers from source *i* could, in principle, support water supply in a region. C_i gives the ratio of the actual demand of the region for interbasin water from source *i* to the maximum capacity of that source. See Equations 1 to 3. – = data not available.

The values of the three indices in Table 2 illustrate the changes in Shandong's sources of water. From 2011 to 2016, Shandong Province was highly dependent on interbasin water transfers (A_3: 26.3~31.1%); however, the dependence on the Yellow River (A_1: 26.3~30.6%) was much higher than on the SNWTP (A_2: 0.1~0.6%). The current plans are that (as compared to a dependence in 2016 of 30.6%), dependence on the Yellow River (A_1) should decrease (to 23.5% and 22.3% in 2020 and 2030) as increasing amounts of water are drawn from the SNWTP (6.541, 6.219 and 6.503 Bm^3 in 2016, 2020 and 2030, respectively) to supply the increasing demands in Shandong (21.399, 26.410 and 29.224 Bm^3). This is a simple substitution, as the province's total dependence on interbasin water transfers (A_3) in 2020 and 2030 were predicted to remain virtually constant (29.1% and 32.4%, as compared 31.1% in 2016).

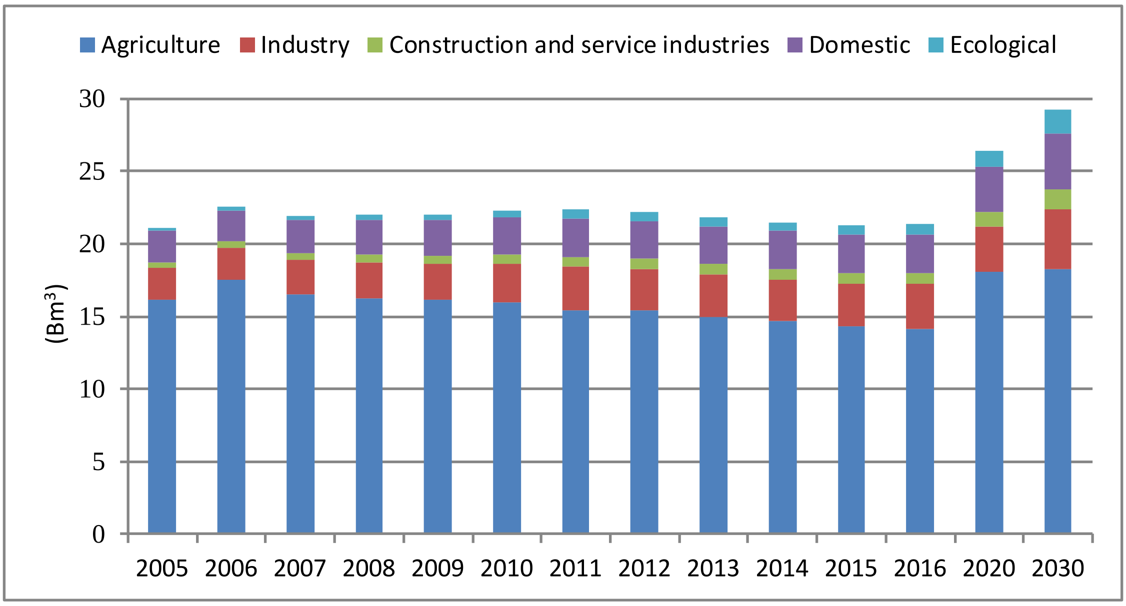
Interbasin water transfers, even before the SNWTP began operating, formed an important part of Shandong's water supply (B_3: 29-37.5%). Between 2011 and 2016, the theoretically supportable level of water transfers from the Yellow River remained around 30% (B_1) of the maximum allowable water abstraction of 6.503 Bm^3; however, abstractions from the SNWTP have remained low, approaching 7% (B_2) of the maximum of 1.467 Bm^3. The degree of reliance on the Yellow River (B_1) is planned to decrease to 24.6% in 2020 and 22.3% in 2030, from 30.4% in 2016, since the maximum allowable water abstraction will remain constant (6.503 Bm^3) and the demand is projected to increase. The maximum quotas from the SNWTP are planned to increase from 1.467 Bm^3 in 2016 and 2020 to 2.951 Bm^3 in 2030, which will lead to an increase share of SNWTP water in Shandong's total water supply (to 10.1%). The total reliance on interbasin water transfer (B_3) is expected to decrease to 29.1% in 2020 but rise again to 32.4% in 2030.

In other words, the actual demand from Shandong for interbasin water transfers has always been relatively large, and this water has mainly come from the Yellow River; the significance of the SNWTP, however, has so far been close to zero, since the water transferred in 2014-2016 was less than the planned quotas. In contrast, the actual volume transferred from the Yellow River almost approached the maximum allowable volume. The supply of Yellow River water to Shandong has become increasingly reliable since 2000 when the first phase of the Xiaolangdi Dam was completed and the Water Allocation Program was more strictly enforced; thus Shandong's thirst for Yangtze River water, transferred via the SNWTP, has decreased. However, the structures of consumption in Shandong have also been changing.

Water consumption in Shandong Province (Figure 3) is dominated by the needs of agriculture, with that sector accounting for about 70% of all water consumption, as compared to about 26% for industry and domestic users. Agricultural water consumption has declined from 16.173 Bm^3 in 2005 (76.6% of the total) to 14.15 Bm^3 in 2016 (66.1%). In contrast, industrial and domestic users have used increasing amounts of water – 4.693 Bm^3 in 2005 (22.2%), and 6.468 Bm^3 in 2016 (30.3%) – an increase which is rather less than the reduction in agricultural water use. In addition, ecological water consumption has also been increasing – 237 Mm^3 in 2005 (1.1%), but 764 Mm^3 in 2016 (3.6%). If Shandong's entire annual water quota from the SNWTP (1.467 Bm^3) had been supplied for industry and domestic use in 2014-2016 (6.2-6.5 Bm^3 per year), it would have contributed 23% of the province's usage; in actual fact, the contribution was only 1.4, 5.2, and 8.4% in 2014, 2015 and 2016, respectively.

Figure 3 also indicates the sectoral composition of the increases in demand for water that were projected by the *Mid- and long-term planning report on comprehensive utilization of water resources in Shandong Province* (Shandong Provincial Government, 2016). In a sharp reversal of historical trends, the report projects that the demand for water from agriculture will rise by 28% between 2016 and 2020 and by another 1% between 2020 and 2030. Agriculture will still consume 68.5% of the total water available in 2020 and 62.5% of water available in 2030 (compared to consuming 66.1% of available water in 2016). Industrial and domestic water demand are projected to increase by 11% between 2016 and 2020 and by another 52% between 2020 and 2030. By 2030, industrial and domestic users are expected to demand 37.5% of all water; ecological water demands are also predicted to rise sharply, though from a small base.

Figure 3. Water consumption in Shandong in 2005-2016 and projected demand in 2020 and 2030.



Source: Data for 2001-2016 are from *Shandong Province Water Resources Bulletins (2001-2016)* (Department of Water Resources in Shandong, 2017). Projections for 2020 and 2030 are for normal hydrologic years and are from the *Mid- and long-term planning report on comprehensive utilization of water resources in Shandong Province* (Shandong Provincial Government, 2016).

The report predicts that priority will be given to ensuring "stringent water resources management", in the context of a water management policy articulated in the 2011 Central Committee No.1 Document of the Communist Party of China. This policy was symbolically dubbed the 'Three Red Lines' policy: control of total water consumption, control of water use efficiency, and restriction of pollutants in water function areas. Measures to be adopted include: adjustment of industrial and economic structures; strengthening of water conservation; interbasin water transfer; use of rainwater, recycled and desalinated water, and development of local water sources; and reallocation of water resources across place and sector. The planned water diversions into Shandong are projected to reach 7.686 Bm^3 in 2020, with 6.219 Bm^3 from the Yellow River and 1.467 Bm^3 from the Yangtze River; diversions are projected to reach 9.454 Bm^3 in 2030, with 6.503 Bm^3 from the Yellow River and 2.951 Bm^3 from the Yangtze River. These projections emphasise the greater importance of water from the Yellow River than from the Yangtze River.

Data in the *Shandong Province water resources bulletins* (2001-2016) indicates that annual water consumption in Shandong fell from 25.273 Bm^3 in 2001 to 21.399 Bm^3 in 2016 (Department of Water Resources in Shandong, 2017). There is no evidence that the reduction resulted in a net loss of agricultural production or of economic growth in Shandong (Shandong Provincial Government, 2016); rather, allocations to irrigation areas are increasingly strictly controlled, many wells have been closed or controlled, canals are being lined, and farmers are being encouraged to use efficient irrigation techniques to replace flood irrigation. In this way, water shortages in Shandong are largely avoided through demand management. In practice, especially in recent years, water conservation measures and socio-economic policies in Shandong have moderated the demand for water in agricultural (from 18.29 Bm^3 in 2001 to 14.15 Bm^3 in 2016) and industrial sectors (from 4.19 Bm^3 to 3.06 Bm^3) and among domestic users (from 2.79 Bm^3 to 2.68 Bm^3). In other words, the increasing and more reliable supply from the Yellow River has been accompanied by an increase in the efficiency with which water is used within the province. So far, then, the urgency given in the late 1990s to the SNWTP as a means of alleviating Shandong's water shortages has not translated into an actual need for much of that water.

PROVINCIAL CHALLENGES IN USING SNWTP WATER

The actual use of SNWTP water in Shandong has so far (2013-2018) been lower than expected. This is in part due to the increase in quantity and security of supply from the Yellow River (from 5.21 Bm^3 in 2001 to 6.54 Bm^3 in 2016), and to decreasing water use in agriculture (from 18.29 Bm^3 in 2001 to 14.15 Bm^3 in 2016) and industry (from 4.19 Bm^3 in 2001 to 3.06 Bm^3 in 2016), but it is also due to challenges that the Shandong government faces in using water from the SNWTP. For the provincial government, given the availability of groundwater and of transfers from the nearby Yellow River, the challenge is to integrate the SNWTP into its province-wide plans for water supply and to encourage Shandong's cities to incorporate SNWTP water into their plans for water supply. The Shandong provincial government is, in this respect, a link in the connection between the SNWTP and the consumers who actually decide to use SNWTP water, which is to say the water supply companies, which are generally owned by city governments. So far, three principal challenges have arisen: the construction of auxiliary projects to move water from the main Eastern Route canal into individual cities, meeting the price charged by the SNWTP for water, and extracting payments for SNWTP water from cities.

Auxiliary projects

Without the completion of local auxiliary projects, the main trunk canals of the ER-SNWTP in Shandong, despite being finished in 2013, have not been able to deliver the water they are designed to supply. Principally, these auxiliary projects are those built and funded by the province and comprise sluice gates, storage, and secondary canals that deliver the water from the trunk canals to the cities. One of the key tasks of the ER-SNWTP in Shandong, since it began operating, has thus been to accelerate the construction of local auxiliary projects; however, this has been difficult because of the huge investments that are needed, the large areas of land that have to be requisitioned, and the short period allowed for construction.

According to the *Planning report on the local auxiliary projects of the first stage of the ER-SNWTP in Shandong*, which was approved by the Shandong provincial government in 2011, the total investment budget for local auxiliary projects was 22.489 billion yuan, close to the budget for the main project in Shandong (22.511 billion yuan) (Shandong Provincial Government Information Office, 2017). Around 20 to 30% of the investment can be subsidised by the provincial government but the remaining funds need to be raised by local governments at city and county levels. The 2.596 billion yuan budgeted for local auxiliary projects in Dezhou city, for instance, consisted of the provincial government's contribution (30% of the total), corporate financing (56%), and the contribution of the local government (14%). Dezhou, which was the province's pilot city for the construction of local auxiliary projects, was the first city in Shandong to complete this task. Cities with limited capital resources and poor opportunities to find financing have found it difficult to make such huge capital contributions; therefore, since city and county governments are responsible for the auxiliary projects within their jurisdictions, they endeavour to finance them through bank credit and corporate financing, which carry interest costs.

Besides the huge investment of capital, land acquisition is a challenge for the construction of local auxiliary projects. The trunk canal project in Shandong involved 57.36 square kilometres (86,000 Chinese *mu)* of permanent land acquisition, and 2.85 square kilometres (4280 *mu*) of temporary land acquisition; this led to the resettlement of 43,100 farmers and 8937 non-farmers, the demolition of 425,000 m^2 of houses, and the relocation of 1200 items of power and transportation facilities. Altogether, this cost 10.2 billion yuan (~ €1.3 billion), which was comprised of 8.5 billion yuan from national sources and 1.7 billion yuan from provincial sources. Local auxiliary projects, in comparison, required the permanent acquisition of 136, 700 *mu* of land, which was nearly 60% more than required by the trunk canal project. This land acquisition task has been costly and politically unpopular for local governments.

Finally, there is the time constraint. According to the *Planning report on the local auxiliary projects of the first stage of the ER-SNWTP in Shandong*, all local auxiliary projects were to have been completed before the end of 2015; this date, however, was postponed (Shandong Provincial Government Information Office, 2017). By the end of 2016, a total of 20.864 billion yuan (~ €2.7 billion Euro) had been invested, 92.8% of the total investment budget; by the end of 2017, 98.6% of the budget had been spent. In other words, local auxiliary projects were largely completed in 2016 and 2017; only then was the SNWTP fully capable of transferring the water supply quotas to Shandong's cities.

To address these issues, Shandong has prioritised the construction of local auxiliary projects; the provincial party committee and the provincial government incorporated this task into the key provincial working list as one of the top five priorities. On 27 February 2014, Shandong's provincial government issued a provincial-level document, *Guidelines for speeding up the construction of local auxiliary projects* (Shandong Province South-North Water Transfer Memorabilia, 2014). This document stated that local governments were responsible for the construction and performance of auxiliary projects, and this was included in the government's cadre responsibility assessment system. (This system is used by provincial governments to assess the performance of local governments; it also determines the promotion of local cadres.) Many local governments have thus taken on this task as a political task, which means that it is of crucial importance and must be achieved. The designation of auxiliary projects as a political task also reflected the difficulties that municipal governments faced in completing local auxiliary projects. Although huge investments on local auxiliary projects stimulated local construction industries and their suppliers, the financial debts of local governments were high as were the potential risks to construction quality (meeting deadlines rather than achieving high quality) and contract precision. According to the principles of cost pricing, such investments should be paid for through charging end users higher water prices; the pricing of water is, however, a contentious issue for the ER-SNWTP in Shandong.

Charging for SNWTP water

Appropriate pricing of water is crucial to the sustainable operation of the SNWTP; however, prices of the water transferred from the Yangtze River (on average 1.54 yuan/m^3) are far higher than those from the Yellow River and local water sources (0.12-0.14 yuan/m^3) (Xinhuanews, 2015). (Note that this price, 1.54 yuan/m^3, does not include additional charges for delivery of water from the main trunk canal to cities.) This fact has dampened the enthusiasm of Shandong's cities for receiving SNWTP water. Yet the *Planning Report on the Eastern Route of SNWT Project (revised in 2001)* (Huaihe River Commission and Haihe River Commission of the Ministry of Water Resources, 2001) estimated that the average price of SNWTP water for Shandong would be only 0.59 yuan/m^3, the upper limit of people's willingness to pay.

From the perspective of local governments, increasing water prices will have social, economic and political risks; interviews with local officials reveal that local governments are paying more attention to public trust and to their image and reputation. They are concerned about potential complaints about, disputes over, or opposition to increasing water prices from water users or water supply companies. They are also worried about the possibility of adverse impacts on the local investment environment and industrial water users; after all, economic growth with high rates of GDP is still the major objective of local government officials and, moreover, slow and inefficient reforms of water pricing result in high administrative, timing and economic costs. Given an unconstrained choice, rather than paying for expensive water from the SNWTP, many cities would prefer to meet increasing demand by using more Yellow River water, continuing to overexploit groundwater, and exploring the potential of local water sources. Given this preference, local governments are reluctant to invest in local auxiliary projects to connect with the Eastern Route.

In general, the price of SNWTP water from the Yangtze River is a key factor determining whether and in what quantities cities are willing to purchase it. Local governments have to consider the efficiency and equity of high prices for their local users; however, they must also carry out the political task of receiving the planned water quotas from the SNWTP, which leads to higher prices. Recently, under political pressure, some local governments have accepted their water quota and allocated it for local uses regardless of price; however, some governments still resist the pressure and accept only a portion of their quota. Shandong Construction Command of SNWTP has organised many meetings to address the issue of high prices, and in these meetings have discussed guidelines for local water pricing policies. The idea of a 'one place, one price' policy (under which a city charges the same price for all water, regardless of its source) was first proposed in January 2014, at the official annual meeting of Shandong Construction Command of SNWTP; however, this policy is still being piloted and has not yet been widely promoted, which is a sure indication of the complexity of local pricing of SNWTP water.

Extracting payment from cities

Extracting payment for SNWTP water from cities has become a great challenge for Shandong. Provinces on the Eastern Route face a two-part tariff consisting of a fixed annual access fee and a single volumetric charge; Jiangsu, Anhui and Shandong have different fixed charges, depending on their planned quotas. Shandong has had to pay this fixed annual charge since November 2013, no matter how much SNWTP water has actually been transferred into the province every year. According to the standards set by China's National Development and Reform Commission, the average fixed charge of water from the Eastern Route for Shandong is 0.76 yuan/m^3 of water quota and the volumetric charge is 0.78 Yuan/m^3; the two charges add up to 1.54 yuan/m^3 (€0.20/m^3). It is estimated that this fixed annual fee for Shandong will reach about 1 billion yuan (~ €0.13 billion). Between 2014 and 2016, few cities were actually connected to the SNWTP trunk canal through auxiliary projects, so it was difficult for the Shandong provincial authority of the SNWTP to extract the fixed fee. Reportedly, by 2016 only a few cities had paid part of their bill, and then only under duress (Shandong Province South-North Water Transfer Memorabilia, 2016); in December 2016, therefore, the Shandong provincial government reluctantly paid around 3 billion yuan from provincial revenues on behalf of water-receiving cities, planning to gradually recover the money at a later point.

Extracting water charges from cities has been difficult. On 26 February 2016, the Department of Water Resources, the Department of Finance, and the Authority of SNWTP in Shandong jointly released a provincial-level document entitled *Notice on the collection of water charges for SNWTP (关于做好南水北调水费征收工作的通知)*, which was approved by the provincial government (Shandong Province South-North Water Transfer Memorabilia, 2016). It demanded that water-receiving cities should sign water supply contracts with the Authority of SNWTP in Shandong and should pay fully and on time; this demand, however, has been only partially met. Among the 13 water-receiving cities, Weihai became the first to pay (45.15 million yuan/~ €5.8 million) on 31 March 2016); this earned it the formal written praise of Zhao Runtian, Vice Governor of Shandong, who also emphasised that other cities should learn from Weihai and take action immediately. By September 2016, a total of 0.303 billion yuan (~ €0.039 billion) had been collected from the 13 cities, and by the end of 2016, 1.013 billion yuan (~ €0.13 billion) had been collected. In September 2016, the cities of Weihai, Weifang and Qingdao were officially praised and positively identified as role models due to their effort in paying their water bills. Another provincial-level document, *Notice on the compulsory collection of water charges for SNWTP (关于做好南水北调水费征缴工作的通知)*, was released on 21 December 2016 (Shandong Province South-North Water Transfer Memorabilia, 2016). This time the word '*collection*' *(征收)* in the title was changed to '*compulsory collection*' *(征缴)*. This document emphasised that water-receiving cities should develop their own long-term mechanisms for collecting water charges and that the fixed annual access fee would be integrated into the financial budgets of local governments. On 3 November 2017, the Department of Finance in Shandong released an important provincial-level document, *Notice on charging the fixed annual access fee for the first stage of the East Route by direct transfer from the city level finance to the provincial finance (关于结算上解相关市南水北调东线一期工程基本水费的通知)* (Shandong Province South-North Water Transfer Memorabilia, 2017), i.e. by deducting the fee from fiscal transfers from upper-level governments. At this point, the policy of integrating the fixed annual access fee into the financial budgets of local governments was approved and began operation.

This policy, however, can only mitigate the difficulties in charging for SNWTP water in Shandong. Local government officials believe that, in the long run, this policy of paying the fixed annual access fee through government finances may not be sustainable, especially among county-level governments that have little fiscal revenue. The main purpose of government fiscal expenditure is to meet public, social and economic development needs at the lowest cost; financial expenditure on the fixed annual water access fee thus has opportunity costs in that some local governments must reduce their investment in other local public services and infrastructure in order to pay these fees, which damages the interests of local people. Some local governments partially rely on loans from banks and corporations, which increases their debt. The social, economic and political impacts of this policy are thus potentially serious, and reasonable water pricing mechanisms must reflect this.

Meeting the challenges

Evidently, it is difficult for Shandong to operate and manage this interbasin water transfer project within the constraints of its internal political and social circumstances. Reports on the official website of the SNWTP in Shandong document many important meetings to discuss the key problems and negotiate various countermeasures. Behind the documents lies a great deal of investigation and thought, though not a resolution of the problems; however, according to the *Mid- and long-term planning report on comprehensive utilization of water resources in Shandong Province* (Shandong Provincial Government, 2016), the planned annual water diversion to Shandong is expected to increase to 1.467 Bm^3 by 2020 and to 2.951 Bm^3 by 2030 (based on the new planning for the terminal phase of the Eastern Route). Given the current arrangements, it will be an even greater challenge for Shandong to manage so much SNWTP water.

Moreover, in light of the actual demand of Shandong, the possibility needs to be raised of revising the planned water quotas at the fixed Eastern Route water prices. Of course, to reduce Shandong's planned quotas would have political consequences for the central government, since it would both reduce the revenue of the project and demonstrate that the SNWTP had not reached its water supply target. The SNWTP is a political object, but it cannot fully achieve its goals by relying solely on government regulation. The demand for transferred water cannot be constant, which means that there must a dynamic process for allocating water quotas to different water-receiving areas. Market mechanisms (particularly water rights trading among these areas) may be needed to improve the current administrative pricing mechanism and water allocation scheme.

ACTUAL USE OF WATER FROM THE SNWTP

Although the first phase of the Eastern Route of the SNWTP began transferring water from the Yangtze River to Shandong in November 2013, this project has not reached the annual planned water transfer of 1.353 Bm^3 per year (later revised to 1.467 Bm^3 per year). The reasons were given in the previous section: unfinished local auxiliary projects, high water prices, conflict and lack of coordination among stakeholders, and ambiguous management policies. Measured at the boundary of Jiangsu and Shandong, the total volume of water transferred into Shandong between November 2013 and May 2017 was 1.99 Bm^3, only 36.77% of the planned 1.353 Bm^3 per year. Even more revealing is the data in the *Shandong Province water resources bulletins (2001-2016)* (Department of Water Resources in Shandong, 2017), which report the transfers into individual cities; between 2014 and 2016, the volume of these transfers – water that actually reached end users – was 0.219 Bm^3, only 5.39% of the planned allocation to Shandong (the rest being stored in reservoirs, lakes or rivers, or used for environmental purposes). Many local cities in the water-receiving areas remain unwilling to take large amounts of water from the SNWTP. On average, cities only used 8.4% of their allocated quota of SNWTP water; Weifang used 50% of its quota, but seven cities used none (Qingdao, Zibo, Dongying, Jining, Liaocheng, Binzhou, Heze).

According to the *Planning report on the Eastern Route of* SNWTP which was revised in 2001 (Huaihe River Commission and Haihe River Commission of the Ministry of Water Resources., 2001), the water transferred by the SNWTP was mainly intended for industrial and domestic use in cities along the route of the water diversion canals and in eastern Shandong. By 2016, the project had not resulted in any increase in the total supply of water to Shandong, and had contributed significantly to supply in only a few areas; however, the Shandong government continues to evaluate the project positively, listing its achievements as "wide coverage, many functions, reliable, and inseparable" (Shandong Provincial Government Information Office, 2018). There are strong claims about two achievements in particular.

The first achievement claimed is that SNWTP water contributes to replenishing Shandong's groundwater. The province has historically overexploited groundwater. An area of 43,408 km^2 is designated as an overexploited; 14,094 km^2 is identified as the cone of depression in the plains, where groundwater is more than 6 metres below the surface; and in an area of 1560 km^2, groundwater is subject to seawater intrusion. In 2015, the maximum depth to groundwater was 34.44 metres. Replenishment of groundwater by SNWTP water is the subject of an important planning report entitled *Scheme of the comprehensive treatment in groundwater overexploitation areas in Shandong (2015-2025)* (Shandong Provincial Government, 2015). Dependence on groundwater continues, however, though withdrawals decreased from 13.37 Bm^3 in 2001 (52.9% of the total water supply) to 8.23 Bm^3 in 2016 (38.5% of the total), as the total water supply in Shandong fell from 25.27 Bm^3 to 21.39 Bm^3, and agricultural water consumption fell from 18.29 Bm^3 to 14.15 Bm^3. The *Mid- and long-term planning report on comprehensive utilization of water resources in Shandong Province*, however, projects that the planned groundwater withdrawals will rise to 8.47 Bm^3 in 2020 and to 8.60 Bm^3 in 2030 (Shandong Provincial Government, 2016). The Chinese media have reported extensively on the contribution of the SNWTP to Shandong's groundwater system; for instance, it was said that because of reduced groundwater abstractions the average groundwater level in the plains of Shandong rose by 0.18 metres from 2016 to 2017 and that between 2014 and 2017 the project contributed 0.13 Bm^3 of water to the recovery of springs in the city of Jinan. The *Scheme of the comprehensive treatment in groundwater overexploitation areas in Shandong (2015-2025)* proposes that by 2020, 93 Mm^3 per year of overexploited groundwater be replaced by SNWTP transfers, rising to 183.75 Mm^3 by 2025 (Shandong Provincial Government, 2015). SNWTP water would also be used to reduce the annual exploitation of 158.1 Mm^3 of deep confined water.

The second achievement claimed is that the Eastern Route of the SNWTP has contributed to environmental water, as reported in an official press conference about the SNWTP in Shandong. In 2014 and 2015, through the engineering facilities of the Eastern Route, 95.36 Mm^3 of SNWTP and Yellow River water were added to Nansi Lake, the second-largest freshwater lake in the Huai Basin. In 2016, 0.2 Bm^3 of SNWTP water was added to Nansi Lake and Dongping Lake. Such environmental flows have been widely used to improve water quality in polluted rivers and lakes in China and to restore their ecosystem functions.

Several features of these achievements are noteworthy. First, most of the claimed benefits are planned or projected, rather than currently evident. Second, there is no direct evidence as yet that the use of SNWTP water has contributed to any decrease in withdrawals from the Yellow River; indeed, withdrawals have continued to increase. Third, whatever the actual contributions of the SNWTP to Shandong's groundwater system and to the ecological functions of its rivers and lakes, it was not these but industrial and domestic water use that were the main original planning objectives of water supply by the SNWTP.

CONCLUSIONS

Since it began to operate in 2013, the Eastern Route has faced many challenges in Shandong, including failure to achieve planned water quotas, difficulties in constructing local auxiliary projects, expensive water, and high charges imposed on cities. To address these challenges, government officials have proposed (and in some cases adopted) administrative and political solutions, measures that are not sustainable since they ignore actual levels of demand.

These difficulties must be superimposed on even longer-term problems. First, planners have consistently overestimated future demands for water in Shandong and have thus overestimated demand for water from the SNWTP. Second, since 2000 there have been no cease-to-flow events on the Yellow River, and Shandong has become more and more dependent on reliable, abundant and cheap water transferred from the Yellow River; its enthusiasm for the SNWTP has therefore gradually weakened. Industrial and domestic water users – the planned consumers of water supplied by the SNWTP in Shandong – increased their consumption by 1.793 Bm^3 between 2005 and 2016, while, at the same time, agricultural use decreased by 2.023 Bm^3; total water demand in Shandong thus did not increase in that period. Increasing transfers from the Yellow River (21% of water supply in 2001 and 31% in 2016) have therefore permitted the province to reduce its reliance on groundwater (53% of supply in 2001 and 39% in 2016). Even recycled and desalinated water (about 4% of supply) has been growing in importance. Such changes in expectations about future demand point to the need for a dynamic mechanism to adjust water transfer quotas, particularly given the long period of discussion, planning and construction of such a project. The story of the SNWTP in Shandong is that of a centralised, hierarchically planned, fixed infrastructure whose deterministic projections come into conflict with the fluidity of water demand and local political circumstances. Thus, our first generalisable conclusion is that hierarchical, technocratic water management does not adjust efficiently to locally specific particularities.

The implementation of this project in Shandong reveals an acute divergence of interests between the central government, the Shandong provincial government, and individual cities. Whatever the reasons for pursuing the SNWTP in the first place, the central government is now concerned principally with supplying water consistently to the provinces which signed agreements to receive and pay for quotas. These contracts both guarantee incomes to pay off the project's capital and running costs, and enable the government to make claims about the successful operation of the project. Shandong was initially a strong supporter of the SNWTP but later, as increasing amounts of water became available from the Yellow River, the province discovered that it did not actually need the water supplied by the SNWTP (not yet, anyway). This rising reluctance to accept water from the SNWTP was exacerbated once the costs of receiving the water became clear, particularly the high cost of the water itself and the costs of building infrastructure to deliver water to consumers within the province. Shandong Province also needs its cities to contribute to its financial obligations to the central government; those cities, in turn, are generally reluctant to pay the high prices demanded for SNWTP water and the costs of constructing auxiliary projects to link their consumers to the main trunk canal, and their budgetary freedom is even more constrained than that of the provincial government. In other words – and this is our second general conclusion of relevance to water management – the planners made projections of demand for which the managers provided supply, but the fixed costs of providing supply mean that the managers must force cities to buy water from the project even if those cities can satisfy their demand for water more cheaply by other means.

The manner in which this conflict has so far played out is, however, specific to the politics of centre – local relations within China. China is a unitary state, which means that the central government makes the rules; nevertheless, the sheer size of the country and its population as well as its environmental and cultural diversity force the central government to cede some power to provincial jurisdictions. In turn, granting some local autonomy provides scope for local initiatives that may be useful nationally (Lim, 2017). Similar considerations apply at the provincial scale. (Shandong's population is approximately equal to that of Egypt, the fourteenth biggest country in the world). In practice, the result is unending tugs of war between the centre and its provinces (Chung, 2017) and between provinces and their cities, the outcomes of which depend on the assiduousness with which Beijing pursues its aims and the provinces delay and obfuscate. The SNWTP is a national iconic project which cannot be seen to fail, so the centre can and does use its fiscal power to force Shandong to comply with its project commitments; facing budget constraints, Shandong in turn can use its fiscal powers to force cities to accept SNWTP water.

Furthermore, if it is assumed that the SNWTP is a response to a water shortage rather than a purely political project, then this story contradicts that assumption; it provides direct evidence of the lack of coordination of the decision-making and management processes in the Chinese water management system. Even as the SNWTP was being planned, changes were taking place in national water management that reduced the need for the project and, in fact, have kept demand below available supply levels; these included stricter control over provincial extractions from the Yellow River, and an increase in the efficiency with which water was being used in agriculture, industry and the domestic sector (Chinanews, 2015). Of course, predictions of catastrophic water shortages in Shandong were also grossly overestimated because the bureaucracy and its associated commercial enterprises had an interest in advertising the need for large-scale infrastructures. Hence, our third general conclusion: even in the most water-stressed regions there is scope to increase the efficiency with which water is used, often sufficient scope to escape predicted catastrophic shortages (predictions which are, in any case, politically motivated).

The story of the SNWTP in Shandong is that of a fixed infrastructure and its deterministic projections bumping up against the fluidity of water demand and local political economy; a seemingly technical, rational project suddenly requires all manner of politically inflected choices to be made and competing interests to be reconciled. If we have been understanding technopolitics as being intentional political goals embedded in or enacted through water technologies, then this story makes us appreciate the unintended long-term political effects of such projects – effects that are clarified by viewing the project from below rather than above.

Acknowledgments

This work was supported by Australian Research Council Discovery Project (DP170104138). We thank Yue Yin, Chengting Zhou, Bo Bi, Di Zhang, Xuechun Li and Peng Zhang for their work in data collection, field surveys and figures preparation.

References

Akbulut, B.; Adaman, F. and Arsel, M. 2018. Troubled waters of hegemony: Consent and contestation in Turkey's hydropower landscapes. In Menga, F. and Swyngedouw, E. (Eds), *Water, technology and the nation-state*, pp. 97-114. London and New York: Routledge.

Barnett, J.; Webber, M.; Wang, M.; Finlayson, B. and Dickinson, D. 2006. Ten key questions about the management of water in the Yellow River Basin. *Environmental Management* 38(2): 179-188.

Barnett, J.; Rogers, S.; Webber, M.; Finlayson, B. and Wang, M. 2015. Sustainability: Transfer project cannot meet China's water needs. *Nature* 527(7578): 295-297.

Cao, J.F.; Ye, X.Y.; Wang, K.J. and Jiang, J.Y. 2008. Effect of no-flow in the Lower Yellow River on groundwater formation and usage in areas along the banks. *Frontiers of Earth Science* 2(4): 379-383.

Chen, D.; Webber, M.; Finlayson, B.; Barnett, J.; Chen, Z. and Wang, M. 2013. The impact of water transfers from the lower Yangtze River on water security in Shanghai. *Applied Geography* 45: 303-310.

Chinanews, 2015. Shandong implements the most stringent water resources management system - China's first pilot demonstration province. http://www.chinanews.com/cj/2015/11-25/7640426.shtml (accessed 14 July 2019).

Chung, J.H. 2017. Implementation: changing norms, issue-variance, and unending tugs of war. In Donaldson, J. (Ed), *Assessing the balance of power in central-local relations in China*, pp. 138-161. London and New York: Routledge.

Crow-Miller, B. 2015. Discourses of deflection: The politics of framing China's south-north water transfer project. *Water Alternatives* 8(2): 173-192.

Crow-Miller, B. and Webber, M. 2017. Of maps and eating bitterness: The politics of scaling in China's South-North Water Transfer Project. *Political Geography* 61: 19-30.

Crow-Miller, B.; Webber, M. and Molle, F. 2017a. The (re)turn to infrastructure for water management? *Water Alternatives* 10(2): 195-207.

Crow-Miller, B.; Webber, M. and Rogers, S. 2017b. The techno-politics of big infrastructure and the Chinese water machine. *Water Alternatives* 10(2): 233-249.

Department of Water Resources in Shandong, 2017. Shandong Province *water resources bulletins (2001-2016)* (SDWRB). www.shandong.gov.cn/col/col2529/index.html (accessed 20 July 2018)

Donaldson, J. (Ed). 2017. *Assessing the balance of power in central-local relations in China*. London and New York: Routledge.

Gorostiza, S.; March, H. and Saurí, D. 2018. Piercing the Pyrenees, connecting Catalonia to Europe: The ascendancy and dismissal of the Rhone water transfer project (1994-2016). In Menga, F. and Swyngedouw, E. (Eds), *Water, technology and the nation-state*, pp. 34-48. London and New York: Routledge.

Gu, W.; Shao, D.; Tan, X.; Shu, C. and Wu, Z. 2017. Simulation and optimization of multi-reservoir operation in inter-basin water transfer system. *Water Resources Management* 31: 3401-3412.

Harmel, R.D.; Cooper, R.J.; Slade, R.M.; Haney, R.L. and Arnold, J.G. 2006. Cumulative uncertainty in measured streamflow and water quality data for small watersheds. *Transactions of the ASABE* 49(3): 689-701.

Hofstedt, T. 2010. China's water scarcity and its implications for domestic and international stability. *Asian Affairs: An American Review* 37(2): 71-83.

Huaihe River Commission and Haihe River Commission of the Ministry of Water Resources, 2001. Planning report on the Eastern Route of SNWT Project (revised in 2001) (PER2001). https://wenku.baidu.com/view/00262b161711cc7931b7169a.html (accessed 20 July 2018)

Li, Y.; Xiong, W.; Zhang, W.; Wang, C. and Wang, P. 2016. Life cycle assessment of water supply alternatives in water-receiving areas of the South-to-North Water Diversion Project in China. *Water Research* 89: 9-19.

Lim, K. F. 2017 State rescaling, policy experimentation and path dependency in post-Mao China: A dynamic analytical framework. *Regional Studies* 51: 1580-1593.

Linton, J. and Delay, E. 2018. Death by certainty: The Vinça dam, the French state, and the changing social relations of irrigation of the Têt basin of the Eastern French Pyrénées. In Menga, F. and Swyngedouw, E. (Eds), *Water, technology and the nation-state*, pp. 49-64. London and New York: Routledge.

Liu, J. and Yang, W. 2012. Water sustainability for China and beyond. *Science* 337(6095): 649-650.

Liu, J.; Zang, C.; Tian, S.; Liu, J.; Yang, H.; Jia, S.; You, L.; Liu, B. and Zhang, M. 2013. Water conservancy projects in China: Achievements, challenges and way forward. *Global Environmental Change* 23(3): 633-643.

Long, Q. B. 2019. An overview of China's water statistics. *Acta Scientific Agriculture* 3 : 108-115.

Ma, X.; Wang, L.; Wu, H.; Li, N.; Ma, L.; Zeng, C.; Zhou, Y. and Yang, J. 2015. Impact of Yangtze river water transfer on the water quality of the Lixia River watershed, China. *PloS one* 10(4): e0119720.

Menga, F. and Swyngedouw, E. (Eds). 2018. *Water, technology and the nation-state*. London and New York: Routledge.

Moore, S. 2014. Hydropolitics and inter-jurisdictional relationships in China: The pursuit of localized preferences in a centralized system. *The China Quarterly* 219: 760-780.

Moore, S. 2018. China's domestic hydropolitics: An assessment and implications for international transboundary dynamics. *International Journal of Water Resources Development* 34(5): 732-746.

Pohlner, H. 2016. Institutional change and the political economy of water megaprojects: China's South-North Water Transfer. *Global Environmental Change* 38: 205-216.

Rogers, S.; Barnett, J.; Webber, M.; Finlayson, B. and Wang, M. 2016. Governmentality and the conduct of water: China's South-North Water Transfer Project. *Transactions of the Institute of British Geographers* 41(4): 429-441.

Sauer, V.B. and Meyer, R.W. 1992, Determination of error in individual discharge measurements. USGS Open File Report 92-144. Washington, DC: USGS.

Shandong Province South-North Water Transfer Memorabilia, 2000. www.sdnsbd.gov.cn/info/10523.jspx (accessed 20 July 2018)

Shandong Province South-North Water Transfer Memorabilia, 2002. www.sdnsbd.gov.cn/info/10525.jspx (accessed 20 July 2018)

Shandong Province South-North Water Transfer Memorabilia, 2014. www.sdnsbd.gov.cn/info/10537.jspx (accessed 20 July 2018)

Shandong Province South-North Water Transfer Memorabilia, 2016. www.sdnsbd.gov.cn/info/20653.jspx (accessed 20 July 2018)

Shandong Province South-North Water Transfer Memorabilia, 2017. www.sdnsbd.gov.cn/info/22364.jspx (accessed 20 July 2018)

Shandong Provincial Government, 2001. Letter of the People's Government of Shandong Province on the construction of the East Route Project of the South-to-North Water Transfer Project. www.sdnsbd.gov.cn/info/10524.jspx (accessed 20 July 2018)

Shandong Provincial Government, 2002. Planning report on sustainable utilization of water resources in Shandong Province in the early 21st Century (PWSD2002). https://wenku.baidu.com/view/40d7fed0a517866fb84ae45c3b3567ec112ddcf1.html (Accessed 10 July 2019.)

Shandong Provincial Government, 2015. Scheme of the comprehensive treatment in groundwater overexploitation areas in Shandong (2015-2025). www.shandong.gov.cn/art/2015/11/12/art_2267_17988.html (accessed 20 July 2018)

Shandong Provincial Government, 2016. Mid- and long-term planning report on comprehensive utilization of water resources in Shandong Province (PWSD2016). www.shandong.gov.cn/art/2016/9/14/art_2172_55519.html (accessed 20 July 2018)

Shandong Provincial Government Information Office, 2017. Introduction to the diversion situation of SNWTP in Shandong (2016-2017). www.scio.gov.cn/xwfbh/gssxwfbh/xwfbh/shandong/Document/1555870/1555870.htm (accessed 20 July 2018)

Shandong Provincial Government Information Office, 2018. Introduction to the current diversion situation of SNWTP in Shandong www.shandong.gov.cn/art/2018/7/26/art_2071_161207.html (accessed 11 June 2019)

Sheng, J. and Webber, M. 2018. Using incentives to coordinate responses to a system of payments for watershed services: The middle route of South-North Water Transfer Project, China. *Ecosystem Services* 32: 1-8.

Sheng, J.; Webber, M. and Han, X. 2018. Governmentality within China's South-North Water Transfer Project: Tournaments, markets and water pollution. *Journal of Environmental Policy and Planning* 20(4): 533-549.

Shourian, M.; Raoufi, Y. and Attari, J. 2017. Interbasin water transfer capacity design by two approaches of simulation-optimization and multicriteria decision making. *Journal of Water Resources Planning and Management* 143(9): 04017054.

Shumilova, O.; Tockner, K.; Thieme, M.; Koska, A. and Zarl, C. 2018. Global water transfer megaprojects: A potential solution for the water-food-energy nexus? *Frontiers in Environmental Science* 6: 150.

Sheppard, E. and McMaster R.B. (Eds). 2004. *Scale and geographic inquiry: Nature, society, and method*. Oxford UK.: Blackwell.

Sneddon, C. 2002. Water conflicts and river basins: The contradictions of comanagement and scale in Northeast Thailand. *Society and Natural Resources* 15(8): 725-741

Swyngedouw, E. 2004. Scaled geographies: Nature, place and the politics of scale. In Sheppard, E. and McMaster, R. (Eds), *Scale and geographic inquiry: Nature, society, and method*, pp. 129-153. Oxford UK.: Blackwell.

Tortajada, C. 2016. Policy dimensions of development and financing of water infrastructure: The cases of China and India. *Environmental Science and Policy* 64: 177-187.

Webber, M.; Barnett, J.; Wang, M.; Finlayson, B. and Dickinson, D. 2008. The Yellow River in transition. *Environmental Science and Policy* 11(5): 422-429.

Webber, M.; Crow-Miller, B. and Rogers, S. 2017. The South-North water transfer project: Remaking the geography of China. *Regional Studies* 51(3): 370-382.

Webber, M. and Han, X. 2017. Corporations, governments, and socioenvironmental policy in China: China's water machine as assemblage. *Annals of the American Association of Geographers* 107(6): 1444-1460.

Webber, M.; Li, M.; Chen, J.; Finlayson, B.; Chen, D.; Chen, Z.; Wang, M. and Barnett, J. 2015. Impact of the Three Gorges Dam, the South-North Water Transfer Project and water abstractions on the duration and intensity of salt intrusions in the Yangtze River estuary. *Hydrology and Earth System Sciences* 19: 4411-4425.

Wilson, M.C.; Li, X.Y.; Ma, Y.J.; Smith, A.T. and Wu, J. 2017. A review of the economic, social, and environmental impacts of China's South-North Water Transfer Project: A sustainability perspective. *Sustainability* 9: 1489.

Xinhuanews, 2015. Cao Jinping as the Deputy Director General of the Department of Water Resources in Shandong said that two hands work together to improve the utilization rate of SNWTP. www.xinhuanet.com/politics/2015lh/2015-03/11/c_1114607570.htm (accessed 20 July 2018)

Yan, D.C; Shi, G.Q.; Hu, Z.J. and Wang, H.B. 2016. Resettlement for the Danjiangkou Dam heightening project in China: Planning, implementation and effects. *International Journal of Water Resources Development* 33(4): 609-627.

Yan, D.H.; Wang, H.; Li, H.H.; Wang, G.; Qin, T.L.; Wang, D.Y. and Wang, L.H. 2012. Quantitative analysis on the environmental impact of large-scale water transfer project on water resource area in a changing environment. *Hydrology and Earth System Sciences* 16(8): 2685-2702.

Yang, H. and Zehnder, A. 2001. China's regional water scarcity and implications for grain supply and trade. *Environment and Planning A: Economy and Space* 33(1): 79-95.

Yang, Y.; Yin, L. and Zhang, Q. 2015. Quantity versus quality in China's South-to-North Water Diversion Project: A system dynamics analysis. *Water* 7(5): 2142-2160.

Yu, M.; Wang, C.; Liu, Y.; Olsson, G. and Wang, C. 2018. Sustainability of mega water diversion projects: Experience and lessons from China. *Science of the Total Environment* 619: 721-731.

Zhang, J., 2009a. *The South-to-North Water Diversion project: Exploration and practice on the source of the Eastern Route*. Nanjing: Jiangsu science and technology press.

Zhang, L.; Li, S.; Loáiciga, H.A.; Zhuang, Y. and Du, Y. 2015. Opportunities and challenges of interbasin water transfers: A literature review with bibliometric analysis. *Scientometrics* 105: 279-294.

Zhang, Q., 2009b. The South-to-North Water Transfer Project of China: Environmental implications and monitoring strategy. *Journal of the American Water Resources Association* 45(5): 1238-1247.

Ce