An Environmental Assessment of China’s South-North Water Transfer Project: Why Engineering-based Solutions Cannot Solve China's Water Crisis

by

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**Introduction**

In April, 2016, the city of Lintao in Gansu province ran out of water. “It was right after Chinese New Year,” Lintao resident Yang Shufang recalled, “water stopped coming out of the tap.”¹ In neighboring Lanzhou, water supplies had been suspended just two years earlier, when benzene – a known carcinogen – contaminated the city’s primary water source. While no culprits were named, the source of leak was likely an explosion in a nearby petroleum plant in 1987, which is presumed to have released benzene, a constituent of petroleum, into the groundwater.²

The 26 million residents of Gansu province are hardly alone. The same year that water stopped coming out of Shufang’s tap, close to half a billion people in four hundred cities across China faced water shortages.³ Even more were exposed to polluted water supplies. Limited access to clean freshwater promises to threaten China’s economic growth, political stability, and social welfare. To put China’s shortages in perspective, although the nation ranks sixth in the world in terms of overall freshwater water resources, per capita its resources are below a quarter of the world average.⁴

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¹ Rob Schmitz, “A Warning for Parched China: a city runs out of water,” *Probe*
³ Schmitz, “A Warning.”
In light of severe water shortages, in 2002 China launched the South-North Water Transfer Project (nanshui beidiao gongcheng 南水北调工程), a grand diversion scheme that aims to transfer nearly 50 billion cubic meters of water from the southern Yangtze River and its tributaries to the drying Yellow. The amount of water being transferred is astonishing, particularly given the uncertain ecological effects of inter-basin diversions. While the east and middle routes of the project have been constructed and operation has begun, planning is still underway for the final, western route. Already, midway through the construction process, the SNWTP is the largest inter-basin transfer in the world. And, if completed, it will outstrip second place by a factor of ten.5

This thesis hopes to intervene in the construction process; ultimately it will recommend its suspension. My central research question concerns the environmental impacts of the water transfer, and my findings challenge the viability of engineering-based solutions to secure China’s water supply. At the moment, the popular success of the project relies on the construction of a national myth surrounding large-scale, public water control projects. Whereas China’s leadership references the project’s potential to increase national welfare, it is primarily an engineering-based policy designed to address critical shortages in Beijing and Tianjin municipalities, and Shandong, Hebei, and sections of Henan, Anhui, and Jiangsu provinces. The first chapter of this thesis will discuss the underlying factors that drain China’s water supplies and result in water shortage. Next, I will evaluate China’s current policy

response through the lens of what I term a “systems approach.” I will conclude by signaling a need for policy change.

Following this analysis, the second chapter situates the SNWTP within a historical lineage of top-down water infrastructure projects. The legend of Da Yu, and how he came to be the first emperor of China by “controlling the waters,” is one of China’s foremost national myths, and carries a powerful political mandate for sustainable conservancy in water infrastructure development today. This chapter will trace how this mandate has shaped the political landscape of China’s conservancy regime through the historical development public water control projects. The final section in this chapter will complicate this history of top-down management to emphasize the ways in which regional and local authorities traditionally ensured the regeneration and long-term security of natural resources. At the province level, gargantuan technological interventions were not an option.

I draw attention to China’s historical legacy, instead of evaluating the transfer project from a comparative or global perspective, to suggest culturally specific ways in which Chinese citizens expect their government to respond to water shortages. Because water scarcity is a global issue, and its management inherently crosses provincial, regional, and national boundaries, most scholarship emphasizes similarities or draws comparisons between international responses to water risks. However, the international perspective often fails to explore how members of a given society understand, and expect their governments to respond to an issue. For this reason, the second chapter hopes to deliver a rich understanding of history and cultural practice that would aid any attempt at policy-making.
Finally, the third chapter considers construction plans for the west route, and how shortages in provinces scheduled to receive supplies could be mitigated through improvements in conservation, efficiency, and allocation. It considers national policy efforts to manage demand, and accentuates agriculture as a key area of reform. The last section of the chapter utilizes the overarching analyses developed in the preceding sections to make policy recommendations for future resource management. My thesis will conclude by considering questions of policy effectiveness, and frames China’s environmental challenges within the context of larger political and macroeconomic trends, such as its stabilization toward lower growth rates and restructuring agenda. This interdisciplinary thesis thus seeks to offer a more holistic evaluation of the SNWTP, and to offer in conclusion a different way to approach water management in China.
Chapter One
The SNWTP: Characteristics, Initial Conditions, Policy Approach, and Evaluation

Today, China is facing an acute scarcity of water supplies. At 2,093 cubic meters of annual renewable freshwater resources per capita, China is below a fourth of the world average. By 2030, due to increasing agricultural, industrial, and residential demand, this number is projected to drop to below to 1,700 cubic meters per capita, meeting the World Bank definition of water stress. However, water supplies in China are regionally imbalanced. Whereas southern provinces enjoy eighty percent of the national water endowment and above-average resources per capita, northern provinces face varying degrees of water stress, scarcity, and acute scarcity.

As shown in Fig. 1, water scarcity is concentrated in a region called the North China Plain (NCP) which covers sections of Hebei, Henan, Anhui, and Jiangsu provinces, includes Beijing and Tianjin, and completely subsumes Shandong province. What isn’t shown in the figure is that this region generates over a quarter of Chinese GDP, accounts for a quarter of its cultivated land and over a quarter of its population. Yet, it only possesses one tenth of the nation’s water resources,

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6 Barry Naughton, The Chinese Economy, 563.
8 See appendix
equivalent to one twentieth of the global per capita average.\textsuperscript{11} For reference, the 112 million population of the Beijing-Tianjin-Hebei part of the plain has water resources equivalent to half of acute scarcity.\textsuperscript{12} Although scarcity on the plain is the most severe in China, the entire region north of the Yangtze River basin is acutely short of water. Including the NCP, together these regions account for 45 percent of China’s GDP, nearly half of its industry, 44 percent of its population, and 59 percent of its cultivated land. Yet, they only have access to less than a fifth of the nation’s water resources.\textsuperscript{13}

I. Characteristics of the SNWTP

The South-North Water Transfer Project (SNWTP) represents a policy response to this disparity which has culminated in critical shortages in the north.\textsuperscript{14} When completed, it will deliver 44.8 billion cubic meters of water annually from the lower and upper reaches of the Yangtze, to water-stressed regions in northeast and northwest China, alleviating scarcity for 300-325 million people.\textsuperscript{15} For some perspective, this delivery is more water than that of many medium-sized rivers, and

\textsuperscript{11} Ibid.
\textsuperscript{12} Charles Parton, “China’s acute water shortage imperils economic future,” \textit{Financial Times}, February 28\textsuperscript{th}, 2018, [\url{https://www.ft.com/content/3ee05452-1801-11e8-9376-4a6390adfb44}].
\textsuperscript{13} Thomson, “Nan Shui Bei Diao,” 120.
\textsuperscript{14} The project is alternately referred to as the South-to-North Water Diversion (SNWD).
\textsuperscript{15} Berkoff, “Is it justified?” 1.
approaches that of the River Thames in England.\textsuperscript{16} The second largest water-transfer project in the world is in California and carries one tenth as much water.\textsuperscript{17}

Although it is difficult to predict the overall distribution of water resources after the project is completed – as existing routes may not be utilized to full capacity and new extensions are constantly proposed – water resources per capita in receiving regions have already improved upon completion of two routes of the project. For instance, upon completion of the middle route in 2014, water resources in Beijing rose from 100 to 150 cubic meters per capita.\textsuperscript{18} At the same time, discharge to southern provinces from the Yangtze has decreased 21 percent during the dry season, and sediment supplies have dropped to the Yangtze Delta region, threatening to cause delta recession.\textsuperscript{19}

As seen in Fig. 2, the project contains three routes which run horizontally through east, middle and western China. The eastern route is 1,150 km long and links the lower reaches of the Yangtze to the Hai, Huai, and Yellow River basins. At full capacity, it supplies up to 14.8 billion cubic meters of water per year principally to agriculture and industry in Jiangsu, Anhui, Shandong, and Hebei provinces, and the

\textsuperscript{16} Lily Kuo, “China is moving more than a River Thames of water across the country to deal with water scarcity,” Quartz Magazine, March 6, 2014, [https://qz.com/158815/chinas-so-bad-at-water-conservation-that-it-had-to-launch-the-most-impressive-water-pipeline-project-ever-built/]

\textsuperscript{17} Thomson, ““Nan Shui Bei Diao”,” 121.


\textsuperscript{19} Quanfa Zhang, “The South-to-North Water Transfer Project of China,” 1243.
city of Tianjin. Of the three routes, it was the first to be completed in late 2013.\textsuperscript{20} Although the east route utilizes existing sections of the ancient Grand Canal from Hangzhou to Beijing, critics have voiced several environmental concerns to its construction that complicate its operation. The primary ecological concerns of the east route include water pollution along the route and insufficient treatment capacity, the high amounts of electricity needed to pump water north, the ecological impact of lake impoundment, secondary salinization of soil in water-receiving and transferring areas, and disease transmission. Today, these concerns are being monitored and addressed to varying degrees of success.

Completed in the next year, the middle route serves different and overlapping northern regions and raises different engineering, environmental, economic and social challenges. Slightly smaller than the east route, at full capacity it provides 9.5 billion cubic meters of water per year to Henan and Hebei provinces, and Beijing and Tianjin municipalities. Geographically, it links “water from the Danjiangkou reservoir on the Han River, which is a tributary of the Yangtze,”\textsuperscript{21} to the dry NCP. Some of the main challenges to building and operating this route include extensive tunneling under the Yellow River, inundating occupied land around the Danjiangkou dam, water contamination along the route, habitat destruction, and discharge reduction downstream of the Han River. Despite these concerns, the route currently supplies one third of Beijing’s total water resources of 3 billion cubic meters per year. However, due to growing demand the project can no longer fully meet the city’s

water needs, and there are plans underway to expand the total route’s capacity to 13 billion cubic meters.\textsuperscript{22,23}

Planning for the Western route is still underway and the route is projected to take another three decades to finish. Nearly twice the size of the other two routes, when completed it would divert another 20 billion cubic meters of water from the upper Yangtze to the upper Yellow River in water-stressed regions in north-central and northwest China. The most ambitious of the three routes, its construction involves extensive tunneling through mountains in regions which lack existing infrastructure, and threatens to heighten the risk of geological disaster along the route.\textsuperscript{24} Given these challenges, it is debatable whether this route will be constructed by the 2050 deadline.\textsuperscript{25}

China’s Ministry of Water Resources has overseen planning and design for the project, which was approved for construction in 2002.\textsuperscript{26} During initial planning, total costs for all three routes of the project were estimated to reach RMB532 billion (US$64 billion).\textsuperscript{27} More recently, independent researchers have reported the cost of the middle and eastern routes alone to be around US$79.4 billion. Chinese state estimates for the first two routes report much lower totals at US$47 billion. However, both estimates only cover reservoir and canal construction, and exclude eviction and resettlement costs for 365,000-375,000 people once living at the catchment of the

\textsuperscript{22} Ibid., 371-372.
\textsuperscript{23} Beijing’s water supplies was calculated by multiplying its population of 21 million by its per capita water supplies of 145 cubic meters per year.
\textsuperscript{24} Thomson, “‘Nan Shui Bei Diao’,” 123.
\textsuperscript{25} Webber et. al, “The South-North Water Transfer Project,” 372.
\textsuperscript{26} Ibid., 372.
\textsuperscript{27} Thomson, “‘Nan Shui Bei Diao’,” 115.
Danjiangkou dam, environmental protection and water treatment along the east and middle routes, or restoring water quality in source regions. To put these figures in perspective, ignoring the long-term costs of environmental degradation and resettlement, between 2004-2013, construction of the first two routes cost over three percent of total government investment. Moreover, the western route, if built, will be more expensive than the first two routes combined.\textsuperscript{28}

The next section will consider the particular challenges – including the recent historical legacies and geographic constraints – that the government faced to supplying key areas with sufficient water. From an economists’ point of view, since 1978 China has embarked on an unsustainable development path that severely degraded its sources of “natural capital” – clean air, water and soil, ecological safety nets, and biodiversity – and ultimately threatens future growth. Another way to conceptualize environmental quality in relation to economic growth is through the environmental Kuznets curve; measuring pollution against GDP, the curve hypothesizes a relationship in which environmental problems worsen during early stages of economic growth, and then improve after a certain “turning point” in income-levels. This curve is useful for contextualizing China’s environmental issues within an economic development path, and identifying particular challenges to environmental restoration in relation to its point on the curve.

Employing this concept, the first part of the section will review evidence for Barry Naughton’s argument that China has surpassed a “turning point” on the curve, and is at a stage where environmental quality is increasingly valued relative to

\textsuperscript{28} Ibid., 372.
continued growth. Following this analysis, the next three parts will explicate the
particular geographic constraints – namely, regional imbalances – and historical
legacies of industrial, agricultural, and urban expansion that have drained China’s
water supplies. Among these legacies, agriculture will be highlighted as the primary
historical demander of water and an important, although not dominant, source of new
demand.

II. Historical Legacies, Challenges, and Geographic Constraints

The SNWTP was first proposed by Mao in a comment he made in 1952: “南方水多，北方水少，如有可能，借点水来也是可以的” (“In the south water is
plenty, in the north there is little; it seems possible, then, to borrow a little water from
the south to give to the north”). However, due a lack of consensus in the scientific
community, and other political considerations that put water at the back of the
agenda, construction did not begin until 2003. In the decades leading up to
construction, many of the initial conditions of China’s social, economic, and political
development had changed drastically.

a. Environmental Kuznets Curve

Before 1978, although China’s development path was at times unsustainable,
the rate of growth was slower than the modern period, and subsequently
environmental damage was serious, but not comparable in many ways to the post-

30 Thomson, “‘Nan Shui Bei Diao’,” 115.
Beginning in 1978, China embarked on an economic development path that would transform its isolated, agrarian economy into the largest industrial market in the world. This transition levied heavy costs on its environment. It is possible to understand the legacy of China’s industrialization and consequent resource shortages through the environmental Kuznets curve. A leading expert on the Chinese economy, Barry Naughton, explains the concept: “According to this conception, pollution and other environmental problems worsen during the early stages of modern economic growth and then begin to diminish as a country reaches middle-income status.”

Graphically, the curve looks like an inverted U. (See Fig. 3).

Naughton explains the relationship between income and pollution in terms of preferences and technology. On the preference side, when GDP is low, populations place priority on economic growth. There is a corresponding growth of the industrial sector, which increasingly pollutes the environment. Once incomes reach a “turning point” which marks middle-income status, people increasingly demand a better environment. In this sense, environmental quality becomes a “luxury good.” On the technological side, as technological capabilities grow, “access to cleaner and more efficient production techniques spread.” In addition, government capacity to regulate polluters improves so that the state is able to enforce pollution controls. According to this pattern, a country may experience several “turning points” in which populations demand cleaner air, more efficient energy, better conservation of

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32 Ibid.
33 Ibid.
resources, and habitat preservation, for instance, although not necessarily at the same time or in a particular order.

In the early 2000s, there were many reasons to believe that China was experiencing the worst stages of environmental pollution. At the turn of the century, total energy consumption was growing nine percent annually and coal production would rise for another decade. In terms of efficiency, although China made significant gains lowering total energy use per output between 1978-2000, in the early 2000s progress slowed as the state increased its investment in heavy industries. At the same time, China’s air, water, and soil pollution was reaching crisis proportions. As the proliferation of airborne particulate matter “made cancer the leading cause of death in China,” industrial, agricultural, and municipal pollutants rendered one fifth of China’s water literally toxic and unfit for human contact, and one fifth of its soil contaminated by heavy metals and non-point agricultural pollutants.34 On the policy side, polluters went unrestrained as China did not begin developing an environmental agenda until 2005.35

In *The Chinese Economy: Adaptation and Growth* (2018), Naughton locates a turning point in 2005 when there is a discernible shift in preferences and technological capacity that indicates that China has bypassed the peak pollution point on the curve. Some of the evidence he cites includes a 2016 Pew poll that reports 70 percent of respondents expressing that air and water pollution are big problems, and 65 percent agreeing that China should reduce its air pollution even at the cost of slower economic growth. In the energy sector, since 2013 the trend of rapidly rising

coal production slipped into reverse and was increasingly replaced by a rapid growth of renewables.\textsuperscript{36}

On the technology side, Naughton cites data showing the tremendous drop in energy use per unit of GDP since 2005, although China still stands above the OECD average. Just under half of China’s electrical generation makes use of supercritical technology which is significantly less polluting and more efficient than US models. There is evidence from the policy end that efficiency improvements in the energy sector are not market driven, but in fact reflect policymaker’s willingness to pay significant costs to improve energy conservation and the environment.\textsuperscript{37} For instance, since 2005 China’s five-year plans have included clear environmental goals. Released in 2006, China’s 11\textsuperscript{th} five-year plan speaks about a new development strategy with a “smaller environmental footprint” and moving to a “knowledge intensive growth path.”\textsuperscript{38} In the same year, the Chinese Academy of Sciences published a report suggesting that “it will be possible to sidestep the worst of the Kuznets curve and get on a clean development path.”\textsuperscript{39}

Since the 11\textsuperscript{th} five-year plan was released, an enhanced policy effort has targeted a 20 percent reduction in energy use per unit of GDP, adopted a national climate change program, and revised an energy conservation law to specify that conservation of natural resources is a fundamental national policy.\textsuperscript{40} Naughton concludes that despite the salience of environmental issues since 2005, actual

\textsuperscript{36} Ibid., 543-546.
\textsuperscript{37} Ibid., 547-558.
\textsuperscript{38} Ibid., 552.
\textsuperscript{39} Ibid.
\textsuperscript{40} Ibid.
progress remains uneven because of recalcitrance in the state sector to relinquish growth-driven incentives. This discussion will be taken up in the last chapter of this paper.

At the same time, China’s enhanced capacity to regulate polluters may indicate that it is ahead of the environmental Kuznets curve. In 2018, the PRC implemented a new environmental tax that charges polluters per unit of emitted air, water, solid waste, and noise pollution.\(^{41}\) Since 2006, the state has reduced concentrated sources of pollution through innovative policy mechanisms such as pollution fees and cap and trade programs.\(^{42}\) Cap and trade programs are particularly suitable to the Chinese regime because they have both bureaucratic and market components. Looking forward then, China’s experience with dual-track programs may give it hybrid tools to mitigate environmental challenges.

While the third chapter of this paper will consider this argument in regards to China’s current regulatory regime, what is important for the proceeding sections is Naughton’s identification of a hypothetical “turning point” in China’s economic development in relation to environmental quality, and how this point coincides with the end of high-speed growth, approximately in 2010. As China normalizes slower economic growth, its demand for energy-intensive industries will decrease, and economic output will shift to the service sector. However, the high-speed growth period ended only recently, and until 2010 the rate of China’s urban, industrial, and agricultural expansion depleted its water resources – through over-use and pollution – to crisis proportions. The next sections will trace China’s geographic limitations to

\(^{41}\) Ibid., 557.
\(^{42}\) Ibid., 554.
ensuring long-term water security, and how urbanization, industrialization, and agricultural expansion has interacted with these constraints to produce a water crisis.

b. Geographic Constraints

China faces several geographic constraints to supplying sufficient water across its expansive and topographically diverse territory. For all of Chinese history, water has been regionally imbalanced between north and south. In 2003, over 80 percent of the country’s “water resources [were] distributed in the Yangtze River Valley and areas south of it,” which “accounts for 54 percent of the country’s population, 35 percent of its arable land, and generates 55 percent of GDP.”43 Of the remaining northern provinces, 11 exist in water scarcity at less than 1,000 cubic meters per capita per year, and eight only have half or less of that amount. Naturally arid landscapes leave many northern provinces prone to recurring drought, which includes four out of five of China’s biggest farming provinces.

Given this natural endowment, it would seem to make sense to grow food in the south and develop industry in the north. In fact, for the majority of China’s history as a unified nation this was the case, and until the 1980s the southern provinces collectively produced over half of the nation’s food, and a majority of its wheat. However, when China embarked on its economic transition in 1978, due to favorable policies and geographic advantage, industry developed more rapidly in the south. The associated increases in land and labor costs made low-value agriculture less attractive to southern farmers, and wheat production moved north.

43 Thomson, “Nan Shui Bei Diao,” 120.
c. Burgeoning Demand: Urbanization, Agriculture, and Industry

Since 1978, China’s economic development has worsened geographic resource imbalances. Between 1978-2005, China saw rapid population growth, and industrial and agricultural expansion, which are the main demand-side factors draining China’s water supply. In the 50-year period between 1949 and 1999 China’s population more than doubled.\(^4^4\) Between 1978-2001, the years before the SNWTP was approved, the population in China classified as “urban” increased from under a quarter to over a third of the population.\(^4^5\) These figures exclude the thousands of migrant workers housed illegally in Chinese cities.

China’s urban growth has directly led to the depletion of its natural resources, swallowing up acres of arable land and requiring growing amounts of water. China’s urban growth, along with rising incomes, has also led to an increased demand for food. As global food prices rise, policies promoting near self-sufficiency in grain at 95 percent remain stalwart, despite the large amounts of water required to sustain grain agriculture. As incomes rise, Chinese consumers demand increasing proportions of meat in their diets, which is relatively more water-intensive to produce than staple crops.


\(^{45}\) Thomson, “Nan Shui Bei Diao,” 120.
tripled.\textsuperscript{46} Besides being incredibly polluting, industry, and mining and manufacturing sectors, are highly water intensive. According to the US EPA, it takes 40,000 gallons of water to manufacture a car and 60,000 gallons to manufacture one ton of steel. Presumably, these numbers are even higher in China whose industries are three to ten times less efficient, depending on the product, than those in developed nations. In 2008 it was estimated that each RMB 10,000 of industrial output required 103 cubic meters of water, which is 10-20 times the average of developed countries.\textsuperscript{47}

In agriculture, China’s total irrigated area increased from 11 million hectares in 1949 to 56 million hectares in 2003. In 2008, an estimated 75 percent of total grain crops, 90 percent of vegetable output, and 80 percent of cotton production in China came from irrigated areas.\textsuperscript{48} As covered previously, agricultural expansion regionally imbalanced owing to industrial concentration, and also to changing production patterns. During China’s transition period, the southern provinces enjoyed more rapid urbanization and economic development, leading to higher opportunity costs for land and labor. As a result, agriculture became less attractive to southern farmers, who had obtained more opportunities to work in the non-agricultural sector. As fewer farmers stayed on the land, and urbanization expanded into arable croplands, China’s breadbasket was driven north.

In 2008, about 70 percent of total wheat and 60 percent of total maize were harvested in the northern region of the Yellow, Huai and Hai River basins (NCP),

\textsuperscript{46} Ibid., 546.
\textsuperscript{47} Thomson, “Nan Shui Bei Diao,” 124.
where more than 60 percent of the area is irrigated and groundwater resources are famously overexploited. Moreover, the percentage of national wheat output from the north is rising. In 2004, northern provinces contributed 77 percent of national wheat output 78 percent of national maize production, up from less than 60 percent in the early 1980s.\(^\text{49}\) This is an issue because on the dry NCP, agriculture accounts for 75 percent of all water withdrawals, which is higher in proportion to the national average of 61 percent.\(^\text{50}\) Moreover, water is used with a two-thirds efficiency rate, at best. In many areas, flood irrigation techniques are practiced when sprinklers could sufficiently water crops.

In total, China’s population growth has increased demand for water resources, and inefficient agricultural and industrial expansion has depleted the nation’s limited endowment. Besides creating water quantity issues, China’s industrial, agricultural, and urban expansion has polluted its limited resources, further exacerbating scarcity issues. The next section will cover some of China’s most pervasive sources of pollution, and briefly consider current levels of response and containment.

\(d.\ \text{Pollution}\)

Pollution is the byproduct of urban, industrial, and agricultural expansion, and is a serious constraint to China’s continued growth. Many specialists consider water pollution an even greater problem than sufficiency. For some perspective, in 2001, it was found that 16 of the world’s 20 most polluted rivers were in China. In the same

\(^{49}\) Ibid., 506.

year, air and water pollution, combined with the widespread use of food additives and pesticides, “made cancer the leading cause of death in China.”\textsuperscript{51} Around the same time, across the nation rivers became dumping grounds for chemical, metallurgical, and pulp and paper waste in industry, and municipal waste in cities. On the municipal side, construction of water purification and sewage treatment plants still lags far behind urban population growth, and as a result pollution threatens the safety of urban and rural drinking water.\textsuperscript{52}

Agricultural byproducts are also a serious source of non-point pollution, and account for fifty percent of all water pollution. In 2003, over one fifth of the country’s total water resources were classified as literally toxic and unsuitable even for irrigation.\textsuperscript{53} Water at this level of pollution cannot be purified for human use. By 2015, this percentage had dropped in half. But still, in many parts of the north water shortages are compounded by unchecked industrial, municipal, and agricultural waste practices. Consequently, reservoirs throughout the north meant to provide drinking water are contaminated, and many riverbeds have become eutrophic, contain build ups of heavy metals, and receive high amounts of chlorinated hydrocarbons, which are found in agricultural fertilizers.

Given these legacies, China embarked on a strategy in 2002 to mitigate a water crisis that regional imbalances, critical shortages, and rising demand promised to deliver. Coinciding with these trends was China’s ascension to middle-income

\textsuperscript{51} McBeath and McBeath, “Environmental Stressors and Food Security in China,” 62.
\textsuperscript{52} Thomson, “Nan Shui Bei Diao,” 120.
\textsuperscript{53} Naughton, The Chinese Economy, 561.
As economists note, often upon attaining middle-income status, countries are at risk of falling into reform traps, which jeopardize long-term productivity growth and eventually stagnate incomes. Resource constraints are a significant factor limiting economic expansion for middle-income countries, and thus China’s circumstances leave it vulnerable to this kind of trap.

As policy-makers became more aware of the dangers of environmental degradation to China’s future productivity-growth, several competing narratives have emerged to explain China’s response to the problem. This policy response has consisted mainly of engineering-based solutions to increase water supplies, and has neglected demand-management in favor of short-term or “band-aid” fixes. In his article “China meets the middle-income trap: the large potholes in the road to catching up,” Wing Thye Woo finds China’s policy strategy consistent with other countries whose growth is threatened by resource constraints. This similarity reinforces an interpretation of the SNWTP as a response to critical shortages. In contrast to a project that benefits the entire nation, as flaunted by its planners, the SNWTP represents a short-term, engineering response to address critical shortages in the populous cities of Beijing and Tianjin, northern mining industries, and grain agriculture.

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55 Ibid.
III. Policy Narrative: A Response to Critical Shortages

Wing Thye Woo is a Malaysian-American economist, and professor of economics at UC Davis, Sunway University in Kuala Lumpur, and The Chinese Academy of Sciences (CAS) in Beijing. His particular expertise is in East Asian economies, and it is significant that he teaches at CAS, where many researchers have opposed the viability of the SNWTP. In 2012, Woo published an article which introduces the concept of a middle income trap and considers the major types of traps to which China is vulnerable.

Most precisely, the middle income trap refers to a country’s performance over a period of time on a “Catch-Up Scale” (CUI). Taking into account that the income of the world’s richest countries have been steadily rising, the CUI measures a country’s income level to that of the US. Expressed as a percent of US income (in which a high percentage score approaches US levels), the CUI score over time demonstrates whether that country’s economy has ‘caught up’ or stagnated with respect to the world’s highest-income countries. More broadly, the middle income trap refers to the fact that reforms can get stalled when a coalition emerges that is strong enough to ‘capture’ the process.

One symptom of reform trap in China is the outsized role of the state sector in the economy despite ongoing reform efforts to diversify ownership. Woo terms this potential trap and any other “breakdown of the economic mechanism” a “hardware failure.” According to Woo, the most likely instances of hardware failure in China are the emergence of a banking crisis due to an over expansion of credit at the local

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56 Ibid., 317.
level and underperformance in the state sector. The second category of vulnerability is the potential for inequality, corruption, and other flaws in governance, or so-called software failures, to stall reforms. Lastly, Woo anticipates that China may face natural or externally imposed limits to growth, which falls under the category of “power supply failures.” Two likely failures in this sense include environmental collapse or a collapse of Chinese exports due to a trade war.

Although both scenarios present potential risks, environmental collapse is increasingly imminent. Officially approved for construction when China was on the verge of a water crisis, the South-North Water Transfer Project represents a reaction to critical shortages that might have induced a “power supply failure” in the Chinese economy. Among the interrelated issues of coal dependence, high pollution, low per capita availability of land and water, and climate change, water shortage in China’s northern regions stood out at the turn of the century as the most immediate environmental threat to sustaining the country’s high growth.57

Woo’s power supply reform agenda emphasizes the interdependencies between the natural environment and the efficacy of certain policy reforms. Another way of stating this is that Woo advocates for a systems-approach to policymaking. As will be developed later in this chapter, a systems approach takes into account the interrelatedness of multiple sectors of the economy. Although Woo’s application of systems-thinking is only applies to a handful of examples as related to water, the later sections of this paper – especially the third chapter – will elaborate how agricultural and industrial reforms could be designed to indirectly increase water supplies. In

57 Woo, “China meets the middle income trap,” 324.
advocating for such an approach, Woo joins the ranks of a group of economists, scientists, and policymakers who argue that water resources should be conserved by managing the sectors in which it is highly demanded.

The following sections (a-d), will cover proposals by parties interested in solving China’s water issues that emphasize sustainability, and account for the interaction multiple sectors of the economy to reform the underlying factors draining China’s water supplies. Whereas Woo emphasizes China’s energy production, other authors have highlighted agricultural policy, conservation and price reform efforts, and “green water storage” as potential solutions to limiting water demand. The last section will then consider to what degree Chinese policy has embraced a “systems approach” to water management.

a. Diversifying China’s Energy Mix

One solution that Woo and others have proposed that falls into the category of systems-thinking is diversifying China’s energy mix. As the second largest demander of water after agriculture, coal production accounts for one sixth of all water withdrawals in China.\(^\text{58}\) Moreover, 53 percent of China’s ensured coal reserves in 2011 were located in water-scarce regions and 30 percent in water stressed regions. Not only is coal mining water intensive, but it is also heavily polluting. In Shanxi province, which lies at the heart of the NCP and is one of the driest regions in the country, studies estimate that 1.07 cubic meters of groundwater is destroyed per ton of coal extracted.\(^\text{59}\)

\(^{58}\) Kuo, “China is moving more than a River Thames of water across the country.”

\(^{59}\) Debra Tan, “China’s future energy security will depend on water,” China Dialogue, (January 30, 2014),
There is substantial evidence that industrial water use not only pollutes China’s limited supply, but also contributes to its changing rainfall pattern and intensified flooding and drought. Besides degrading air, water, and land quality, China’s black carbon emissions have “contributed significantly to the shift to a climate pattern that produces northern droughts and southern floods of increasing intensity.” Given these conclusions, Woo recommends that water and energy policy be coordinated to fulfill political goals on multiple fronts. A more sustainable development policy would require investment in waste treatment and extractive technologies in order to decrease pollution and increase efficiency of mining. In tandem with diversifying the national energy mix, these policies would reduce China’s coal dependency, conserve its water supplies, alleviate regional water imbalances, stabilize national climate patterns, and curb industrial pollution.

b. Solving the Paradox – China’s virtual water trade

Another ‘systems approach’ to sustainable development argues that the key element to solving China’s water scarcity crisis is agricultural reform. As of 2019, irrigation accounts for just under two thirds of national water use, although this proportion is declining. Moreover, a vast and rising majority of domestic food production occurs in the water-scarce north. Proponents of agricultural reform identify a paradox in China’s interregional trade flows – namely, that the water-abundant South exports large volumes of water to the water-scarce North, while the

[https://www.chinadialogue.net/article/show/single/en/6693-China-s-future-energy-security-will-depend-on-water]

60 Woo, “China meets the middle income trap,” 334.
61 Naughton, The Chinese Economy, pg.
North exports substantial volumes of food and agricultural products to the food-scarce South.⁶²

These interregional transfers can be quantified and compared through the concept of ‘virtual water,’ which measures the water used in the production process of agricultural or industrial products. When put into the context of water availability per region, one study from 2005 found that “the higher the per capita water availability in a sub-region, the larger the volume of virtual water import.”⁶³ Historically, this was not always so. Due to extensive irrigation in the north, and rapid economic development, urbanization, and industrialization in the south, historical food flows between the water-abundant southern provinces and the dry northern ones was reversed in the 1990s.

Although water is not the only constraint on agricultural policy, the paradox of China’s interregional water flows has levied heavy economic, environmental, and social costs on its population. The maintenance of this paradoxical system has required extensive damming, inter-basin south-to-north water transfers, widespread irrigation, and overexploitation of groundwater resources in the north, which ultimately dislocates populations, degrades the environment, and arguably exacerbates water scarcity by generating new demand. Due to the overexploitation of

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⁶³ Ibid., 841.
groundwater, areas in the north are sinking – Beijing is no exception, and studies from 2016 concluded that some districts were falling by four inches per year.64

More concretely, proponents of agricultural reform propose food trade, investment in irrigation technologies, and price reform as active policy tools to help mitigate water scarcity. Upon accession to the WTO, Chinese policymakers agreed to liberate agricultural policy somewhat, cutting tariff rates on certain products, introducing a tariff rate quota (TRQ), and reducing market distortions on agricultural trade domestically and internationally. Proponents of trade reform see the potential for trade regimes, such as the WTO as well as domestic trade policies, to encourage water conservation through import of water-intensive crops.65

Although full trade liberalization and import of water-intensive crops is infeasible due to China’s interests in maintaining around 95 percent food self-sufficiency, in order to reduce domestic demand for water the authors suggest that China reduce its sown area in the north for fruits and vegetables, increase its import quantity under the TRQ for maize, which is largely used for feed, and introduce drought-tolerant plants for silage in the north. The reduction in growth of fruit and vegetable production would address over exploitation of groundwater, whereas the second two measures would meet China’s growing demand for meat without straining its water supplies.

Another policy solution to addressing water shortage is to improve irrigation efficiency. In 2006, it was estimated that Chinese agriculture used 43 percent of its

65 Liao et. al, “Global trade,” 506.
water resources efficiently, compared to 70-80 percent of irrigated water in developed countries. Reformers suggest that practices such as flooding fields should be replaced with sprinkler systems, for a start. Moreover, water is lost at almost every point in the chain of collecting, storing, and delivering water. In China’s irrigation systems, it is estimated that 25 percent of water is lost through pipe leakage, compared to 10 percent in the U.S. and 9 percent in Japan.  

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\[c. Conservation and Price Reform\]

Water conservation is advocated as a ‘systems approach’ to mitigating water scarcity issues across all sectors. One vocal proponent of conservation reform is Changming Liu, a retired hydrologist from the CAS. In order to increase water supplies across all sectors, Liu recommends various fixes such as “making greater use of sea water where possible in the coastal industrial cities, using brackish and other low quality water for purposes that do not necessitate pristine water, developing rainwater harvest, enhancing weather modification capacities, developing high efficiency water-saving technologies such as sprinkler irrigation and water recycling, and improving conservation management.”  

\[67\] Together, these measures could save more than 100 billion cubic meters of water per year, which is far more than any proposed transfer.

One method that has been proposed to address the last item on Liu’s list, namely conservation management, is to reform water prices. For much of the transition period, the price that farmers paid for water did not reflect its relative

\[66\] McBeath and Huang McBeath, “Environmental Stressors,” 62.
scarcity. Until the turn of the century, water prices for commercial, industrial, and household uses were not well-differentiated and did not vary in proportion to water use. Moreover, water costs did not account for treatment and delivery fees. For example, for Handan city in Hebei province, which suffers one of the most acute water scarcity crises in the country, actual water cost in 1998 was calculated to be six RMB per cubic meter, when residents were only being charged for one tenth of that.

Although full price liberalization of water is politically infeasible, price reform is an effective strategy that the state has wielded in resource sectors in order to encourage conservation. One example is in energy. Between 1978 and the end of the twentieth century, energy use per unit of GDP in China dropped by two thirds. Whereas energy in the socialist period had been heavily subsidized and was not priced to reflect its scarcity, prices in China’s transition period were raised to reflect resource costs with the effect of increasing producers’ incentives to reduce energy use.

d. The Environmental Perspective – Green Water Storage

Whereas Woo and Liu contend that industrial, agricultural and cross-sector conservation reforms can be pursued in tandem with some engineering-based solutions to increase supplies – as in mitigating an imminent crisis, there is a strong argument to be made against large-scale infrastructure projects altogether. In the environmental community, critics have argued that dam storage is neither the most

68 McBeath and Huang McBeath, “Environmental Stressors,” 62.
70 Naughton, The Chinese Economy, 549.
cost-efficient, safe, nor efficient solution for securing a nation’s water supply.\textsuperscript{71} According to freshwater conservationists, dams are one of the most susceptible structures to climate change, one of the most subject to cost overruns, and often fail to meet the water needs of transfer beneficiaries.\textsuperscript{72}

For the SNWTP, all of these risks are present, as the cost of the project has more than doubled and its routes will lose efficacy if river flows are affected by climate change. The last point by environmentalists of failing to meet recipient needs is also salient. In an article from last September titled “China’s Water Problems,” author Amit Ranjan projects that “the two operational channels of the SNWTP will be able to transfer around 20.9 billion cubic meters of water by 2030. However, this will have little impact on the water situation in provinces like the Beijing/Tianjin/Hebei area. It would only raise water available per capita in those provinces to two thirds of the level of acute water scarcity.”\textsuperscript{73} Other studies concurred with Ranjan’s estimates, concluding that even at full capacity the east route only meets a third of Beijing’s water needs.\textsuperscript{74}

\textsuperscript{71} To clarify, small-scale dams hydropower projects do not present the same risks as large-scale ones to the economy or the environment. On the contrary, smaller dams often save scarce arable land supplies, and are managed to promote long-term water and energy security. It is gargantuan projects that environmentalists reject on the basis of environmental soundness – these projects often present too many ecological risks to be “worth it” by any environmental metric.

\textsuperscript{72} Zachary Hurwitz, “Why Large Dam Storage is Not the Right Option for Climate Resilience,” \textit{International Rivers}, March 17, 2012, [https://www.internationalrivers.org/blogs/258/why-large-dam-storage-is-not-the-right-option-for-climate-resilience]


\textsuperscript{74} Barnett et. al, “Sustainability,” \textit{Nature}. 
These findings are complicated by conclusions that the net virtual water transfer from north to south supplies more water than the projected total transferred from south to north of the SNWTP. Against this backdrop of a net domestic flow of water from south to north, and food from north to south, the project seems especially illogical if it cannot meet the water needs of recipients. Besides not serving the needs of receiving regions, inter-basin transfer projects can cause novel water shortages in source areas that do not have a large surplus of water to export. And water is not as abundant in the south as the government reports – the year before the SNWTP was completed, evidence suggests that there was too little rainfall in the south to have transferred any water north.

This issue of novel shortages halted the middle route of the project for four years before the national government could negotiate a compensation to Hubei province for its reduced flows. Along the middle route, it was discovered that decreased discharge from the Han River reduced the amount of water left for irrigation and navigation in the province. Several studies have focused on the water shortage risk along this route and suggested that these issues can only be mitigated by initiating more engineering projects.

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75 Jing et. al.  
78 Ibid., 3493.
that will be discussed in the next section is that transfer projects often lead to the pollution of water resources in the transferring and receiving regions. So far, the government has set aside US$80 million to Jiangdu, Huaian, Suqian and Xunzhou in eastern Jiangsu province to build water treatment facilities along the route.80

Instead of dam storage, environmentalists argue for a “green water storage” in which water is stored in fields and plants, soil humidity is maintained through reduced use of fertilizers and pesticides, groundwater is restored through recharge and rainwater harvesting, and dam storage is limited to local ponds and small reservoirs. Although the latter two solutions are technically shorter-term fixes, when practiced at the local level they can be carried out sustainably. For instance, groundwater can be withdrawn within “safe yield” ranges where recharge rebalances withdrawals. These solutions will be discussed throughout the next chapters in relation to sustainable agriculture practices.

e. Implementation - Assessing the sustainability of China’s policy effort

The next question to be considered is to what extent China has embraced a “systems approach” to environmental and economic policy and embarked on a sustainable development path. First, it has completed two routes of the SNWTP. In light of critical shortages, the construction may have been necessary to sustain current levels of economic activity and welfare and therefore might be justified. But, as will be discussed in the next section, water transfer is ultimately unsustainable in terms of the environment and cannot be justified as a long term solution to water shortages.

In regards to agricultural policy, China has made significant improvements since 2002. Since WTO accession, an increasing proportion of China’s feed is imported rather than domestically produced. Today, around 80 percent of soybean volume in China is imported, a large proportion of which is crushed in order to make meal and used for feed. In addition, in 2016 China began to phase out direct minimum purchase price procurement on agricultural commodities, which resulted in overcapacity, oversupply, and huge wastes of land and water resources owed to stockpiling. To replace the security net that procurement offered, in the past two years the government has phased in an agricultural insurance policy to protect farmer incomes.

However, trade liberalization and agricultural price procurement gains management should not be overestimated. As of 2018, over 80 percent of maize crop is grown domestically and China’s 95 percent grain self-sufficiency policy remains stalwart. Although the prices of some agricultural commodities have been reformed, the price of water remains artificially low, which will still discourage conservation and induce waste. The status quo will only become harder to maintain as China’s municipal and industrial demands for water grow in proportion to those of agriculture. Agricultural water demands are projected to increase too, as Chinese incomes rise and consumers demand an increasing proportion of meat in their diets, which is incredibly water intensive relative to staple crops.

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82 Ibid.
In regards to efficiency, China has made significant and steady progress in implementing less wasteful irrigation techniques. In energy, China has reduced its coal dependence and energy consumed per unit of GDP. The end of the high income growth period will also reduce energy consumption by industries and associated pollution. In pollution control, China has both invested in cleaner technologies and enhanced its regulatory capacities to restrain polluters. As discussed previously, a new environmental tax has been instigated per unit of pollution emitted that improves on previous regulatory efforts.\(^{83}\) In price reform, full liberalization of water prices is infeasible in the near future, however, it is inevitable that water users will have to pay higher costs for supplies. Already, the cost of transferred water by the SNWTP is higher than that of local sources, and even the cost of local water is rising.

In technological capacity, China has invested heavily in desalination technologies and currently leads the world in cloud-seeding capacity. The latter technology should not be viewed as an improvement, however, because it could exacerbate extreme weather patterns and is unsustainable when practiced on a large scale. Another innovative initiative is China’s ‘sponge city’ project, which combines nature-based solutions and traditional ‘grey infrastructure’ projects (those involving concrete and steel) to encourage water conservation in cities. As of 2018, China has declared an objective that by 2020, 80 percent of urban areas should use ‘sponge cities’ techniques to absorb 70 percent of rainwaters through improved retention, storage, purification, drainage, permeation, saving, and re-use methods.\(^{84}\)

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\(^{83}\) Naughton, *The Chinese Economy*, 543-567.

\(^{84}\) Amit Ranjan, “China’s water problems,” 653.
While this discussion excludes major water laws and national efforts to curb pollution, set water-use limits, and promote institutional reform, these efforts will be reported and assessed in the third chapter of this paper. Overall, China’s policy approach has neglected to manage demand in favor of increasing supplies; however, China’s current environmental crisis may reverse the political response, as the limitations of engineering-based solutions become apparent.

IV. Evaluation: is it justified?

Given the incomplete nature of demand-focused solutions, the question becomes whether or not inter-basin water transfer is justified. Jeremy Berkoff asked this question in his widely cited article on the project, titled “The South-North Water Transfer Project – is it justified?” In the article, he concludes that also the transfer project is environmentally and economically impracticable, it may be justified for political and social reasons which conform to a “broader regional and agricultural development setting.” Overall, his analysis makes sense. Although not emphasized by Berkoff, the political symbolism of the project will be placed in the context of China’s history of water management in the second chapter, and considered in total evaluation of the project. Despite his strong defense of social and political imperatives met through the project, Berkoff’s conclusions underestimate both the capacity of demand-management to improve regional allocation and overall supplies, and the gravity of environmental risks.

The following two sections will detail the environmental costs of the SNWTP, focusing on the two constructed routes of the project and on intra-jurisdictional water trade-offs. This analysis differentiates involved provinces according to their water-exporting, transferring, and receiving functions, and finds that the project degrades southern ecological systems at the expense of northern water needs. Next, it will assess compensation efforts for water-exporting provinces, and suggest that the only feasible way to alleviate environmental damages is to limit the scope of the project.

*a. Environmental Evaluation*

On balance, the greatest costs of the SNWTP, and of inter-basin water transfer schemes generally, are clearly environmental. One difficulty in assessing the environmental impacts of water transfers is that they are hard to anticipate with absolute certainty. Moreover, even if certain negative consequences are foreseeable, environmental degradation is difficult to monetize. Conceptions such as the environmental Kuznets curve attempt to approximate how “worth it” a good environment is to certain populations according to income level. However, these hypothetical relationships are approximate and cannot reliably predict the costs of environmental damage.

From the outset it is obvious that environmental consequences tend to favor water-receiving regions and hurt water-source regions. Whereas Beijing and Tianjin increased their available water resources by at least a third after the opening of the eastern and middle routes of the SNWTP, the annual discharge of the Yangtze River during the dry season will be reduced by nearly a fifth.\(^{86}\) Clearly, water transfers

present a trade off between multiple economic, social, and political interests. Shanghai, which is a southern city lying on the eastern coast, is expected to experience seawater intrusion that will eventually lead to the recession of the Yangtze River Delta if water volumes along the SNWTP continue to be transferred at their current rate. The recession of the delta would be catastrophic to Shanghai’s economy, but current water shortages are crippling livelihoods and industry in the capital, as depicted in Berkoff’s “without” scenario and the losses that would incur if the SNWTP was not built.

More specifically, environmental consequences can be assessed according to water exporting, transferring, and importing regions. On the eastern route, the water will be drawn from the lower reaches of the Yangtze, which is also one of the most economically developed regions in the country. This region will not experience any benefits, and may experience negative environmental consequences such as sea water intrusion resulting from reduced flows to the estuary of the Yangtze. As water is transferred east, it will pass through and impound four lakes and eventually link up with the northern section of the Grand Canal. The primary environmental concerns for water-transferring regions along the eastern route include the ecological impact of lake impoundment, water quality degradation along the canal, and invasion of alien species. The last two concerns also apply to water receiving areas with the added risk of secondary salinization.

The most dramatic effects of lake impoundment result from a reversal in the hydrologic regime. After the middle route was inaugurated, water levels in the lakes

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were reversed to be higher in the winter and lower in the summer. This change is expected to negatively impact aquatic plant communities in the lake and severely reduce their biomass. Another primary concern is water quality degradation along the canal, as the transfer will pass through some of the most populous and economically developed areas in China. The lakes in which water will be stored currently serve as dumping grounds for vast amounts of municipal and industrial waste. In addition, the water will pass through rural areas which contain no sewage treatment facilities at all and are heavy sources of agricultural non-point pollution. As the amount of polluted water passing through lakes increases, the risk of eutrophication will increasingly threaten limited freshwater supplies. Eutrophication poses a serious risk to lake survival, and in 2008 China’s lakes were estimated to be disappearing at a rate of 20 a year because of this issue.\(^8\)

The water receiving areas of the eastern route include Tianjin, and the provinces of Jiangsu, Anhui, Shandong, and Hebei that lie in the NCP. Most of these areas lie below 100 meters above sea level and already contain saline soils. Salinization is further exacerbated by excessive groundwater extraction, which is pervasive throughout the NCP. As the spread of secondary salinization is counterproductive to irrigation of cropland, water transfer to this regions seems to be a particularly bad idea, as water passing below the ground surface could eventually aggravate this problem.\(^9\) The last risk which is also one of the hardest to fully foresee

\(^8\) McBeath et. al, “Environmental Stressors,” 65.

is the potential for southern species to migrate north. Not only could this be destructive to northern ecosystems, but migration also poses the threat of spreading parasitic diseases.  

Along the middle route, in addition to secondary salinization and invasion of alien species in water receiving areas, the primary concerns include the social costs of resettlement, water contamination, and potential scarcity in the source and transferring regions, and discharge reduction downstream of the primary water source area. The middle route involved the expansion of the Danjiangkou Dam, which inundated agricultural land and forests around the river as well as human settlements. Initial estimates of displacement estimated resettlement figures around 250,000, but these numbers have grown to 375,000 since the project has been completed. Figures from the Three Gorges Project suggest that resettlement costs RMB 100,000 per person, excluding the costs to households. Another concern of dam enlargement was that it reduced the amount of arable land per capita and increased competition for this scarce resource.

Potential water scarcity in the source region has been discussed in the previous section as a paradoxical consequence of water transfer. In addition, the water source region of the middle route, which is the area serviced by the Danjiangkou Dam, is at risk of contamination of its remaining supplies. Without a reduction in waste dumped into the Han river, reduced discharge will lead to higher proportion of polluted water supplies. Increased nitrogen and phosphorus levels will create plankton blooms, among levying other harmful ecological effects. Downstream of the

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90 Ibid., 1242.
91 Webber et al., “Remaking the Geography of China,” 372.
dam, decreased discharge will cause similar ecological problems and eventually change the structure of riverine ecosystems.

The environmental consequences of the western routes will not be explicated until the third chapter of this paper, and are markedly different from those of the first two routes as the terrain and population density of west China differ drastically from that of the more populous and flatter east. One notable aspect of the western route, and what distinguishes it from the first two, is that some of the water will be used for ecological restoration in receiving areas. This is largely because one of the water-recipient regions, in Qinghai, is the source of China’s Yangtze and Yellow Rivers and therefore clean supplies is paramount. Another notable difference is the heightened risk of ecological disaster on the west route. Because of its gargantuan scale, it faces enormous feasibility challenges.

The benefits of the eastern and middle routes can also be understood in terms of water-source, water-transferring, and water-importing regions. Overall, water transfer does not bring any tangible benefits to water-source regions that are not shared with the rest of the country. Water transfer regions can negotiate to divert water supplies for their own purposes, as areas in provinces such as Jiangsu have done. Water receiving regions reap the lion share of the benefits, with water transfers alleviating critical shortages in the NCP, elevating the standard of living for people with little access to unpolluted supplies, and promoting regional equity across north and south China. More broadly, water will be supplied in the north to sustain domestic, irrigation, industrial and mining activities, hydropower generation, and
flood control efforts. To the extent that the whole nation interacts with north China, these benefits are national in scope.

b. Compensation – Is it possible?

Although it is true that water-exporting regions do have a stake in the welfare and economic development of water-importing regions, on balance the project overwhelmingly favors the interests of water-importing regions over water-exporting ones. Ideally, in order to mitigate environmental concerns in the latter areas, water recipients would fairly compensate water-exporting and some transferring regions for associated losses. As an economic good, water transfer implies the export of a resource and associated economic value from a source to a receiving region. As such, in the south, the loss of water is predicted to translate to associated losses of GDP. Of course, GDP is not the only measure of lost value and can only calculate losses in the short term. However, proper compensation is difficult for practical and political reasons. Practically, environmental loss is difficult both to quantify and to fully assess. Politically, urban interests are given priority over rural ones, high-income regions and industries over lower ones, and powerful interest groups, such as the state, over disaggregated or weaker ones.

The only clear way to alleviate damages is to limit the scope of the project. As Changming Liu writes, “in general, the uncertainty of the environmental impacts of a water transfer project is in direction proportion to its scale.”\textsuperscript{92} The only way to reduce the amount of damage, then, is to manage demand through what Changming Liu calls

\textsuperscript{92} Liu, “Environmental Issues,” 905.
“water-saving measures.” As discussed in the previous section, demand management through efficiency gains and better conservation is advocated as a ‘systems approach’ to water scarcity alleviation across all sectors. Moreover, since SNWTP construction was first initiated in 2003 conservation efforts have made significant inroads into Chinese policy and public discourse.

To the extent that water saving occurs in tandem with the transfer project, the initiative is justified on the grounds that it provides critically needed resources to key regions in the north, which include numerous agricultural, industrial, and mining facilities in the NCP, communities which are sinking from overexploitation of groundwater, and the dry municipalities of Beijing and Tianjin. In addition, the transfer has increased water supplies and improved the livelihoods of around 100 million people along its route. In addition, it has been argued that the water transfer is needed to restore the ecological systems in the north, which have recently suffered severe desertification.

As justified as these political, social, economic, and environmental ends may be, the massive scale of the project and the plans underway to expand it are not. Ultimately, the transfer is unsustainable and presents higher costs and fewer returns than water conservation measures in the long term. In 1998, it was estimated that the cost of the project was twice as great as the benefits, taking into account long-term losses to the environment. The reason it was approved is that these gains are dispersed regionally and benefitting regions were given priority over exporting ones.

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93 Ibid.
94 Ibid., 908.
95 This statistic is included not to imply its factuality, but to show that attempts at quantifying long-term losses have been made, despite their ultimate uncertainty.
Without any change in its policy mechanism to deal with water shortages, China will continue to embark on an unsustainable development path which may ultimately exacerbate existing scarcities, stunt economic development, and further degrade China’s environment.

c. Conclusion

Ultimately, the problem of China’s water shortage is less of an issue of absolute scarcity, and more the product of poor management. Until China develops its conservation capacity, and successfully curbs the most serious sources of water pollution, the existing routes of the SNWTP may be justified for the short-term in that they sustain minimum residential, agricultural, industrial, and ecological water needs in the nation’s capital. However, given its environmental impacts, as well as its failure to meet water needs in recipient regions, the project is too costly to be sustainable in the long-term.

One question that emerges from this analysis is why, if the transfer was initially proposed in 1952, it took half a century to be constructed. If China’s leadership anticipated increasing supplies, why did it not pursue demand-management as an alternative fifty years earlier? The answer is that the first leaders of the PRC did not anticipate critical resource shortages, and that throughout history the motivations of state-led water control projects – and of the SNWTP itself – have continually shifted. The next section will situate the SNWTP within a historical lineage of large-scale, public water-works in China, revealing long-standing debates between constructive and destructive forms of management. These debates are reflected
through various interpretations of the story of Da Yu, undoubtedly China’s most famous water-hero.
Chapter Two

Historical Frameworks of Water Management

As legend has it, over four thousand years ago, the divine sage-king and tribal leader Da Yu of the Xia people recognized that the dikes his father constructed along the banks of the Yellow River repeatedly collapsed. As a result, Xia settlements suffered annual floods that wiped out entire villages and destroyed fields. Because of the floods, the Xia people could not develop sedentary agriculture and lived in a state of constant insecurity. To tame the great deluge, the Great Yu proposed dredging the riverbed in order to provide an outlet for floodwaters to the sea. After three years of strenuous labor, Yu successfully drained the swamps and floodplains along the river, connecting the Nine Rivers and securing valleys for cultivation by the Xia people. For performing this stunning feat, he was named the first emperor of China.96

Of course, Da Yu’s effort is metonymic for the thousands of early peoples who actually completed the work. However, over the course of Chinese history the story of Da Yu became a powerful political mandate establishing imperial right of rule. During the Zhou dynasty, the Mandate of Heaven political theory (天命) was developed based on emperors’ claims that like the Great Yu, they too were “semi-divine conduits between heaven and earth charged with the task of imposing order upon a chaotic natural world.”97 Under mandate theory, Chinese emperors could lose

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favor with heaven through the occurrence of natural disasters. When lands were flooded, it signaled that the emperor had poorly managed the nation’s waters and could be legitimately overthrown.

Throughout history, the story of Da Yu has been interpreted in conflicting versions that reflects the well-documented tension between constructive and destructive environmental management. In contemporary China, the adage of Da Yu is still referenced in connection with the nation’s largest water management projects. Often, the story is evoked to justify “scientific” approaches to water management, which generally fosters large-scale engineering projects.  

However, other interpretations throughout history have emphasized the non-interventionist directive of the Da Yu story. According to this interpretation, the story of Da Yu directs managers to “guide the stream in accord with the current.” These contrasting interpretations call into question whether the modern turn to engineering reflects the best interests of Chinese people concerned with preserving the nation’s water resources and natural landscapes.

This chapter will trace the emergence and development of China’s major water-works from its earliest dynasties, through the pre-modern, republican, and socialist periods, to the market-socialist present. Beginning with the ingenious Dujiangyan irrigation system and ending with the controversial and ultimately catastrophic Three Gorges, this chapter will establish how the Chinese state gradually engineered the nation’s natural water systems into human-managed networks to meet

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the needs of flood control, irrigation, transport, and – beginning in the Republican period – economic expansion. Although often of limited practical value, state-led projects provided powerful symbols of state legitimacy.

At the same time, at the regional level resource shortages were often solved by looking at questions of conservation, efficiency, and allocation. Rather than debating whether dykes should be built high and narrow or low and wide, such as the Confucian and Daoist political theorists, local leaders and community members conserved water through seasonal ordinances restricting environmental exploitation, sustainable farming practices, and interregional trade patterns that reflected each region’s comparative advantage, resource endowment, and demographics. In local management there was room for small-scale flood control, however few resources or philosophies advocated gargantuan technological interventions. The last section of this chapter will trace how local and regional management approaches reflected traditional knowledge of conservation, and how this knowledge is imperative to solving China’s water issues today.

I. Taming the River – How Hydraulic Engineering Shaped China’s Political Landscape

How has China historically managed its waterways – through top-down management or grass-roots initiatives? Has state management of China’s waterways been characterized by despotism or benevolence, and how far into the empire did state control pervade? Phillip Ball, former editor of Nature magazine and columnist in Chemistry World attempts to answer these questions in his book, The Water
"Kingdom: A Secret History of China" (2016) which combines historical research with personal accounts to arrive at a political, economic, and social history of water in China. He begins his fourth chapter on the political significance of water by positing that through the 20th century, the study of Chinese political history in the West was almost exclusively associated with the theory of “oriental despotism.” First proposed in 1783 and popularized by the German-American historian and sinologist Karl Wittfogel in 1957, the term describes a centralized, absolutist form of government particular to Asiatic states in which political power was founded on control of water.\(^{100}\)

A variation on oriental despotism, hydraulic despotism refers to civilizations in which dominion over water guarantees control over agrarian production and distribution, and labor. In a country as vast as pre-modern China, Wittfogel concludes that only a centralized authority could mobilize the masses to build water-works for irrigation and flood prevention, and only a despotic one could enlist the compulsory service of dependent classes and in doing so strengthen those classes’ dependence on the proper functioning of the state.\(^{101}\)

Although compelling to nineteenth century European historians, since Edward Said’s seminal work *Orientalism*, the “hydraulic despotism” thesis has drawn criticism for oversimplifying the complexities of imperial authority, and predetermining the course of Chinese history. Despite these shortcomings, Wittfogel’s characterization of China’s “hydraulic despotism” does contain a kernel of truth. Preserving the association between hydraulic engineering and state-building,

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\(^{100}\) Ibid., 100-102.

\(^{101}\) Ibid.
according to Phillip Ball’s research the Chinese historian Ji Chaoding has complicated Wittfogel’s thesis to argue that “much of Chinese history has revolved around “key economic areas” of significance both for their agricultural productivity and as communications highways.”\[^{102}\]

Chaoding’s “key areas” model relies on the state development of public works for water control. The three examples from imperial history that this paper will examine are the Dujiangyan irrigation system in modern-day Sichuan, the grain-tribute system and Grand Canal constructed to support it, and the formal river conservancy system (in particular, the Yellow River Administration) erected in the Ming dynasty and sustained through the Qing. Varying in objectives, environmental impacts, and historical reputation, each was foundational to the development of top-down water management technique and discourse.

\[a.\] *The Dujiangyan Irrigation System – The Way of Li Bing*

Today, the irrigation needs of the Chengdu plain are met by the Dujiangyan irrigation system, constructed in 256 BCE by water hero and Qin hydraulic engineer Li Bing.\[^{103}\] Of all the Chinese water idols, Li Bing is perhaps the most celebrated for balancing human intervention with a respect for nature. Before earning the status of a deity, Li Bing was an administrator and engineer for the Qin clan placed in charge of irrigating the modern-day Chengdu plain, then the kingdom of Shu. In order to tap the water of the Min River (岷江), Li split the channel in two and constructed an artificial promontory where the channels divided, now called the “Fish Mouth” or *yuzui* (鱼嘴

\[^{102}\] Ibid. 
Of the two river channels, one was narrow and deep and the other shallow and wide. Li’s logic was to allow the deep channel to carry water during the dry season and for the shallow channel to fill during times of flood. Li’s saying “dig the channel deep, and keep the dykes and spillways low” guides water diversion to this day.\(^\text{104}\)

The two channel model effectively mitigated the risk of flooding in the region without the assistance of dams. Next, in order to irrigate the plain between the two channels, Li Bing constructed a network of irrigation ditches from the inner, deeper route that were controlled by sluice gates and weirs. Besides providing water to the plain, the artificial waterways were also harvested for hydropower and used to drive waterwheels for hulling and grinding rice. The system, called Dujiangyan (都江堰), or “All Rivers Weir,” is still in operation today in much of its original form and serves the irrigation needs of an entire county (approximately 668,000 hectares of farmland).\(^\text{105}\) All the more remarkable, there is evidence that the project required no conscripted labor, which distinguishes it from most Qin and Warring States-era initiatives.\(^\text{106}\) Today, the Dujiangyan is a UNESCO World Heritage Site and Li Bing is venerated as a local water god.

In terms of the ancient debate between constructive and destructive water management, the ideological legacy of Li Bing is mixed. On the one hand, the Dujiangyan irrigation system conforms to the Daoist interpretation of the Da Yu story in that it directs water to human purposes without changing its natural direction or current. An interesting fact is that the birthplace of Daoism lies on Qingcheng

\(^{105}\) “Mount Qicheng,” UNESCO.  
mountain just south of the plain where founding philosopher Zhang Ling first codified the doctrine. On the other hand, Li’s directive to “dig the channel deep, and keep the dykes and spillways low” is a measure of “taming” the river in order to make its fluctuations more predictable and habitable to people, an interventionist view often associated with Confucianism.

However, the measure to which Li imposed a human will on the river must be qualified. Today, locals celebrate Li’s achievement for how it “uses natural topographic and hydrological features to solve problems of diverting water for irrigation, draining sediment, flood control, and flow control without the use of dams.” Confucian wisdom in fact advocates for an opposite design to Li’s – to build dykes high and narrow to force the river to do man’s bidding, an idea that will be discussed further in the context of river conservancy. In terms of environmental impacts, the Dujiangyan system requires little maintenance and is largely self-sustaining, and until China’s rapid economic development supported diverse ecological populations.

The Dujiangyan irrigation system is an important source of learning for contemporary water conservancy (shuili 水利 in Chinese), in part for its sustainable design and also for its enduring political symbolism as a heritage site in Chengdu. During the Qin era, the Dujiangyan system allowed a prosperous, agricultural society to flourish in modern-day Sichuan, which was vital to Qin consolidation of power. In fact, excellence in hydraulic engineering, as displayed by top administrators like Li

107 “Mount Qicheng,” UNESCO.
108 Ball, The Water Kingdom, 112.
109 “Mount Qicheng,” UNESCO.
Bang, arguably led to Qin expansion of power over other states.\textsuperscript{111} This legacy stands in stark contrast with the fraught political history of China’s next great achievement in public water infrastructures, the Grand Canal (\textit{da yunhe} 大运河).

\textit{b. The Grand Canal}

Although ultimately serving many purposes, the Grand Canal was initially conceived as a transport channel for grain. At its beginnings in the late Zhou, the grain-tribute system described “the systematic delivery of “tribute grain” to the imperial capital.”\textsuperscript{112} As established in the first chapter, the southern Yangtze valley enjoys a natural endowment of vast arable land and water resources, and was quickly exploited by China’s earliest dynasties to supply the empire with grain. Under the Zhou, Qin, and early Han dynasties, grain was predominantly transported by land, which was expensive, slow, and perilous. When the route passed through river gorges, grain was carried over wooden “gallery roads” that were inserted into the sides of cliffs and traditionally lacked railings. In order to ease transportation, Han Wudi (ruling 141-87 BCE) commissioned the construction of a new water route called the \textit{caoyun} (漕运) – or canal route – that greatly boosted the supplies that could be carried north. Under the later Han dynasty, the system grew to supply grain

\textsuperscript{111} During the Warring States Period, rival states competed to construct better networks for navigation, irrigation, and flood control. One of the earliest artificial channels commissioned by a king, the Han Gou canal, was constructed by the Kingdom of Wu in order to create a military navigation route between the Yangtze and Huai Rivers. A century after the Han Gou was finished, the rival kingdom of Wei built the Hong Gou canal connecting the Bian and Si Rivers near modern-day Kaifeng. However, Qin accomplishments overshadowed the hydro-works of other states.

\textsuperscript{112} Ibid., 113.
to the imperial court and to officials and soldiers on the northern frontier, where it was used to feed armies, pay salaries, or stockpiled.¹¹³

Through successive dynasties, the system expanded under the Han dynasty and became critical to imperial survival. Under the Ming dynasty, over half of the grain consumed in Beijing was supplied from the south by means of the *caoyun*. Throughout history, several emperors – such as Han emperor Guangwu and Sui emperor Wendi – moved the Chinese capital to Luoyang in order to secure a reliable connection to the Yangtze river basin. In the later Han period, irrigation and canal projects were so successful that several economic centers emerged throughout the country that eventually collapsed the dynasty’s centralized hold. The next dynasty to preside over a unified nation was the Sui, which commissioned and completed the “Great Traffic River,” another name for the Grand Canal.¹¹⁴

Described as “one of the most ambitious hydraulic engineering projects in human history,” the Grand Canal effectively centralized Chinese civilization by linking together five of its river systems.¹¹⁵ In doing so, it created reliable inland shipping and transportation routes between the cities, regions, and provinces across each river system. From end to end, it extended 1,795 km from the coastal city of Hangzhou in the south, across the Yangtze, Yellow and Huai Rivers to the northern cities of Luoyang, Chang’an, and Kaifeng, and finally all the way to Beijing. Later dynasties appended canals onto the main route, and by the Yuan dynasty it consisted of over 2,000 km of channels. In the Sui dynasty, construction of the main body

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¹¹³ Ulrich Theobald, “Cao Yun, transport of tribute grain,” *China Knowledge*, December 1st, 2015, [http://www.chinaknowledge.de/History/Terms/caoyun.htm](http://www.chinaknowledge.de/History/Terms/caoyun.htm)


¹¹⁵ Reilly, *Disaster*, 221.
utilized the existing Han Gou and Hong Gou routes and connected patchwork networks constructed in previous dynasties.

It is the history of conscripted labor required to build the canal that is often cited to evidence Wittfogel’s “hydraulic despotism” thesis. The Sui is estimated to have conscripted 5 million laborers for the project and induced extreme suffering. What is more, the social and financial burden of the canal, compounded by northern invasions and other immense projects, quickly weakened the Sui dynasty to the point of collapse after only 37 years. However, without generalizing the complex institutional arrangements of Chinese history that led it at moments to resemble despotism, the history of the Grand Canal also fits into Chaoding’s “key areas” model, in which the state invested in public infrastructure to ensure greater social and political control.

In regards to the Grand Canal’s legacy, the great costs of the project are often overshadowed by the benefits. Throughout its history, maintenance of the Grand Canal, and the scope of the grain-tribute system which depended its operation, was often used to symbolize imperial power. From the Tang to Ming dynasties, annual transport grew from 130,000 to 450,000 tons of grain, greatly boosting imperial supplies, however repairs stalled during the Qing dynasty. For many Chinese, this failure to repair dyke breaches along the canal presaged the dynasty’s collapse. In *Disaster and Human History: Case Studies in Nature*, Benjamin Reilly catalogues instances of flooding in Chinese history, and concludes that water is the most poorly managed – and disaster imminent – under circumstances of chronic political

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117 Ibid.
instability, military pressure, and internal dissent. As a powerful symbol of national unity, the Grand Canal was particularly devastating to the legitimacy of the Chinese state in times of failure.\textsuperscript{118}

Today’s eastern route of the SNWTP and the Grand Canal share many similarities, although the resource being transported has changed. The east route of the SNWTP that began operation in 2012 utilizes around 1,200 km of the main body of the Grand Canal from Hangzhou to Beijing. SNWTP construction involved the deepening and broadening of the Da Yunhe’s main channel, which was accomplished without inundating any land. However, numerous water-pumping stations and treatment plants were built along the way to carry and clean the water travelling north. The large energy resources required to pump the diverted water to north to elevations higher than the Yangtze has been cited by Liu Changming as one of the main environmental drawbacks to the route.\textsuperscript{119} In some areas, the direction of the current has even changed, as resource-exporting and resource-receiving regions have shifted.

The significance of this comparison is political, as both projects represent centralized efforts to command the nation’s waterways, and to reallocate domestic resource distributions to enrich the capital. In many ways, the Grand Canal presaged the south-north axis of water conservancy that has come to dominate political decision-making and infrastructure development today. This relationship has allowed the Chinese state to exploit the legacy of the Grand Canal in its effort to galvanize

\textsuperscript{118} Reilly, Disaster, 219-229.
\textsuperscript{119} Changming Liu, “Environmental Issues and the South-North Water Transfer Scheme,” 899-910.
support for the SNWTP, by framing the project as a solution to a national water crisis.\textsuperscript{120}

In terms of the environmental impacts, it is difficult to assess the Grand Canal as a whole because each of its channels interacts uniquely with the surrounding ecology and was constructed in different time periods by different engineers. The Canal is perhaps better understood as a network which has been adapted to meet the agriculture, transportation, energy, and military needs of each epoch. However, in mandating interregional cooperation, the Grand Canal system necessitated trade-offs between rich and poor provinces and inevitably created conflicts of interest. As will be discussed in the final section of this chapter, based on the findings in economist Kenneth Pomeranz’s book \textit{The Great Divergence} (2000), local demographic and environmental changes in a poor or periphery province could create a need for a previously exported resource that, if ceased to be in surplus, would jeopardize a reliant, “core” region such as the capital.\textsuperscript{121} In this sense, a grand network between provinces discourages local or regional solutions to shortages – which are generally more environmentally sound – in favor a national agenda.

c. River Conservancy – Confucian and Daoist Theories of Flood Prevention

The last great achievement, covered in this section, of the pre-modern era with important consequences for modern political development was the erection of a formal river conservancy system. Earlier dynasties had laid the foundations for systematic dredging and flood control across river systems. In 1073, the Song

\textsuperscript{120} Kuo, “China is moving more than a River Thames of water,” \textit{Quartz Magazine}.
emperor Shenzhong established the Yellow River Dredging Commission, which pioneered technologies such as the “iron dragon-claw silt dispersing machine” and “river-deepening harrow.” As formidable-looking as their names, the machines were pulled along the riverbed to loosen silt and return it to the flow of the river. Successive dynasties improved these technologies, employed during the wet season. During the dry season, opportunities to exploit hydropower were removed and silt was dredged manually.\textsuperscript{122}

As river management became increasingly systematized, rival theories of flood prevention gained prominence. In the Daoist school, water engineers argued that rivers should be managed according to the principle of \textit{wu wei} or “no action.”\textsuperscript{123} In practice this meant digging many irrigation channels and leaving a wide plain between for the river to find its way, or \textit{dao}. The irrigation network would catch excess floodwater, but not force the river to take a particular path. Daoists who advocated this position interpreted the Da Yu story very differently from its mainstream meaning today. Rather than hailing the great sage as the first man to “tame” the river and assert control over its course, Da Yu is contrasted to his predecessor and father, the mythological Gun, whose flawed, control-based management philosophy urged him to “block rivers and topple mountains” in violation of a natural order.\textsuperscript{124} A foundational Confucius text called the \textit{Mencius} adheres to this interpretation, writing that the Great Yu allowed the waters to find

\textsuperscript{122} Ball, \textit{The Water Kingdom}, 159-167.  
\textsuperscript{123} Ibid., 163.  
\textsuperscript{124} Ibid., 61.
their natural *dao*. Although it defends consideration of the environment, the text also emphasizes that this work involved dredging the Nine Rivers and opening up various channels, leaving the “way” dependent on masterful engineering.

In 1565, Ming official Pan Jixun became the commissioner of the river conservancy, effectively implementing and standardizing rival Confucian principles of management. In contrast to the Daoists who proposed building numerous, low-lying irrigation networks, Confucians advocated for high and narrow dykes that would force the river to follow a predicted course. Invoking the Han-era Confucian text *Zhou Li*, Pan argued that the Confucian dyke-building also channeled waterpower to scour silt from the river bed. The idea to use hydropower to accomplish this task, captured in the saying *shu shui gong sha* (输水攻沙) – “restrict the current and attack the silt” – became commonplace by the Qing era. Pan’s vision did not stop at high and narrow dykes, however. Pan’s innovations included the construction of a twin dyke system to constrain the water into a predictable channel in a dry season and catch excess water in a second dyke in times of flooding, and to transform nearby lakes into reservoirs for storage of excess floodwater, to be released when silt accumulated on the Yellow River.

Pan’s system of diverting water into reservoirs and releasing it back into the river to meet irrigation and flood control purpose envisioned the “entire Yellow-Huai system” as “an almost wholly human-managed plumbing and drainage network.”

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125 Ibid., 95.
126 Ibid.
127 Ibid., 163-165.
128 Ibid., 163.
129 Ibid., 165.
One problem that quickly surfaced was that so much silt was diverted through the Huai River into lakes, that eventually the lake beds rose and silt needed to be manually dredged from the water. The second problem was that until the advancement of modern machinery, this system could only be sustained through the conscription of labor. Although in the Qing-era wage labor was employed to build, repair, and maintain dykes, conditions were infamously dismal as most of the work was accomplished by wheelbarrow and shovel.\(^{130}\)

The growing tension between Daoist and Confucian theories of management came to a head in 1841 when the city of Kaifeng flooded due to a dyke breach upriver.\(^{131}\) After the barrier was broken, the river flowed in full force over the Huaibei plain surrounding the city, widening the initial gap by over a kilometer. Kaifeng was transformed into an isolated island by the river’s new path and quickly submerged in two meters of water. The gap took nearly seven months to close, but five months after it was plugged another storm hit and broke another dyke upstream. These floods were particularly devastating because of the inability of local officials or inhabitants to drain the floodwaters.\(^{132}\) In most river systems, the river itself can carry excess water to the sea. But, as the Yellow River bed is higher than the surrounding plains, largely as a result of dyke construction, Kaifeng cropland remained submerged in water for most of the growing season and the city suffered intense famine.\(^{133}\)

After the second flood hit, the official in charge of Kaifeng’s river conservancy, Wenchong, argued that Confucian wisdom may have prevented

\(^{130}\) Ibid., 164.
\(^{131}\) Ibid., 173.
\(^{132}\) Ibid., 169-178.
\(^{133}\) Reilly, Disaster, 225.
flooding in several instances, but high and narrow dykes were ultimately untenable because they only exacerbated the force of disasters. Under Confucian principles, the concentration of the current into narrow dykes made it nearly impossible to plug when it travelled off-course. Additionally, the construction of taller and taller dykes required upon the accumulation of silt eliminated the river as a source of drainage. It was much better, argued Wenchong, to follow the Great Yu’s “superior strategy” of “guiding the stream in accord with the current.”\(^{134}\) Of course, because of the political directive of officials to “tame” nature, at this point Wenchong had failed his post and was officially disgraced and forced to stand on the river bank every day for three months wearing a wooden collar. Given his public defacement, it wasn’t until much later that anyone heeded his critique.

The Kaifeng floods presaged successive disasters that ultimately bankrupted the river conservancy, disabled travel on the Grand Canal, and destroyed the homes and livelihoods of thousands of peasants living along the river bank and within its floodplains. It was not until the Republican era that the government re-claimed control over the nation’s river systems.\(^{135}\) One emerging problem for China’s future leaders, which would be insufficiently addressed in the republican and socialist eras, was the growing ecological pressures on river resources caused by population growth. Although dike breaches were not uncommon before the Qing dynasty, especially in times of civil disorder, corruption, official incompetence, or financial burden, there was evidence of ecological degradation especially in the areas surrounding the

\(^{134}\) Ball, *The Water Kingdom*, 173.
\(^{135}\) Ibid., 169-178.
As population grew upriver, deforestation and land reclamation for farming caused erosion downriver, ultimately increasing the silt-load of the Yellow River and risk of flooding.

However, the republican era leaders were more concerned with harnessing China’s rivers as a force for economic expansion than addressing environmental degradation. The next section will introduce the concept of “multi-purpose” management, and suggest that economic focus of the republican era informs the dominance of engineering-heavy, technocratic solutions to water management today. Beginning in the Republican period and further entrenched in the Maoist era, the historical debate between Confucians and Daoists over interventionist versus passive management has been settled in favor of command-and-control-based approaches.

II. Modern “Multi-Purpose” Management – Republican Era Conservancy and Mao’s Technocratic Environmentalism

Under the leadership of the Guomindang or Nationalist Party, the Republican era ushered in important changes in water conservancy. On the one hand, nationalist leaders like Sun Yat-sen and his successor Chiang Kai-shek continued to harness rivers for flood prevention, transport, and irrigation. This continuation was realized in renewed efforts to enhance drainage of the Yellow-Huai river systems and ensure the connection of China’s major river systems to the sea to prevent flooding. Continuation was also realized through the reinforcement of mandate theory. Throughout the nationalist period, the Yellow River was woven into national

\[136\] Reilly, *Disaster*, 220-221.
consciousness as the birthplace of Chinese civilization. On the other hand, the Republican era saw a shift in river conservancy from water control to the development of hydroelectricity. Rather than merely controlling the river, modern leaders sought to harness its power as a means of economic expansion.

a. The Huai River Conservancy Commission and National Reconstruction

Following the Xinhai Revolution in 1911, the Republic of China was established on January 1st, 1912 by the short-lived but vastly influential leader Sun Yat-sen. Shortly after founding the Republic, Sun stepped down as President and eventually established a rival government in modern-day Guangdong. His move did not weaken his influence, and the Guomindang party (KMT) continued to organize, staff, and administrate Beijing’s bureaucracy and water conservancy program. In 1924, Sun announced his plans for “national reconstruction” or shiye jihua 事业机会 in a speech that was later supported by the First National Party Congress in the same year. The plan proposed a radical economic and social platform “granting land to tenants for the ordering of water control and land reclamation.” It continued to outline specific conservancy projects, including control of the Huai and Yellow river systems.

By 1929, under the leadership of Chiang Kai-shek, Sun’s plan was realized in the newly founded Huai River Conservancy Commission (HRCC). The organization became the first institution, after the abolishment of the Qing-era Yellow River Administration in 1861, preside over an entire river valley. Unlike river conservancy

administrations in China’s dynastic history, the HRCC included an Engineering Office staffed by technocrats or hydraulic engineering professionals. This key unit was led by Li Yizhi, who was trained in Berlin at the University of Danzig and is regarded as the father of modern Chinese hydraulic engineering. In 1930, Li established the guiding principle of the conservancy to be in line with the rest of the industrialized world, which pursued “multi-purpose river basin development.”

This directive essentially reformed Chinese management to consider hydropower generation along with traditional control objectives. Under Li’s “multi-purpose” scheme, in 1931 the HRCC adopted the Huai River Engineering Plan and a sea access route to enhance drainage, navigability, irrigation, and hydropower generation of the Huai. International expertise was consulted to formulate the plans, including contributions from the American Red Cross.

Although Nationalist rule lasted only a matter of decades, and over the majority of those years control was fragmented as the country devolved into warlordism, the basic pattern of water management developed in the republican era informs the top-down bureaucratic system that dominates management today. The legacies of the republican era include official dedication to scientific management, centralization, internationalization, and the placement of trained personnel. It is largely through the political mythology of Da Yu that these ideals of republican-era water conservancy are endorsed. Today, the story is almost exclusively invoked to justify large-scale hydraulic interventions – besides the prevalence of this


139 Ibid., 97.
interpretation in Chinese media, statues of the water hero preside next to China’s largest dams, such as the Sanmenxia Dam.\footnote{Ball, \textit{The Water Kingdom}, 66.}

The last point on personnel placement is also important, and stands in contrast to the dynastic period, when water conservancy positions were typically staffed by moral exemplars and accomplished scholars. On the one hand, placing officials who have technical training in charge of water conservancies prevents personnel mismatches that prevailed through the dynastic era, when top officials like Kaifeng’s Wenchong had little technical knowledge of the systems they were in charge of maintaining. On the other hand, it discourages more systems-like approaches to water management in favor of technical intervention. This is certainly the case today.

Although technical knowledge of water systems was subordinated to ideological commitment during the Cultural Revolution, the majority of China’s hydraulic works for the rest of history were planned and approved by trained engineers, including in the Maoist era. The technical orientation of China’s ruling party is arguably at its strongest today. Since its transition to a market-socialist system, every Chinese president has been trained as an engineers: Deng Xiaoping (hydraulic), Jiang Zemin (electrical), Hu Jintao (hydraulic), and current president Xi Jinping (chemical). This does not include the outsized role of engineers in other top positions. When the SNWTP was approved under the Hu Jintao administration, eight out of nine of China’s highest-level officials were engineers.\footnote{Patricia Eldrige, “The Chinese Government is Dominated by Scientists and Engineers,” \textit{Gineer Snow}, December, 2018, [https://gineersnow.com/leadership/chinese-government-dominated-scientists-engineers].} At the local level, in
2018 it was estimated that eight out of ten Party secretaries, mayors, and members of the General Committee at all levels of government were trained as engineers.\textsuperscript{142}

Besides a brief period of administrative decentralization under Deng Xiaoping, China’s water management in the socialist era through the present has evolved the KMT’s centralized approach to water management. The most recent justification by the state for centralization is to solve national issues of resource shortages and pollution, although this argument has already been challenged by presenting modern shortages as regional in character. In terms of internationalization, the involvement of the League of Nations and global technocrats in the Nationalist era set the precedent for international investment and aid in later periods. In the Maoist era, League of Nation technocrats were replaced by Soviet engineers, and today, Chinese infrastructure investments attract large funds from international organizations and frequently contract foreign companies. Most immediately, personnel placement impacted the socialist era as top-level technocrats retained many of the most powerful positions through the regime change.

Overall, many legacies of the nationalist period informed water conservancy in the socialist era. However, Mao’s “war against nature” brought the interventionist orientation of the nationalist government to new heights.\textsuperscript{143} The next section will analyze two large-scale dams planned or constructed during the socialist era that exemplify Maoist ambitions to dominate nature, and expose how these efforts ultimately created more problems than they solved.

\textsuperscript{142} Ibid.
b. Mao’s Technocratic Environmentalism–Sanmenxia and The Three Gorges

The Communist government announced its victory over the Nationalists with grand plans to harness the nation’s waters. As in the republican period, efforts to engineer water systems began with the Huai and Yellow rivers. During the 1950s, Mao’s government embarked on a project to finally tame the Yellow River, constructing over fifty dams to control siltation along its banks. The largest structure of the series “was at Sanmenxia, where splitting the river into three main channels…offered the opportunity to span the mighty river in manageable stages.”\(^{144}\)

Constructed between 1957-1960, Sanmenxia was the first case of forced resettlements that would become commonplace.

At the time of initial planning, Mao’s minister of water resources Huang Wanli fiercely resisted the project, arguing that Mao’s fantasy to make the waters of the Yellow River “run clear” from the removal of yellow silt “distorted the laws of nature.”\(^{145}\) In contrast, the most effective way to prevent flooding was to promote reforestation and replanting of grasslands upstream, as well as small-scale flood control measures near the river’s headwaters. In time, Huang Wanli’s predictions were proved correct. In total, construction cost three times the original budget and generated barely five percent of estimated hydropower. In addition, it forced the relocation of 280,000 villagers and destroyed local ecological systems.\(^{146}\)\(^{147}\)

\(^{144}\) Ball, *The Water Kingdom*, 229.
\(^{145}\) Ibid., 230.
\(^{146}\) Ibid., 229-234.
\(^{147}\) Today, Huang Wanli – who is a professor emeritus at Qinghua University – remains a vocal critic of the PRC’s large-scale hydroworks, publically opposing the SNWTP.
Although the dam was of little practical value, it carried an important symbolic message of the superiority of Marxist-Leninist ideology over previous value systems. Instead of managing water effectively through smaller-scale measures, a large project stood as a visual symbol of technocratic domination of nature. This symbolism fit with Mao’s technocratic “struggle against nature.” Under Maoist environmentalism, the river itself became an emblem of oppression that was used by previous leaders to exploit peasants, rather than to build a cohesive society. Practical value was subverted to ideology.

Closely following Sanmenxia’s approval, the Mao administration turned to the Yangtze River basin. In 1919, Sun Yat-sen had first conceived of plans to dam the “Long River” in hope of tapping into its vast hydropower resources. The first plans to construct what would become the Three Gorges Dam were drawn by the Japanese in 1940 during the warlord period when foreign armies occupied a significant portion of east China. Adopted by the Nationalists in 1944, the dam at Three Gorges was approved that year and even secured a $3 billion loan from the U.S. government for construction. After a brief interruption owing to the civil war, the Communists revived consideration of the project and settled on construction at the Japanese engineers’ planned location in the fishing village of Sandouping. Because the dam was to be the biggest in China and the world and the effects on the river and environment unknown, in 1957 the Party agreed to construct a pilot forty kilometers downstream of Sandouping at Gezhouba.\(^{148}\)

\(^{148}\) Ibid., 237-250.
Gezhouba was largely a failure, taking eighteen years to finish and barely generating any hydroelectricity.\(^\text{149}\) Despite these results, the project was passed on to the next regime, receiving enthusiastic approval by the Deng administration to move forward. In 1982, foreign investments poured in from Merrill Lynch, the US Army Corps of engineers, the World Bank, and the Canadian, Swedish and Japanese governments. During the later half of the decade, however, Deng’s top ministers began to voice criticism. Concerned with increasing risk of natural disasters, officials like Li Rui and Li Peng (before he was promoted to Premier) argued that flood control and hydropower generation would be more effective through the construction of a series of smaller dams. Like Huang Wanli, these critics saw little practical value in gargantuan projects, and used their technical training in engineering to advocate less risky projects.\(^\text{150}\)

By the 1990s, however, the dam had become less a matter of practical concern and more representative of international prestige. After foreign investors backed out following a tide of official criticism, China was forced to finance and construct the project by itself.\(^\text{151}\) Officially finished in 2003, the dam today stands at the largest in the world, and represents one of the last big pushes of a centrally planned Chinese economy. To date, it has displaced 1.5 million people, and threatened environmental safety as far away as Sichuan province, whose residents connect its construction to the 2008 earthquake.\(^\text{152}\)

\(^{149}\) Ibid., 238-240.  
\(^{150}\) Ibid., 239-244.  
\(^{151}\) Ibid., 243.  
\(^{152}\) Ranjan, “China’s Water Problems,” 649.
Whether or not it can be connected to this particular earthquake, it is argued that the project increases seismic activity in nearby areas due to the sheer weight of the water seeping into the rocks below, as well as carrying other environmental harms such as destruction of local ecology and heritage sites. In addition, the cost of the project has increased overtime due to so-called “band-aid” measures to fix new problems triggered by construction, such as extensive drought in once flood-prone cities downstream of the dam and incursions of seawater into the Yangtze delta region. In 2009, one of the dam’s most vocal critics Dai Qing reported that these externalities raised the cost of the dam from the officially reported RMB130 million to RMB600 million.

The sheer cost of such projects have led many to argue that large-scale, state-led hydraulic initiatives create more problems than they solve. Although the first two routes of the SNWTP began to operate by 2014, and its consequences felt by water-exporting provinces, criticism of the project is continuously emerging and has helped to mitigate some of the associated environmental, social, and economic consequences. Opposition to the first two routes fueled research that successfully suspended the west route in 2006 until further study.

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155 Carla Freeman, “Quenching the Dragon’s Thirst: The South-North Water Transfer Project – Old Plumbing for New China?” Wilson Center, July 11th, 2011,
Increasingly, Chinese officials and citizens alike argue that China’s water problems can only be solved by looking at questions of allocation, efficiency, and conservation. Rather than turning to the state to implement top-down water policies and infrastructure, involved parties ask how to manage water from a local or regional perspective. The next section will discuss how problems of conservation, allocation, efficiency, and shortage have been solved at the local level, through the examples of traditional conservation law, sustainable agricultural, and internal patterns of trade.

III. Traditional Management – Conservation Law, Sustainable Agriculture, and Interregional Trade

While debates proceeded at the highest levels of government between Confucian and Daoist approaches to supply-side water conservancy, provincial officials and community members developed effective regulatory regimes, sometimes based on philosophy and ritual, to manage demand for resources. Perhaps even more effective than laws governing resource-use, traditional agricultural practices were developed over millennia to preserve the fertility of the soil and ensure biological diversity without the use of external inputs. Termed the “agriculture without waste model,” these practices are the subject of recent scholarly and public inquiry, as the harmful consequences of China’s chemically-intensive farming regime take effect.

The following sections will briefly review these historical developments not to advocate whole-sale adoption of these policies and practices, but in order to emphasize how before the mid-twentieth century, conservation was an ingrained

[https://www.wilsoncenter.org/publication/quenching-the-thirsty-dragon-the-south-north-water-transfer-project-old-plumbing-for-new]
social practice. Moreover, these patterns of resource-use were reflected in legislation, even beyond explicitly-formulated conservation laws. The last part of this section will trace how during the pre-modern era, growing resource shortages in different regions of the country generated complex patterns of internal trade, which became a key means of relieving ecological bottlenecks.

\[\textit{a. Qin and Han-era Environmental Law}\]

Throughout imperial history, the most robust forms of environmental law flourished during periods of ecological strain and destruction. This pattern holds true as early as the first century CE, when Qin leaders were drafting legislation, often adopted from their Zhou predecessors, to protect the degradation of mountains, rivers, forests, and lakes. The examples of conservation law in this section are taken from historian Charles Sanft’s discussion of recently excavated legal codes from the Qin and Han eras. In his essay “Environment and law in Early Imperial China,” Sanft discusses three of these laws to show that “demonstrable conservationist intent existed in China no later than the beginning of the first century CE.”156

Although environmental problems have always existed alongside civilization, issues of deforestation and soil erosion greatly accelerated in the Qin and Han dynasties. Owed in part to increasingly concentrated populations, both dynasties saw the massive destruction of grasslands and forests, leading to serious problems of water and soil erosion. In the Qin dynasty, the poet Du Mu (803-852 CE) wrote how every tree on Mount Shu was logged to construct the Epang Palace in Xi’an. In the

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Han dynasty, the North China Plain that was once covered in rich vegetation was cleared to create farmland, exposing the soil to desiccation and erosion that has lasted until today.\(^{157}\)

In response to the massive clearings, officials in charge of administering north China and the frontier formulated strict rules governing the exploitation of natural resources. Among these, the Qin “Statutes on Fields” or Tian Lü is famous for being the most comprehensive environmental regulations in the ancient world. As Sanft relates, the statute contains large sections on seasonal governance; for instance, it forbids logging and damming in the second month of spring, burning grass for ash before it is summer, and picking new flowers, taking eggs or hatchlings, and catching animals by poison or trap before the end of summer.\(^{158}\) Han regulations adopted new rules against hunting pregnant animals.\(^ {159}\) Importantly, these codes were excavated from two sites in Hubei where imperial logging and land reclamation was rampant.

Another major site of environmental destruction in the Han period in particular that Sanft discusses was the western frontier, in modern-day Gansu. Agriculture and logging expanded greatly in this area with Han military expansion, and local efforts at preservation succeeded in formulating legal protections that eventually were disseminated throughout the realm.\(^ {160}\) The “Edict of Monthly Ordinances for the Four Seasons” from the Hanging Spring Han military post detailed


\(^{158}\) Sanft, “Environmental Law and Early Imperial China,” 704-706.

\(^{159}\) Ibid.

\(^{160}\) Ibid., 706.
actions to be undertaken or forbidden during each month of the year, according to early Chinese correlative cosmology. Greater in scope than the Han and Qin-era Statutes on Fields, the Monthly Ordinance laws excavated at the Hanging Spring Post include commentary articulating that the intent of refraining from destructive activities, such as hunting by fire and draining waters, is to sustain ongoing harvests and prevent permanent environmental damage.\textsuperscript{161}

Together, the ordinances created a systematic legal apparatus protecting over-hunting, over-logging, and other forms of unsustainable resource exploitation. The stated goal of limiting interference with water resources specifically was to sustain fish populations and promote ongoing human use and enjoyment. For instance, one ordinance on water from the edict forbids “draining or otherwise impinging on various bodies of water” for all but one or two months of the year.\textsuperscript{162} Despite the strength of conservationist ideas evidenced in law, ritual, and philosophy, Sanft concludes that the statutes and ordinances had limited effectiveness, in part because protections were based on annual rather than multi-year growth and development, and also because of the limitations of seasonal governance. For instance, if draining of water is allowed at one time of the year but not another, the regulation will merely slow but not prevent environmental degradation.\textsuperscript{163}

Despite its arguably limited long-term effectiveness, conservation before the mid-twentieth century was deeply embedded in social and cultural practice. Ingrained in ancient statutes forbidding impingement on bodies of water are systems of belief

\textsuperscript{161} Ibid., 706-714.
\textsuperscript{162} Ibid., 711.
\textsuperscript{163} Ibid., 715-716.
and valuation that clearly prioritize conservation and environmental respect. Although environmental justice is a strong and growing movement in contemporary China, and many individuals and communities continue to act with respect towards the environment on a small-scale basis, in general China’s economic development has been incongruous with conservation. Whereas individuals in ancient times would be held accountable for over-exploiting resources, under today’s system – albeit a reforming one – there are few incentives to conserve resources. The next section will move to the topic of how traditional agriculture embodied conservationist principles.

*b. Traditional Agriculture*

To begin, the consensus among prominent environmental historians of China such as Mark Elvin and Joseph Needham is that the trajectory of Chinese agriculture from ancient to modern times was generally unsustainable.164 On the agricultural end, according to this view the main reason for gradual environmental decline was the sheer scale and intensity of China’s agricultural operations. By the Ming and Qing dynasties, long-term trends of land reclamation, draining, and deforestation for farming had reduced the biodiversity of China’s natural resources, exposed great swaths of land to flooding and other extreme weather risks, and greatly depleted the fuel, timber, and fertilizer sources required to keep growing food.165

The root of the problem for pre-modern development was that although intensive agriculture supports dense populations better than reliance on non-farm sources of food, ultimately it reduces the net primary productivity of the biosphere,

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and exposes humans to increased health risks. In his article “Three Thousand Years of Unsustainable Growth,” Elvin estimates that by the early 1990s, agriculture and other human economic activities reduced the mean annual creation of new organic matter in the biosphere by 40 percent.\textsuperscript{166} Rice paddies, in particular, through the release of methane contribute to general warming of the climate. In addition, in pre-modern China, intense cultivation of land reduced the availability of water, wood, fuel, and other resources, reduced the variety of human diets, and exposed populations to “crowd diseases” and sicknesses associated with exposure to untreated manure used for fertilizer.\textsuperscript{167}

Despite the overarching trend of degradation, specific sectors of traditional Chinese agricultural practices sustained some of the highest population densities per acre of land in the pre-modern world. The development of wet-rice farming in the south, and intensive composting systems that supported dry-land farming in the north ranked Chinese agriculture (at least for food crops) among the most sustainable in the world in the period of European exploration.\textsuperscript{168} In wet-rice farming, or paddy rice farming, water, rather than soil, carries most of the nutrients to the crops. Under this system, a year’s worth of dried algae, when applied to the fields, can replete the nitrogen loss caused by twenty-four successive crop cycles.\textsuperscript{169} In north China, data from sorghum and wheat-growing regions from 1800 suggests that forty to sixty

\textsuperscript{166} Mark Elvin, “Three Thousand Years of Unsustainable Growth,” \textit{East Asian History}, 6 (1993), 12.
\textsuperscript{167} Ibid., 12-13.
\textsuperscript{168} Pomeranz, \textit{The Great Divergence}, 226-227.
\textsuperscript{169} Ibid., 226.
percent more manure – and of higher quality – was applied to fields than in European farming.\textsuperscript{170}

The achievements of early Chinese farming relied on an “agriculture without waste model.” In his 1910 book \textit{Farmers of Forty Centuries: Permanent Agriculture in China, Korea, and Japan}, the agronomist F.H. King documents permanent practices of waste collection and composting, recycling of organic matter and crop residues, and schemes to promote land and water productivity and maintain biodiversity such as terracing and intercropping.\textsuperscript{171} Although King makes certain assumptions about green fertilizers that are inaccurate, such as dating practices such as manure application in fields back to time eternal rather than noting their emergence around the Song dynasty – a measure to keep up with population increases – his observations sufficient to present a case for the sustainability of traditional agriculture.

Another important aspect of this system was the biological control of pests. Without the use of pesticides, Chinese farmers in Pearl Delta regions integrated the processes of mulberry cultivation, silkworm rearing, and fish farming to “fully exploit the production potentials of the ecosystem” without the use of external inputs.\textsuperscript{172} This system is termed mulberry dike-pond sericulture, and dates back at least two millennia. Another example of biological control emerged Congjiang and Liping counties, in Guizhou, where farmers traditionally integrated rice cultivation, and fish

and duck farming.\textsuperscript{173} These area-specific models of biological control proliferated throughout China among various communities who developed sustainable localized forms of production and land use, and continue to varying degrees today.\textsuperscript{174}

Although examples of sustainable agriculture practiced at the family and village-level are plenty, it is more difficult to identify the motivations behind these systems as conservationist. Whereas conservation laws specifically stated that their objective was to ensure ecological regeneration of resources, individual families may just as well have been aiming to increase yields, and finding that biological control and organic composting methods did so the most effectively.

In contrast, monasteries, imperial grounds, and collectively managed gardens developed, by nature of what Elvin terms their “structure of decision-making and time-horizons,” developed stronger ideologies of conservationist management on the whole than agricultural production, even when practiced sustainably.\textsuperscript{175} For instance, \textit{fengshui} ideology taught that the preservation of groves around temples, villages, and houses promoted good fortune, both for the practical benefits of shade, fruit, and timber, but also by cultivating the spiritual energy of trees. Because of a lack of emphasis on extraction, collectively managed orchards, temple groves, and gardens


\textsuperscript{174} Biological control as a method to reduce pests, increase value, and limit pesticide use has found increasing reception in agricultural science. In 2011, a study from Hangzhou’s Zhejiang Technology University found that “raising fish in rice paddies reduced the need for fertilizer by 24 percent…and pesticide use is reduced about 68 percent or more because the fish not only eat the pests but also dislodge them from the rice stems.” (Anderson, “An Overview,” 276).

\textsuperscript{175} Elvin, “Three Thousand Years of Unsustainable Growth,” 11.
successfully stimulated, rather than destroyed, natural patterns and resilient features in nature.\textsuperscript{176}

While conservation law and traditional agriculture took millennia to flourish, the next section will examine patterns of internal trade that emerged in response to regional resource shortages that emerged in the eighteenth century. Like agricultural techniques and conservation legislation, domestic trade has been responsive to changing circumstances throughout history. And, in the mid-eighteenth century, resource shortages had severely restricted growth in key areas of the country.

c. Interregional Trade

On the eve of European industrialization, China’s most densely populated, market-driven, and commercially sophisticated provinces faced serious ecological obstacles to further growth.\textsuperscript{177} Due in part to a population boom beginning around 1700, resource shortages on China’s southeast coast, the Lingnan area encompassing Guangdong and Guangxi provinces, and especially the lower Yangtze left little room for growth without a significant increase in supplies, either through expanded imports of land-intensive commodities or utilization of idle capacity.\textsuperscript{178}

Although not as pervasive and extreme, resource shortages were nothing new to Chinese economic development, and as early as the Zhou dynasty interregional trade became a key means of relieving bottlenecks. Although sometimes – as in the case of the grain-tribute system – inter-provincial trade was managed by the central

\textsuperscript{177} Pomeranz, \textit{The Great Divergence}, 225.
\textsuperscript{178} Pomeranz, 242
government, often trade was conceived at the provincial level as a solution to ecological stresses and shortages.

In *The Great Divergence: China, Europe, and the Making of the Modern World Economy*, Kenneth Pomeranz explains how because idle capacity was already low in China’s most commercially sophisticated provinces, these “core” regions of China all increasingly relied on trade with peripheral and inner regions to alleviate ecological obstacles to growth. This period is significant partly because of the availability of extensive data, and also because shortages constituted a clear ecological bottleneck.

In the eighteenth century, China’s most commercialized and densely-populated macro-regions faced increasingly critical shortages of fuel, food, and fertilizer. In the Yangtze Delta, between 1550-1820 the cost of wood rose by 700 percent, and rice prices doubled.\(^\text{179}\) The second largest macro-region, Lingnan, was forty percent forested – around the national average of China – but per capita supplies were lower than the rest of the nation and dropping.\(^\text{180}\) Along the Southeast Coast, deforestation eventually led to soil erosion and increased risk of flooding. In agriculture, wet-rice farming and to a lesser extent highland farming was practiced sustainably to preserve nutrients in the soil and conserve water, but cotton production where it was practiced in the Yangtze Delta and North China greatly depleted soil resources.\(^\text{181}\)

\(^{179}\) Ibid., 226  
\(^{180}\) Ibid. 229  
\(^{181}\) Ibid. 226-227
Like China’s contemporary water crisis, resource shortages in these key areas directly impeded growth. In Lingnan, a growing population faced diminishing wood and alternative wood supplies, like crop residues, leading to a third drop in fuel supplies per capita between 1753-1793 and a nearly three fourths drop in non-forested woods per capita by 1853.\(^{182}\) Excessive lowland reclamation in the lower Yangtze did not immediately threaten wood supplies for the population like deforestation did in Lingnan, as most of the areas drained were lakes and swamps, however it did initiate drainage problems that would become serious in the nineteenth century.\(^{183}\) In North China, deforestation led to desiccation and serious soil erosion, and extensive drilling of groundwater led to the disappearance of lakes and rivers.\(^{184}\) In all three regions, the costs to the soil of cotton production caused a dramatic drop in per capita supplies over the century.\(^{185}\)

Although not as imminent as China’s water crisis today, resource shortages in the eighteenth century constrained any sharp improvement in living standards. In order to mitigate ecological bottlenecks, core regions increasingly imported land-intensive commodities from inland areas. By 1750, the Lower Yangtze, Lingnan, and the Southeast Coast all imported significant amounts of food (13-18 percent of total supply in the Lower Yangtze) and timber from the Upper and Middle Yangtze and North China, and the Lower Yangtze imported beancake fertilizer for its cotton-growing operations from Manchuria. Lingnan also began to import more fertilizer and cotton in the nineteenth century as its population continued to grow. In return for

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\(^{182}\) Ibid. 230
\(^{183}\) Ibid. 228-229
\(^{184}\) Ibid. 237
\(^{185}\) Ibid., 245
land-intensive imports, core regions exported manufactures, particularly textiles, to the periphery.\(^\text{186}\)

Several characteristics stand out from the system of internal trade that developed between China’s core and peripheral regions in the pre-industrial period. First, many of the reallocations of labor that created an exportable surplus in peripheral counties were “natural” in that they were not subject to state management. The downside of local management for many importing regions was that once exporting counties started experiencing their own population booms, many of the areas that the Lower Yangtze, Lingnan, and the Southeast Coast relied on for primary products reduced exports to feed their own populations and convert land for their own proto-industrial development. Also known as import substitution, this process weakened the trading regime between the Lower Yangtze and upriver regions, and North China and the Yangtze Delta.

The second characteristic of the eighteenth century system of internal trade was that it was accompanied by an intensification of agriculture, fuel-gathering, and local specialization. When timber became scarce in the Lower Yangtze, residents avoided burning wood for fuel and turned to crop residues, grasses, and dung to expand fuel supplies. In the mid-eighteenth to nineteenth centuries, hillside settlement emerged in North China in response to land shortages. Along with the adoption of foreign food crops like potatoes, corn, tomatoes, papayas, and sweet potatoes, highland farming allowed farmers to earn a livelihood on inferior soils and diversified exports to the Lower Yangtze region. Lastly, interregional trade was used only to

\(^\text{186}\) Ibid., 242-244
meet the shortfalls of local specialization. Within the Lingnan region, Guangxi had become the rice bowl for Guangdong province, although the entire region imported rice from the Middle Yangtze.

Patterns of internal trade are interesting because they reflect the comparative advantages of each region in relation to its resource and institutional endowments, and are inherently flexible as demographics, consumption patterns, and institutional factors like prices, civil disorder, and land and labor restrictions change. Besides grain transport for the capital, the Qing government did not intervene to find local palliatives to resource shortages in China’s provinces, and the system of internal trade that developed was regionally managed and conceived. For resources like rice and timber, China’s macro regions looked to the closest possible supplier for import. For goods like beancake fertilizer, Lingnan and the Lower Yangtze had to import from the relatively far-flung Manchuria. These initiatives were possible because of the relatively low restrictions on core-periphery trade, extremely efficient use of resources, and effectiveness of local land management.

As discussed in the closing section of the first chapter, China’s interregional water and food trade today defies many of the characteristics of the eighteenth century system in that it levies heavy economic, environmental, and social costs on participants. Rather than striving for maximum efficiency utilizing interregional trade to meet the shortfalls, the paradoxical system of transferring water from south to north and food from north to south strains water-exporting and transferring regions, and hurts water-importing regions in the long term by generating new demand. In addition, today’s trade pattern reinforces a powerful coalition in the capital who
would resist a more sustainable approach to water and food policy if it meant lowering short-term supplies.

**IV. Conclusion: Constructive Management Today**

Today, the sustainable development and management of resources is even more important than in past eras. As the global climate is warming, rainfall patterns have become even more unpredictable in China’s most ecologically precarious regions. As static infrastructures, dams, canals, and other large-scale engineering works are inflexible to changing environments and climate patterns. For instance, in the Republican period, the HRCC’s plans of adoption for the Yellow River dams were based on the heaviest river flows to date. However, as the Tibetan glaciers melt at an increasingly faster rate, the heaviest flows have broken past records. Climate movement is critical to take into account, yet it is nearly impossible to predict its full ecological impacts.

Pollution has also altered the ecological resilience of China’s environment, and complicated resource management. In terms of water management, pollution has levied heavier costs on transport because water must be treated. A majority of the cost of building the eastern route of the SNWTP remains the treatment of diverted water. Sustainable agricultural practices that limit pesticide application and long-distance transport would lower the cost of water allocation and management even more than in the past, before pollution was as pervasive an issue as it is today.
Chapter Three

The West Route: Drawing Policy Recommendations

From the historical genealogy of water management in China, it becomes clear that a successful solution to water insecurity in China will only succeed with a regional focus. Since the turn of the century – approximately when the environmental costs of China’s economic expansion had become apparent – local and national efforts have attempted to curb specific sources of pollution, limit inefficient and overall water use, and improve recycling mechanisms. Among various policy approaches, the government has implemented pollution caps, water use limits and rights, and cap and trade programs for key pollutants and greenhouse gases; it has invested in water-saving technologies, and funded education campaigns to promote their use; in agriculture, the state has slightly shifted its domestic price support system to boost resource productivity. In addition, it has experimented with area-specific ecological restoration efforts, like afforestation in regions experiencing desertification.

Despite the proliferation of water policies managing demand, and the diversity of approaches, engineering-based solutions remain prominent on the national water-resource agenda. The highest profile solution in consideration is the west route of the SNWTP, to be completed by 2050. Although it is grouped with the east and middle routes as the same project, its motivations, characteristics, and risks are quite different. Whereas this paper argues that the east and central routes were a response to critical shortages – more specifically, the water crisis on the NCP – shortages in
provinces scheduled to receive water on the west route are sometimes serious, but largely not critical, and could be alleviated through heightened conservation efforts.

While shortages in some of the scheduled recipient provinces are severe, the west route fits into a family of policies such as China’s “Go West” campaign and the more recent Belt and Road Initiative implemented to overcome the unbalanced development between west and east. Although this chapter does not consider the complexities of China’s western expansion, this motivation makes demand management efforts even more attractive than diversions. If the goals of the west route are primarily development, then is no imminent need to supply water; this should support a recommendation to pursue demand management, because it gives policymakers more freedom and a longer timeline to influence consumption and ingrained patterns of water use.

The first section of this chapter will investigate shortages in provinces slated to receive water deliveries from the west route, emphasizing the unique circumstances that have led to water quantity and quality issues in each locality. It will then cover regional efforts to improve allocation and management based on the regionally specific underlying factors driving shortages. The next section will cover national policy approaches to managing demand, with an emphasis on agricultural reform efforts. The last section will draw from the first two, as well as the preceding chapters, to make policy recommendations for water resource management.
I. The West Route – Initial Conditions, Policy Approach and Evaluation

The nature of water shortages in China’s central and western provinces differ vastly from those on the NCP. Whereas the Beijing-Tianjin-Hebei region ran completely dry at the turn of the century, recipients of the proposed western route of the SNWTP exist in varying degrees of water and ecological stress, but not all in acute scarcity. More importantly, the factors that led to conditions of scarcity where they exist are different in every province. Nonetheless, a western diversion plan of the SNWTP is underway. Connecting the headwaters of the Yangtze and Yellow Rivers, the disjointed segments of the western route would divert water from up to five river basins on the Yangtze to tributaries of the Yellow River. Eventually, the diversions would supplement downstream Yellow River flows to meet municipal, industrial, and agricultural needs in Qinghai, Gansu, Ningxia, Inner Mongolia, Shaanxi, and Shanxi Provinces.

The first of the recipient provinces – Qinghai – is rich in water resources. With 12,515 cubic meters of water per capita per year between 2005-2015, Qinghai enjoyed the second highest provincial average over the period, after Tibet.187 Despite the aggregate average, water resources in Qinghai are under increasing stress, and the response has been mild compared to efforts at restoration in the eastern regions. The *Diplomatic Courier* cites “decreasing ice valleys, grassland degradation, increasing temperatures, species loss, salinization of lakes, and loss of wetlands” as key

environmental concerns in the province.\textsuperscript{188} Although each of these problems impacts neighboring regions, water pollution control in Qinghai has enormous national ramifications, as the headwaters of the Yellow, Yangtze, and Mekong rivers all originate within its territory.

The next recipient of water from the west route faces acute water scarcity. At 819 cubic meters of water per capita between 2005-2015, Gansu ranks in the middle of Chinese provinces in terms of water stress, and under acute scarcity globally. However, this stress is concentrated in key areas, such as the capital city Lanzhou and smaller Lintao, which makes localized shortages more severe. In 2016, the city of Lintao dried up when shortly after Chinese New Year water stopped coming out of the tap. Since then, residents have been serviced by the middle route of the SNWTP for their residential water use. In the cities of Lanzhou, Wuwei, and Dingxi, water scarcity has stifled economic development and urbanization, and increased waste and pollution. As one of the driest areas in the country, groundwater is overexploited throughout the province and areas in its center are sinking.\textsuperscript{189}

Ningxia’s situation is similarly dire. At 152 cubic meters per capita per year over the period, Ningxia is comparable to China’s NCP in terms of critical shortages of supplies. With yearly rainfall averages sinking, and temperatures rising, Ningxia’s Xiji county suffered widespread drought in 2016, leading the local government to

\textsuperscript{189} Christina Larson, “Growing Shortages of Water Threaten China’s Development,” \textit{Yale Environment 360}, July 26\textsuperscript{th}, 2010, [https://e360.yale.edu/features/growing_shortages_of_water_threaten_chinas_development]
boost its artificial rain operations. Even with the weather modification, the potato harvest fell by ten percent from the previous year, when water was also scarce. One issue compounding water shortage in Ningxia is – like in Gansu and throughout the NCP – the overexploitation of groundwater. Unsustainable withdrawals eliminate an important emergency source of clean water for families; before widespread digging, families could drill wells and procure fresh water. Nowadays, drilling only produces bitter or salinized water unfit for drinking.\(^{190}\)

The region of Inner Mongolia presents a different case. Between 2005-2015, the province had 1944 cubic meters of water per capita per year, which does not constitute acute scarcity. However, like in other cases water stress is more highly concentrated in a few key areas. With a naturally arid climate, Inner Mongolia is one of the prime sites of desertification in China. In recent years, China’s deserts have spread at a rate of 1,300 miles per year. In Inner Mongolia, climate change – along with overgrazing – is attributed for this expansion. Like in Ningxia, desertification has led to the relocating of “climate refugees,” which numbered at 30,000 by 2013 in Inner Mongolia. Between 1983-2013, the Tengger desert region in the province received under 250 millimeters of average precipitation annually, contributing to sandstorms as far as Beijing. In Inner Mongolia, the water tables are also dropping from over-withdrawal.\(^{191}\)

\(^{190}\) Kang Ning, “In China’s Ningxia Province, water shortage is so severe that the government is relocating people,” Scroll.in, Feb 8, 2017 [https://scroll.in/article/828748/in-chinas-ningxia-province-water-shortage-is-so-severe-that-the-government-is-relocating-people]

Shaanxi province was below Inner Mongolia and just above Gansu in terms of water resources per capita, at 1014 cubic meters over the period. The main issue in Shaanxi is not just water quantity, but quality. In July last year, Shaanxi’s water pollution became the subject of public discourse when an artist named Brother Nut displayed 9,000 bottles of Xiaohuatu’s murky water at an art gallery in Beijing. The remote town is far from an isolated case, with complaints of polluted water emerging throughout the region. In Xiaohuatu, the culprit of pollution was Sinopec, which operates three coal mines and a gas field near the town. Throughout Shaanxi, the quality of surface water and within the Wei River is degrading even as water quality on the Yellow, Yangtze, and Pearl Rivers improves. This is due in large part to extensive coal mining operations that pollute the Wei and other waters with heavy metals. Last year, the province accounted for a fifth of total coal production in the country.


193 Brother Nut’s work is part of a lineage of artistic reflections on the recent pollution and scarcity of China’s waters. In a powerful exhibit in 1995, Yin Xiuzhen collected polluted water from the “mother river” of Sichuan – the Fudan River – and froze it into ice cubes placed along the bank of the river. Standing by the cubes, she invited passerby to wash the water, invoking the idea of water as a universal cleanser, and questioning what might wash water when it is polluted. (See “The Fluid Art of Expression” in The Water Kingdom by Phillip Ball)

While pollution in China’s Shaanxi province is serious, on aggregate the problem in neighboring Shanxi province is even worse. Shanxi is the single largest producer of coal in China, and also faces acute shortages of water at 296 cubic meters per person per year in the 2005-2015 period. In 2016, nearly one third of all surface water in the province was unfit for human contact.\textsuperscript{195} According to the Shanxi Provincial Water Resources Committee, water shortages were not only damaging the environment but also threatening business. As early as 2002, the committee estimated that direct losses in industrial and mining enterprises due to water shortage amounted to RMB 5.5 billion (US$663 million) and indirect losses totaled RMB 13.8 billion (US$1.66 billion).\textsuperscript{196} Before the SNWTP, the third largest water diversion project in China after the Three Gorges and Xiaolangdi dams was the Wanjiazhai dam operated in Shanxi. Opened in 1998 and completed in 2000, the Wanjiazhai dam services three of Shanxi’s largest industrial areas – Taiyuan, Pingsuo, and Datong – which all experience critical pollution issues.

\textit{a. Regional Solutions to Shortages}

Given that the extent, concentration, and underlying causes of provincial water shortages differ by province, the orientation of water management must also be area-specific. In Qinghai, water resources are abundant, but the infrastructure to supply these resources to urban residents, and especially farmers and villagers is insufficient. One demographic factor that distinguishes Qinghai from other provinces


scheduled to receive water along the west route is that most its rural population lives in mountainous areas which are beyond the reach of water treatment facilities or irrigation infrastructure. Whereas constructing more ubiquitous and complex treatment facilities may make sense in Shanxi, where industrial pollution dramatically reduces available water resources and the population is already concentrated enough near pollution sources to make treatment realistic and effective, in Qinghai the government has focused on expanding infrastructure to supply farmers with clean water and promoting household-level purification technologies like slow sand filtration which do not require proximity to treatment plants.\(^{197}\)

In regions experiencing rapid desertification, water conservation has focused on encouraging planting, farming, and moderate grazing. For instance, residents in Inner Mongolia who live on the edge of expanding deserts have slowed this process by planting trees to block wind and stabilize soil. Besides subsidizing farmers for “grassland ecological protection,” the government has also encouraged families to reduce the size of their herds – because over-grazing aggravates desertification – by offering compensation to families downsizing their flocks.\(^{199}\) The efficacy of these measures is being debated, especially given the imperative to preserve and respect the traditional herding lifestyle of Inner Mongolia’s Mongolian ethnic minority. However, these debates demonstrate another variable that must be taken into account


\(^{198}\) Smurthwaite Wang, “Improving Water Quality in Qinghai Province,” *Diplomatic Courier*.


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that differs between provinces, which is the degree to which water management conforms to local cultural practices.

Whereas Inner Mongolia’s efforts to curb desertification have been focused on changing household-level behavior and farming practices, Gansu’s approach to afforestation and tackling desertification has focused on the pioneering role of large industries to develop and promote water-saving technologies and drought-resistant farming. In March of last year, China’s National Forestry and Grassland Administration reported on the efforts of Gansu-based companies such as XinMiao and RongHua to promote “desert-featured breeding, fruit and medicinal materials planting, and...modern sand industry development” on the border of Gansu’s encroaching desert in Wuwei.\(^2\) While the achievements of the project may have been optimistic coming reported from a government channel, it is apparent that the differing approach of these two provinces depends on factors like demographics, causes of water shortage, and level of urbanization and industrial development.

\textit{b. Characteristics and Risks of the West Route}

Although this is far from an exhaustive list of the measures taken in each province to address water shortage – this discussion will be taken up in the next section of this chapter through an analysis of national policy efforts – it is sufficient to demonstrate that regional, demand-oriented solutions are attempting to change long-term habits and patterns of water consumption. In contrast, measures to increase

supplies to these provinces reinforce established patterns of water use. Approved with the east and middle routes under the SNWT Comprehensive Plan in 2001, the west route is designed to divert a total of 20 billion cubic meters of water annually to China’s northwest and north-central provinces. However, it was discovered early on from the fieldwork of independent geologists that planned diversion amounts at specific points exceeded annual flows at those points. For instance, former government scientist and geologist Yang Yong concluded that the planned diversion of nine billion cubic meters of water per year at a single point was impossible, as the water flow at that point was only seven billion cubic meters.\(^{201}\)

Inflated estimates of water transfer was only one of many issues that contributed to the project’s suspension in 2006 until further study. Another issue that was widely voiced – related to the inflated estimate finding – was general infeasibility. The west route is the most technically complex of the three routes, as it involves tunneling through high-altitude mountain ranges at sub-zero temperatures. At some points, the water diversion must ascend over 500 meters, which requires vast amounts of electricity. According to the plan, the water must be pumped from the Yangtze’s tributaries, uphill over the Himalayas, to the elevated Tibet-Qinghai plateau.\(^{202}\) Other challenging pieces of infrastructure that would need to be built include seven dams (some located 3,000 - 4,500 meters above sea level) and a tunnel

[https://e360.yale.edu/features/on_chinese_water_project_a_struggle_over_sound_science](https://e360.yale.edu/features/on_chinese_water_project_a_struggle_over_sound_science)

\(^{202}\) Jeffrey Hays, “South-North Water Transfer Project: Routes, Challenges, Problems,” *Facts and Details*, November 11th, 2011,  
[http://factsanddetails.com/china/cat10/sub66/item1661.html](http://factsanddetails.com/china/cat10/sub66/item1661.html)
through the Bayan Har Mountain range to connect the Yellow and Yangtze River drainage basins.²⁰³

Besides presenting a technical challenge, the route would increase the potential for earthquakes in areas along and in close proximity to the route. Evidence suggests that construction would induce land degradation, slope failures, and landslides that would heighten seismic activity and increase the likelihood of natural disasters in water-transferring provinces, such as Sichuan. Moreover, the route would undoubtedly destroy the sensitive wetlands, dryland, and protected ecosystems around the Yangtze River’s headwaters, and disrupt other rivers implicated in the diversion. For downstream communities as far away as Shanghai, diverting water from the Yangtze along the west route would shutter hydropower stations and lead to blackouts. Besides these known consequences, the effects on the ecosystem of the Yangtze and Yellow Rivers are largely unknown. However, the extent of ecological damage is likely greater on the west route than the middle or central ones because “transferred volumes comprise a larger percentage of in-stream flows.”²⁰⁴

Taken together, these problems caused a group of scientists from China’s National Academy of Engineering, including former Minister of Water Resources Qian Zhengying, to issue a report in 2006 criticizing the proposed plans and urging the government to delay construction. Their criticisms were drawn from memorandums gathered from over fifty researchers at the Sichuan Provincial Academy of Social Sciences in 2005. In this report, retired researchers Lu Jiaguo and Lin Ling summarized the group’s main conclusions when they questioned whether

²⁰³ Magee, “Moving the River?” 1510-1511.
²⁰⁴ Ibid.
the west route would “save the Yellow River at the Yangtze’s expense.” For Sichuan province, construction of the west route would mean reduced water flows and increased likelihood of natural disaster; the latter risk has heightened public concern over the project since the earthquake in 2008, which many Sichuan residents and officials connect with the Three Gorges Dam. Sichuan is not the only province that would be harmed by the project, however, and the memoranda rejected the viability of the entire route, not just the parts affecting Sichuan province.

Since challenges emerged on the national and international front to the route (see previous footnote), the Chinese government has refocused water management to emphasize sustainability, while at the same time pursuing construction projects. In 2015, the Vice Minister of Water Resources Jiao Yong reported that while the government is still drawing up plans for the west route, it will give “top priority…to water conservation and environmental protection.” The next section will cover the current policy approach to managing demand, including conservation laws, initiatives, and policies, pollution control, administrative reforms, water pricing and trading programs and laws, agricultural reform, and ecological restoration projects. Although some of these measures are specific to the provinces implicated in the west route, many current policy efforts are national in scope. However, such national

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205 Carla Freeman, “Quenching the Dragon’s Thirst.”

206 A final issue with the west route that is not covered in the scope of this paper is that it would dam the Yalong Tsangpo River right before it enters India as the Brahmaputra, impacting millions in India and Bangladesh. Without an international framework for river conservancy, the west route could become an important national security issue.

policies take a “hotspot” approach to regulation in which provinces at the highest risk of water insecurity are prioritized for reform, or are held to stricter rules during the process.

II. Policy Evaluation: Managing Demand

As the limits of supply-side solutions become apparent, demand-management has grown in popularity and strength among Chinese agencies responsible for comprehensive planning and management of China’s water resources. These agencies are broadly the Ministry of Water resources, the newer and less established Ministry of Environmental Protection – which enforces pollution control – and China’s seven major river basin commissions. In addition, outside actors such as the hydropower sector and agricultural interests impact decision-making, as will be discussed briefly in this section and elaborated in the final section on policy recommendations.

In the meantime, this section will merely introduce a handful of national policy efforts that have promoted a more comprehensive management of water resources in line with a “systems approach” to management, and specify particularly policies in agriculture that have reduced pollution, increased efficiency, and limited water use. The emphasis on reform efforts in this sector resides from the fact that it accounts for nearly two-thirds of all water use, and half of water pollution. In the NCP, where water is the most scarce, agriculture accounts for an even higher proportion – three-fourths – of all water use.²⁰⁸

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a. Major Water Policies – Conservation and Pollution Control

As discussed in the first chapter, since 2005 China’s five-year plans have all included clear environmental goals. Besides setting overall objectives, several specific laws, policies, and initiatives have attempted to limit overall water use, improve efficiency, and manage pollution of water resources. The first milestone in water management was the 2002 Water Law, which declared virtually all water the property of the state and made its use contingent on obtaining a license. In theory, this law would improve water use efficiency, by authorizing local officials to oversee and approve water uses, and at the same time limit overall demand.\textsuperscript{209} This law was revised in 2009 and 2016 to introduce water rights trading, among the addition of other supplemental regulations.

The 2010 Three Red Lines Policy (\textit{santiao hongxian 三条红线}) reinforced the objectives of the 2002 Water Law by establishing specific limits on national water use, strengthening leadership to achieve targets, and emphasizing pollution and efficiency issues. Under “three red lines,” the state declared that national water consumption would be limited to 700 billion cubic meters per year by 2012, and drop to 635 billion cubic meters by 2015 – amounting to three quarters of China’s exploitable water resources.\textsuperscript{210} Although statistical variations exist among China’s water administration agencies, national use goals have been largely met.\textsuperscript{211} In order to achieve these targets, the “three red lines” policy aimed to improve efficiency.


\textsuperscript{210} Ibid.

Several quantitative measurements of efficiency were established for industry and agriculture, such as water used per RMB 10,000 (US$1,600) industrial added value and irrigation efficiency, respectively.\footnote{212}{Amit Ranjan, “China’s Water Problems,” 650.}

The goals set out under the policy were to raise water efficiency in seven key, water-intensive industries, which were “thermal power generation, oil refining, steel and iron, textiles, papermaking, and food crops.”\footnote{213}{Ibid.} In agriculture, it was to increase irrigation use efficiency to 55 percent by 2015, and 60 percent by 2030.\footnote{214}{Ibid.} This target was supplemented by a RMB1.8 trillion investment between 2011-2015 in irrigation infrastructure improvements, rural clean water delivery and reservoir enhancements.\footnote{215}{Scott Moore, “Issue Brief,” Brookings.} In addition to improving efficiency, the policy set national goals for water quality. By 2015, under the plan 60 percent of China’s water resources were expected to reach standard (level III or higher) quality.\footnote{216}{China’s water pollution is measured on a gradient, I-V scale, with Grade I representing the highest quality, potable water and Grade V representing toxic water unsuitable for irrigation or purification for human use. Grade IV can be used by some forms of industry, but is unfit for human contact. Grade III is “standard” quality as it can be purified for drinking.} The policy also piloted key demonstration projects in water-desalination technology, industrial wastewater recycling, and water pricing systems.

The main issue with particularly the pollution cap policies and provincial-level water limitations is that many of the goals set out were not met. Between 2011-2015, it was found that nearly half of China’s provinces missed water pollution targets, and in three provinces – Shanxi, Inner Mongolia, and Sichuan – water quality
deteriorated.\textsuperscript{217} For provincial water-use limits, in times of shortage provinces “regularly appropriate water in excess of MWR quotas.”\textsuperscript{218} In response to growing pollution, the government launched the 2015 Water Pollution Prevention and Control Action Plan, popularly called the Water Ten Plan. The plan was signed into law in 2017, becoming the Water Pollution Prevention and Control Law.\textsuperscript{219}

The law hopes to improve water quality through gradual reforms, including supporting economic restructuring, stricter conservation, and establishing incentives to protect the environment and long-term water security.\textsuperscript{220} In order to do so, the plan has strengthened monitoring and enforcement mechanisms in China’s water regulating bodies, which also tackles provincial non-compliance with water use limitations.\textsuperscript{221} Besides gradual reforms, the plan also specifies targets for specific issues, such as urban and rural drinking water, ground and surface water supplies, and coal mines.

Although the long-term accomplishments of China’s Water Ten Plan have yet to take shape, in the short term there has been an increase in factory shutdowns and penalties since 2015.\textsuperscript{222} In particular, textile, dyeing and finishing, and pulp and paper

\textsuperscript{217} Deng Tingting, “In China, the water you drink is as dangerous as the air you breathe,” \textit{The Guardian}, June 2\textsuperscript{nd}, 2017, [\url{https://www.theguardian.com/global-development-professionals-network/2017/jun/02/china-water-dangerous-pollution-greenpeace}]

\textsuperscript{218} Scott Moore, “Issue Brief,” \textit{Brookings}.


\textsuperscript{220} Ranjan, “China’s Water Problems,” 651.

\textsuperscript{221} Moore, “Issue Brief,” \textit{Brookings}. One creative and successful effort to regulate water use is the “Digital Yellow River” system that monitors flows in close to real-time.

\textsuperscript{222} Ranjan, “China’s Water Problems,” 652.
factories have been the hardest hit. However, this is only a fraction of what the plan purports to cover. Besides industrial and urban water use, the agricultural sector is a primary focus of conservation efforts, efficiency improvements, and technological upgrading. In agriculture, Water Ten adopts a “hotspot” approach in which areas at highest risk of water scarcity are targeted first. The next section will elaborate how the Water Ten Plan specifically aims to promote a more sustainable agricultural regime, attempting to decrease pollutants and environmental damage while maintaining high yields.

A concluding note on major water legislation is that although environmental protection is rising on China’s national agenda, regulations suffer pervasive issues of implementation and enforcement. This can be understood through a common conclusion of polluting companies that “compliance is expensive, [and] evasion is cheap” (shoufa chengben gao, weifa chengben di 守法成本高，违法成本低). So, although government spending in 2019 in water pollution will increase over 45 percent from last year, much of this investment may simply be lost. At the same time, China is strengthening pollution control efforts, as is apparent through the implementation of China’s toughest environmental tax to date, phased in early last year. Despite an emboldened policy effort, the last section in this chapter will suggest

225 Chien Tat Low, “Key Water Policies: 2018-2019,” China Water Risk, March 19th, 2019, [http://www.chinawaterrisk.org/resources/analysis-reviews/key-water-policies-2018-2019/]. For the first time since China began regulating pollution, spending in water pollution prevention will outstrip that of air pollution by RMB 5 billion. In addition, spending in soil pollution will increase 43 percent from last year.
that reforms will only work to the extent to which they solve issues of implementation and enforcement.

*b. Agricultural Policy – Water Ten Plan, Organic Certification, and Domestic Price Support Reform*

Before drawing policy recommendations to address China’s current water crisis, this section will elaborate policy efforts to manage water use and pollution in agriculture. As the largest consumer of water and greatest single source of pollution, agriculture holds the key to managing water sustainably and rebalancing China’s economy towards long-term productivity growth. Last year, agriculture accounted for 61 percent of all water use and nearly 50 percent of water pollution.\(^{226}\) The percentage of exploitation is higher on the NCP, at nearly three-fourths of all water use. Moreover, agriculture is projected to become more water intensive. As Chinese income increases and the urbanization rate rises, consumers will demand more high-value and water-intensive foods, such as meat, fruits, and vegetables. According to an HSBC Report “No Water, No Food,” urban residents spend 2.6 times more on food on average than their rural counterparts, and China’s urbanization rate is rising. In addition, the percentage of protein as a portion of Chinese diets continues to increase.\(^ {227}\) In 2012, China overtook the United States in its daily, per capita consumption of calories from “meat, poultry, seafood, and offal.”\(^ {228}\)


\(^{227}\) Ibid.

\(^{228}\) Tracie McMillan, “How China Plans to Feed 1.4 Billion Growing Appetites,” *National Geographic*, February 2018,
As these issues strain China’s water resources, three major policies and initiatives have emerged to reduce the amount of water used in agriculture and curb its pollution: the Water Ten Plan and associated policies, a certification system for “hazard-free,” “green,” and organic agriculture, and increased use of international markets for feed. Taking pollution as its main focus, the Water Ten Plan aims to reduce excessive use of pesticides and fertilizers, increase irrigation efficiency, promote traceability of agricultural products, and curb pollution from large-scale breeding and poultry operations.\(^ {229}\)

Excessive fertilizer and pesticide application, and the prevalence of high-toxicity fertilizers, are a serious source of non-point pollution. The OECD found that in 2014 only 40 percent of nitrogen fertilizers were applied efficiently, while the remainder evaporated or produced run-off. Concurrently, pesticide use in China rose by 135 percent from 1991-2012, while use in OECD countries increased by 18 percent, and has been declining since 2008.\(^ {230}\) In response to this issue, the Ten Plan was followed by a 2020 Zero Growth Action Plan for Chemical Fertilizers and Pesticides, in which the Ministry of Agriculture (MoA) declared a zero increase rate for pesticides and fertilizers in 2020.\(^ {231}\)

At the same time as the government sets a zero increase rate, officials acknowledge the importance for China’s large population of maintaining high yields.


\(^{230}\) OECD, “Innovation,” 63-64.

\(^{231}\) Ibid., 135.
If China stopped using pesticides altogether, its production would be estimated to fall 25-40 percent after the first year, and 40-60 percent in two years.\(^\text{232}\) The MoA has responded by implementing a gradual approach to pesticide reduction that targets hazardous chemicals (such as heavy metals) and those that contribute to non-point pollution first, supporting the shift from high-toxicity to low and micro-toxic pesticides, and promoting a sustainable agriculture regime that prioritizes high land productivity and pollution reduction over chemical and input reductions.\(^\text{233}\)

Since 2006, the MoA has endorsed the spread of “circular agriculture” (\textit{xunhuan nongye 循环农业}) and “ecological agriculture” (\textit{shengtai nongye 生态农业}) systems, which “use improved production systems like vertical planting and biological control of pests” and promotes a shift to organic fertilizers to protect yields and reduce pollution.\(^\text{234}\) In addition, since 2001 China began developing a unique eco-labeling regime for “hazard-free” (\textit{wugonghai shipin 无公害食品}) and “green” products (\textit{lüse shipin 绿色食品}), in addition to an organic certification (\textit{youji shipin 有机食品}).\(^\text{235}\)

These policies to reduce pesticide use in agriculture are significant for two reasons. Firstly, they allow China to phase in higher standards gradually, rather than attempting to expel all pesticide-use at once. The labeling regime is a good example of how policies were designed to encourage gradualism. The easiest label to achieve

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\(^{233}\) Ibid.


\(^{235}\) Ibid., 4.
and the only one fully initiated by the government, “hazard-free” emerged from food safety issues threatening Chinese markets in the 1990s. Rather than imposing a strict ecological standards on agribusiness, this label represents a bare minimum for consumers concerned about contamination.\textsuperscript{236}

A step up from the hazard-free label, a “green food” labeling narrows the number and variety of synthetic fertilizer and pesticides allowed in products with an eye toward environmental protection. The green label is unique to China and supports production processes that have adopted the ecological and circular agriculture methods. The hardest label to achieve is the organic certification, which combines consumer and environmental concerns to achieve the prime standard of sustainability.\textsuperscript{237} Altogether, the certification system is designed to encourage a gradual progression to more sustainable food production.

The second important characteristic of China’s pollution control policies in agriculture is that they reflect the particular challenges of promoting sustainability in China – namely, maintaining high yields and limiting pollution with limited land and water resources, mitigating the environmental effects of intensive farming, and making sustainability compatible and accessible to the majority of Chinese farmers. What distinguishes China from western countries practicing sustainable agriculture is its low per capita land and water endowment, high population, relatively intensive and ecologically destructive agriculture, and small average plot size. These characteristics are reflected in Chinese agricultural policy in several ways.

\textsuperscript{236} Ibid., 7.
\textsuperscript{237} Cook et. al, “Back to its roots,” 4-9.
Firstly, whereas sustainability in the west focuses on reducing energy and chemical inputs (such as mineral fertilizers and pesticides), in China sustainable agriculture emphasizes high land productivity, through methods such as intercropping, vertical planting, using household courtyards to grow fruits and vegetables. Under this scheme, some chemical inputs are allowed, but not highly toxic or excessively applied pesticides. Second, the green label is a direct response to the pollution resulting from an intensive agricultural sector that applies twice the amount of pesticides per hectare than the world average.\textsuperscript{238} No other nation has quite the same labeling scheme arising specifically from water and soil pollution issues due to intensive agriculture. Lastly, in order to reduce pollution, China’s government and private sector have carried out trainings to farmers on appropriate pesticide application, which is meant to target small-holding farmers, which are greater in relative number in China than in other countries.

Pesticide reduction is only one issue – albeit an important one – that Water Ten aims to tackle. The next problem draining China’s water resources is irrigation efficiency. At present, China wastes about a third of water used for irrigation.\textsuperscript{239} This is a large percent of total water use. In terms of overall water use in agriculture, in 2010 it was estimated that close to half of agricultural water was lost before it reached farmers either through evaporation, absorption into the walls of dirt channels, or taken by users upstream.\textsuperscript{240} One basic improvement would be to line transporting channels with concrete to prevent water loss. Another issue straining water resources is the

\textsuperscript{238} OECD, “Innovation,” 64.
\textsuperscript{239} Ranjan, “China’s Water Problems,” 650.
\textsuperscript{240} Larson, “Growing Shortages,” Yale 360.
prevalence of “flood irrigation,” despite the availability of sprinkler irrigation or other water-saving techniques.\textsuperscript{241} When cereal crops are irrigated through flood techniques, nearly fifty percent of water is lost.\textsuperscript{242} One potential solution is to carry out trainings, under Water Ten, to reduce reliance on wasteful techniques, or to reform rural water prices.

Coupled with “red line” limits on water use, and Documents No. 1 of 2011 and No. 1 of 2017 which improve the allocation of water, Water Ten supports efficiency targets by improving investment in agricultural water resource infrastructure.\textsuperscript{243} In 2014, the government invested RMB70 billion in infrastructure improvements.\textsuperscript{244} The next year, it focused investments in pilot projects for controlling over-exploitation of surface and groundwater, which are used in irrigation. The goal under Water Ten was to have 700 million mu (47 million hectares) of farmland employing water-efficient irrigation technologies and techniques.\textsuperscript{245} In addition, in 2016 the government pledged to “establish a new agricultural water price mechanism within ten years,” and pricing reform is a focal point in Water Ten.\textsuperscript{246} Lastly, Water Ten establishes zones in which livestock and poultry farming is limited or restricted in order to reduce pollution, and introduces pilot projects to reduce the cultivated area of water-intensive crops in water-scarce regions.\textsuperscript{247}

\begin{thebibliography}{9}
\item Barnett et. al., “Sustainability,” \textit{Nature}.
\item OECD, “Innovation,” 111.
\item OECD, “Innovation,” 113.
\item Ibid., 111.
\item Ibid., 113.
\end{thebibliography}
The last notable policy effort since 2014 to control water use is reforming China’s domestic price support systems for grains. Since 2004, China has carried out a minimum purchase price policy for rice and wheat, which is announced before sowing season so that farmers can take this price into account when decided crop mixes. Between 2008-2014, this price was annually raised, widening the gap between the lower international price and domestic minimum. Besides policies for rice and wheat, the government extended support to producers of corn, soybeans, canola, cotton, sugar, meat, and other agricultural products through the temporary purchase and storage policy. The value of overall market price support peaked in 2015, successfully boosting domestic food production and achieving national targets of self-sufficiency or near self-sufficiency (95 percent for grain).

The consequences of these policies was severe price distortion, with Chinese consumers burdening most of the cost of the subsidy program. Since 2015, the government began to replace the domestic price support system with a system of direct payments to producers that brings domestic commodity prices closer to their international values. Today, much of the support system for corn and soybeans has been converted, with the effect of increased reliance on international markets for these key ingredients of animal feed.\footnote{Ibid., 152.} Despite movements to reform the price support system for rice and wheat, China’s grain self-sufficiency policy remains stalwart. At times, older support policies even contradict China’s newer environmental measures. For instance, even though the exemption of VAT on fertilizer sales was removed in 2015 in concurrence with the 2020 Zero Growth
Action Plan for Chemical Fertilizers and Pesticides, the subsidy to fertilizer producers on rail transport remains, largely to supply grain production.\textsuperscript{249}

In short, reform of the domestic price support system for rice and wheat in China still has a long way to go. These staple crops are especially important to water conservancy because of their water-intensity. For reference, it takes 2,300 liters of water to produce 1 kg of rice – in other words, a bathtub of water per bowl. Wheat is less water-intensive than rice, at 1,300 liters per kilogram, but is grown at higher proportions in water-scarce and stressed regions.\textsuperscript{250,251} The fundamental difficulty of reforming the domestic price support system for grain is political. Due to China’s unique historical circumstances, food self-sufficiency for staple crops has enormous political support, and it is not a policy that China’s MoA would drop lightly. As recently as 2013, President Xi Jinping told officials that “our rice bowl should be mainly loaded with Chinese food.”\textsuperscript{252} However, as will be elaborated in the next section, China’s current environmental degradation has opened potential political pathways that were once considered impossible. It is abundantly clear that deep-rooted institutional, economic, and social reforms must be pushed forward to solve the nation’s self-induced water crisis.

\textsuperscript{249} Ibid., 31.
\textsuperscript{250} Around half of China’s rice crop is grown in water scarce and stressed regions, compared to nearly ninety percent for wheat.
\textsuperscript{251} Debra Tan et. al, “8 Things,” China Water Risk.
\textsuperscript{252} McMillan, “How China Plans to Feed,” National Geographic.
III. Policy Recommendations – Managing Demand and Improving Governance

Collectively, the three chapters of this work have established that China’s current water crisis is a product of China’s unsustainable economic development, and not easily reduced to the term “shortage,” or even “scarcity” and “acute scarcity.” Despite utilizing these terms, this paper has articulated the characteristics of water shortages and their driving forces – that is, that they are concentrated in the Beijing-Tianjin-Hebei region, motivated by China’s urban and industrial growth, and exacerbated by water pollution. Unlike the east and middle routes, besides a supply-side solution to alleviating shortages, the west route is a development plan, on par with China’s “Go West” campaign at the turn of the century and the more recent “Belt and Road Initiative” to move excess industrial capacity from the coast inland, and perhaps expand China’s geopolitical influence to Central Asia and Europe.

Given this overarching analysis, several key policies emerge. Firstly, China should abandon plans for the west route of the SNWTP and reduce the amount of water being transferred on the existing east and central routes. Plans for extensions of the east and middle routes should be suspended. As established in the first chapter, the costs of the west route are enormous. With an estimated budget higher than the first two routes combined, the investment is enormous for a project that is arguably unnecessary, and more likely dangerous. The risks posed to provinces like Sichuan of increased seismic activity are not worth the benefits of short-term supplies to receiving provinces, not to mention the reduced water flows downstream that will not only destroy the ecological environment in unpredictable ways, but also cut off power supplies to millions of people.
The water shortages that do exist in provinces slated to receive supplies from the western route could be solved by increasing conservation efforts, and boosting efficiency. As developed in the section on managing demand, national policies such as the Water Law, “three red lines,” Water Pollution Prevention and Control Action Plan (or Water Ten), and several other associated policies and regulations have begun to target pervasive water waste and pollution issues, and have done so through a “hotspot” approach that takes into account regional characteristics. In addition, several successful pilot demonstrations, such as seawater desalination, wastewater recycling, rain-water collection, sponge cities, zero waste cities, urban and rural water pricing reforms, domestic price support reforms, and afforestation efforts have achieved great success, and could be scaled up to meet national conservation needs. For instance, one demonstration that has been widely successful is groundwater pricing reform on the NCP to raise prices to cover the costs of water delivery, infrastructure maintenance, and operation.

It was the success of pricing reforms, conservation efforts, and efficiency improvements where piloted, and their low level of national implementation, that prompted the former vice minister of Housing and Urban-Rural Development Qiu Baoxing to state that if one third of all buildings in Beijing collected rainwater, the SNWTP would be unnecessary.\textsuperscript{253} He also endorsed an expansion of desalination technology, and expansion of wastewater recycling. Although some water-saving technologies such as seawater desalination present drawbacks, such as requiring large energy inputs, Qiu’s logic is sound.

\textsuperscript{253} Jon Barnett et. al, “Sustainability,” \textit{Nature}.
The primary reason that water diversions should be reduced on the east and central routes of the SNWTP is that increased supplies only provide a “band-aid” solution to deep-rooted management problems, and arguably only generate new demand. Gohari, Alireza et. al. found this to be true in their study of diversions into the Zayandeh-Rud River Basin in Iran. Through a “system dynamics models” analysis (i.e. modeling the sub-systems that drive water supply and demand in the basin), the authors show that increasing supply of water without controlling demand will generate a greater demand for water – a conclusion applicable to the SNWTP.254

Another way of looking at the problem of uncontrolled demand is to consider that when the SNWTP was planned, the 14.8 billion cubic meter capacity along the east route and 9.8 billion cubic meter capacity along the central route were enough to meet demand in their respective sites of transfer. Now, the east route of SNWTP barely meets a third of water needs in the receiving regions and plans are underway to increase the capacity of the route. The underlying issue is that water transfer begets more transfers, for both environmental and social reasons.

On the environmental side, China’s historical record reveals that large-scale damming efforts often increased the potential for natural disaster, and at times jeopardized or damaged land and water resources and natural processes of ecological restoration. On the behavioral side, once there is an increase of water supplies, and if these supplies are undervalued through artificially low prices, then there is little incentive to conserve resources. Lastly, because of the “SNWTP tax” instated to compensate provinces that lost water supplies, water from the east and middle routes

is prohibitively expensive to farmers and urban residents, further calling into question the justification of the delivery.\textsuperscript{255}

Therefore, it is concluded that the harms of the constructed routes of the SNWTP could be mitigated through reducing the amount of water being transferred, and the consequences of the west route avoided if the project is suspended altogether. Instead of continuing with the project to increase supplies, the state should: 1. raise the price of water – urban, rural, ground and surface – to reflect market values; 2. rebalance agricultural policy towards sustainability – replace domestic support systems with direct payments, introduce more conditional support measures based on an environmental protection agenda, and increase the use of international markets for water-intensive crops; 3. diversify its energy mix – move away from the heaviest industrial and energy polluters; 4. encourage public participation and improve transparency – disclose information on water and soil pollution to the public, at least to the extent published for air pollution, and improve monitoring; 5. increase investments in new, water-saving technologies that are, on balance, sustainable – such as wastewater treatment and recycling, and rainwater collection.\textsuperscript{256}

\textsuperscript{255} Ibid.
\textsuperscript{256} Weather modification technologies such as cloud-seeding operations should be dropped as a regular source of water supplies. Besides the unknown environmental risks of weather modification, these operations are energy-intensive and enormously expensive. Currently, China relies on increased water supplies from cloud-seeding in dry regions, as opposed to reserving this resource for emergencies as is done throughout the rest of the world and the US. For more information, see Stephen Chen, “China needs more water. So it’s building a “rain-making network three-times the size of Spain.”” \textit{South China Morning Post}, March 26\textsuperscript{th}, 2018, [https://www.scmp.com/news/china/society/article/2138866/china-needs-more-water-so-its-building-rain-making-network-three].
One argument against the first measure – raising the price of water – is that this is infeasible. Proponents of this position argue that a primary reason that the price of water is kept artificially low is to prevent social instability. Moreover, the goal to raise water prices to world averages is aspirational. Given that Chinese water prices last year were around a fourth of the world average, it is unlikely that reforms will have the political backing to raise the price of water to four times its current price.257

On the one hand, it is correct to doubt the feasibility of a complete liberalization of water prices in the near future. However, the National Development and Reform Commission (NRDC) is set to release a report on the “Innovation and Improvement of the Price Mechanism for Promoting Green Development” on water in July, and it seems likely that the agricultural, urban residential and non-residential, reclaimed, and excessive water use prices will be differentiated and raised (besides the reclaimed water price which will be lowered to make this an attractive option).258

These changes are largely based on successful pilot projects, particularly throughout the NCP, in which differentiating and raising water prices successfully curbed water use. In addition, water pricing reform is critical to rebalancing China’s economy towards greater consumption, particularly as current subsidies favor producers over consumers.

The second recommendation urges agricultural rebalancing toward sustainability and reduced resource-intensity. While policies such as the “three red lines,” Water Ten Law, and associated regulations are moving in the right direction, they do not go far enough to reduce virtual water exports from northern to southern provinces (and, although not covered in this paper, from China to other nations). In addition to current efforts to increase efficiency, reduce pollution, and remove market distortions for various non-staple crops, price support systems should be replaced by direct payments for staple grain crops like rice and wheat (as has been done for corn, soybean, and cotton), existing subsidies should become conditional on environmental protection efforts by producers, and the sown area for water-intensive crops should be reduced, and grain crops switched for higher-value, less water-reliant crops (such as peanuts). The eco-labeling regime should be expanded, and sustainable agriculture cited more often in economic literature as a solution to mitigate China’s water quantity and quality issues.

Next, in order to curb pollution, conserve water, alleviate national imbalances, and mitigate the impacts of climate change, the Chinese state should diversify its energy mix and move away from energy-intensive industries. The first section traced how coal dependency has fallen in recent decades, but how this transition has occurred more slowly than many officials, the public, and other observers had hoped. Returning to Wing Thye Woo’s recommendations presented in the first chapter, energy policy should be coordinated with resource management to fulfill political and environmental goals.
However, China’s power sector remains recalcitrant in the face of China’s growing environmental agenda. In energy, it is coal, aluminum, steel and other key national industries that benefit from the status quo and will shoulder enormous losses if China transitions away from non-renewables and power consuming industries. The influence of state industries over regulatory functions will be addressed in the next section, and arguably presents the greatest obstacle to ensuring long-term water security.

The final two recommendations of this section are to increase monitoring of water pollution, and boost investments in water-saving technologies. One recent policy to improve water pollution monitoring is the introduction of the “River Chief System” and “Lake Chief System.” This policy assigns responsibility to jurisdictional water “chiefs” for maintaining standard water quality of main bodies within their respective watersheds. Monitoring allowances should be extended to EPBs and civil groups to improve data on water flow, pollution levels, and allocation of water rights, and to increase public participation. Next, investments in water-saving technologies should be increased, and initiatives such as sponge and zero waste cities supported.

259 “To curb pollution, China has appointed over 1m river chiefs,” The Economist, December 18th, 2018, [https://www.economist.com/china/2018/12/13/to-curb-pollution-china-has-appointed-over-1m-river-chiefs]

260 In practical terms, river and lake chiefs filter garbage from their respective waters and periodically assess water quality. By December of last year, over 1.1 million chiefs had been appointed. Early in the year, the state produced the first nation-wide water quality survey based on data collected from river chiefs. Despite ongoing issues, the river chief system has produced data for the first national water-quality survey, and reflects the government’s concern over public dissatisfaction with water quality, and signals that it could increase data collection and transparency in the future.
While these policies would promote a more sustainable resource development path, it is recognized that water resources are not the only factor that should be taken into account when assessing China’s environmental policy options. Rather, factors such as the distribution of arable land – which is also in scarcity – and industry should be balanced against water management needs. A final point is that to the fullest extent possible, whatever policy is adopted should be pursued through a “learning by doing” strategy. China has embraced this strategy in the past, as embodied by its transition from a socialist to market-socialist economy, to great benefit. This technique apparent in the prevalence of demonstration projects – officials are learning the effects of new policies by actually implementing them through pilot initiatives. Even if the PRC does not strike the plans for a west route, smaller diversions should be built first to test the effects on the surrounding ecology, and enough time should be given to attain accurate results.

a. Improving Governance – Establishing an Environmental Imperative

While this paper recommends that Chinese regulation progresses in these suggested ways to reflect environmental imperatives, an arguably greater issue in China than passing environmentally sound legislation is ensuring its implementation. In other words, in an overwhelming number of cases even when regulations such as pollution caps are put in place, they are not followed. China’s persistent resource scarcity and pollution issues can only succeed to the extent that they increase the effectiveness of governance. According to Scott Moore, a former guest researcher at the Brookings Institute, the current framework for water governance suffers two major institutional flaws. The first is that it lacks “formalized mechanisms for inter-
provincial consultation…at regional scales.”²⁶¹ In other words, Moore calls for formal representation for provincial governments in national conservancy commissions in order to help alleviate inter-regional water conflicts and improve equity in allocation.

Second, Moore highlights that incentives at the national, provincial, and sub-provincial levels prioritize growth over environmental protection. Moore attributes this partly to the unique “tiao-kuai (条块) administrative system, in which officials at lower levels of government are responsible both to line control by functional bureaucracies, such as the various ministries, as well as to territorial government leaders.”²⁶² Under this system, officials are evaluated and promoted based on a test called the kao he (考核) in which economic growth and stability are prioritized. As such, provincial and sub-provincial officials employ what Moore calls “light touch” regulation to meet pollution standards, causing these “territorial cadres’” jurisdictions to fall short of national quality goals and ultimately jeopardizing the nation’s environmental agenda. In order to solve these issues, Moore suggests that the “evaluation system should be overhauled to emphasize environmental and water resource management metrics.”²⁶³

While this section endorses both of Moore’s recommendations, the issues he identifies are reflected in greater institutional arrangements in the Chinese government. At the highest levels of government, there is a tension between profit and environmental protection – between growth and protecting public welfare. In 2015, Nature magazine published an insightful piece on the underlying issues of

²⁶¹ Moore, “Issue Brief.”
²⁶² Ibid.
²⁶³ Ibid.
governance undermining the efficacy, long-term viability, and environmental agenda of China’s water management regime. In the piece, the authors identify that it is the government’s dual role as “regulator and entrepreneur” that has led to the outsized influence of water infrastructure developers on management, and prioritization of growth over environmental protection.\(^{264}\) This issue can be traced back to China’s transition from a socialist to market-socialist economy, from when the government owned the means of production and industry was fully state-operated to when reforms were undertaken to introduce more coordination of economy activity in markets.

Beginning around 1992 with the state’s endorsement of a “market-socialist” economy, China began to embark on a process of enterprise reform. At this point, China’s industrial landscape was fully populated by state-owned enterprises (SOEs). The first milestone in marketization was the passage in 1994 of the Company Law, which gave a legal framework to corporatization of large SOEs. Corporatization has two important components: first, it creates, from an accounting perspective, joint stock companies. In other words, after the law was passed every large SOE was set up as a company that had potential shares to sell. At first, each company was set up with a single shareholder – the government – but later these shares were either listed on international stock markets, or retained by the government through the State Assets Supervision and Administration Commission (SASAC). The second aspect of corporatization is that it required companies to set up boards of director to address corporate governance issues.

\(^{264}\) Barnett et. al, “Sustainability.”
Overall, the level of privatization (fully non-government owned), corporatization, and diversification of ownership in China’s largest companies has been disappointing. In the Fortune Global 500 rankings from 2015, 93 firms were from the PRC, but nearly half of these were SASAC-owned industrial enterprises.\footnote{Naughton, \textit{The Chinese Economy}, 334.} This a problem because firms rely on protected domestic markets, and are therefore less efficient than private industry. Nearly thirty years after the Company Law was passed, state ownership of industry is still being debated and the tension between “market” and “socialist” aspects of the economy has yet to be reconciled. Besides undermining competitiveness, a major issue with the persistence of government in industry is reflected in the dual directive identified by the Nature magazine article authors, and explicitly stated in the SASACs mandate. As shareholders in profit-driven companies, the SASAC is seeks to maximize asset values. But as a government agency, the central and local SASACs also hold a mandate to pursue the public interest.

This history is relevant to the SNWTP because the companies designing, constructing, and operating the project are all key national corporations owned in part or full by the SASAC. Hanjiang Water Resources and Hydropower Company, a subsidiary of Guangdong No. 2 Hydropower Company, undertook most of the construction of the east and central routes, and the Hai River Watershed Commission designed the plans, with input from the other river commissions.\footnote{Magee, “Moving a River,” 1512.} Moreover, at the decision-making levels, the influence of water infrastructure developers is clear. As stated in the beginning of the section, China’s water resources are broadly managed
by the Ministry of Water, the Ministry of Environmental Protection, and the seven major River Basin Commissions. Although the river basin commissions are nominally in charge, due to close ties with the National State Planning Commission and State Council, developers often overpower decisions of commissions.267

This connection has undermined the sustainability of China’s water management regime. Whereas socially-minded government policies should pursue public health and welfare through environmental protection, profit-minded corporations benefit short-term from the construction of expensive engineering works. When the government itself represents the corporation that benefits from industrial growth, such as hydropower development or investments in infrastructure, then social metrics such as environmental quality, public health, promoting equality, and reducing corruption are easily cast aside. At the broadest level of political reform, economic restructuring should improve management of China’s limited resources, but many more considerations factor into this process than just environmental quality.

Therefore, more specific policy recommendations for governance are drawn from this analysis: 1. the state must restrict the influence of the hydropower sector and other key national industries on water-resource management; 2. more marketization of water-resource management should be promoted, and bureaucratization reduced; 3. profit motives separated from environmental and social considerations upon consideration of water policies at the agency level – the dual mandate of government-owned companies must be addressed, and justifications for state involvement in key industries defended or this involvement dropped; 4.

267 Ibid.
environmental imperatives should be established at every level of government, and be reflected in the evaluation and promotion systems for national, provincial, and sub-provincial officials; 5. communication should be increased between agencies, and provinces given representation in major river basin commissions; 6. transparency of water resource decisions should be increased, pollution and agency monitoring from civil groups and Environmental Protection Bureaus (EPBs) encouraged, and corruption issues addressed.

The governance reforms listed may be particularly hard to achieve, as it is apparent that a powerful coalition (the hydropower sector and other key industrial sectors) has formed with a vested interest in maintaining the status quo. However, a successful water policy must resolve issues of ineffective governance in order to ensure that national pollution reductions are actually met, and water use limited. This policy will likely be gradual to be effective, and the best pathway to reform may rely on transitional institutions to pay dividends to China’s industrial sector while promoting more sustainable resource-management policies.
Conclusion

One issue that this paper has not addressed in a unified manner is the urgency of water resource management in the face of climate change. Each year, our knowledge of the interdependencies between climate patterns and availability of water supplies improves. Several decades ago, the effects of coal mining on weather patterns were largely undetected; even today, the climate’s sensitivity to coal emissions remains somewhat uncertain.

Of paramount importance to China’s water management program is being able to predict how climate change will affect the pace of glacial melt on the Qinghai-Tibetan plateau, which determines flows into China’s main river basins. Although intuition may lead us to believe that flows will increase in the short-term, as the climate warms, and then eventually run dry as supplies wane, the relationship between climate and river runoff has proven to be less consistent.

In 2012, researchers revealed that the amount of water entering the Yangtze River at the Tibetan plateau was actually decreasing, despite a 15 percent increase in glacial melt and increased rainfall over the last four decades.268 This came as a surprise because this is the opposite pattern as observed in most river basins. The decrease is likely owed to changes in permafrost, which has affected the amount of water running off land. Rather than producing a linear relationship, runoff was found

to increase “if the thawing layer was less than 60 centimeters deep, but decreased if the thaw went deeper.”\textsuperscript{269}

The uncertainties predicated by climate change only reinforce the relative benefit of continuing with water policies following a “learning by doing” strategy. Rather than predicting a certain set of outcomes, or cross-sector interdependencies, and planning inflexible projects according to these projected relationships, “learning by doing” monitors the performance of system factors, and bases future decisions on observed results. Overall, demand-management policies do better than large-scale, fixed infrastructures in encouraging proactive monitoring and evolution of management approaches.

The main issue of the SNWTP is its sheer size – as Huang Wanli observed in 1957 and Changming Liu has since restated, the uncertainties of water infrastructures increase in proportion to their scale. Many of the catastrophes of the Mao-era dams could have been avoided if flood control and hydropower generation had been achieved through the construction of multiple, small-scale projects, as was suggested to Mao by numerous advisors. Following these historical lessons, diversions should only be considered to alleviate water stress if their scope is limited, and routes are subject to official and civil monitoring.

In the near future, this ideal of a demand-focused management policy that accounts for and closely monitors the interdependencies between sectors seems achievable. China’s unique political history and recent market-socialist transition has supplied the nation with hybrid tools to mitigate many of the externalities of rapid

\textsuperscript{269} Ibid.
development. Recent policies such as the 2018 environmental tax have combined market and bureaucratic elements to implement policies suited to China’s political and economic system. However, more must be done at the institutional level to prioritize environmental protection over growth incentives to increase the effectiveness of such policies.

Just as importantly, water shortage must be re-conceptualized as a regional issue, with locally-defined characteristics, rather than a national crisis. To the fullest extent possible, palliatives should be directed towards alleviating underlying causes of water shortage, rather than engineering physical transfers of water to increase supplies – no matter the cause of shortage. In relation to critical thresholds or tipping points, political responses should shift away from engineering-based solutions, and adopt a regionally-focused, systems approach. In other words, in order to secure water resources in the future, we must shift out mindset away from technocratic interventionism and toward an openness to active engagement with the complex interdependencies that enable any kind of economic activity to take place at all.

If anything, China’s water crisis has highlighted these interdependencies; mitigation efforts have repeatedly demonstrated that factors like water quality, quantity, and ecological health are all intimately related – afforestation projects upstream prevent erosion downstream, reducing coal dependence stabilizes national climate patterns, and lake inundation in one province may cause eutrophication in another. Rather than “taming the river” to divert supplies to the capital, China’s political history suggests that the wisest managers will follow in the footsteps of Da Yu, and merely collect enough information to guide its flow.
IV. Appendix

Figure 1: China’s interregional water imbalances, 2003-2010

Source: Google images, last accessed December 12, 2018, [https://www.google.com/search?q=china+water+scarcity+map&source=lnms&tbm=isch&sa=X&ved=0ahUKEwjOqJ- q1JvfAhUGSN8KHX4JAIUQ_AUIDigB&biw=1440&bih=744#imgrc=mMCvdzl2Li4h7M]
Figure 2: The SNWTP: eastern, middle, and central routes


Figure 3: Environmental Kuznets Curve

Source: Google images, last accessed December 12, 2018, [https://www.google.com/search?q=environmental+kuznets+curve&source=lnms&tbnid=isch&sa=X&ved=0ahUKEwjyyJOH2JvFAhUEn-AKHbxHBuYQ_AUIDigB&biw=1440&bih=744#imgrc=0G8vAtVTpsGN_M:](https://www.google.com/search?q=environmental+kuznets+curve&source=lnms&tbnid=isch&sa=X&ved=0ahUKEwjyyJOH2JvFAhUEn-AKHbxHBuYQ_AUIDigB&biw=1440&bih=744#imgrc=0G8vAtVTpsGN_M:)
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