Drink, Drank, Drunk: an Analysis of Three Possible Solutions to Urban Residential Potable Water Shortages in China

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DRINK, DRANK, DRUNK; AN ANALYSIS OF THREE POSSIBLE SOLUTIONS TO URBAN RESIDENTIAL POTABLE WATER SHORTAGES IN CHINA

by

Holly C. Smith

A thesis submitted to the University of Mississippi in partial fulfillment of the requirements for completion of the Bachelor of Arts degree in International Studies at the Croft Institute for International Studies and the Sally McDonnell Barksdale Honors College.

Approved

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Advisor: Dr. Michael Harvey

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Reader: Dr. Joshua Howard
ABSTRACT:

China’s urban residential communities are currently facing mounting levels of water scarcity with the potential to impact social and even possibly political stability. China’s central government is currently attempting to mitigate such potential risk by adopting a variety of projects aimed at combating potable water shortages. This paper sets out to analyze three of the national projects adopted by China’s central government to combat critical residential water shortages currently affecting China’s urban areas. The three projects are South North River Transfer Project, the adoption of tiered water pricing system, and the construction of desalinization facilities in some coastal cities. Each of these projects distributional equality, political feasibility, cost effectiveness, and environmental impact will be examined so as to determine which serves as the best viable solution to China’s current water shortages. The variety of these projects suggests a single policy will be unable to provide a complete solution to China’s residential water shortages. Rather the direness of China’s urban water scarcity will require the simultaneous adoption of multiple policies to fully address the potable water needs of China’s urban residential communities.
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ABBREVIATIONS, ACRONYMS AND TRANSLATIONS

改革开放  China’s Opening Up and Reform Policy
关系  Guanxi Chinese concept of the importance of relationships
汉江  The Han River
胡锦涛  Hu Jintao  China’s former president
李克强  Li Keqiang  China’s Premier
马军  Ma Jun a well-known Chinese Environmentalist
毛泽东  Mao Zedong, China’s former Communist leader
国家统计局  National Bureau of Statistics
一国两制  One Country Two Policies (China’s policies towards Hong Kong)
南水北调工程  South North River Transfer (same as SNRT)
铜陵  Tongling a town in China
习近平  Xi Jinping  China’s current President
长江  The Yangtze River
黄河  The Yellow River
CCP  Chinese Communist Party
FDI  Foreign Direct Investment
GDP  Gross Domestic Product
HKD  Hong Kong Dollar
IBT  Increasing Block Tariffs
IPE  The Institute of Public & Environmental Affairs
KM  Kilometers
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tr>
<td>M</td>
<td>Meters</td>
</tr>
<tr>
<td>$M^3$</td>
<td>Cubic Meters</td>
</tr>
<tr>
<td>MOHURD</td>
<td>Ministry of Housing and Urban-Rural Development</td>
</tr>
<tr>
<td>NDRC</td>
<td>National Development and Reform Council</td>
</tr>
<tr>
<td>PSI</td>
<td>Pounds Per Square Inch</td>
</tr>
<tr>
<td>RMB</td>
<td>Renminbi (China’s national currency)</td>
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<tr>
<td>RO</td>
<td>Reverse Osmosis</td>
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<td>SNRT</td>
<td>South North River Diversion</td>
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<td>SNRT</td>
<td>South North River Transfer (same as SNRT)</td>
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<td>UF</td>
<td>Ultra Filtration</td>
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INTRODUCTION:

China’s former Premier Wen Jibiao, was not simply being an alarmist when he stated in 1999, that “the survival of the Chinese nation is threatened by the country's shortage of water.” Today China faces water shortages that threaten to undermine the nation’s social, economic and political prosperity. Although, this research is limited in scope to the water shortages affecting China’s urban residential communities and their associated solutions, finding a viable solution to these communities current water shortages will likely have a sizable impact on China’s overall level of water shortages, as China’s urban residential areas represent the country’s largest population centers. China’s central government is currently exploring a variety of options including solutions that focus on increasing the supply of potable water in urban residential areas, the South North River Transfer (SNRT) project and the construction of desalination facilities, as well as a solution aimed at curbing urban residential demand for potable water, the implementation of an increasing block tariff (IBT) pricing scheme. In terms of the projects’ political feasibly, cost effectiveness, distributional equality, and environmental impact each of the three solutions has its own individual strengths and weakness.

Overall, this research seeks to compare the individual projects along the same criteria to determine which holds the potential to provide a viable solution to the water shortages currently facing China’s urban residential communities. The project which is best able to not only find a sustainable tradeoff between cost effectiveness and environmental impact, but is also able to balance decreasing water demand, encouraging water conservation with increasing the supply of potable water in China’s urban residential areas, will be the one determined to be the most viable.

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of the three projects. This research is focused on examining the projects already adopted by China’s central government in order to determine which among them represents the most practical long term solution to water shortages in China’s urban residential communities.

The ideal solution to China’s urban residential potable water shortages would be a project or multiple projects that are able to be both economical and environmentally friendly, while still individualized enough to suit the specific water needs of a given community. Additionally, China’s central government should seek to incentivize water conservation and try to strike a balance between decreasing residential demand for potable water and simultaneously increasing the available supply of potable water. Overall, the three projects disused in this paper will be compared against these criteria.
RESEARCH METHODOLOGY:

Outline of Research Breakdown:

This paper, apart from the overall introduction and conclusion is divided into four major chapters. The first chapter is a discussion of the impact of continued water shortages in China. This chapter lays out a timeline for the depletion of potable water in China’s urban residential areas. It also provides context on the extent of China’s current water shortages, and provides a framework for the other three projects that gives justification for this research by outlining the importance of implementing a plan to solve effectively the current water urban residential water shortages in China.

The remaining three chapters examine of three different projects currently being implemented by China’s central government to combat China’s urban residential water shortages. The three projects are the SNRT project, an IBT water pricing scheme, and the construction of desalination facilities, each of which will be compared along the same four predetermined criteria. Each of these three chapters is subdivided into six major subsections. These six subsections include a project background explanation, an examination of the project’s distributional equality, political feasibility, cost effectiveness, environmental impact, and then a discussion of that particular project’s overall conclusions. All of the projects are compared along the same criteria in order to determine which project represents the most effective model for combatting urban residential water scarcity in China.
**Justification of Chosen Projects:**

Although a more specific explanation of each project will be provided in the background section of chapters two through four, the three projects were chosen because each is state sponsored approach, undertaken by the Chinese government towards combating urban residential water shortages. As each of the three projects is to some extent being introduced on a national level and is backed by the Chinese central government, there is enough commonality between the projects to compare them effectively along similar criteria. There is also enough variety among the projects to gauge the relative effectiveness of the different approaches to combating China’s residential water shortages. This allows for comparison between projects that are increasing the supply of potable water to those that are oriented towards decreasing demand of water. As these three policies represent a spectrum of China’s response to current urban residential water shortages, by comparing them along the four predetermined criteria this research will be able to judge the inherent strengths and weakness of each approach as it is suited for success in China.

**Definition of the Four Criteria:**

This section provides a basic definition of each of the four criteria used to evaluate the potential success of each of the three projects in combating China’s urban residential water shortages. These criteria include each project’s distributional equality, political feasibility, cost effectiveness, and environmental impact. Although the specific examples discussed in each chapter will be adapted to be relevant to each of the three projects, the following definitions provide a basic explanation of the aspects of each project that will be evaluated by the individual criteria.
Distributional Equality:

This section will evaluate the extent to which the potential benefits of each of the three projects are equally distributed across China. This section will primarily take into account disparities in the geographic distribution of each project, particularly in terms of the divide between Northern and Southern China. When relevant this section will include an examination of the extent to which each project benefits certain regions of China (typically Northern China) at the expense of other regions (typically Southern China). This includes drawing conclusions about potential threats to social stability and increases in social tension due to policies that unevenly distribute water.

Political Feasibility:

This section will examine the political commitment of China’s central government to the successful implementation of each of the individual projects. This includes examining factors that incentivize government and party commitment to the projects. This section will also look at how the unique political structure of China as an authoritarian state, has influenced the structuring and potential success of each project of each individual project.

Cost Effectiveness:

This will be the most quantitative of the four criteria sections. This section will examine the overall cost of fully implementing each of the three projects, as well as the economic benefits and limitations of each project. This will include both initial costs of the projects, as well as future financial costs of continuing the projects, and when relevant the financial stress added to local economies by the project. The section will discuss the economic and financial impacts
uniquely associated with each of the three projects, in an attempt to determine the most cost effective means of combating water shortages in China’s urban residential areas.

**Environmental Impact:**

This section will examine the overall impact each of the three projects has had on the urban residential water situation in China in terms of increasing supply, decreasing demand, and environmental conservation. The section will consider both the short and long term environmental impacts of the each of the three projects. This section will take into consideration the environment costs of each of the three projects, including the potential for pollution and the threat to biodiversity. Overall, this section seeks to determine the ability of each project to decrease water shortages while simultaneously minimizing the risk of environmental damage.
CHAPTER 1: THE THREAT OF WATER SHORTAGES IN CHINA

1.1 Background of China’s Water Shortages:

There is a fundamental shortage of potable water in China. China currently has 21% of the world’s population, but only 6% of the world’s potable water. This situation is further exacerbated by the fact that China’s water resources are not equally distributed across the country, 43% of China’s population lives in Northern China, but this region only holds 19.6% of the country’s water resources. The problem of water shortages in China is likely only to be compounded over the next couple decades as China’s population is projected to continue to increase, while the nation’s supply of potable water will likely decrease.

By 2033, China’s per capita natural freshwater resources will likely decline to only 1,875 cubic meters, down from 2,156 cubic meters in 2007, when China’s freshwater resources already ranked among the lowest per capita for a major country. China’s water crisis has grown so dire that according to Chinese officials “by 2030 [China’s] water use will reach or approach the total volume of exploitable water resources.” Overall, China’s central government must implement new solutions to combat water shortages in order to preserve China’s social stability, economic growth, agricultural security, and prevent China from running out of potable water.

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1.2 Exasperation of Urbanization:

In China in the early 1990s a new wave of economic reforms gradually encouraged rural to urban migration, by 1990 approximately 26% of China’s population lived in urban areas. As a result of China’s Opening Up and Reform Policy, and the increasing economic opportunities available, urbanization rapidly increased in China such that for the first time in 2011 the majority of China’s population (51.3%) lived in urban areas. This rapid urbanization has had a twofold impact on potable water in China’s urban area.

First, this increase in population places many areas in China under increased water stress. As of 2013, 60% of China’s 660 cities were classified as short of water. Additionally, 108 cities, including China’s capital Beijing, face the threat of “serious water shortages”. Beijing, a city that has experienced some of the highest levels of population growth, current water recourses only amount for 230 cubic meters of fresh water per capita. This is considered “far below the world water poverty mark.” Despite policies such as the one child policy aimed at curbing population growth, China’s central government has been unable to stifle increasing population growth and particularly swelling populations in urban areas that place increasing pressures on an already limited source of freshwater resources in China.

Second, the rapid urbanization and economic growth in China has resulted in increased levels of water pollution. This pollution has affected China’s current potable water resource

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8 Ibid., 6
11 Ibid., 1
12 Ibid., 1
situation by causing drinking water standards in roughly half of China’s cities to fall below provincial drinking water quality standards.\textsuperscript{13} China’s numerous urban development projects, and many industrial plants, which have sprung up as a result of China’s rapid urbanization, have only aggravated the pollution of lakes and aquifers in China.

1.3 The Threat of Water Shortages in Beijing

Beijing, like many other cities suffers from natural geographic water shortages of Northern China, exacerbated by the city’s growing population and rapid industrialization. However, such urban residential water shortages are perhaps more precarious in Beijing than in any other Chinese city, because Beijing is China’s capital. The central government is committed to preventing Beijing from running out of potable water, because doing so could threaten the social and political stability of China.

Beijing currently is suffering from a water shortage on par with many countries in the Middle East.\textsuperscript{14} Some experts such as Xu Xinyi, Director of the Beijing Normal University College of Water Sciences, blame these water shortages on overpopulation, which continue to place incredibly high demands on the city’s already overstretched aquifers.\textsuperscript{15} However, certain “local government and business [practices that have] recklessly pursu[ed] quick money by developing projects that devoured resources and caused serious pollution,” have likely worsened Beijing’s already grim water situation.\textsuperscript{16}

\textsuperscript{13} Ibid., 4
\textsuperscript{16} Ibid., 1
Although the problem of potable water shortages is not unique to Beijing, the situation is made more dire because as the capital city Beijing is the center of the government and the Communist Party power in China. Therefore, reports that Beijing residents have been driven to dig illegal wells as a means of combating local water shortages represents the critical point reached by the water shortages in Beijing.\(^{17}\) China’s central government simply cannot afford to let Beijing run out of potable water, doing would likely cause irreparable damage the Communist Party’s image, framing them as unable to even provide the most basic of resources to the people of their own capital. This in turn would likely also incite social and political instability.

It is likely as a result of the high stakes associated with maintaining a state of water stability in China’s capital that all of the projects addressed in this paper are in some way aimed at alleviating water shortages in Beijing. The magnitude of the projects into which China’s central government is willing to invest, particularly the SNRT project, in order to combat residential water shortages in Beijing demonstrates the national political importance of mitigating residential potable water shortages in the city.

**1.4 Domestic Business Implications:**

China’s current water shortages if not reversed or at the very least stabilized will likely threaten to undermine the remarkable economic progress achieved by China over the last thirty years. Chronic water shortages and resulting high levels of pollution in major natural freshwater sources, such as the Yangtze River, could result in China becoming a less attractive destination for foreign companies. Foreign businesses are going to be unlikely to invest in a country facing a chronic shortage of natural resources particularly a resource as critical as water. Freshwater is

not only important to many manufacturing processes, but also the use of coal power, China’s current major source of fuel is a process that is incredibly water intensive.\textsuperscript{18} As a result of these, and possibly other factors, China’s levels of foreign direct investment (FDI) would likely fall should China’s central government fail to enact a viable solution to China’s current problems of water scarcity.

Decreases in FDI would hurt China’s overall economic growth, as many sectors such as manufacturing, have become relatively reliant on high levels of FDI to sustain their business models. In this way failing to solve China’s water shortages pose a direct threat to China’s miraculous economic growth. A lack of the basic natural resources, such as potable water, would cause China to become an undesirable market for expanding foreign companies and their resulting investment and capital.

\textbf{1.5 Implications for Regional Relationships}

Although the focus of this paper is primarily China’s domestic response to urban residential potable water shortages it would be incomplete to assume that water shortages, and the solutions enacted to resolve them did not affect China’s relationships with its regional neighbors in South Asia, several of whom also suffer of similar water shortages.

Perhaps the most significant of these regional relationships effect by China’s current water policy is the Sin-India relationship. The western route of the SNRT project, though currently still in planning phases, will divert water from the head of the Yangtze River at the Himalayan plateau.\textsuperscript{19} This project will potentially have large political consequences for China as construction of the proposed dams on the Brahmaputra and Mekong Rivers are very likely to


have an impact on downstream countries that include India, Bangladesh and Vietnam. Although China’s central government claims that the project would only siphon off approximately 1% of the run-off from the Brahmaputra River, there has still been much uproar in India against the project that is seen as potentially threatening India’s own limited water resources.\footnote{Das, Rup Narayan. "India-China Relations A New Paradigm." Institute for Defense Studies and Analyses, 2013. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0CCEQFjAA&url=http://idsa.in/system/files/Monograph19.pdf&ei=Dzs1VfzTOM-wogSLICwCA&usg=AFQjCNHudwoGTcOi3qqjDStFma86BlJuQ&sig2=6gLzPs65BX1-SyG4STdbUw&bvm=bv.91071109,d.b2w.} The fact that the majority of western route of the SNRT project is located in the contested Tibetan autonomous region only further complicates potential water conflicts and provides strategic motivation for China to maintain control over the water supply.


Given the history between Sino-Indian relations, as well as the increasing severity of the future water shortages facing both countries, it is possible that the western route of the SNRT project could create a potential hotspot as the world’s two most populous countries compete for...
control over the same water source. In this way China’s own plans to increase their supply of potable water as a means to maintain domestic stability may instead jeopardize their political ties with regional neighbors.

1.6 Implications for Sino-U.S. Relations

Finally, it is important to briefly analyze the implications of China’s current water shortages on Sino-U.S. relations, as the United States-China relationship is currently the most important bilateral relationship in the international community. Overall, the impact of Chinese water shortages on Sino-U.S. relations is threefold.

First, chronic water shortages in China will likely have an impact on the two countries’ economic relations. As discussed earlier in this chapter, water shortages will probably make China a less attractive market for foreign investment, and will also impact China’s manufacturing sector that is highly dependent on coal based energy. The United States as China’s biggest trading partner would potentially feel the economic impact of a drop in Chinese manufacturing, particularly of a drop in manufactured goods typically exported to the United States. China’s inability to maintain its natural resources may also drive certain U.S. companies to start to invest in countries other than China.

Secondly, In terms of regional security, the United States has a vested interest in maintaining the regional stability of East Asia.24 Should China’s central government be unable to sufficiently solve current water shortages, or pursue plan of water development that their neighbors perceive as overly aggressive it is possible that a water war could erupt in East Asia. An international conflict over water in Asia has the potential to escalate and disrupt the balance

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of power in the region. As many of the United States’ largest trading partners and important allies are located in the region, as well as the United States’ strong military presence in the Pacific, a regional conflict over resources such as water would have a large impact on United States’ foreign policy.  

Finally, should the three projects discussed in this paper prove to be insufficient in supplying China with water a continued supply of water, it is possible that China may begin to seek out relationships with other countries in order to secure a partnership to provide access to potable water. Should China pursue such a policy of expanding their global hegemony as a means of securing access to other countries’ water resources, this would likely affect Sino-U.S. relations, as such an increase in China’s global influence may be perceived as a potential threat to the United States’ soft power.

1.7 Chapter Conclusions

Overall, this chapter provides a background on the extent of the water shortages currently facing China, as well as provides brief explanation as to the possible of the business, diplomatic, and security repercussions if China’s central government fails to reverse current urban potable water scarcity. Although the repercussions and scenarios discussed in this chapter are not necessarily the primary focus of this paper, they are still relevant as they provide a context for the severity of the problem, which China is attempting to address with the three projects examined in the remaining chapters. This chapter should provide the context for why China’s central government has so heavily invested in multiple attempted solutions aimed at reducing potable water shortages, and the possible stakes at risk should these projects fail.

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CHAPTER 2: SOUTH NORTH RIVER TRANSFER PROJECT

2.1 SNRT Project Background

China’s SNRT project is divided into three major sections (Image 1), the eastern and central routes that have already been completed, and the western route set for completion in 2050. The ultimate goal of the project is to redirect approximately 44.8 billion cubic meters of fresh water from the Yangtze River in Southern China, to the water stressed region of Northern China.

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China. The project is allegedly based on a 1952 quote from Mao Zedong “there is plenty of water in the south, not much water in the north, if at all possible; borrowing some water would be good.” This reengineering of China’s geographically unequal distribution of water represents one of the world’s largest and most expensive engineering projects.

Image 2

SNRT Project Eastern Route

Construction of the eastern route of the project (Image 2) was completed in 2013. The route consists primarily of an upgrade to China’s Grand Canal and increasing the amount of

water drawn from the Yangtze River into the Jiangdu canal. The water is then transferred through multiple pumping stations along the Grand Canal, through a tunnel constructed under the Yellow River and finally into reservoirs near the city of Tianjin. In total, the eastern route of the SNRT project is just over 1,152 km long, with 23 pumping stations and a power capacity of 454 megawatts.

Image 3

SNRT Project Central Route

The central route of the SNRT project (Image 3) which began operation in December 2014 is designed to divert water from the Yangtze River to Beijing. The route runs from the Danjiangkou Reservoir on the Han River, a tributary of the Yangze River, to China’s capital city.

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34 Ibid., 1
of Beijing. The 1,264 km long canal was constructed in such a way that water was able to flow down from the Danjiangkou Reservoir to Beijing via gravity without the need to construct pumping stations. However, the route did require the construction of a tunnel to allow water to flow under the Yellow River. The plan included raising the height of the Danjiangkou Dam from 162 m to 176.6 m above sea level, in order to increase the reservoir’s overall water level.

Image 4

The western route (Image 4) the final stage of the SNRT project, is currently in the planning stages is expected to be completed by 2050. The western route will divert water from the Tongtian, Yalong, and Dadu rivers, tributaries of the Yangtze, to the Yellow River. To


complete the route multiple dams, tunnels, and canals will need to be constructed.\textsuperscript{44} The Tongtian line will be 289 km long, the Dadu line will be 30 km, and the Yalong line will be 131 km.\textsuperscript{45} Overall the route is planned to divert 3.8 billion m\textsuperscript{3} of water across the Bayankala Mountains to Northwestern China.\textsuperscript{46}

Although this paper will reference the environmental and financial impact incurred by the SNRT project as a whole, the majority of this paper will focus on the impact of the central route completed December 2014. Since the central route supplies water directly to Beijing, it is comparable to desalination and the IBT pricing scheme both of which are also aimed at bringing relief to Beijing’s water shortages. Overall, the central route is the section of the SNRT project which best exemplifies the impact of the SNRT project on China’s urban residential water usage, the primary focus of this research.

\subsection*{2.2 SNRT Project Distributional Equality}

\subsubsection*{Relocation:}

The central route of the SNRT project required the relocation of 300,000 residents from Hebei province, whose houses and property were submerged once the route became operational.\textsuperscript{47} Residents had the option either to retreat from the rising water while still staying in

\begin{footnotesize}
\begin{itemize}
\item \textsuperscript{44} Office of the South-to-North Water Diversion Project Commission of the State Council. "Western Route Project (WRP)." South to North Water Diversion. \url{http://www.nsbd.gov.cn/zx/english/erp.htm}
\item \textsuperscript{45} Simons, Craig (2006-09-10). "In China, A Water Plan Smacks Of Mao": Cox News Service. Archived from the original on 2007-09-11.
\item \textsuperscript{46} Bossard, Peter. "South-North Water Transfer Project." International Rivers. \url{http://www.internationalrivers.org/campaigns/south-north-water-transfer-project}.
\end{itemize}
\end{footnotesize}
the same county, or relocate to a new town or city outside the county.\textsuperscript{48} Although this decision was supposed to be left up to the individual residents, local officials came under criticisms for pressuring residents to relocate outside the county rather than simply retreat.\textsuperscript{49}

This pressure to relocate outside their home county is likely the result of lessons learned from the Three Gorges Dam relocation process. During the construction of the Three Gorges Dam, roughly a million residents lost their homes, with the vast majority of them choosing to retreat and remain in Wushan County.\textsuperscript{50} The biggest problem that arose during this relocation process was an insufficient amount of land within Wushan County to allow the large number displaced residents to be able to stay within the county make a living by means of agriculture.\textsuperscript{51} Local governments hope that by forcing residents, displaced by the central route of the SNRT project, to relocate outside their current county, these residents will have access to better job opportunities, more land, and will lower the risk of potential water pollution.\textsuperscript{52}

The local governments compensated displaced residents.\textsuperscript{53} According to government officials, each resident’s compensation package was different, based off a formula that took into account former land holdings and the value of resident’s former home.\textsuperscript{54} In general the standard relocation package included a newly built home, 0.1 hecter of land, and an annual stipend of

\textsuperscript{49} Officials Face Challenges in Relocation (基层移民干部面对挑战). China: CCTV. Film
\textsuperscript{52} China 24. China: CCTV English, 2014. Film
\textsuperscript{54} China 24. China: CCTV English, 2014. Film
roughly 600 RMB (88 USD) per person for 20 years. Relocated residents often left behind house that they built themselves. Many complained that the government erected their new homes too quickly, and there are multiple reports of shoddy construction, including cracked foundations. Additionally, the 0.1 hectares of land was often much less than the amount of land residents been forced to give up. Such small plots of land, often in worse soil conditions did not allow for the majority of residents to be able to continue with the type of agriculture they had been pursuing prior to their relocation. Residents who relocated to new towns also often faced social tensions and were unwelcome by their new neighbors. Such unsatisfactory compensation has resulted in violent outbursts between migrants and local residents, as well as “demonstrations in Qianjiang by migrants protesting” the government’s insufficient compensation.

Despite the seemingly generous opportunity offered to residents through relocation, many in Hebei were reluctant to leave. Relocation, for many residents meant the end of an agrarian lifestyle that they had enjoyed for generations. Additionally, once relocated residents will no longer be able to pay proper respects to their ancestors, for even those graves that were not submerged became too far of a journey for family members to make once they had relocated outside the province. Finally, perhaps the largest concern of those relocating is the loss in

61 Human Sacrifice for South-North Water Diversion Project （为调水工程而牺牲）. China: CCTV. Film.
62 Watts, Jonathan. "China’s South-North Water Diversion Resettlement - in Pictures.” The
“guanxi” or relationships. Relocating for majority of residents meant permanent separation from kinship networks and other local friendship networks, which they have developed over their lifetime. Many residents worried that they would not be able to replicate such relationships once they had relocated to more urban areas, fearing urban lifestyles would be too impersonal.

Even those residents retreating to a new rural environment within their home province, still faced the prospect of adapting to unfamiliar land, learning to have to grow new crops, and losing the expertise they have developed over a lifetime. Additionally, those who remain near the water source face the added challenge of a ban on pesticides and other chemicals, a measure meant to decrease the threat of pollution to the water source. As a result of these struggles, regardless of whether the residents relocated to an urban environment, or simply retreated further into the same county, both groups still faced large challenges that required them to completely change their lifestyle. Overall, the relocation processes embodies the distributional inequality of the central route of the SNRT project, as thousands of South China residents were forced to sacrifice to help provide their northern counterparts with a supply of potable water.

South to Sacrifice for the North:

Slogans such as “supporting the south-north water diversion is an unshakable duty,” “ensure clean water gets to Beijing,” and “sacrifice the small family for the big family,” all make
clear the fundamental distributional inequality of the construction of the SNRT project. The central route of the SNRT project forces the South to bear the burden of sacrifice for the water scarce north. Overall, the South is sacrificing “44.8 billion cubic meters of water per year from the Yangtze River in southern China to the Yellow River Basin in arid northern China.” Although it is Northern China that will experience the potential benefits of the SNRT project’s central route, Southern China will not remain unaffected. As will be discussed later on in the chapter, large amount of diverted water will affect, not only the many residents of Southern China displaced by the project, but also ecosystems and industry located in the South.

2.3 SNRT Political Feasibility:

Official Opposition:

There can be little doubt that the SNRT project is controversial. There have been those who applauded China’s ingenuity in attempting to overcome natural geographic water disparities, while at the same time there have also been those who opposed the project as it poses a large environmental threat to multiple river ecosystems and increases the risk of pollution because of the redirection of water through new channels and reservoirs. Finally, there have been those who at every stage have questioned whether this project with its large price tag, will even truly

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69 Human Sacrifice for South-North Water Diversion Project （为调水工程而牺牲）. China: CCTV. Film.


be effective at relieving water shortages in Northern China, and suggest that perhaps the money would have been better invested into projects that encourage water conservation or more effective conversion of wastewater.\textsuperscript{72}

What is surprising is that many officials in China have voiced publicly their criticisms of the project. Ma Jun the director of China’s Institute of Public & Environmental Affairs (IPE), Zhang Jinsong the deputy director of the Jiangsu office of the SNRT project, and Zou Qingping the deputy chief of the Hubei Province bureau of environmental protection, have all publicly voiced their concerns over the central route of the SNRT project, particularly their reservations over the project’s environmental impact, yet those higher up in the party such as premier Li Keqiang, current president Xi Jinping, and former president Hu Jintao have all professed their continued support for the project since its start in 2002.\textsuperscript{73} Overall, the finer points of these officials’ support or opposition are less important than the fact that within the authoritarian state that is China, there exists such a vocal opposition to a state sponsored project. It is likely that these disagreements among public officials are due to the magnitude of the SNRT project, and therefore the magnitude of associated risks and benefits.

It is important to note two aspects of this official discontent with the project. First, although there have been those officials who have publically disagreed with the SNRT project,
their criticisms have not affected and likely will not affect the continuation or completion of the project. This is because those who have publicly disagreed with the project are largely a small minority of officials, and typically do not hold very ranking positions.\textsuperscript{74} Therefore, though there are officials who have expressed reservations over the continuation of the project they did not affect ultimate the competition of the central route nor will they likely noticeably impact the construction of the remaining western route.

Secondly, among those officials who disagree with the SNRT project, their criticism for the most part revolves around the project’s environmental impact. Though the environmental impacts of the three routes are disputed, what is not disputed is the need for China to solve its current urban residential water shortages. Northern China is currently using water at an “unsustainable rate.”\textsuperscript{75} Beijing, with an average annual water supply of only 100 m\textsuperscript{3} per person, suffers from a water scarcity that is on par with Saudi Arabia.\textsuperscript{76} Therefore, though Chinese officials may to some extent debate the environmental costs of the SNRT project, they are not necessarily denying that the state should intervene to reverse national water shortages. The extent of the water scarcity in Northern China, is likely enough to overcome the majority officials’ reservations on the potential negative environmental impacts of the SNRT project, which will therefore likely not impede the political feasibility of the project going forward.

\textsuperscript{75}Wong, Susanne. ”China Bets on Massive Water Transfers to Solve Crisis.” International Rivers. December 15, 2007.\texttt{http://www.internationalrivers.org/resources/china-bets-on-massive-water-transfers-to-solve-crisis-1899.}
National Pride:

In successfully completing this project, China’s central government has the opportunity to once again lay claim to having constructed the world’s largest engineering project. The successful completion of the SNRT project will no doubt be a source of national pride for China’s central government and the Chinese Communist Party (CCP). The CCP will have redirected nature in an attempt to overcome chronic water shortages in Northern China. As this particular project is potentially, an object of national pride it only increases the political pressure to successfully complete the SNRT project. Although many consider the project controversial, once the central government committed to starting the project in 2002, despite the multiple delays and overages in the budget, all three sections are still likely to be completed. This is likely because the SNRT project will be a testament to the efficiency of China’s central government. The central government may hope to be able to inspire national pride by undertaking a massive feat of engineering so as to overcome natural geographic water shortages in China, demonstrating that even forces of nature can be bent to their will.

Continued Delays in Construction:

Thus far, both of the completed segments of the SNRT project, the eastern and central routes have been delayed well past their expected completion dates. Construction on the

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80 *South-North Water Diversion Project* (南水北调工程综述). China: CCTV. Film.
project’s central route began in December of 2003. Although the project was originally set for completion by the start of the Beijing Olympics in August 2008, the route did not become operational until December 2014. The hope originally was that the central route would be able to supply Beijing with a much needed increase in potable water prior to the start of the 2008 games. However, by September 2008 construction had only been completed on 307 km of the 1,267 km route. The project was then on track to be finished by 2010, but was delayed again until 2014 because unforeseen environmental concerns, which required the expansion of the Danjiangkou reservoir.

What these continued delays in construction demonstrate is that China’s central government has vastly under estimated the amount of time needed to complete a set of such massive engineering projects. Additionally, the environmental impact of the project has been the aspect of the SNRT project that the central government appears to have most overlooked and has resulted in the greatest amount of delays. For in both the eastern and central routes, the need to postpone the projects’ completion in order to try to mitigate unanticipated environmental

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consequences have caused the projects’ the longest delays.\textsuperscript{87} Due to these long delays, overall the SNRT project will likely continue to drain the central government’s budget well through 2050.\textsuperscript{88}

\section*{2.4 SNRT Project Cost Effectiveness:}

\textbf{Over Budget:}

Originally, the budget for the entire SNRT project was 53.7 billion RMB. However, China’s central government has already surpassed this with the final construction cost of the eastern and central routes totaling approximately 254.6 billion RMB (37.44 billion USD).\textsuperscript{89} The cost of the SNRT project is likely only to increase as the construction continues on the western route of the project through 2050. The final total cost of the SNRT project is now estimated to be approximately 79.4 billion USD, more than twice the cost of the Three Gorges Dam.\textsuperscript{90} This is not only one of the largest, but also one of the most expensive engineering projects a country has ever undertaken.\textsuperscript{91} This ever-increasing budget’s failure to thus far derail the completion of the SNRT project demonstrates the central government’s commitment to solving the current water shortages in Northern China, particularly in cities such as Beijing.

\textsuperscript{87} Environmental problems cause delays
Negative Impact on Local GDPs:

The central government’s massive budget for the project fails to take into account the additional costs borne by local governments, many of which will face notable decreases in local GDPs as a result of the SNRT project. Such decreases in local GDPs are not only the result of reductions in arable land due to flooding to expand reservoirs, but also because of the increased environmental regulations put in place to protect the water supply.92 The new regulations that include restrictions on both local agricultural and industry pollution have forced multiple local governments along the route of the SNRT project, to sacrifice economic development for environmental protection.93 Some local governments, such as China’s Shennongjia district, have asked for “financial subsidies to make up for potential losses in local GDP.”94 Though local governments have yet to receive any such subsidies, the case of Shennonjia indicates financial costs incurred by local governments because of SNRT project.

Money Diverted From Conservation:

The money the CCP has invested, and will continue to invest in the SNRT project represents money that will not be available to invest into water conservation in China. In fact, some experts believe that were the money instead invested into better waste management facilities, rainwater collection, and other projects geared towards water conservation, it is possible that mega cities, such as Beijing, could solve or significantly decrease current potable

water shortages. By choosing to pursue this massive engineering project, China’s central government has demonstrated its commitment to a supply-driven rather than a demand-driven method for solving water shortages. However, focusing on increasing the supply of potable water rather than decreasing the demand for water has thus far proved to be a more expensive and environmentally harmful method of combating water shortages in China.

**An Incomplete Solution:**

Although the SNRT project is divided into three different major sections, problems caused by the project, have forced the central government to invest even more money into multiple additional minor water projects. One example of this occurred upon completion of the central route of the SNRT project. The central routed caused the water level of the Han River to fall. This falling water level will likely have a large impact on fishing, transportation, and agricultural production in multiple villages that depend on the Han River for their livelihood. As a result, a “10-billion-yuan package of minor projects have been formulated to reduce the impact of the water diversion projects on the Han River.” The main aspect of this additional minor project will consist of the construction of a 67 km man made canal that will give the Han river access to water from the Yangtze river, in order to supplement for water lost as a result of

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the SNRT project.\textsuperscript{100} This 10 billion yuan construction package is likely just the first of many more packages that the government will have to invest in order to alleviate problems created by the SNRT project. The cost of these minor projects will be in addition to 254.6 billion RMB already spent on the construction of the central and eastern routes.\textsuperscript{101} Demonstrating that in terms of cost effectiveness, the construction of the SNRT project, as thus far been little more than a continual drain on the budgets of both the central and local governments.

2.5 SNRT Environmental Impact:

Increased Pollution in the South:

One of the largest shortfalls of the central route of the SNRT project is that the design of the project increases the likelihood that the supply of the water diverted by the project becomes polluted. As stated earlier, central route siphons water from China’s Yangtze River in order to supplement the Han River.\textsuperscript{102} By diverting the water of the Yangtze River water down unnatural channels, the central route lowered the water level of the Yangtze River.\textsuperscript{103} Lower water levels, leave the Yangtze River more susceptible to pollution, since there is now simply less water in the river to dilute polluted waste and run-off.\textsuperscript{104}

\texttt{http://www.nsbd.gov.cn/zx/english/1/201211/t20121108_249811.html}.
At present approximately 40% of the China’s wastewater is dumped into the Yangtze River.\textsuperscript{105} The completion of the central route of the SNRT project will make this pollution more toxic by leaving less water in the Yangtze River dilute it. This will likely have adverse effects on the biodiversity of the Yangtze River, as well as on agricultural production conducted near the river, and on residents who depend on water from the Yangtze River.\textsuperscript{106} Though the underlying cause of the water pollution does not necessarily lie with the SNRT project, the construction of the central route further exacerbated the problem, increasing the threat of water pollution in Southern China.\textsuperscript{107}

**Increased potential for Pollution in the North:**

When the central route of the SNRT project became operational, the water level of the river in Xiangyang City, the first big city downstream from the Danjiangkou Dam, dropped by 41 cm and could continue to drop to as much as 78 cm.\textsuperscript{108} The lowering the river’s water level will likely have a range of adverse environmental consequences. One example of this is the one third of fish species that could now face extinction, because of threats to winter breeding grounds, increased levels of pollution, and temperature changes in the water.\textsuperscript{109}

As in Southern China, lower water levels in Northern China make it more difficult for rivers to be able to clean themselves, and pollution levels will likely become more toxic

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\textsuperscript{105} Ibid., 1
overtime. Unless the government implements proper management of that stretch of the river, a range of environmental and ecological problems could arise. Additionally, the amount of time during which the river would be navigable could decrease making water transportation less efficient and shipping more costly.

These harmful environmental consequences of the central route of the SNRT project on this segment of the river, also increases the likelihood that the water that eventually reaches cities such as Beijing, will likely be undrinkable because of high level of pollution. Furthermore, this demonstrates that the damaging environmental and ecological impacts of this route of the SNRT project are not limited to Southern China, but like the water from the project will flow North affecting cities such as Beijing.

**The SNRT Project Does Not Create Clean Water:**

The central route of the SNRT project does provide Northern China with increased amounts of water; however, this project does not guarantee the quality of the diverted water. It is not enough to simply supply cities with a high quantity of water if the quality of the water is highly polluted and ultimately unpotable. As discussed earlier, the central route of the SNRT

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112 Ibid., 1


project increases the susceptibility of the diverted water to pollution.\textsuperscript{116} Overall, the SNRT project demonstrates the focus of the central government on increasing water quantity rather than water quality.

There are very few mechanisms in place within the project, which guarantees that the water diverted to Northern cities, meets minimum baseline quality standards.\textsuperscript{117} The government has put some mechanism in place along the central route to help prevent water pollution, including constructing an ecological forest preserve of some 356,667 ha (881,342 acres) around the Danjiangkou reservoir; establishing erosion control measures throughout 680 ha (1,680 acres) immediately surrounding the reservoir; and shutting down more than 800 small, but heavily polluting businesses.\textsuperscript{118} However, these measures are preventive rather than proactive in nature. They allow the government to stop further pollution of the water, but do not have the means to clean water that has already been polluted by the time it is diverted by the central route of the SNRT project.

Additionally, the responsibility for purifying the water, and bearing the costs of constructing and maintaining water cleaning faculties has fallen to the shoulders of the local governments of towns and cities in North China.\textsuperscript{119} Many of these local governments have begun to balk at the high price tag associated with purifying the water diverted from the SNRT

\textsuperscript{116} See National SNWTP Project Office, “Li Jincheng Fuzhuren diaojiu Nanshuibeidiao dongxian jiewu daoliu gongcheng he zhwo gongzuo [Vice-Director Li Jincheng inspects the SNWTP east line pollution control efforts]”, available at http://www.nsbd.com.cn/NewsDisplay.asp?id=195490


Therefore, though the central route of the SNRT project to some extent solves the water scarcity in numerical terms, it fails to address the problem of water pollution, an issue that is intricately intertwined with issue of water scarcity in China.

### 2.6 SNRT Project Overall Conclusion:

#### The Amount of Water Provided:

<table>
<thead>
<tr>
<th>Water resource</th>
<th>Billion cubic meter per year</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundwater</td>
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<td></td>
</tr>
<tr>
<td>Local Rivers</td>
<td>1.0</td>
<td>Variable</td>
</tr>
<tr>
<td>Reclaimed Water</td>
<td>0.3</td>
<td>Estimated</td>
</tr>
<tr>
<td>South-North Water Transfer</td>
<td>0.3</td>
<td>Northern Section of Central Route</td>
</tr>
<tr>
<td>Total</td>
<td>3.6</td>
<td></td>
</tr>
</tbody>
</table>

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120 Ibid., 6
The data from Table 1 shows the breakdown of the total water resources available to Beijing after the competition of the central route of the SNRT project. These numbers are based on projections of the total water resources available to Beijing in 2014, after the SNRT project’s central route begins operation in 2015. If the projected 3.6 billion m\(^3\) per year were divided by Beijing’s population of approximately 21 million in 2014, the amount of water available annually to individual Beijing residents would be approximately 170 m\(^3\). Such a low annual per capita water level would place Beijing in a state of water stress according to United Nations’ standards. This data would suggest, that the central route of the SNRT project will likely be inadequate in solving Beijing’s current water scarcity. Diverted water from the South is simply insufficient to quench Beijing’s massive thirst for potable water.

**Increasing Population Pressures:**

Perhaps the biggest shortfall of the SNRT project is that once the project is complete, China’s central government cannot increase the capacity of water transferred by project in order to meet the demands of rising population pressures in cities such as Beijing. Beijing’s population in 2010 was 19.6 million people, and by 2020, the population is projected to increase by 20% to reach upward of 25 million. Increasing population pressure will only further exacerbate Beijing’s current level of water stress. Though the SNRT project will help to alleviate some of the water stress experienced by Northern Chinese cities such as Beijing and Tianjin,

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123 Ibid., I


once the project begins to operate at full capacity, this massive engineering project cannot be expanded to increase water flow in order to meet the pressures of raising urban populations.127

**Water Shortages in Southern China:**

The 9.5 billion gallons of water supplied annually to Northern China by the central route of the SNRT project represents water diverted from Southern China to meet the needs of Northern China.128 This water supplied to Northern China is water that is now unavailable to those in Southern China. Historically, Southern China has not suffered from the water shortages that plague Northern Chinese cities.129 This is basis of the reasoning behind the SNRT plan, first suggested by Mao Zedong in the 1950s as a simple solution to China’s natural water disparity by the having, the South “share” their excess water with the North.130

However, there are two fundamental problems with Mao’s logic. The first is that though three fifths of China’s water is located in the South, China’s rapid industrialization has increased water pollution and left a large proportion of this water unsuitable for transfer to Northern China.131 As already discussed, SNRT project compounds these pollution problems because of the increased risk for pollution along the newly constructed channels.132

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The second flaw of this plan is that the majority of the water diverted by the central route comes from China’s Yangtze River, and there is fear this project may overstretch the capacity of the Yangtze River.\textsuperscript{133} Prior to the start of the construction of the central route, many areas along the Yangtze had already begun experience water shortages.\textsuperscript{134} Cities and towns along the Yangtze that have historically prepared for the impact of the flooding of the Yangtze River on their communities, are now facing a new unforeseen disaster of drought.\textsuperscript{135} According to local officials in 2007 the town of Tongling located on the Yangtze River, experienced its worst drought in over 30 years.\textsuperscript{136}

According to China’s National Bureau of Statistics, the cities located along the Yangtze River account for 41% of China’s total GDP.\textsuperscript{137} The Yangtze threads its way through 11 different regions in China, and since China’s opening up and reform policy (改革开放) water from the Yangtze has been intensively siphoned off for factories, hydroelectric schemes and agriculture.\textsuperscript{138} The result is that water levels of the Yangtze River have continued to drop, leading some experts to predict that further water diversions of SNRT project will result in water shortages in Southern China.\textsuperscript{139} A project, which attempts to solve water shortages in the North at the cost of potentially creating shortages in the South, is not a viable long-term solution to water scarcity in China. Though China's water is inequitably distributed geographically, the solution is not to attempt to reengineer nature to redistribute the water, but rather to focus on

\textsuperscript{134} Ibid., 1
\textsuperscript{135} Ibid., 1
\textsuperscript{136} Ibid., 1
\textsuperscript{137} Ibid., 1
\textsuperscript{138} Ibid., 1
conservation, and perhaps adapt to the country’s geography by relocating more water intensive industries to Southern China.
CHAPTER 3: IBT PRICING SCHEME

3.1 IBT Pricing Scheme Project Background:

The CCP designed China's IBT water pricing scheme in order to “punish” intensive water users by raising their rates, while also slowing down the rate of water usage “in the face of rising urbanism.”140 This tiered pricing system would charge urban residents based off their monthly water consumption as compared to the national average household rate of consumption.141 Overall, the first, second and third tier will follow a pricing ratio of 1:1.5:3.142 Those households whose consumption rate is not more than 80% of the national average household rate of consumption are part of the first tier and will not have their water rates increased.143 Those residents who use between 80% and 95% of the national average household rate of consumption will comprise the second tier and households who use more than 95% will be part of the third tier.144 Those in the third tier will pay three times the base rate for water, and those in the second will pay one and a half times the base rate.145

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144 Ibid., 1
<table>
<thead>
<tr>
<th>Residential Volume (m³)</th>
<th>Guangzhou Water Tariff Pricing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RMB</td>
</tr>
<tr>
<td>0-12</td>
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<td>3.96</td>
</tr>
<tr>
<td>&gt;62</td>
<td>3.96</td>
</tr>
</tbody>
</table>

China’s central government introduced a pilot IBT pricing program in Guangzhou in 2008, using the rates outlined in Table 2. According to official reports, since the programs implementation residential water consumption in Guangzhou has fallen 8%.

When the IBT pricing scheme was implemented in Guangzhou the base rate tariff for water was 1.98 RMB per cubic meter of water (Table 2). The “switch point” between the tier one and tier three, was set at a rate of about 25% above the median consumption rate (Table 2). The central government has expanded the plan, implementing it in other major cities, such as Shanghai and Beijing.

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149 Ibid., 1
On January 3, 2014 China’s National Development and Reform Council (NDRC) and the Ministry of Housing and Urban-Rural Development (MOHURD) announced that they were issuing a document outlining the three tiered water tariff system to be implemented in all Chinese cities by the end of 2015. According to their statement, the IBT pricing system is meant to “promote sustainable use of water resources and to help conserve water amongst urban residents.” The document released by the NDRC stated that the pricing scheme would be implemented under “strict supervision” but that adjustments will be made as necessary, and the “monitoring process will be transparent.”

3.2 Distributional Equality of the IBT Pricing Scheme

North South Distributional Inequality:

The NDRC’s plan to implement the IBT pricing scheme in all Chinese cities by the end of 2015, as part of a plan to curb both residential urban water usage, divides China more in terms of east and west (along China’s relative urban rural divide) rather than dividing it by north and south (along China’s water shortage).

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154 Ibid., 1
Once the IBT plan has been fully implemented, Chinese cities will all be subject to relatively the same water-pricing scheme. This is intriguing as not all cities in China suffer from the same severity of water shortages. Water scarcity and shortages have historically always been more of a problem in Northern China, than in Southern China. Although the majority of cities in China have experienced increased pressure placed on water supplies as a result of rapid

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urbanization, the level of water scarcity differs between cities in Northern and Southern China (Image 5).  

Nationally the level of water scarcity is inconsistent across China (Image 5). For this reason the adoption of a single plan for all cities, though undoubtedly better than no change in the current water pricing system, does not incorporate enough flexibility for individual cities to be able to adopt and adapt pricing schemes to take into account unique factors that affect each city’s individual levels of water scarcity. The adoption of more localized versions of the IBT pricing scheme would allow for the development of pricing schemes that would better reflect the use of water as a limited resource in that particular region.

**Impact on Urban Residents:**

In terms of distributional equality, the most unequal aspect of China's new IBT plan is that it fails to include China’s rural areas. However, this urban-rural disparity is not necessarily a debilitating weakness of the plan, nor does it affect the potential conservation benefits of the plan in China’s urban areas. China’s urban rural gap is simply too large for the adoption of a single national IBT pricing scheme to be affective. China’s urban and rural communities differ greatly in their use of water, particularly in terms of rural communities’ heavy dependence on water for irrigation and agricultural.  

It would simply be too difficult design a single water pricing policy that was able to reconcile such difference in water consumption.

China's current IBT pricing scheme has been designed specifically for use in China’s urban areas. This means although China’s rural areas will fail to experience any of the


conservation benefits associated with new pricing scheme, it is unlikely that an IBT pricing scheme designed for implementation in urban areas would be successful in rural China. Therefore, the urban-rural distributional inequality is not necessarily a weakness of the IBT pricing scheme, but a necessity dictated by China’s social dichotomy.

**Distributional Equality within the Cities:**

After the implementation of the IBT water-pricing scheme in China’s urban areas, the burden paying for rising water costs will be unequally distributed among residents. Those in the top 5% of water users (residents in the top tier of the IBT scheme) will see their water rates raised to triple the base rate paid by the majority of urban residents. The central government may have unequally distribution of the costs of increased water tariffs, in order to strike a balance between increasing prices to reflect the reality of water scarcity in China, while at the same time protecting social stability by not increasing the financial burden of water on the majority of urban residents.

The IBT pricing scheme is unlikely to pose a threat to social stability so long as the majority of urban residents’ water tariffs constitute less than 3% of household’s annual incomes. The 3% threshold for social stability is from a study conducted by China’s Ministry of Construction. This study stated that if water expenditure was held to 1% or less, households

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would have little to no reaction to the change in water pricing policy, at 2% households would begin to “become more aware of water usage,” while 3% was designated the threshold at which “water expenditure is too large to exceed the affordability of household.”\textsuperscript{161} When this data is compared to China’s pricing scheme, where those in the top tier would be charged prices that account for approximately 2.4% of household income, even those in the top tier of the new pricing scheme should still fall below the 3% threshold.\textsuperscript{162} According to this data, the probability of increasing water-pricing leading to the threshold of large-scale urban social unrest is relatively low.

Additionally, the Chinese government views access water as an inherent right of the population, a viewed shared by the majority of people in China.\textsuperscript{163} As an inherent right, water must be an affordable resource, and should not be a financial strain for the average Chinese household. Due to this belief in the right to water, it is unlikely that the Chinese government will raise prices on the bottom tier as doing so would mean raising prices on 80% of urban residents, violating their perceived right to inexpensive water, and in doing so perhaps posing a threat to social stability.

The unequitable distribution of water tariffs is rational, as water is an essential element of daily life in China and drastically increasing the majority of urban residents' water tariffs would likely result in adverse political, social and economic consequences.\textsuperscript{164} China's implementation of a new IBT scheme plan seeks to increase urban residents' awareness as to the current state of

water shortages, while placing the financial burden on only a small segment of China’s urban population to avoid such threats unrest.

**The Relationship Income and Support:**

A report submitted to the World Bank by Zhang Shiqiu, Deng Liangchun, Yue Peng, Cui Huishan from Beijing University’s College of Environmental Studies and engineering, lays out data that suggests that there is a relationship between household income and support for an IBT pricing system.\(^{165}\) Of the 200 households surveyed in Beijing, when asked which aspect of water they “care the most about,” 50% of households’ whose monthly income was less than 100 RMB person, indicated that price was most important.\(^{166}\) This percentage steadily decreases as the households’ income increases with only 26.9% of households’ earning more than 5000 RMB per month indicating that price was most important.\(^{167}\)

<table>
<thead>
<tr>
<th>Table 3</th>
<th>Beijing Resident Water Survey Continued</th>
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</thead>
<tbody>
<tr>
<td><strong>Income of respondents ( )</strong></td>
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</tr>
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<td>Respondents numbers</td>
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<tr>
<td>Quality</td>
<td>number</td>
</tr>
<tr>
<td>Percentage</td>
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</tr>
<tr>
<td>Quantity</td>
<td>number</td>
</tr>
<tr>
<td>Percentage</td>
<td>5.6%</td>
</tr>
<tr>
<td>Price</td>
<td>number</td>
</tr>
<tr>
<td>Percentage</td>
<td>50.0%</td>
</tr>
<tr>
<td>Pressure</td>
<td>number</td>
</tr>
<tr>
<td>Percentage</td>
<td>5.6%</td>
</tr>
</tbody>
</table>


\(^{167}\) Ibid., 10

There are two overall conclusions drawn from Table 3. First, it is clear that residents in all income categories perceive water quality to be a more important issue than water pricing.\textsuperscript{169} This would imply that for any plan the government wishes to implement that affects residential water supply, linking the potential plan with improving residential water quality would likely increase the amount of popular support the plan would receive.

Table 4\textsuperscript{170}

<table>
<thead>
<tr>
<th>Income of respondents ($)</th>
<th>lower than 1000</th>
<th>1000—2000</th>
<th>2000—3000</th>
<th>3000—5000</th>
<th>Above 5000</th>
<th>Total</th>
</tr>
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<tbody>
<tr>
<td>(1)</td>
<td>36</td>
<td>56</td>
<td>54</td>
<td>28</td>
<td>26</td>
<td>200</td>
</tr>
<tr>
<td>(2)</td>
<td>30</td>
<td>51</td>
<td>51</td>
<td>28</td>
<td>22</td>
<td>182</td>
</tr>
<tr>
<td>(2) / (1)</td>
<td>83.3%</td>
<td>91.1%</td>
<td>94.4%</td>
<td>100%</td>
<td>84.6%</td>
<td>91%</td>
</tr>
</tbody>
</table>

Notes: (1) Total number of respondents; (2) Number of residents who support the IBT

Secondly, there appears to be at least a loose relationship between household income and concern with water prices.\textsuperscript{171} Lower income families tend to be more concerned with water prices than those with higher monthly incomes do.\textsuperscript{172} This is unsurprising as water represents a greater financial burden for lower income families. This coupled with the data displayed in Table 4 indicates that lower income families are less likely to be supportive of water pricing reform. This again is logical as lower income families likely worry more about the potential financial burden of increasing water pricings. However, China’s IBT pricing system appears to reflect this

\textsuperscript{169} Ibid., 10
\textsuperscript{170} Ibid., 19
\textsuperscript{172} Ibid., 21
concern for lower income families, as it is likely that the majority of them will not have their water rates increased even after all cities have implemented the IBT pricing scheme.

### 3.3 IBT Pricing Political Feasibility:

**Factors of Feasibility:**

As stated earlier, China’s central government through the NDRC has set forth guidelines outlining China’s new IBT pricing scheme, and has stated that the plan, which has already been implemented in some of China’s largest cities, will be implemented in all cities in China by the end of 2015\(^\text{173}\). There are numerous factors in play that suggest this program will be successfully expanded to all cites by the NDRC’s self-imposed 2015 deadline. This includes the efficiency with which the Chinese government has in the past been able to implement nationwide reforms, due to the centralized nature of China’s authoritarian government. Additionally, since the majority of residents in the cites where the plan is set to be implemented will experience no change in their current water tariff, there is little impetus for citizens to resist or impede the plan’s implementation. Finally, as will be discussed in depth later in this chapter, Chinese local officials now have direct incentive from the central committee to ensure reforms in water management policy are fully implemented. All of these factors combined point towards the likelihood that China’s central government will have successfully implemented the IBT pricing scheme into all cities by the end of 2015.

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The Impact of Water Management:

Since 1978, one of the drawbacks of China’s merit based promotion system for government officials has been an overwhelming reliance on economic growth as the main criteria in evaluating cadres. Consequently, local officials overzealous in their attempts to meet the promotion criteria set forth by the central government have enacted policies to pursue high growth rates while disregarding the impact on the environment and natural resources. Only recently, has the government begun to focus on environmental conservation, and integrated it as part of the criteria considered in evaluating cadres. Prior to the announcement in April 2014 of the plan to implement the IBT water pricing scheme in all Chinese cites, China’s NDRC also introduced a plan in February 2014 to factor “water management” as one of the criteria used by the government to judge the performance of local officials. Many hope that this new system will require Chinese officials to become more accountable for the environmental impacts of China’s record-breaking economic growth.

The impact of adding “water management” as part of the criteria by which local cadre are evaluated and thereafter implementing the IBT pricing scheme is two-fold. First, the addition of “water management” and other criteria that place value on environmental conservation, demonstrates the changing priorities of China’s central government, and the extent to which China’s top leaders are beginning to realize the need for China to adopt policies that strike a

176 Ibid., 1
balance between economic growth and the preservation of natural resources and the environment. Second, the criteria of “water management” will likely mean that policies, such as the IBT pricing scheme, will not only be enacted but also enforced to their fullest extent by local officials, as these officials now have a direct incentive for the pricing scheme and other water saving policies to be successful.

3.4 China’s IBT Pricing Scheme Cost Effectiveness

**Comparison to the Los Angeles Model:**

In the case of China’s IBT pricing scheme, it is difficult to determine the future cost effectiveness of a plan that has not yet been fully implemented. Therefore, in order to make assertions as to the plan’s cost effectiveness, China’s IBT plan will be compared to a successful IBT plan previously implemented in Los Angeles in the 1990s. This comparison will determine the extent to which China’s IBT plan matches the criteria laid out by the Los Angeles IBT plan. Los Angeles’ IBT scheme’s success was contingent on top tier prices being set at “the cost of replacement” or a level that was an accurate reflection of local water scarcity.\(^{178}\) China’s IBT scheme failing to reflect China’s current national level of water scarcity would likely undermine the effectiveness of the plan in solving current urban residential water shortages.

Los Angeles introduced increases in residential water prices in the 1990s based on a three-tiered pricing scheme that is similar to the one which China has planned to implement.\(^{179}\) The LA plan was designed so that the price point paid by those in the bottom tier of the pricing

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\(^{179}\) Ibid., 1
scheme reflected the average cost of water.\textsuperscript{180} If China’s IBT is to imitate the LA model, those in the bottom tier, 80% of urban residents, should be paying the current average price for water in China.

Currently, average water price in China is approximately 0.8% of urban households’ annual income.\textsuperscript{181} However, a report from China’s NDRC indicates that a water tariff that constituted 2.5-3.0% of a household’s annual income would be a price that would accurately reflect China’s limited water resources.\textsuperscript{182} Although the gap implies that the current baseline price of water is not an accurate reflection of the water scarcity currently faced by China, this does not necessarily imply that the government needs to adjust the base price to account for water scarcity. Based on the Los Angeles model, the increased prices in higher pricing tiers should be able to supplement for such water shortages.

According to the Los Angeles model, the price paid by the top block should reflect the true price of water.\textsuperscript{183} The true price of water is “the real price of scarcity.”\textsuperscript{184} This price should reflect the current state of water scarcity in China. As part of China’s IBT plan, residents in the top tier’s water price will increase to three times the amount paid by those in the bottom tier. Therefore, if residents in the bottom block are paying 0.8% of their income, those in the top block will pay approximately 2.4% of their household’s annual income. This would appear to put China just short of being in line with the Los Angeles plan, as according to China’s NDRC 2.5% is the minimum price level needed to account for water scarcity in China.\textsuperscript{185}

\textsuperscript{180} Ibid., 1  
\textsuperscript{181} Ibid., 1  
\textsuperscript{182} Ibid., 1  
\textsuperscript{184} Ibid., 1  
\textsuperscript{185} Ibid., 1
However, the long-term success of China’s IBT plan is contingent on the current base rate paid by residents in the bottom tier accurately reflecting the price of the average cost of supply of water in China, as the prices paid by the other two tiers are determined based off the bottom tier’s price. There has been no indication from China’s central government that has plans to unilaterally increase the base price of water for residents in all urban areas. Yet, if the base level price is inadequate then the tiered pricing system will fail to have a sustainable impact on water conservation in China’s urban areas.

**Hong Kong Base Level Water Price Comparison:**

By comparing average price of water in mainland China (the baseline price of the IBT scheme) to the average price of water in Hong Kong, it is possible to judge roughly the accuracy of the current baseline prices of China’s IBT scheme. Overall, Hong Kong is the best city to make such a comparison to mainland China. Due to its proximity, Hong Kong suffers from a level of water stress similar to many of the cities in China that will be subject to price reform. Additionally, because of the one country two-system policy (一国两制) in place in China, Hong Kong’s water prices more accurately reflect market prices, as they are not subject to as strict of government controls and subsidies. Therefore, the Hong Kong prices may be a more correct representation of accurate baseline prices.

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187 一国两制 or the one country two systems is constitutional principle formulated by Deng Xiaoping, used during the reunification of China during the early 1980s. Under this principle there is only one China, but certain Chinese regions such as Hong Kong and Macau are able to retain their own capitalist economic and political systems.

The baseline price for water in Hong Kong is 4.16 HKD or 0.55 USD. While in Guangzhou, one of the cities in China to have already implemented the new IBT pricing scheme, the baseline price is 1.98 RMB or 0.33 USD. From this data, it is evident that residents in Hong Kong are paying a base average rate almost double that of mainland China. This would imply that even if China’s tiered prices scheme were to be successfully implemented in all cities, the program would be insufficient to make up for China’s water shortage as base prices are set too low.

3.5 IBT Pricing Scheme Environmental Impact:

Water Quality and Quantity:

Table 5

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<th>3000 ~ 5000</th>
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<td>89.3%</td>
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<td>7.7%</td>
<td>5.5%</td>
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<th>76</th>
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<td>Percentage</td>
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<td>42.9%</td>
<td>31.5%</td>
<td>35.7%</td>
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<td>38.0%</td>
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<table>
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<th>1</th>
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<tr>
<td>Percentage</td>
<td>5.6%</td>
<td>1.8%</td>
<td>1.9%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>2.0%</td>
<td></td>
</tr>
</tbody>
</table>

189 Ibid., 1
190 Ibid., 1
Table 3 indicates is that across all income groups in China the largest concern among urban residents is water quality. Table 5 makes clear that of the 200 households surveyed, the majority\(^{192}\) ranked water quality as more and/or equally “important” than water pricing.\(^{193}\) This emphasis on water quality is significant because though the IBT pricing scheme poses little to no direct threat of worsening water pollution, altering the price of water in urban areas does not change the quality of water provided to residents. Beijing, the city in which the survey was conducted, suffers from both water increasing shortages and declining water quality.\(^{194}\) The implementation of the IBT pricing scheme in Beijing, will therefore not be able to solve problems in water quality, the aspect of water with which local residents are most concerned.\(^{195}\) This is an inevitable limitation of China’s IBT plan and there is very little that the central or local governments can do to modify the pricing scheme to improve water quality.

### 3.6 IBT Pricing Scheme Overall Conclusions:

#### Tariff Threshold for Water Conservation:

The extent to which adopting at tiered pricing system will be effective in terms of its environmental impact is largely dependent on the extent to which it is able to promote individual urban residents to conserve water. The adoption of an IBT scheme may help make urban

\(^{192}\) Respondents were allowed to rank two of the options as equally important, this accounts for the percentages totaling more than 100%.


residents aware of water shortages and by doing so may promote them to make lasting life-style changes in their use of water.\textsuperscript{196} However, in order to be effective China’s IBT plan must find a balance between the percentage of annual household income spent on water tariffs needed to insight immediate changes in residential water usages and the threshold at which the percentage of income becomes so large that it poses a threat to social stability.

In order to have the greatest impact on water conservation China’s cities would need to adopt an IBT plan that would adjust the water prices in such a way that the largest possible number of participants were paying a water tariff that constituted a large enough percentage of their annual income so as to encourage them to change their water usage habits. According to a report by the World Bank, 5\% is the threshold for the percentage of a household’s annual income spent on water, which will prompt immediate short-term changes in households’ water consumption patterns.\textsuperscript{197}

China has not designed the recently adopted IBT scheme in such a way that majority of urban residents’ water tariffs will constitute 5\% of their annual income.\textsuperscript{198} The IBT plan in its current form only alters the price of water for the top 20\% of users.\textsuperscript{199} For the majority of urban residents, whose water tariff rates will remain unchanged, and the water tariff will only constitute


\textsuperscript{198} Ibid.,29

approximately 1% of their annual household income. This base rate water price is unlikely to be altered and falls well below the 5% of annual household income specified by the World Bank report. These urban residents in the bottom tier of the pricing scheme are unlikely to feel any incentive or pressure to alter their current water usage habits. Even those residents in the top tier, who do experience an increase in their water tariff, will only have water prices raised to constitute approximately 2.4% of their annual household income. This would imply that even after the IBT pricing scheme has been fully implemented China’s urban water prices will remain too low to bring about an immediate changed in urban residential water consumption patterns.

However, though China’s IBT scheme is unlikely to cause short-term changes in water consumption patterns, the adoption of this policy may have a long-term impact on China by altering people’s mindset towards water conservation. Over the long term, implementing an IBT pricing scheme may increase China’s urban residents’ awareness of water shortages through expose to the goals of the policy presents to residents through the media and other mediums.

An investigation by the Beijing Municipal Water Conservation Management Center determined that of the respondents surveyed, over 53% felt that their awareness of water scarcity in China “is closely related to [the implementing of] water price reform.” As people are made more socially aware of water shortages in China, this is likely to result in changes over the long-term in urban residential water consumption patterns. Therefore, the impact of adopting an IBT plan may increase social understanding of water shortages in China, which could manifest itself

in changes in urban resident’s patterns of water consumption. This, in the long term, might lessen the severity of water shortage currently faced by urban communities in China.
CHAPTER 4: DESALINATION PLANTS

4.1 Desalination Plants in China Project Background:

Reverse osmosis (RO) desalination exploits the fact that solutions at different concentrations will always seek to average out their concentrations.\(^{203}\) Thus, if fresh water and salt water are kept apart by a porous membrane, over time the concentration of salt in the salt water will decrease, while the concentration of salt in the fresh water will increase, until both approach a similar value.\(^{204}\) To reverse this process, essentially making freshwater from salt water, the water must be highly pressurized to separate the salt from the water.\(^{205}\)

Below are basic steps outlining how RO desalination works (Image 6):

1. Salt water is brought in from the ocean and filtered to keep large living creatures and waste out of the water.\(^{206}\)

2. The salt water is then highly pressurized (to 3000-4000 psi or more than 200 times atmospheric pressure) using a pump.\(^{207}\)

3. This pressurized water is then passed through a porous membrane to separate the salt from the water.\(^{208}\) The pores are small enough that only water molecules can pass

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\(^{207}\) Ibid.

This is the first stage of separation to get the maximum amount of freshwater output. The waste streamed from this process is brine, or high concentration salt water. (Image 7)

4. The brine is then re-pressurized by another pump to pass through another set of membranes to extract more potable water.

5. The pressurized brine is passed through another set of membranes, resulting in a smaller amount of freshwater, and a more concentrated stream of brine.

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209 Ibid., 2
210 Ibid., 2
211 Ibid., 2
213 Ibid., 2
Reverse osmosis membranes are typically very expensive due to the precision required for the construction of such fine membranes. However, advances in materials, science and nanoengineering, specifically the ability to mass produce microscale structures has resulted in a relatively lower cost for producing the membranes required for RO desalination.

China’s two largest RO desalination plants are the Qingdao and Tianjin Dangang RO desalination facilities. Together the two plants supply China with approximately 200,000 m$^3$ of potable water a day.
Tianjin’s RO plant receives feed water from the Bo Sea that has been pretreated using an ultrafiltration membrane system supplied by Hyflux, a Singapore based company. The plant is designed to produce up to 150,000 m³ a day of potable water. One of the world’s largest RO plants, the Tainjin plant’s pretreatment system processes approximately 250,000 m³ of seawater a day. Seawater intake pumps deliver the seawater through the pretreatment system to eight

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222 How much water does it produce a day  
independent seawater RO trains, (image 8) each of which is designed to deliver up to 12,500 m³ of treated water a day.\footnote{Ibid., 16} Equipped with a single main high pressure pump, membrane rack, energy recovery system and circulation pump, each train runs between 12.5% and 100% capacity.\footnote{Clemente, Rodney. ”China’s Mega-Desalination Plant Experience: A White Paper on the Long-term Energy Efficiency of China’s Largest Desalination Plants.” Energy Recovery Inc., 2013. http://www.energyrecovery.com/sites/default/files/ERI-WP_China_MegaPlants_Oct2013.pdf.}

The Qingdao desalination plant provides up to 100,000 cubic meters of drinking water daily to Qingdao’s municipal grid.\footnote{Furest, Bárbara, and Patricia Meléndez. ”Abengoa Starts Commercial Operations at the Qingdao Desalination Plant in China.” www.abengoa.com.} The plant began operation in June of 2012, the plant’s six
trains supply between 15 and 20 percent of the water used by Qingdao’s nearly three million residents. The majority owner of the plant is the Spanish company Abengoa. The Qingdao plant operates similarly to the Tianjin RO plant. Water from the Jiaozhou Gulf is pretreated by an ultra-filtration (UF) membrane system that processes up to 250,000 m$^3$ of feed water a day. Then intake pumps deliver feed water through the UF pretreatment system to three main high-pressure pumps and the plant’s energy recovery system. However, unlike the Tianjin plant the Qingdao plant uses a semi-pressure design, where each high-pressure pump supplies two membrane trains, though each train still has an individual energy recovery system and circulation pump. (image 9)
4.2 Desalination Distributional Equality:

The Distribution of Desalination Plants:

The distribution of desalination plants in China has thus far been limited to the east coast making this geographically a rather limited solution to combating water shortages in China. As looking at the map makes clear only those cities and towns located along China’s eastern coast would have access to an abundant enough source of salt water to be able to sustain viable desalination plants. Though desalination is likely not a solution for the majority of landlocked Western China, it is also important to consider that China's current population is by no means equally distributed across the country.

According to China’s 2010 census, 57.3% of China's population lived in urban areas with the most populated cities being Shanghai, Beijing and Guangzhou, all of which are located on China’s eastern coast. China’s National Bureau of Statistics has projected that China’s urban population will grow to constitute 60% of China’s total population by 2020. The possible construction of desalination facilities in such eastern coastal cities would potentially have a large impact on local water shortages, likely only to be exacerbated by growing populations. This combination of raising populations and increasing levels of water scarcity make coastal urban areas the core of China's water shortage crisis. Therefore, despite the limited geographic reach of desalination, it is still an effective tool in fighting water shortages in China. The construction of desalination plants could provide a continuous source of potable water directly to coastal cities in China suffering from water shortages.

**The Possibility of Piping Water:**

One option to potentially increase the distributional equality of desalination in China would be to build up a water transportation infrastructure of pipes, which could be used to transfer water from desalination facilities to other water stressed areas. Currently the best example of this is the desolation plant in Tianjin that in addition to providing water to its own municipality also pipes water into Beijing. Beijing is considered a severely water stressed city,
due primarily to geographic factors such as historically low rainfall, rising population pressures, and rapidly increasing levels of industrialization.\textsuperscript{237}

The piping of desalinated water from Tianjin has been effective as another means used to increase Beijing’s dwindling water supply.\textsuperscript{238} Since 2013, two 275 km long pipelines, each approximately 1.5 m in diameter, pass through two pumping stations in order to pass potable water directly to eastern Beijing.\textsuperscript{239} However, the current success of this project does not necessarily ensure that other piping projects will be equally effective. The Tianjin-Beijing pipeline is not necessarily an accurate reflection of the potential impacts of piping desalinated water to other sites. The relative proximity of the two cites as well as the heavy industrialization of both cities, provide close to ideal conditions for the piping of desalinated water to occur. Piping along longer routes could have a negative environmental impact due to the construction of the required infrastructure that would disrupt local ecosystems, and increase levels of water pollution. As a result of these potential environmental impacts, desalination is likely to remain a relatively limited in its distribution.


4.3 The Political Feasibility of Desalination:

Current Government Involvement:

The 11th five-year plan represents the first time desalination is presented as part of the solution to China’s water management, and set targets for national desalination output.\(^{240}\) This indicates that China's central government recognizes desalination as a legitimate and feasible solution to chronic water shortages. Desalination also appeared as the part of China’s water management initiative in the 12th five-year plan, and in 2016 will likely continue to be incorporated as part of the solution for solving water scarcity in China’s 13th five-year plan.\(^{241}\)

This recognition and support from the central government will likely play an important role in the development of China’s future desalination plants in. China is an authoritarian state and history would suggest that of those projects that are able to have the largest impact on Chinese society have been those implemented from the top down with the support of China’s central government. Therefore, should the Chinese government prioritize the construction of desalination facilities as a solution to water scarcity, it is likely that the number of desalination plants in operation in the future would steadily increase.

Despite this potential for expansion, there are two shortcomings that could possibly prevent the central government from increasing their investment in desalination. The first is that the CCP has already invested large amounts of time and money into the SNRT project, and hails


\(^{241}\) Ibid., 12
the project as the savior solution to water shortages in Northern China.\textsuperscript{242} Because of the emphases placed by China's central government on the SNRT project, it is likely that there will be fewer resources and less motivation to finance the construction of desalination plants. The ever-increasing price tag of SNRT project has required the central government to continue to pour resources into the project, resources which otherwise could be used to finance the construction and operation of desalination plants.\textsuperscript{243}

Secondly, as will be examined later China currently lacks a domestic desalination technology market.\textsuperscript{244} This means that the majority of the expertise and technology for the construction of desalination plants will continued to be imported. Cities such as Qingdao, have dealt with the lack of domestic technology by allowing an outside foreign companies to such as Spain’s Abengoa, to use their own expertise and technology to construct a desalination plant in China.\textsuperscript{245} However, adopting the strategy of encouraging foreign companies to construct desalination plants in China, places perhaps too much of the direct control over the development of desalination outside of the hands of China's central government. Therefore, though China’s central government may be reluctant to finance desalination plants, as a result of the SNRT project, they will also likely be even more reluctant to adopt measures that encourage foreign control over domestic desalination operations.


\textsuperscript{243} Ibid.,1


Privatization and Government Regulation:

Even if the central government not wish to invest directly in desalination, in order for the market to be successful, the central government will still likely need to adopt legislation that makes the desalination market more appealing and profitable to private companies. The desalination market in China is still relatively new and developing and as a result is largely unstructured.\(^{246}\) Only China's central government will be able to provide the structure needed to make the desalination market in China appealing to private companies.\(^{247}\) Private companies will need to see that desalination is profitable before they are willing to invest in a venture with such a high startup and operations cost.\(^{248}\)

Currently, upward of 70% of desalination facilities in China are “financed by the industry end users or the government.”\(^{249}\) Nearly 90% of desalinated water in China is currently being used by key industries such as metal production, nuclear power, and large industrial parks that are highly centralized and monitored by the government.\(^{250}\) Though the percentage of desalinated water used for residential purposes is still relatively small, it is one of the fastest growing sector of the desalination industry. This growth is fueled by an ever-increasing need to overcome residential water shortages in China.


\(^{247}\) Ibid., 1


As the government currently appears to remain apathetic towards financing the
collection of desalination facilities for residential use, the argument can be made that another
way to finance such projects would be through private firms. These firms potentially could be
either Chinese or foreign, though due to the high cost and relatively novelty of desalination
technology in China, it is more likely that financing would come from foreign firms. One
example of this is the desalination plant in Qingdao, financed by Spanish company Abengoa.251

There are many advantages in privatizing the desalination industry in China. First, coastal
towns and cities in China would be able to enjoy immediate relief from the current and future
water shortages many of them currently face. Additionally, China’s desalination plants would be
able to take advantage of newer, more advanced, and ecologically friendly foreign desalination
technology, without waiting for a domestic desalination technology industry mature. In terms of
economics, China would also be able to take advantages of these benefits without the need for
the government to allocate funds to finance desalination facilities. By increasing the privatization
of their desalination industry China is able to receive all of the benefits of increased use of
desalination to solve residential water shortages, without the central or local governments
needing to bear the brunt of the financial burden.

251 Furest, Bárbara, and Patricia Meléndez. "Abengoa Starts Commercial Operations at the Qingdao Desalination
4.4 Desalination Cost Effectiveness:

Expensive Technology:

One aspect impeding the expansion of desalination in China is the high cost associated with the technology. The high prices of the desalination technology significantly push up the startup costs for firms looking to enter the market.\textsuperscript{252} The most prominent type of desalination technology used in China is the RO process.\textsuperscript{253} Although RO technology is no longer novel at the international level, as it has been used by commercial desalination plants for over 50 years, it is still a relatively new phenomenon in China.\textsuperscript{254}

The most important consequences of the relative newness of this industry in China, is that Chinese firms have not yet caught up to the global learning curve in terms of RO desalination. In China, there is currently little domestic development or production of RO desalination technology.\textsuperscript{255} Additionally, foreign companies have the patents on much of the world’s desalination technology, particularly the newest and most eco-friendly methods of desalination. This means that Chinese companies must import almost all of the RO technology and equipment used in desalination, as they cannot purchase it from domestic manufactures. This in turn drives up the price of constructing desalination facilities in China.

Were desalination to become a more popular and widespread form of combating water scarcity in China, Chinese companies both privately owned and those sponsored by the

\textsuperscript{253} Ibid., 1
government would likely have more incentive to direct funds towards developing China’s own desalination technology market. This increase in investment in RO technology development would in turn likely reduce startup costs, thus making desalination a more affordable alternative to combat water scarcity primarily in China’s coastal regions. However, this is the contradiction currently faced by China’s desalination industry. Until the construction of desalination facilities is a strategy prominently adopted by China’s coastal regions to lessen the severity of water shortages in China, there is little incentive to invest in the domestic development of the technologies needed for China to be able to run large scale desalination facilities that are both economically, and environmentally efficient. Although Chinese companies are beginning to invest in the development of desalination domestic technologies, for this to become a profitable industry it must expand with the speed necessary to be able to support China’s potential growing desalination plants.256

Again, it is likely that the solution to overcoming the current high cost of desalination in China lies in the Chinese government continued support for the construction of desalination facilities as a potential solution to water shortages. However, there are currently no government incentives or funds designated for desalination projects. Financing remains the largest obstacle preventing Chinese companies with the technology from being able to “tap into the Chinese market.”257 Should the Chinese government begin to make desalination a higher priority it is likely that this would drive domestic development of RO technology and foster the growth of a desalination industry in China through lower prices and better technology.

Low Water Prices:

Perhaps the largest barrier to fostering a successful desalination industry for residential use in China is low water prices. Due to the limited timeframe of operations RO plants are not cost effective in areas where freshwater sells for under 0.50 USD per cubic meter, since the membrane replacement and plant construction costs are never recovered by the desalination plant operator.\textsuperscript{258} In China, the CCP subsidizes residential water prices, ensuring that the value of water is far below market price.\textsuperscript{259} By keeping water tariffs low, the CCP is able to help guarantee that all citizens are able to afford water, one of the necessities of life. However from a business standpoint, foreign companies are unlikely to undertake the arduous process of constructing and maintaining a desalination plant in China, when start-up costs for such projects are already incredibly high, and there is a limited timeframe of feasible operation.\textsuperscript{260} China’s low water prices severely restrict the profit such a frame would be able to generate through the project. This means that there is little incentive for foreign firms, or even private Chinese firms to invest in such a project without the support and financing of Chinese government, a support which to date has been limited.

Limited Lifespan:

Another factor, which must be considered when examining the cost effectiveness of desalination facilities in China, is the longevity of the operations. For example, the Qingdao desalination plant that began operation in 2010 is only designed to operate for twenty-five years,

or until 2035. Twenty-five years is the typical operational lifespan of the RO desalination plant. This relatively short lifespan is due to the process of RO, which as explained earlier, works by forcing pressurized saltwater through a membrane filter. Overtime, these membrane filters become clogged, and thus unable to remove salt from water.

There have been some recent developments towards redesigning RO membrane filters so that they do not become clogged overtime, and there are other methods of desalination such as forward osmosis (FO) which have the potential to offer desalination facilities a longer lifespan. However, these technologies are still experimental, and are not currently in use in China. Therefore, desalination facilities in China continue to operate under a twenty-five year lifespan. This limited timeframe of viable operation is likely to prevent China from being able to attract increased private financing for desalination facilities. Although firms in the desalination industry understand that twenty-five years is the limited timeframe under which they can be profitable, this coupled with China’s low water prices, and the high cost of startups, do not create an optimal environment for the development of a profitable industry.

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265 FO or Forward Osmosis is a process similar to RO that uses water’s hydraulic pressure to separate potable water by passing water over a semi-permeable membrane.
4.5 Desalination Environmental Impact

Brine Disposal:

One of the largest environmental hurdles countries encounter when building desalination plants, is brine disposal. Brine is the super concentrated salt by-product that left after the potable water has been separated during the desalination process. The output of brine by desalination facility can be equivalent of up to 55% of the plant’s intake flow. Therefore, once seawater has been desalinized and the potable water is removed, the issue remains of how to dispose of the sizable amount of brine waste left behind by the process.

The simplest method for brine disposal is of course to pipe it back out into the ocean, through a brine outflow pipe. Though this is the easiest method for brine disposal it is also the least environmentally friendly. Since brine has a much higher concentration of salt than the surrounding seawater and is much denser, when pumped back into the ocean brine tends to settle


268 Ibid., 23


near the seafloor.\textsuperscript{271} This creates a plum of ultra-salty water on the ocean floor, which can adversely affect some aquatic ecosystems.\textsuperscript{272}

Another, more environmentally friendly means to dispose of brine is to recycle the brine by converting it into saltcrete.\textsuperscript{273} Saltcrete is a compound formed through a mixture of brine, salt, and cement.\textsuperscript{274} Many communities that rely on desalination, then often use saltcrete as part of the mixture for asphalt when paving roads.\textsuperscript{275} The converting of brine into saltcrete is the most common form of brine disposal used by desalination plants across the globe.\textsuperscript{276}

The final method of brine disposal is to convert the brine into salt, which the case of the Tianjin plant is then collected and sold to generate revenue.\textsuperscript{277} In order to form salt, once desalination is complete the brine is put through an additional RO process that “produces very salt concentrated water.”\textsuperscript{278} This concentrated solution is then left to dry out.\textsuperscript{279} Once all the water has evaporated, what is left is the salt that the company is then able to repackage and sell.\textsuperscript{280} Although the process of recycling brine to form salt is more time and perhaps energy intensive, it is more environmentally friendly than pumping the brine back into the ocean, and offers desalination plants an additional revenue source.


\textsuperscript{273} Ibid., 38
\textsuperscript{274} Ibid., 38
\textsuperscript{275} Ibid., 38
\textsuperscript{276} Ibid., 36

\textsuperscript{278} Ibid., 1
\textsuperscript{280} Ibid., 1
RO and Energy Consumption:

Table 6

<table>
<thead>
<tr>
<th>Source of Water</th>
<th>Energy Requirement (kWh/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local surface water</td>
<td>0.43</td>
</tr>
<tr>
<td>Water transfer (from the Yellow River)</td>
<td>0.70</td>
</tr>
<tr>
<td>Local groundwater</td>
<td>0.78</td>
</tr>
<tr>
<td>Reclaimed water</td>
<td>0.82</td>
</tr>
<tr>
<td>Water transfer (from the Yangtze)</td>
<td>1.14</td>
</tr>
<tr>
<td>Desalination (brackish water)</td>
<td>1.40</td>
</tr>
<tr>
<td>Desalination (seawater)</td>
<td>4.00</td>
</tr>
</tbody>
</table>

The largest environmental concern for China in terms of expanding desalination is the amount of energy required to operate a RO desalination plant. In order for RO to be effective, the water must be highly pressurized before it can be pumped through the membrane that draws out potable water. This pressurizing of the water is the most energy intensive aspect of the RO process.

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desalination process.\textsuperscript{283} Table 6 indicates that in Qingdao the desalination of seawater consumes roughly 10 times more energy than the extraction and processing of local surface water.\textsuperscript{284}

Currently in China, coal is the “dominant energy source, accounting for approximately 79% of the total electricity produced in 2012.”\textsuperscript{285} Much of China’s current desalination industry is equally as coal dependent. Therefore, the production of more desalinated water would likely “simultaneously increase greenhouse gas emissions.”\textsuperscript{286} This is particularly alarming as China is already one of the world’s largest producers of greenhouse gases.\textsuperscript{287} One study, conducted prior to the construction of Qingdao’s desalination plant, indicated that the plant would increase the city’s greenhouse gas emissions by as much as 80%.\textsuperscript{288} Although this number may be a slight overestimate, especially as the Qingdao plant has yet to operate at full capacity, the construction of the desalination plant has still likely increased Qingdao’s overall greenhouse gas emissions.\textsuperscript{289} The increased energy and environmental costs of desalination are important, as a long-term solution to China’s current water shortages should be one in which China does not have to


\textsuperscript{289} Ibid., 9
choose between maintaining sufficient amounts of potable water, or low levels of environmental pollution.

One way for China to overcome the potentially adverse environmental effects of desalination is the method used in the Tianjin desalination plant. In the Tianjin model, the desalination facility operates in tandem with a local power plant. This model recycles the excess steam produced by the power plant, and harnesses the energy produced by the steam to pressurize the water in the desalination plant. This method of using the steam produced by the power plant has decreased the amount of energy consumed by the Tianjin desalination plant. Thus, the Tianjin desalination plant may represent a model that China could expand upon in an attempt to strike a balance between water shortages and environmental pollution.

**Threat to Marine Biodiversity:**

Over the long term, another environmental threat inevitably posed by desalination plants is the threat to the local marine biodiversity. In order to be productive desalination plants rely on a steady stream of salt water. As a result, the majority of desalination facilities are located on the coast, often built with large pipes that extend directly into the ocean. The problem is that these pipes often inadvertently draw in thousands of plankton, certain types of fish eggs, and

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291 Ibid., 1
292 Ibid., 1
other microorganisms disrupting local marine biodiversity.\textsuperscript{296} The inability of these pipes to separate such organisms from the seawater required by desalination plants, poses a threat in the long-term to the biodiversity of the local saltwater ecosystems on which the desalination facilities rely.\textsuperscript{297} This potential threat to biodiversity is a weakness of the process of desalination that is difficult to overcome.\textsuperscript{298} This is a risk that must be taken into consideration, should the construction of desalination facilities become prevalent in China’s coastal cities.

\section*{4.6 Desalination Overall Conclusions:}

\textbf{Tianjin:}

Tianjin and nearby Beijing suffer from some of the highest rates of water scarcity in China, made worse by the two cities’ large and ever-growing populations.\textsuperscript{299} Due to the population pressures for an increasing water supply, in 2010 China began construction on the country’s largest desalination facility in Tianjin.\textsuperscript{300} The facility opened in 2013, and by 2014 the plant’s output had reached approximately 200,000 m\textsuperscript{3} of water a day.\textsuperscript{301} At this rate, the plant would only be able to annually produce 73 million m\textsuperscript{3} of water.\textsuperscript{302} Though not unimpactful, the output of potable water from desalination alone is insufficient to solve Beijing or Tianjin’s current water crisis. Beijing alone in 2009 consumed over 1 billion m\textsuperscript{3} of water for residential

\bibliography{references}{\textsuperscript{296} Ibid., 14}
\bibliography{references}{\textsuperscript{300} “Desalination Costly Drops.” The Economist, February 9, 2013}
\bibliography{references}{\textsuperscript{302} Ibid., 1}
This number does not include the city’s even higher annual industrial consumption of water. This indicates that desalination, though it will undoubtedly help to alleviate some strains of water shortages, on its own is not enough to solve the water scarcities of either of these two cities.

**Qingdao:**

As discussed earlier the Qingdao plant it is only able to produce 100,000 m³ of potable water a day, enough according to Abengoa, to fulfill the daily water needs of roughly half a million people. Qingdao has an urban population of over 3 million, and a total population of over 7 million. This means that desalination alone is only able to meet the consumption needs of approximately 16% of the city’s urban population, and only approximately 7% of total residential consumption needs. This additional output of potable water has undoubtedly aided Qingdao, relieving some of the water scarcity faced by many northern cities in China. However, it is clear from the data, as well as the twenty-five year limited timeframe of operation for the Qingdao desalination plant, that desalination in Qingdao, as in Tianjin is neither a permanent nor a complete solution to combating residential water shortages.

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304 Ibid., 12

305 Shi (史), Qiujuan (秋娟), and Jie (洁) Feng (冯). "How to Quench a Thirst? (北京解渴：要南水北调，还是海水淡化?)." *China Dialogue (中外对话)*. August 7, 2011. https://www.chinadialogue.net/article/show/single/en/4396-How-to-quench-a-thirst-.


Limited Timeframe:

As discussed earlier in the chapter, RO desalination facilities currently being constructed in China have an operational lifespan of only twenty-five years, due to the clogging over time of the filtration membranes.\(^{308}\) This limited timeframe of operation dictates, that desalination is not a long-term solution to China’s water problems. Even if coastal cities in China were to begin to rely on desalination to ease current water shortages, this would be the equivalent of simply putting a very expensive Band-Aid on the problem of urban residential water scarcities.

This is because in twenty-five years when current desalination facilities become inoperable, those areas that are dependent on them for water will be forced to find another solution. It is possible that in the future desalination technology will have developed innovations that increase the operational longevity of desalination plants. Nevertheless, as no such technology currently exists outside of the experimental phase, this paper must operate under the assumption that the utility of current desalination plants will be limited to a twenty-five year operational lifetime.

Failure to Meet Official Output Goals:

As mentioned earlier, China’s 11\(^{th}\) 5-year plan (2006-2011) was the first to mention desalination.\(^{309}\) Additionally, the plan set target output levels of desalination in China that China


fell short of meeting.\textsuperscript{310} Although failing to meet the stated goals a five-year plan is rather unusual in China, the 12\textsuperscript{th} five-year plan also sets aggressive targets for China’s coming desalination output at 2.2 - 2.6 million m\textsuperscript{3} daily capacity by 2015.\textsuperscript{311} The continued incorporation of desalination into China’s five-year plans is an encouraging sign for the industries development. However, the conclusion drawn from this chapter is that without additional measures taken to allocate funding, increase financing, and adopt legislation desalination projects will not be able to find the momentum they need to become a viable solution to supplying China’s urban residential areas with potable water.


CONCLUSION:

China, particularly China’s urban residential areas are currently facing water shortages that if left unsolved will likely not only undermine China’s economic progress, but could also threaten the nation’s political and social stability. In order to combat such water shortages, China’s central government has enacted a variety of policies, which seek to solve China’s water crisis through a variety of different methods. Overall, the conclusion that can be drawn from this paper is that of the three projects examined above, each has its own unique strengths and yet none is capable of on its own completely solving China’s current urban residential potable water shortages.

The three projects examined in this research represent the diversity, of both projects that seek to curb the demand of potable water, as well as projects focused on increasing the supply of potable water in China. However, there is one aspect of solving China’s water shortages that these three project that fail to address; a solution that primarily seeks to increase water conservation among China’s urban residents. Increasing water conservation on an individual level does not necessarily decrease individual residents’ demand, however it does aid in increasing the supply of potable water without the need for massive engineering projects as residents are able to reuse the water already available to them. The inability of any of the three projects discussed to seek to incentivize individual water conservation is perhaps each project’s greatest weakness, as water conservation is the most sustainable means to combat water shortages in China.
When examining the current projects constructed to combat China’s urban water scarcity, it is important to consider the differences in water scarcity inherent in China’s geography. Projects, such as the IBT pricing scheme, that are meant to be unilaterally adopted across China are weak in that they fail to allow enough individualism to necessarily be the most appropriate method of dealing with localized issues of water scarcity. Additionally, projects such as the SNRT project, which seeks to take advantage of the natural disparity in China’s potable water distribution, is not sustainable as this project threatens to create water shortages in Southern China in order to solve water shortages in Northern China.

Additionally, one of the other weaknesses is that projects such as the SNRT project and the construction of desalination facilities struggle to maintain both a high level of cost effectiveness and a simultaneously low environmental impact. Any plan that would require China supply urban residents with potable water at the cost of further environmental denigration would ultimately prove to be unsustainable.

Overall, perhaps the most viable solution to combating water shortages in China’s urban residential areas may not come through the implementation of a single policy, or project. Rather the unique strengthens and weaknesses inherent in each of the three projects examined above would suggest that the most sustainable and impactful solution would be to simultaneously adopting multiple plans and projects. Ultimately to be effective such plans would need to strike a balance between economic efficiency and environmental conservation, be individualized enough to suit the localized needs of specific communities, and focus on curbing water demand, encouraging water conservation while simultaneously seeking to increase the amount of potable water to China’s residential areas.


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