Water Quality, Perception and Knowledge in China

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write this abstract later…

Contents

1 Introduction

`Copied from the thesis proposal`

Access to freshwater is something many people take for granted. Simply turning on the tap or buying a bottle of water makes it easy to underappreciated the immense value of clean freshwater. Water is essential for almost all aspects of modern civilization and is connected to all three pillars of sustainable development – environment, society, and the economy.

While water is a permanent resource, water that is usable and consumable by humans is not. Globally, only 2.5 percent of the Earth' s water is non-saline, with most of the remaining freshwater being inaccessibly located in glaciers, ice caps or permafrost. (Shiklomanov 1993)

Water scarcity, being the scarcity of availability or access to usable freshwater resources, is a significant and increasing global issue. (UN-Water n.d.) Globally, water usage has increased at a rate of 1.7 times the rate of population increase over the past century. (F.A.O. 2014) Water stress and scarcity can be caused by increased water withdrawal, population increase, and climate, amongst others. (F.A.O. 2014) Water scarcity is three dimensional, including physical, infrastructural and institutional factors. (F.A.O. 2011b) While some regions are affected more than others, every continent is affected. Four billion people experience extreme water scarcity at least one month out of the year. (Mekonnen and Hoekstra 2016)

The implications of water scarcity cannot be understated. Global water crises stemming from water scarcity are predicted to be the largest risk globally within the next decade. (World Economic Forum 2016) Since water is vital for human existence, a lack of water can be directly or indirectly related to almost any societal indicator.

One direct impact of water scarcity can come in the form of food production. Globally, 70 percent of global renewable water resources withdrawn for human use is used for agriculture. (F.A.O. 2011b) Affected by population growth and the increased consumption of more water-intensive food due partially to economic development, it is estimated that food production must increase by 70 percent to meet demand. (F.A.O. 2011b) Another impact is health. Health can be affected by the quantity and quality of water. The impacts of dehydration, water-borne diseases, and consumption of polluted water are well documented. A third impact is economic. By 2050, some regions could see a GDP growth rate decline of up to six percent due to "losses in agriculture, health, income, and property" caused by water scarcity. (The World Bank 2016)

1.1 Chinese Shortage

Water issues in China are especially prevalent. On average, China's renewable freshwater resources were 2,062 cubic meters per capita in 2014, a decrease from 4,200 cubic meters in 1962 and far less than the half of the world average in those respective years. (F.A.O. 2016) China's renewable freshwater resources are also highly location dependent. For example, only 19.7 percent of total internal renewable surface water and 30 percent of groundwater resources reside in northern China. (F.A.O. 2011a) Northern China's renewable freshwater access is only 757 square meters per capita per year, far below the water scarcity limit of 1,000 square meters per capita per year. (Zhang et al. 2010)

1.2 Chinese Pollution

In addition to the already strained water resource problem, poor water quality caused by pollution is amplifying the problem and is causing further economic, societal and environmental problems. Roughly 80 percent of groundwater resources were found to be unsafe for human contact. (Jing 2016) Economic costs attributed to poor water quality in 2003 were over 1.16% of GDP. (Wu et al. 1999)

Historically, and especially since the Opening Up and Reform era post-1978, the Chinese government has prioritized economic growth over environmental protection. In terms of water resource management, the government's investment strategies have prioritized large scale water infrastructure projects over environmentally-friendly pollution-control policies, due to a variety of political and non-political reasons. (Rogers and Crow-Miller 2017) Mao Zedong famously embraced the idea of the now-partially-completed South-North Water Transfer Project, one of the largest infrastructure endeavors in history, by saying "The south has plenty of water and the north lacks it, so if possible why not borrow some?" (Reuters 2009)

In addition to having the political will and prowess to pursue economic development, Chinese leadership has also at times shown a campaign-style action to mitigate environmental pollution. One such example was the substantial air quality improvements in Beijing during the 2008 summer Olympics. (Zhang et al. 2010) However, similar outcomes regarding improved water quality have not been as positive. Analysis of water quality trends has been hampered partially due to data limitations, including public accessibility, the scope of measurement, and technological limitations including long latency peri-

ods. (Zhang et al. 2010)

Recently, further policy has been implemented to address water scarcity and pollution issues. In 2015, the State Council released an ambitious attempt to do this, colloquially known as the "Water Ten Plan," which sets water quality-related goals to be met by 2020. (国务院. 2015) However, results so far have been mixed, with nearly half of all provinces missing their water quality targets in 2017. (Greenpeace 2017) One factor which may help this progress, and one of the goals outlined in the Water Ten plan, is the improvement of water quality sensing technology and data management.

2 Background

2.1 Environmental Policy, Knowledge and Perception

Water quality and quantity issues in China and abroad sit within the context of environmental policy, environmental education, and societies' perception of the two. (Caldwell and others 1990) Analysis linking environmental knowledge and attitudes (perception) have existed for decades. The assumption, and common model, is that:

> "increased knowledge leads to favorable attitudes towards pollution abatement which in turn lead to an action promoting environmental quality." (Ramsey and Rickson 1976)

At the time, in the 1970s, most scholars agreed with this model, concluding that "a broad public literacy of biological and ecological concepts is at the heart of defining, reclaiming, and maintaining environmental quality," but also concedes that the results of education are variable. (Ramsey and Rickson 1976)

Understanding the background of environmental policy, knowledge, education and perception is important in understanding how they interact in the concept of water quality in China and abroad.

2.1.1 Environmental Policy

Environmental conservation has a long and global history, at times being documented as early as the seventh century, with examples afterwards often being local or anecdotal. (BBC News 2013) In the broader context of environmental appreciation or dependency, the history likely goes back to the dawn

of humanity. This is evident in written and modern-day history as some indigenous cultures do not separate the environment and the society. (Armiero and Sedrez 2014, 2–3)

Much of the documented history of modern environmentalism and environmental policy comes from the United States. Preservation was one of the first policy instruments, most notably with the Yellowstone National Park Act of 1972 ("Rules and regulations of the Yellowstone national park. Department of the interior." 1881) Water pollution was one of the first environmental issues which received federal legislation with the The Federal Water Pollution Control Act of 1948 ("The Modern Environmental Movement | American Experience | PBS" n.d.), which later became known as the Clean Water Act. (US EPA 2013)

Despite much of the literature covering history in the United States, environmental protection can be seen as a global phenomenon in many parts of the world and throughout the 20th and 21st centuries, albeit with differing impact, scope and timeliness. The link to its global nature is highlighted in a study which finds that international organizations and communities have central importance in the diffusion of one particular type of environmental policy, the Environmental Impact Assessment, and its particular importance for less-developed countries. (Hironaka 2002)

2.1.2 Environmental Knowledge and Education

Knowledge about most topics is learned through theory (education) and practice (experience). This is no different with the environment. The term 'Environmental Knowledge' accounts for multiple ways of learning and acquisition. In the 1970s, authors stressed the complicated pathways from information to knowledge:

> "…the acquisition of environmental knowledge involves a complicated series of processes – sensation, perception, imagery, retention, recall, reasoning, problem solving, judgment, and evaluation. It is an individual process, each person having a unique cognition of the world, but the overlap in images among individuals permits environmental communication." (Holcomb 1977)

Environmental Education (EE) is a subset of Environmental Knowledge and is inexorably tied to environmental protection and policy One of its main goals is "Awareness - to help social groups and individuals acquire an awareness

and sensitivity to the total environment and its allied problems." ("Intergovernmental Conference on Environmental Education, Tbilisi, USSR, 14-26 October 1977: Final Report - UNESCO Digital Library" n.d.) An earlier definition was presented in 1969 from the United States, and has proved reliable and accurate since:

> **Environmental education** is aimed at producing a citizenry that is **knowledgeable** concerning the biophysical environment and its associated problems, aware of **how** to help solve these problems, and **motivated** to work towards their solution. (Stapp et al. 1969)

While there is a longer document environmental protection movement in the United States than in China, it is important to note that Dr. Stapp wrote this definition with the perspective that only 50 years had passed since much of the United States was rural and underdeveloped. It can be argued that China shares this temporal perspective today.

Progress continued with development and deployment of EE the international level, with many landmark events in environmentalism and sustainability putting EE at their core, including The International Environmental Education Program (IEEP 1975), the World Conservation Strategy (IUCN 1980), 'Tbilisi Plus Ten' (1987), Our Common Future (WCED 1987), and The Earth Summit (UNCED). (Neal and Palmer 2003, p13–15)

EE also has the potential for direct and indirect positive environmental impacts. One study reviewed 105 EE studies which emphasized conservation outcomes, and found that EE programs which included and focused on ecological indicators (such as improved water quality) had outcomes with the most directness (as opposed to indirect impact categories such as community capacity building), and concluded that local aspects of regional and global problems are important for the directness of the link. (Ardoin, Bowers, and Gaillard 2020)

Several other studies have mixed results. One study examined the relationship between environmental knowledge and attitudes of fourth-graders in Germany but found no correlation between the two. (Liefländer and Bogner 2018) However, the authors noted that the lack of correlation was probably caused by measurement constraints. Another study examined high school students' environmental knowledge and attitudes and found "significant difference in both knowledge gain and attitudes of students after exposure" where "environmental knowledge scores increased by 22%" after the completion of a 10-day environmental course, and "environmental attitudes became more environmentally favorable." (Bradley, Waliczek, and Zajicek 1999)

2.1.3 Environmental Society (Perception)

There is an intuitive link between the state of the environment and one's perception of the environment. Environmental perception has been defined as "awareness of, or feelings about, the environment, and as the act of apprehending the environment by the senses." (Zube 1999) A more detailed definition takes into account its multi-dimensional aspects, as a "transactional process between the person and the environment." (Ittelson 1973) He offered three general conclusions:

1. It is not directly controlled by the stimulus.
2. It is linked to and indistinguishable from other aspects of psychological functioning.
3. It is relevant and appropriate to specific environmental contexts.

Ittelson continues in his theoretical framework and suggest that environments "surround the person, provide opportunities for exploration, and provide information that is received through all senses – feeling, hearing, seeing, smelling, and tasting." (Zube 1999, section. Definition) Environments provide more information than the person can apprehend, thus leaving the potential for the environment to influence in unperceivable ways. Additionally, according to Ittleson, environments have ambiance - a "quality, mood or atmosphere" which can relate to the social context of environmental experience, and is viewed through the lens of past experience and current perceptions. Simply put, environments affect both individuals and societal groups in ways which are not always easy to understand, and can change or be affected in the present and the past. This has an affect on policy, as information regarding how the general population feels about the environment can inform policy makers.

While studies into societies' perception of the environment often focuses on positive aspects when investigating wilderness and landscape aesthetics, studies regarding air, water and sound usually focus on negative factors. (Zube 1999, section. Air, water, and sound) These studies often focus on maximum levels of pollutants (quantitatively or qualitatively) or annoyance thresholds. Interestingly, different cultures have been found to have different threshold qualitative pollution or annoyance levels, which could be seen as a limitation of this study.

One other factor in environmental perception was the "magnitude, diversity and rapidity of environmental change." (Zube 1999, section. Major envi-

ronmental changes) Studies in this domain indicate that "physical proximity to the change, magnitude and kind of change, length of time in current residence, and personal value orientations are all related to the perception of and response to the phenomenon." (Zube 1999, section. Major environmental changes)

2.1.4 In China

Despite its international perception (often correct) of poor environmental protection, China does have a long history of environmental policy, with "great leaps" of progress and reform every decade or so since the political reform in the early 1970s. (Xie 2020) There is also evidence showing that environmental issues and their repercussions are deemed important by the local population. One study found that Chinese university students were more concerned about environmental risk, and deemed "environmental issues to be more harmful to health, to the environment, and to social economic development of the nation than did the American respondents.environmental issues to be more harmful to health, to the environment, and to social economic development of the nation than did the American respondents." (Duan and Fortner 2012) Furthermore, they found that Chinese students were concerned about fresh water shortage, and safe drinking water shortage more than other environmental concerns, and only less so than human population growth.

2.2 Water Quality and Perception

2.2.1 Factors in Water Quality

Talk about components of water quality, aesthetics, harmful vs. non-harmful components, local and global rankings, drinking vs using, etc.

2.2.2 Water Quality in China

China often cites its developing country status as a reason that it under-performs on environmental indicators. However, China ranks lower than other countries with similar or even lower GDP. (Wendling, Z. A. et al. 2020, X, fig. ES-1) Overall, China ranked 120th with a score of 37.3 in 2020, which was the same ranking as in 2018 but with a decreased score from 50.74.[1] (Wendling, Z. A. et

[1]The framework of the overall EPI score is comprehensive and weighs 32 indicators. However, the weighting of some indicators changed between 2018 and 2020, making comparison difficult. The visualization of each years breakdown can be seen in 2018 (Wendling et

al. 2020, XII; Wendling et al. 2018, 15)

In 2020, China ranked 54th (6th regionally) in sanitation and drinking water, with a score of 59.4/100. (Wendling, Z. A. et al. 2020, 57) Specific rankings for sanitation and drinking water were not available for 2018. For the broader category of Environmental Health (HLT), China scored 31.72/100. (Huang and Xu 2019)

Access to water is another factor in the population's perception of water.

China has increased its use of basic sanitation services by 28% from 2000-2017 (Organization and others 2019, 31, fig. 33) and achieved 100% safely managed drinking water access. (Organization and others 2019, 48, fig. 51)

{table} Minimum water access in China in 2000 and 2017 :name: jmp-2019-china-wat

Year	Population	% Urban	At least basic - National	At least basic - Rural	At least basic - Urban
2000	1 283	36	80	70	98
2017	1 489	58	93	86	98

(Organization and others 2019, 89, annex. 3.1)

{table} Minimum national improved water details in China in 2000 and 2017 :name: jmp-2019-china-water-detail-national

Year	Safely Managed	Accessible on premises	Available when needed	Free from contamination	Piped	Non-piped
2000	-	65	77	-	51	30
2017	-	92	90	-	76	18

(Organization and others 2019, 89, annex. 3.1)

{table} Minimum rural water details in China in 2000 and 2017 :name: jmp-2019-china-water-detail-rural

Year	Safely Managed	Accessible on premises	Available when needed	Free from contamination	Piped	Non-piped
2000	-	46	65	-	31	40

al. 2018, 6, fig. 2.1) and 2020 (Wendling, Z. A. et al. 2020, XI, fig. ES-2).

Year	Safely Managed	Accessible on premises	Available when needed	Free from contamination	Piped	Non-piped
2017	-	86	81	-	54	34

(Organization and others 2019, 89, annex. 3.1)

{table} Minimum urban water details in China in 2000 and 2017 :name: jmp-2019-china-water-detail-urban

Year	Safely Managed	Accessible on premises	Available when needed	Free from contamination	Piped	Non-piped
2000	93	98	97	93	87	12
2017	92	96	96	92	92	6

(Organization and others 2019, 89, annex. 3.1)

China's improvement in water infrastructure has gone on for decades, with particular improvement since 1990 with an increases in municipal water supply utilities coverage from 50% in 1990 to 88% in 2005. (Browder et al. 2007, xvii) In the same report on infrastructural improvements, the authors repeatedly cite concerns for water quality and quantity issues, citing the problem originating from "outdated water treatment technology and high levels of pollution in the raw water." (Browder et al. 2007, 17) The report also states that "Water quality monitoring is generally poor and the data is consequently unreliable," however this is outdated. (Browder et al. 2007, 17) The report continues that national policies, including drinking water quality, are only implemented in higher-tier cities and are often loosely enforced. (Browder et al. 2007, 30) The problem was especially evident in second tier, third tier and non-urban towns, as evident below:

{table} Urban Water Market Segments :name: wb-2005-urban-water

Market Segment	Number of Cities	Total Population (million)	Per Capita GDP (RMB)	Average Wastewater Treatment Coverage (%)	Average Water Supply Coverage (%)
Pop > 2m, GDP/cap > $3k	21	90	35,900	61	93
0.5m < Pop < 2m, $1.5k < GDP/cap < $3k	331	201	19,100	38	91
Pop <0.5m, GDP/cap < $1.5k	310	58	7,300	21	86
Country Towns	1,636	96	N/A	11	82

(Browder et al. 2007, 31, tab. 3.1)

The report continues, noting a slight increase in average category V or V+ in Chinese rivers from 1991 - 2002. (Browder et al. 2007, 33, fig. 3.3) It also notes discrepancies between water supply, water quality and public information for residents to judge the quality themselves (i.e. perception), noting that most urban residents do not drink water directly and is first boiled, which is both a cultural tradition and response to "the uncertain quality of the water from the tap." (Browder et al. 2007, 61)

China's water quality faces continued scrutiny in the 2010s. In 2011, as a part of the 12th Five Year Plan (2011-2015), China's central government earmarked almost RMB 700b (roughly US$108b) for water improvement, including water treatment and piping systems. (Hongqiao LIu 2015, section. Intro) Within this timeline, China's 'National Drinking Water Quality Standard' (GB 5749-2006)' was aimed to be implemented.[2] (中华人民共和国国家 2006) While improvements have been made in access to water, the quality of the water is questionable. China has historically been reluctant to release such data - the mid-2013 water quality assessment report was "classified" as of 2015 (Hongqiao LIu 2015, 4), and the state of china's soil pollution was classified

[2]This standard was first introduced in 2007 in accordance to international water quality standards. However, since the water quality across China then was far below the new standard, it only went into full effect in July 2012.

as a "state secret" until 2014. (Hornby 2014) Greenpeace East Asia determined that "Fourteen provinces failed to meet their water quality improvement targets during the 12th Five-Year Plan period (2011-2015)." ("Nearly Half of Chinese Provinces Miss Water Targets, 85% of Shanghai's River Water Not Fit for Human Contact" 2017) The analysis noted that national progress was made during the first half of the 12th Five-Year Plan period, but 'flattened off' beginning in 2013.

2.2.3 Water Quality Perception

While actual water quality is clearly important, so too is perception. Many factors exist in the public's perception of water quality. While "organoleptic properties" exist, most notably flavor, others exist including "risk perception, attitudes towards water chemicals, contextual cues provided by the supply system, familiarity with specific water properties, trust in suppliers, past problems attributed to water quality and information provided by the mass media and interpersonal sources." (Miguel de França Doria 2010) Water quality perceptions are especially important when water is used for drinking or other domestic purposes, causing some to consider perceptions of water quality more important than actual water quality. (Sheat 1992) Thus, it is important for policy makers to consider not only reality of water quality, but also the public's perception. Trends indicate that water quality policy should include not only the protection of human health, but also "acceptability." ("The Bonn Charter for Safe Drinking Water" 2004, sec. 7.7)

Research into water quality perception has existed since the 1960s, but is very heterogeneous, including; different use cases of water (drinking, household, agricultural, etc.); different delivery methods (piped, bottled) and different geographic and demographic localities, with most research conducted on bottled water and in developed countries. (Miguel de França Doria 2010)

One study represented research in an under-studied theme and demographic. Stakeholders' perceptions of important measures of river water quality in one region of Ghana suggest that in developing countries (or regions with lower objective water quality), faecal matter in and around rivers, and presence of plastic waste in rivers was deemed to be the most important measure, followed by the smell, clarity, color, and taste ("organoleptic properties") of the water. (Okumah, Yeboah, and Bonyah 2020, fig. 3)

Multiple factors drive perception of environmental issues. In a related issue, water scarcity, one study examined farmers' ($n = 446$) awareness and perception of water shortages in irrigation. (Tang, Folmer, and Xue 2013) They

found that "age, percentage of time spent on farming and social network are the main determinants of awareness," and that "water price and drought experience are the most important explanatory variables of perception" in the Guanzhong Plain, Shaanxi Province, China. Furthermore, they found that awareness and perception strongly interact, citing literature which found that households who used less water show a higher level of awareness of water conservation. (Gregory and Leo 2003) However, these study water quantity, not water quality, so they are not necessarily analogous.

2.2.4 Linking the Two

While many studies have examined the issues discussed earlier, few have looked at the alignment of water quality perceptions and actual water quality. One such study was conducted in Newfoundland, Canada, which "investigated public perceptions of water quality and the perceived health risks and associated with the actual quality of public water supplies in the same communities." (Ochoo, Valcour, and Sarkar 2017) While they found "no association with public satisfaction level and actual water quality of the respective communities," they did show demographic disparities in water quality perception.[3] Furthermore, the authors found that differences in opinion existed between respondents who were supplied by the same water system. However, this is expected due to the problematic nature of public opinion. (Shepard 1909) The authors also mentioned that water quality data is publicly available, but is most likely not communicated in a way which facilitated knowledge transfer.

Notes

China's political situation does not negate the impact that society can have on environmental policy. One study found that Chinese civil society organizations (CSOs) work in similar ways to those in more liberal and democratic countries. (Teets 2018)

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[3]The authors concluded that "Older, higher educated and high-income group respondents were more satisfied with water quality than the younger, less educated and low-income group respondents." However, they also stated that "We had little scope to explore the possible explanations, and hence further studies are required to verify the age, gender educational status and income differential about the satisfaction of public service like water supply."

3 Literature Review

`Taken from the thesis proposal`

This research proposal looked at many publications covering a broad range of related topics, some of which are outlined below:

- (Mekonnen and Hoekstra 2016) analyzed the current situation of water scarcity worldwide and found "two-thirds of the global population (4.0 billion people) live under conditions of severe water scarcity at least 1 month of the year," with nearly half living in China and India alone.
- (Liu and Yang 2012) look at water sustainability in China. They conclude that while China's recent policy efforts to alleviate water scarcity have been laudable, they are insufficient.
- (Araral and Wang 2013) look at water governance, water insecurity, and its related research. They find that a second-generation research agenda on water governance, including a focus on incentive structures and other multi-disciplinary approaches, is required.
- (Kahn, Hanjra, and Mu 2009) looks at the effects that water management has on crop production and food security in China. They conclude that water management affects many aspects of China's development, it also affects food pricing and security globally.
- (Araral and Wang 2013) looks at the relationship between water resource management and droughts in China and find that demand-side management can be more effective in meeting the challenges imposed by increasingly-severe droughts.
- (Piao et al. 2010) looks at the impacts of climate change on water resources and agriculture in China. They recommend that further research should be conducted to further understand the impacts of climate change.
- (Bai and Imura 2001) look at sustainable urban water resource management with a case study analysis of Tianjin, China. They suggest that a holistic, systems approach to water management is key for sustainability.
- (Lu 2014) looks at the importance of full project life-cycle cost analysis in addressing water challenges, particularly with wastewater treatment facilities, concluding that there are serious inefficiencies currently.
- (Rogers and Crow-Miller 2017) take more of an overview approach in synthesizing literature regarding the politics of water in China. They find that there are serious gaps in the literature regarding hydropolitics in China.

- (Webber, Crow-Miller, and Rogers 2017) look at the infrastructure side of water resource management in China with a review of the South-North Water Transfer Project. They find that this project is emblematic of the engineering-heavy approach often taken in China and will pose serious risks to regional governance and have serious environmental impacts.
- (Jin, Andersson, and Zhang 2016) looks at air pollution control policies in China with a retrospective perspective. They break down the history of air pollution policies into three phases, and conclude, amongst other takeaways, that there's a continuously increasing demand for quantification of all aspects regarding air pollution, including air quality, source identification, atmospheric modeling, and health risk assessments. These conclusions have the potential to be analogous to future water policy.
- (Hofstedt 2010) looks at the implications of domestic and international stability stemming from China's water scarcity and the government's current plans to address it. They argue that many of the options to alleviate water scarcity (increase water pricing, remove the requirement to be self-sufficient in grain production, increased efficiency of water usage in agriculture) all have serious downsides, and can have serious negative effects on political stability domestically and internationally.
- (Ward and Loftis 1986) looks at water quality monitoring and improvements (at the time) in data collection. They argue that increased data collection itself is not enough to affect the management of water resources; data analysis and reporting are also very important, and that understanding why monitoring water quality is important in the design process of water quality monitoring itself.
- (Glasgow et al. 2004) looks at the emerging technology surrounding real-time remote monitoring (RTRM) and concludes that this technology will have a progressively-larger impact and importance for monitoring water quality.
- (Shirode et al. 2018) and (Abubaker et al. 2018) look at the emerging technology of an Internet of Things (IoT) based water quality monitoring system. They show that this kind of system can address some of the limitations of manual, lab-based water quality testing (time-consuming, costly, etc.), and their real-time monitoring capabilities offer a large potential for improved water quality monitoring.

4 Research Questions

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Several questions are examined:

- How do peoples perception of water quality (importance, status, severity, their knowledge, etc) align with actual water quality?
- Is there a correlation between water quality and perception of water quality? (I.e. do perceptions and reality match)?
- Does knowledge of water quality affect perception?
- Does general education affect perception?

5 Methodology

5.1 Data Sources

The main analysis of this thesis center around two data sets, described below.

5.1.1 Chinese General Social Survey (CGSS)

This national survey, originally launched in 2003, aims to monitor and document relationships between quality of life (in both individual and collective scope) and social structures, both in urban and rural environments. (“Home-中国综合社会调查” n.d.) One of the main benefits is its longitudinal design – however this feature is not utilized in this thesis, which will be discussed later. The survey has been conducted nearly annually since 2003, with a major redesign conducted in 2010. Thus, surveys conducted prior to 2010 are referred to as “Cycle II” while surveys conducted in 2010 or later are referred to as “Cycle II.”

The CGSS is conducted by face-to-face interviews, which on average require 90 minutes to complete. (“Implementation-中国综合社会调查” n.d.) The survey consists of a questionnaire, which is composed of three modules (beginning in Cycle II):

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  {table} CGSS2010 Components and Description  :name: cgss2010-components
<!-- ~ put table here -->
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Module	Frequency	Dimensions	Variables	Coverage	Comments
Core	Annual	11	152	All participants	-
Background Variables	Annual	-	71	All participants	-
Social Change Trends	Annual	-	81	All participants	-
Topic	Annual (5 year rotation)	-	-	All participants	Either one or two topic modules per year.
Additional	-	-	-	1/3 - 1/2	Coverage depends on quantity of other questions and demand

(“Questionnaires-中国综合社会调查” n.d.)

The published data is in the form of a Stata file, which consists of 11783 rows (respondents) and 871 columns (variables).

The Environmental Module (“环境(ISSP)” or “L部分”[4]) is of particular interest in this analysis. (“调查问卷-中国综合社会调查” n.d.) It asks 25 questions and sub-questions, most of which are directly or indirectly related to the environment. There are several interesting questions which ask things related to environmental protection, importance, perception and knowledge:

The primary question regarding water quality perception was question `l14d` ask about the severity of harm to the environment caused by pollution of rivers and lakes.[5]. Survey participants can respond with a range from one to five, with one being “extremely harmful to the environment,” to five being “there is no harm at all.”[6] This question is significant because it quantifies the re-

[4] “How do you think the pollution of rivers, rivers and lakes in China is harmful to the environment?” which has been translated from the original Chinese question “您认为中国的江、河、湖泊的污染对环境的危害程度是?”

[5] “How do you think the pollution of rivers, rivers and lakes in China is harmful to the environment?” which has been translated from the original Chinese question “您认为中国的江、河、湖泊的污染对环境的危害程度是?”

[6] Extremely harmful to the environment – 1; Very harmful – 2; Some hazards – 3; Not very harmful – 4; There is no harm at all – 5; Cannot select – 8. This was translated from

spondents' perception of the severity of water quality on the environment. However, this question does not directly regard the perception of drinking water quality, or the importance of drinking water quality for health or other factors.

The primary question regarding water quality knowledge was question `12409` tests respondents' knowledge of the water quality scale used by China. The question requires respondents to state if a statement about water quality is correct, incorrect, or if they don't know.[7] This question is important since it tests respondents' knowledge of the water quality scoring system used in China. However, this question does not directly test users knowledge of the underlying environmental and pollutant issues which are the basis of this water quality scale, nor does it test their knowledge or education about environmental issues or protection directly.

Many other interesting questions are present in the data set. For this thesis, several others were selected, and the values were analyzed. This discussion is presented later in this thesis.

5.1.2 Blue City Water Quality Index Ranking (WQIR)

The second data set was compiled by the author from a report from the Institute of Public & Environmental Affairs, a non-profit environmental research organization based in Beijing. ("About IPE" n.d.) The report, the Blue City Water Quality Index 2019, compiles various surface, drinking, and ground water quality data published by various government agencies and assigns a score (their proprietary Blue City Water Quality Index Score (BCWQI)) and publishes the results at a sub-provincial level (second administrative level, or "admin 2"). (Jun, Sunan, and Haijin, n.d.) The methodology and conversion to the government's water quality score is provided. This report was chosen as the basis for this data set since it was the most comprehensive data the author could find with the closest publication date to the CGSS. The difference in time of the two data sets is discussed in the section. In the appendix of this report, the BCWQI for each second administrative level, including the city

对环境极其有害 – 1; 非常有害 – 2; 有些危害 – 3; 不是很有害 – 4; 完全没有危害 – 5; 无法选择 – 8

[7] The question is in a superset of knowledge about environmental knowledge, which states: "We also want to know your mastery of environmental protection knowledge. Please listen carefully to each of the following statements, and according to your solution to determine whether they are correct." The question is: "In the domestic water pollution report, the water quality of Category V (5) is better than that of Category I (1)," which is false. This question was translated from: "国内水体污染报告中,V(5)类水质要比I(1)类水质好."

name, province, and ranking, is included. This data, in a table in the PDF report, was exported into a comma separated value (.csv) file for later analysis.

5.2 Analysis

Analysis for this thesis was conducted using the general-purpose computer programming language Python. To allow for accessibility, readability, and reproducibility, the primary data analysis medium was a Jupyter notebook (Kluyver et al., n.d.), a document format which allows for text and code to be read and execute in an easy-to-read format, which was hosted on GitHub, to allow for accessibility. (Rynearson 2020) This was chosen after initial data analysis was conducted in a more traditional Python file, which was less collaborative and more cumbersome.

The two main data sets were loaded into the Jupyter notebook and reviewed for initial analysis, beginning with the CGSS2010. Then, after reviewing the data, it was cleaned and processed in several ways:

5.2.1 Choosing Appropriate Questions

Demographic Questions The thesis proposal and hypothesis were created before the author reviewed the data set, and before the author was aware of the environmental module of the CGSS. While many variables were deemed interesting, several variables were initially selected for broader analysis:[8]

“ ‘{table} Relevant CGSS2010 Demographic Components :name: cgss2010-demographic

```
| Code | Variable (English)             | Variable (Chinese) | Importance
|------|--------------------------------|--------------------|--------------------
| s41  | Province                       |                    | Location of the indi
| a2   | Gender                         |                    |
| a3a  | Birth year                     |                    | Age of respondant
| a7a  | Highest level of education     |                    | Education could be l
| a8a  | Personal total income          |                    | Income could be link
| a15  | Subjective personal health     |                    | Health could be link
| a62  | Family total income            |                    |
| a91  | Rural / agricultural household |                    |

As evident, not all of the variables were utilized, for several reasons. **Reasons*
```

[8] Translated from Chinese into English.

```
#### Environmental Questions
The CGSS includes many demographic data on each respondent. Of which, the following

```{table} Relevant CGSS2010 Environmental Components
:name: cgss2010-env
<!-- ~put table here -->
```

Code	Question (English)	Question (Chinese)	Response Types	Impact Drawback	Analyzed?
l1a	In your opinion, in terms of the current situation in our country, which of the following issues is the most important?				
l1b	like l1a, but 2nd most important				
l6a	In your opinion, in terms of the current situation in our country, which of the following issues is the most important?				
l6b	How serious are env. problems facing China?				
l7a	Which is most important env. issue in China?			Response types are categorical, so differences in severity is not captured.	
l7b	Which has greatest impact on you/family?				
l8a	Knowledge of causes of environmental problems from ?l7				
```

Code	Question (English)	Question (Chinese)	Response Types	Inspired Analysis	Drawback	Analyzed?
l8b	Knowledge of solutions of environmental problems from ?l7					
l12a	In order to protect the environment, to what extent are you willing to pay a higher price?					
l12b	like l12a, but with higher taxes					
l12c	like l12a/b, but with willingness to lower living standards					
l137	Environmental issues directly affect my daily life					
l14d	How do you think the pollution of rivers, rivers and lakes in China is harmful to the environment?					X
l15a / b	see question, about statements of responsibility for environmental protection (individuals/companies, government, etc.)					
l16c	In terms of solving environmental problems in your area, how do you think the local government has done in the past five years?”					
l20e	Do you often save water or reuse water specifically for environmental protection?					

Code	Question (English)	Question (Chinese)	Response Types	Inspo Drawback	Analyzed?
l2409	In the domestic water pollution report, the water quality of Category V (5) is better than that of Category I (1)				X

As evident, these questions include questions related to the environment in general, perceptions of the local, national and global environment, water, and knowledge of water quality issues.

Many more survey questions were included in the main and additional module sections. Many of these relate to social satisfaction, political involvement, and future aspirations. Future analysis could be done with many of these questions, but were not within the scope of this analysis.

5.2.2 Geographic Alignment

The two data sets are of differing geographic precision. The CGSS2010 (and all CGSSII data sets) include data on the province of where the respondent resided. Based on the structure of the data, it is assumed that more precise geographic information is included, however the CGSS publishing team chooses only to release the provincial information.

This is different than the WQIR2018 data, which is published at the sub-provincial level (admin 2). Thus, for comparative analysis, the mean water quality per province was calculated (more on this below).

Insert Admin1 and Admin 2 maps here.

5.2.3 Procedure

Once the data sets were loaded and reviewed for importance and quality, initial data analysis was conducted. Due to the author's limited experience with Python, multiple versions of the analysis were conducted in order to gain working knowledge of Python and of the data set.

For provincial comparative analysis, the data was sorted by province `s41` and grouped into visual and numerical approaches of looking for differences

between provinces. Several functions were created which allowed the author, and users, to see provincial comparative analyses on any question by inputting the question code. Either quantities of responses or their mean value would be output, as well as a heatmap for quick comparison. This initial analysis helped the author validate the main variables that were analyzed, which are discussed later.

Then, the WQIR2018 data was loaded. An initial plot was created to see the distribution of water quality per sub-province, sorted by province. Histograms were added to visualize the distribution of water quality measurements and values.

`{figure} ../wqir2018.svg :name: wqir2018-vis WQIR2018 distribution per province.`

From the previous steps, a subset of questions were created. The subset `cgss_strict`, which include only variables s41, l14d and l2409 were used for further initial analysis for simplicity.

Within these subsets, some values were revealed to be outside of the acceptable range (negative numbers). Since the origin or reason behind these values could not be determined, they were discarded. This lead to further discrepancies in the number of values depending on the province.

Once invalid values were removed, the two data sets were merged on their shared province values. This was done in two separate ways, which allowed for different analysis.

1. **On Provinces**: The mean water quality per province was added to the mean value per province of each analyzed variable. This allows for simpler data analysis, but loses some individual demographic data (gender, income, age, education, etc.).
2. **On Individuals**: The mean water quality per province was added to the individual response values. This makes the analysis slightly more complicated, but allows for comparison across the demographic data mentioned above. However, it should be noted that it runs the risk of providing a false sense of improved precision, and the mean water quality of the province may not accurately reflect the local situation of the individual.

5.3 Limitations

Several limitations exist based on the scope of both data sets, as well as limitation with some of the assumptions made by the author.

First, as discussed previously, there is misalignment between the CGSS and the WQIR data sets on two dimensions. The first is geographic. Since water quality data offered more geographic precision than the social survey responses (i.e. smaller regions), the effectiveness of comparison is reduced. This is in addition to the fact that water quality scores were originally presented as mean values per prefectural regions. This is different than the CGSS responses – while they were recorded at a more local level, geographic alignment information is only available at the provincial level. Further, the comparison between individuals and mean values per prefectural region results in the possibility that an two individuals in the same prefectural region experience different water quality, which is not possible to account for in the current methodology.

The second misaligned dimension is temporal, as the CGSS responses and water quality data differ by seven years. This is not ideal, since multiple indicators could have changed between that time. One is water quality, which has changed due to factors including the national government's initiatives, but this change has not been uniform across the country. Another indicator which could have changed is knowledge about water quality issues. Third, perception of water quality could have changed as well.

Further limitations come from the perceived findings based upon the CGSS question set. The two main questions which were analyzed, `l14d`[9] and `l2409`[10], are not perfectly analogous to the conclusions the author made. `l14d` refers more to rivers and lakes in China, which are not necessarily the drinking water sources which are used by the respondent. Further, the severity of pollution being harmful to the environment is not necessarily the same as the respondents' perception. `l2409` directly tests respondents' knowledge of water quality scales used by China, but this question, and `l14d`, do not necessarily test for knowledge, and perception, of the local water quality - the question refers to China in general.

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[9] "How do you think the pollution of rivers, rivers and lakes in China is harmful to the environment?" which has been translated from the original Chinese question "您认为中国的江、河、湖泊的污染对环境的危害程度是?"

[10] The question is in a superset of knowledge about environmental knowledge, which states: "We also want to know your mastery of environmental protection knowledge. Please listen carefully to each of the following statements, and according to your solution to determine whether they are correct." The question is: "In the domestic water pollution report, the water quality of Category V (5) is better than that of Category I (1)," which is false. This question was translated from: "国内水体污染报告中,V(5)类水质要比I(1)类水质好."

6 Water Quality, Perception and Knowledge in China

6.1 Draft Outline

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- Introduction
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"About IPE." n.d. Accessed February 1, 2021. http://wwwen.ipe.org.cn/about/about.html.

Abubaker, Alfiya, Kavya C. R, Tilju Thomas, Nikhil Joseph, and Shifana Begum. 2018. "A Study on IOT Approach for Monitoring Water Quality Using MQTT." International Research Journal of Engineering and Technology

(IRJET 5 (3): 3329–31. https://s3.amazonaws.com/academia.edu.documents/56787557/IRJET-V5I3785.pdf?response-content-disposition=inline%3B%20filename%3DA_Study_on_IOT_Approach_for_Monitoring_W.pdf&X-Amz-Algorithm=AWS4-HMAC-SHA256&X-Amz-Credential=AKIAIWOWYYGZ2Y53UL3A%2F20190613.

Araral, Eduardo, and Yahua Wang. 2013. "Water Governance 2.0: A Review and Second Generation Research Agenda." Water Resources Management 27 (11): 3945–57. https://doi.org/https://link.springer.com/article/10.1007%2Fs11269-013-0389-x.

Ardoin, Nicole M., Alison W. Bowers, and Estelle Gaillard. 2020. "Environmental Education Outcomes for Conservation: A Systematic Review." Biological Conservation 241 (January): 108224. https://doi.org/10.1016/j.biocon.2019.108224.

Armiero, Marco, and Lise Sedrez. 2014. A History of Environmentalism: Local Struggles, Global Histories. A&C Black.

Bai, Xuemei, and Hidefumi Imura. 2001. "Towards Sustainable Urban Water Resource Management: A Case Study in Tianjin, China." Sustainable Development 9: 24–35.

BBC News. 2013. "St Cuthbert: Father of Conservation," June 30, 2013. https://www.bbc.com/news/av/uk-england-23048394.

Bradley, Jennifer CAMPBELL, T. M. Waliczek, and J. M. Zajicek. 1999. "Relationship Between Environmental Knowledge and Environmental Attitude of High School Students." The Journal of Environmental Education 30 (3): 17–21. https://doi.org/10.1080/00958969909601873.

Browder, Greg, Shiqing Xie, Mingyuan Fan, Lixin Gu, David Ehrhardt, and Yoonhee Kim. 2007. Stepping Up: Improving the Performance of China's Urban Water Utilities. The World Bank. https://doi.org/10.1596/978-0-8213-7331-6.

Caldwell, Lynton Keith, and others. 1990. "International Environmental Policy: Emergence and Dimensions." International Environmental Policy: Emergence and Dimensions., no. Rev. Ed. 2.

Duan, Hongxia, and Rosanne Fortner. 2012. "A Cross-Cultural Study on Environmental Risk Perception and Educational Strategies: Implications for Environmental Education in China." International Electronic Journal of Environmental Education 1 (1): 0. https://dergipark.org.tr/en/pub/iejeegreen/104013.

F.A.O. 2011a. AQUASTAT Country Profile - China. AQUASTAT, Rome: The Food and Agriculture Organization of the United Nations. http://www.fao.org/3/CA0221EN/ca0221en.pdf.

———. 2011b. The Food and Agriculture Organization of the United Nations,

and Earthscan. Rome; London: FAO; Earthscan. http://www.fao.org/3/i1688e/i1688e.pdf.

———. 2014. AQUASTAT. http://www.fao.org/nr/water/aquastat/didyouknow/index2.stm.

———. 2016. AQUASTAT Main Database. Rome: Food and Agriculture Organization of the United Nations (FAO. http://www.fao.org/nr/water/aquastat/data/query/index.html?lang=en.

Glasgow, Howard B., JoAnn M. Burkholder, Robert E. Reed, Alan J. Lewitus, and Joseph E. Kleinman. 2004. "Real-Time Remote Monitoring of Water Quality: A Review of Current Applications, and Advancements in Sensor, Telemetry, and Computing Technologies." Journal of Experimental Marine Biology and Ecology 300 (1-2): 409–48. https://doi.org/https://www.sciencedirect.com/science/article/pii/S0022098104001066.

Greenpeace, 绿色和平. 2017. 十二五. https://energydesk.greenpeace.org/2017/06/01/china-water-quality-data-shanghai-beijing/.

Gregory, Gary D., and Michael Di Leo. 2003. "Repeated Behavior and Environmental Psychology: The Role of Personal Involvement and Habit Formation in Explaining Water Consumption1." Journal of Applied Social Psychology 33 (6): 1261–96. https://doi.org/https://doi.org/10.1111/j.1559-1816.2003.tb01949.x.

Hironaka, Ann. 2002. "The Globalization of Environmental Protection: The Case of Environmental Impact Assessment." International Journal of Comparative Sociology 43 (1): 65–78. https://doi.org/10.1177/002071520204300104.

Hofstedt, Todd. 2010. "China's Water Scarcity and Its Implications for Domestic and International Stability." Asian Affairs: An American Review 37: 71–83.

Holcomb, Briavel. 1977. Review of Review of Environmental Knowing: Theories, Research, and Methods, by Gary T. Moore and Reginald G. Golledge. Human Ecology 5 (3): 273–75. https://www.jstor.org/stable/4602415.

"Home-中国综合社会调查." n.d. Accessed February 1, 2021. http://cgss.ruc.edu.cn/English/Home.htm.

Hongqiao LIu. 2015. "China's Long March to Safe Drinking Water." China Water Risk. https://www.chinawaterrisk.org/wp-content/uploads/2015/03/Chinas-Long-March-To-Drinking-Water-2015-EN.pdf.

Hornby, Lucy. 2014. "China Admits Widespread Soil Pollution in 'State Secret' Report." April 18, 2014. https://www.ft.com/content/c250bd4c-c6b4-11e3-9839-00144feabdc0.

Huang, Bihong, and Yining Xu. 2019. "Environmental Performance in Asia: Overview, Drivers, and Policy Implications." SSRN Electronic Journal. https:

//doi.org/10.2139/ssrn.3541554.

"Implementation-中国综合社会调查." n.d. Accessed February 1, 2021. http://cgss.ruc.edu.cn/English/About_CGSS/Implementation.htm.

"Intergovernmental Conference on Environmental Education, Tbilisi, USSR, 14-26 October 1977: Final Report - UNESCO Digital Library." n.d. Accessed February 10, 2021. https://unesdoc.unesco.org/ark:/48223/pf0000032763.

Ittelson, William H. 1973. Environment and Cognition. Environment and Cognition. Oxford, England: Seminar Press.

Jin, Yana, Henrik Andersson, and Shiqiu Zhang. 2016. "Air Pollution Control Policies in China: A Retrospective and Prospects." International Journal of Environmental Research and Public Health 12.

Jing, Li. 2016. 80 Per Cent of Groundwater in China's Major River Basins Is Unsafe for Humans, Study Reveals. https://www.scmp.com/news/china/policies-politics/article/1935314/80-cent-groundwater-chinas-major-river-basins-unsafe.

Jun, MA, SHEN Sunan, and ZHUGE Haijin. n.d. "2018 Blue City Water Quality Index," 25.

Kahn, Shahbaz, Munir A. Hanjra, and Jiaxin Mu. 2009. "Water Management and Crop Production for Food Security in China: A Review." Agricultural Water Management 96: 349–60.

Kluyver, Thomas, Benjamin Ragan-Kelley, Fernando Pérez, Matthias Bussonnier, Jonathan Frederic, Jessica Hamrick, Jason Grout, et al. n.d. "Jupyter Notebooks—a Publishing Format for Reproducible Computational Workflows," 4.

Liefländer, A. K., and F. X. Bogner. 2018. "Educational Impact on the Relationship of Environmental Knowledge and Attitudes." Environmental Education Research 24 (4): 611–24. https://doi.org/10.1080/13504622.2016.1188265.

Liu, Jianguo, and Wu Yang. 2012. "Water Sustainability for China and Beyond." Science 337: 649–50.

Lu, Shuping. 2014. "Water Infrastructure in China: The Importance of Full Project Life-Cycle Cost Analysis in Addressing Water Challenges." International Journal of Water Resources Development 30 (1): 47–59.

Mekonnen, Mesfin M., and Arjen Y. Hoekstra. 2016. "Four Billion People Facing Severe Water Scarcity." Science Advances 2 (2).

Miguel de França Doria. 2010. "Factors Influencing Public Perception of Drinking Water Quality." Water Policy 12 (1): 1–19. https://doi.org/10.2166/wp.2009.051.

Neal, Philip, and Joy Palmer. 2003. The Handbook of Environmental Education. 0th ed. Routledge. https://doi.org/10.4324/9780203422021.

"Nearly Half of Chinese Provinces Miss Water Targets, 85% of Shanghai's River Water Not Fit for Human Contact." 2017. Greenpeace East Asia. July 1, 2017. https://www.greenpeace.org/eastasia/press/1459/nearly-half-of-chinese-provinces-miss-water-targets-85-of-shanghais-river-water-not-fit-for-human-contact.

Ochoo, Benjamin, James Valcour, and Atanu Sarkar. 2017. "Association Between Perceptions of Public Drinking Water Quality and Actual Drinking Water Quality: A Community-Based Exploratory Study in Newfoundland (Canada)." Environmental Research 159 (November): 435–43. https://doi.org/10.1016/j.envres.2017.08.019.

Okumah, Murat, Ata Senior Yeboah, and Sylvester Kwaku Bonyah. 2020. "What Matters Most? Stakeholders' Perceptions of River Water Quality." Land Use Policy 99 (December): 104824. https://doi.org/10.1016/j.landusepol.2020.104824.

Organization, World Health, and others. 2019. Progress on Household Drinking Water, Sanitation and Hygiene 2000-2017: Special Focus on Inequalities. World Health Organization.

Piao, Shilong, Philippe Cias, Yao Huang, Zehao Shen, Shushi Peng, Junsheng Li, and Liping Zhou. 2010. "The Impacts of Climate Change on Water Resources and Agriculture in China." Nature 467: 43–51. https://doi.org/https://www.nature.com/articles/nature09364.

"Questionnaires-中国综合社会调查." n.d. Accessed February 1, 2021. http://cgss.ruc.edu.cn/English/Documentation/Questionnaires.htm.

Ramsey, Charles E., and Roy E. Rickson. 1976. "Environmental Knowledge and Attitudes." The Journal of Environmental Education 8 (1): 10–18. https://doi.org/10.1080/00958964.1976.9941552.

Reuters. 2009. FACTBOX: Facts on China's South-to-North Water Transfer Project. https://www.reuters.com/article/us-china-dams-sb-idUSTRE51Q02L20090227.

Rogers, Sarah, and Britt Crow-Miller. 2017. "The Politics of Water: A Review of Hydropolitical Frameworks and Their Application in China." Wiley Interdisciplinary Reviews: Water.

"Rules and regulations of the Yellowstone national park. Department of the interior." 1881. Online text. Library of Congress, Washington, D.C. 20540 USA. May 4, 1881. https://www.loc.gov/resource/rbpe.2380030a/?st=text.

Rynearson, William. 2020. "Wrynearson/China-Water." GitHub. 2020. https://github.com/wrynearson/china-water.

Sheat, A. 1992. "Public Perception of Drinking Water Quality. Should We

Care." In New Zealand Water Supply and Disposal Association Annual Conference, Christchurch, New Zealand.

Shepard, Walter J. 1909. "Public Opinion." American Journal of Sociology 15 (1): 32–60. https://www.jstor.org/stable/2762619.

Shiklomanov, L.A. 1993. "World Freshwater Resources." In Water in Crisis: A Guide to the World's Fresh Water Resources, edited by Peter H. Gleick, 13–24. New York: Oxford University Press.

Shirode, Mourvika, Monika Adaling, Jyoti Biradar, and Trupti Mate. 2018. "IOT Based Water Quality Monitoring System." International Journal of Scientific Research in Computer Science, Engineering and Information Technology 3 (1): 1423–28.

Stapp, William B, Dean Bennett, William Bryan, Jerome Fulton, Jean MacGregor, Paul Nowak, James Swan, and Robert Wall. 1969. "The Concept of Environmental Education." Journal of Environmental Education 1 (1): 30–31. http://www.hiddencorner.us/html/PDFs/The_Concept_of_EE.pdf.

Tang, Jianjun, Henk Folmer, and Jianhong Xue. 2013. "Estimation of Awareness and Perception of Water Scarcity Among Farmers in the Guanzhong Plain, China, by Means of a Structural Equation Model." Journal of Environmental Management 126 (September): 55–62. https://doi.org/10.1016/j.jenvman.2013.03.051.

Teets, Jessica. 2018. "The Power of Policy Networks in Authoritarian Regimes: Changing Environmental Policy in China." Governance 31 (1): 125–41. https://doi.org/https://doi.org/10.1111/gove.12280.

"The Bonn Charter for Safe Drinking Water." 2004. London, UK: International Water Association. 2004.

"The Modern Environmental Movement | American Experience | PBS." n.d. Accessed February 13, 2021. https://www.pbs.org/wgbh/americanexperience/features/earth-days-modern-environmental-movement/.

The World Bank. 2016. High and Dry: Climate Change, Water and the Economy. Washington, D.C: World Bank Group.

UN-Water. n.d. "Water Scarcity." UN-Water (blog). Accessed February 9, 2021. https://www.unwater.org/water-facts/scarcity/.

US EPA, OP. 2013. "History of the Clean Water Act." Overviews and Factsheets. US EPA. Great Lakes. February 22, 2013. https://www.epa.gov/laws-regulations/history-clean-water-act.

Ward, Robert C., and Jim C. Loftis. 1986. "The 'Data-Rich but Information-Poor' Syndrome in Water Quality Monitoring." Environmental Management 10 (3): 291–97.

Webber, Michael, Britt Crow-Miller, and Sarah Rogers. 2017. "The South–

North Water Transfer Project: Remaking the Geography of China." Regional Studies 51 (3): 370–82.

Wendling, Z. A., Emerson, J. W., de Sherbinin, A., Esty, D. C., and et al. 2020. "2020 Environmental Performance Index." New Haven, CT: Yale Center for Environmental Law & Policy.Yale Center for Environmental Law & Policy. epi.yale.edu.

Wendling, Zachary, Jay Emerson, Daniel Esty, Marc Levy, and Alex de Sherbinin. 2018. 2018 Environmental Performance Index (EPI). https://doi.org/10.13140/RG.2.2.34995.12328.

World Economic Forum. 2016. The Global Risks Report 2016. 11th ed. Geneva: World Economic Forum.

Wu, C., C. Maurer, Y. Wang, S. Xue, and D.L. Davis. 1999. "Water Pollution and Human Health in China." Environmental Health Perspectives 107 (4): 251–56.

Xie, Zhenhua. 2020. "China's Historical Evolution of Environmental Protection Along with the Forty Years' Reform and Opening-up." Environmental Science and Ecotechnology 1 (January): 100001. https://doi.org/10.1016/j.ese.2019.100001.

Zhang, Junfeng, Dennis L. Mauzerall, Tong Zhu, Song Liang, Majid Ezzati, and Justin Remais. 2010. "Environmental Health in China: Challenges to Achieving Clean Air and Safe Water." Lancet 357 (9720): 1110–10. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4210128/.

Zube, Ervin H. 1999. "Environmental Perception." In Environmental Geology, 214–16. Dordrecht: Springer Netherlands. https://doi.org/10.1007/1-4020-4494-1_120.

中华人民共和国国家. 2006. "生活饮用水卫生标准." 中华人民共和国国家. http://www.chinacdc.cn/jdydc/200701/P020070118322144919922665749200 6497.pdf.

国务院. 2015. 国务院关于印发水污染防治行动计划的通知. http://www.gov.cn/zhengce/content/2015-04/16/content_9613.htm.

"调查问卷-中国综合社会调查." n.d. Accessed February 1, 2021. http://cgss.ruc.edu.cn/xmwd/dcwj.htm.