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Transformation of water resource management: a case study of the South-to-North Water Diversion project

Zhen-Yu Zhao ^{a, b, *}, Jian Zuo ^{b, c}, George Zillante ^b

^a School of Economics and Management, North China Electric Power University, Beijing 102206, China

^b School of Architecture and Built Environment, The University of Adelaide, Adelaide 5005, Australia

^c Entrepreneurship, Commercialisation and Innovation Centre (ECIC), The University of Adelaide, Adelaide 5005, Australia

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ABSTRACT

Water transformation plays a crucial role in the rational allocation and avoiding over-exploitation of natural resources. Mega water transformation project will not only bring opportunities for ecological and economical use of water resources, but also contribute towards regional industrial and societal transformations. The scarcity of water is a serious issue for north China, accordingly the Chinese government decided to implement the South-to-North Water Diversion project in order to transfer water from the water rich south China to China's northern region. The South-to-North Water Diversion project is the largest water diversion project in the world involving significant long distance and inter-basin water transfer features. The management of this mega project faced a number of significant challenges as it had to contend with a variety of issues including politics, the economy, society, local culture, the environment and the local ecology. This project has also drawn global attention to the question of how to coordinate, manage and implement the world's largest water resource project. This study focuses on management practices of the South-to-North Water Diversion project by investigating the project's eastern and central routes. The three project management approaches that were used in this project, i.e. project owner direct management, project consignment management, and agent construction management (Daijianzhi) were investigated. Management regulations, control measures and common issues associated with the South-to-North Water Diversion project were also examined. These included: land acquisition and resettlement, bidding and tendering, construction supervision, quality management, cost management and schedule management. A questionnaire survey was conducted with key project participants in order to identify the key factors that contribute towards cost overruns and delays in the project. This is one of very limited number of studies which have in-depth investigation of mega water transformation projects in a systematic manner. The findings are expected to assist both academics and industry practitioners gain a better understanding of management practices in this mega water transformation project. This is particularly useful as the project team has to deal with a variety of sustainability related issues apart from traditional project management duties. Similarly, the lessons learnt from this case study will provide a valuable reference for the management of mega engineering projects and act as useful inputs for an international benchmarking exercise.

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1. Introduction

Water is one of most essential natural resources for human beings. As a result, water resource management has attracted a

growing attention from both academic and industry practitioners. This is also due to the significant impacts of water resource management on the economy, society and environment (Dvarioniene and Stasiskiene, 2007; Umaphathi et al., 2013). Government normally plays a critical role in the water resource management, e.g. ensuring both the quality and quantity of water supply for local residents. China is a nation with a shortage of water resources as illustrated by the fact that its water resource per capita is only a quarter of the world average (State Council, 2012). Forty per cent of China's population lives in water-deficient areas. This is

* Corresponding author. School of Economics and Management, North China Electric Power University, Beijing 102206, China. Tel.: +86 10 61773150; fax: +86 10 80796904.

E-mail address: zhaozhenyuxm@263.net (Z.-Y. Zhao).

compounded by the uneven spatial population distribution where south China generally has much richer water resources than the northern regions (Bian et al., 2014; Zhang and Anadon, 2014). The conflict between water resource capacity and socio-economic development is most significant in the Yellow–Huai–Hai river (the Yellow River, the Huai River, and the Hai River) basins where the amount of water resource per capita is as low as 21% of the national average (Zhu et al., 2011; He et al., 2014). The Yellow–Huai–Hai river basins play a critical role in the Chinese economy, accounting for 35% of its population and 35% of its gross domestic Product (GDP) whilst holding as little as 7.7% of China's total water resources (Li et al., 2011, 2007). In order to alleviate the pressure of water scarcity, the Chinese government decided to implement the South-to-North Water Diversion (SNWD) project, the largest water diversion project in the world, to transfer water from the Yangtze River which is located in water rich south China to its northern region. This is indeed a transformation of water resource with a focus on environmental, social and economic issues.

According to the “Master Plan for the SNWD” approved by the State Council in 2002, the SNWD project consists of three routes, i.e. the east route, the middle route and the west route. These routes draw water from upstream, mid-stream and downstream of the Yangtze River. These three routes, together with the Yangtze River, the Yellow River, the Huai River and the Hai River will form a new water resource network for China.

The SNWD project is implemented in three stages as shown in Table 1. The final water volume transferred will reach some 44.8 billion m³ per year by the year 2050; which is the equivalent of the total water volume of the Yellow River.

Indeed, there are a number of challenges associated with managing mega infrastructure projects. This is mainly due to the complex nature of these projects which resulted in significant risks and uncertainties (Giezen, 2012). Risk management plays a crucial role in managing mega infrastructure projects where risks evaluation and system engineering methods could be adopted (Li and Zou, 2011; Locatelli et al., 2014). This is compounded by the fact that there are a large number of stakeholders involved in mega infrastructure projects (Gil et al., 2012). It is imperative to engage all stakeholders into the management of mega infrastructure projects, preferably from the early project stage (Mok et al., 2015). In addition, mega infrastructure projects are often under the scrutiny on the sustainability issues. For instance, the environmental issues associated with hydro projects such as the Three Gorges Complex have drawn global attention (Tullos, 2009). Similarly, social conflicts may emerge from mega infrastructure projects if related issues were not dealt with properly (Jia et al., 2011). All these add to already challenging tasks to manage conventional projects to ensure projects are delivered on time, within budget and with a desired quality.

The SNWD project is a national strategic infrastructure project for China which is featured with large scale, massive investment, involving a large number of participating parties and having significant impacts on the sustainable utilization of water resource in China. This mega project faces a number of complexity issues and challenges that had not been experienced in previous projects. This study aims to analyze the management approaches in the SNWD

project on such issues as project organization, land acquisition, resettlement, quality management, cost management and schedule management; thereby revealing how the Chinese Government managed the world's largest water resource project.

2. The eastern route and middle route of the SNWD

The construction of both eastern and middle routes commenced in December 2002. These two routes are expected to supply water from 2013 to 2014 respectively. These routes involve 5 provinces (i.e. Jiangsu, Shandong, Hebei, Henan and Hubei), 2 municipalities (i.e. Beijing and Tianjin) and more than 130 counties.

The east route draws water from Yangzhou city of Jiangsu province, downstream of the Yangtze River. Diverted water will travel along the Jinghang Canal and existing river channels to north China and will be divided into two channels. The northern oriented channel crossing the Yellow River supplies water to the north of Yellow River whereas the eastern oriented channel supplies water to Yantai and Weihai cities. The extent of the diversion of the east route is 1466.5 km.

The middle route discharges water from Danjiangkou reservoir, and crosses the Yellow River at the western Zhengzhou city. The diverted water can then flow to Beijing and Tianjin cities simply under the influence of gravity with little dependence on pumping stations. The extent of the diversion of the middle route is 1432 km in length.

The SNWD project involves a range of subprojects including channels, reservoirs, buildings, pumping stations, tunnels, aqueducts, water diversion gates, pollution control, river diversion, soil and water conservation, resettlement of migrants and communication and monitoring facilities.

3. Research methods

This research aims to investigate how the SNWD project was organized and managed. The case study approach places focuses on the complexity nature of the case (Bryman and Bell, 2015). Therefore, a comprehensive case study based research methods involving interviews, field studies, policy review and questionnaire survey was adopted for this research. The collection of data from multiple sources was considered to be an essential component of the methods as it facilitates the triangulation and validation of the data (Bryman and Bell, 2015). These multiple sources are complementary and improve the reliability of data similarly.

The complex nature and scale of the SNWD project gives rise to a number of factors that affect the management of the project. Accordingly, it is imperative to determine effective and efficient management regulations and measures are in place in order to ensure the project's success. These include guidelines, policies and measures released by the Government for the control of the project and the coordination of the various participating parties. These guiding principles are reflected in the various aspects of the project management practices within the SNWD project. These include quality management, land acquisition and resettlement, bidding and tendering, investment management and schedule management. Therefore, these issues were selected as the main topics of this research.

3.1. Interview and field studies

The research team interviewed project participants in Beijing, Tianjin cities, and Hebei, Henan, Jiangsu, and Shandong provinces all of which are locations for some important aspects of the SNWD project. The purpose of the interviews was to investigate how this mega project was managed and the effectiveness of those

Table 1
The three stages and annual water volume transferred by SNWD.

Stages	Years	Annual water volume transferred (billion m ³)
I	2002–2010	20
II	2011–2030	16.8
III	2031–2050	8
Total		44.8

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