Water Scarcity and Pollution:

The effect of improved water quality monitoring data on China's water policy

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INTRODUCTION

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 underappreciate 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 (H_2O) 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.[1]

Water scarcity, being the scarcity of availability or access to usable freshwater resources, is a significant and increasing global issue.[2] Globally, water usage has increased at a rate of 1.7 times the rate of population increase over the past century.[3] Water stress and scarcity can be caused by increased water withdrawal, population increase, and climate, amongst others.[4] Water scarcity is three dimensional, including physical, infrastructural and institutional factors.[5] 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.[6]

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.[7] 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 Globally, 70 percent of global renewable water resources withdrawn for human use is used for agriculture.[8] Affected by population growth and the increased consumption of more water-intensive food due partially to economic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

[1] (Shiklomanov, 1993)
[2] (UN Water, n.d.)
[3] (FAO, 2014)
[4] (FAO, 2014)
[5] ((FAO) & Earthscan, 2011)
[6] (Mekonnen & Hoekstra, 2016)
[7] (World Economic Forum, 2016)
[8] ((FAO) & Earthscan, 2011)

demand.[9] 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.[10]

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.[11] 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.[12] 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.[13]

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.[14] Economic costs attributed to poor water quality in 2003 were over 1.16% of GPD.[15]

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.[16] 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?"[17]

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.[18] 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 periods.[19]

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

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[9] ((FAO) & Earthscan, 2011)
[10] (The World Bank, 2016)
[11] (FAO, 2016)
[12] (FAO, 2011)
[13] (Zhang, et al., 2010)
[14] (Jing, 2016)
[15] (Wu, et al., 1999)
[16] (Rogers & Crow-Miller, 2017)
[17] (Reuters, 2009)
[18] (Zhang, et al., 2010)
[19] (Zhang, et al., 2010)

Ten Plan," which sets water quality-related goals to be met by 2020.[20] However, results so far have been mixed, with nearly half of all provinces missing their water quality targets in 2017.[21] 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.

SIGNIFICANCE

As outlined above, water scarcity is one of the most likely and most impactful risks facing humanity in the medium-term future. China acutely suffers from water quality issues stemming from pollution. One of the most effective ways to address this problem is with the introduction or improvement of water policy. Policy regarding water usage, preservation, or cleanup decided by the central government, or lack thereof, will affect not only all Chinese citizens but those directly affected by the products and resources derived from water in China, including manufacturing, services, and agriculture.

Water pollution further limits the already scarce water in many regions in China, where much of the freshwater resources available in streams, rivers, and aquifers are unfit for human consumption or use. The lack of freshwater could prove catastrophic to civilizations. Understanding the connections between water scarcity, water pollution, and water policy is vital for having a holistic view of the issue at hand.

LITERATURE REVIEW

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

- (Mekonnen & 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.
- (Jianguo Liu, 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 & 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.
- (Shahbaz Kahn, 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.
- (Wang, et al., 2012) 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.

[20] (国务院, 2015)

[21] (Greenpeace 绿色和平, 2017)

- (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 & 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 & 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, et al., 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, et al., 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 & 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.

RESEARCH OBJECTIVE

This research wants to investigate the relationship between water quality data, education and water policy in China. The hypothesis is that improved data on water quality (including quality, precision, quantity, and frequency improvements) can lead to improved knowledge by the general population and by policymakers, which can lead to improved action on water policy. Specifically, the proliferation of water quality monitoring technology and its associated data analysis capabilities, commonly referred to as big data, have the potential to have very significant impacts on water quality awareness, education, and policy.

ANTICIPATED CONTRIBUTION

Since the technology advances of this "big data" of water quality, there has been limited research so far analyzing the impacts of this improved technology worldwide, let alone in China. Additionally, China has only recently (2015) announced aggressive policy approaches towards improving water quality. Since the problems of water scarcity and poor water quality are extremely unlikely to go away soon, new policy initiatives have the potential to consider the education and knowledge aspects of water quality and water quality monitoring.

RESEARCH PLAN, METHODOLOGY AND ELABORATION

This research project plans to be done in several stages and uses several different methodologies.

The first stage will deal with background research. First, desktop research into the current state of water scarcity, water quality, water quality monitoring, and water policy, both in China and internationally, will be conducted, and an overview will be provided. Next, literature review and case study analysis will be conducted, looking for previous instances of "big data" water quality monitoring and any policy decisions surrounding this. Additionally, an analysis of current water quality organizations will be conducted.

The second stage will look at the current level of water quality education amongst the populous and amongst policymakers. This stage will include a cross-regional analysis of primary and secondary source data collection through interviews and surveys. The primary source data collection will be conducted by interviewing the general population and policymakers, both of which who are and who are not directly affected by poor water quality. The secondary source data will consist of analyzing nationwide survey responses, including the China Social Survey (中国综合社会调查).

Ideally, the second stage will be able to isolate the level of education of water quality from other factors, such as location, local GDP, age, education levels, as well as education from other sources, including school, news, and media. This last part will be a challenge of this research project.

The third stage will be to find a correlation between the education of water quality from water quality data and water quality policies that improve water quality. This correlation could be shown by showing regions with real water quality improvement, or by looking at the quantity and quality of new water policy being proposed and implemented locally.

SOLUTIONS AND IMPACTS

The solutions and impacts provided by this thesis could be immense. If a correlation between water quality data, education and policy can be made, it has the potential of providing the academic backing to push for more water quality-friendly policies, which can then lead to reduced water scarcity.

SCHEDULE

Thesis Writing Schedule

Stage one will be conducted during the summer and fall of 2019 and the spring of 2020. During this time, a comprehensive look at all background information and literature review will also be conducted. Parts of stage two, including the secondhand survey data analysis, will also be conducted during this time.

Stage two will be conducted during the summer of 2020. Field visit locations, contacts, and other details will be determined prior to this time.

Stage three will be conducted during the fall of 2020, including data analysis of the data collected during stage two, and the crafting of the final research report.

Proposed Date of Defense

It is proposed that this research defense should be held on or around January 15th, 2021.

CONCLUSION

In conclusion, water scarcity has been shown to be a large risk to people worldwide, especially so with people in northern China. This risk is amplified by the poor state of water quality throughout the country. Recent developments in water quality monitoring data and analysis have led to the technological capability of large arrays of data sources. This improvement in data quality, quantity, precision, and frequency have the potential for having profound impacts on water policy in China. This research project proposes to investigate this link and hypothesizes that an improvement in data on water quality can lead to an improvement in water quality education, which can, therefore, lead to an improvement in water quality policy. Research into this topic will be of a mixed-methodology method, including primary and secondary source data collection. A cross-regional analysis will attempt to isolate the effect of improved water quality data on water quality-related policy and will be done through general population interviews, policymaker interviews, national survey data analysis, and global case study analysis. The findings of this paper can hopefully serve as a tool for current and future water policymakers to address water quality issues in China and abroad.

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