CHINA'S WATER QUALITY, QUANTITY, ENVIRONMENTAL MANAGEMENT ISSUES AND THE EFFECTIVENESS OF GOVERNMENT-IMPOSED SOLUTIONS: AN ANALYSIS FROM THIRTY THOUSAND FEET

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Submitted to the Undergraduate Faculty of

The Swanson School of Engineering, Department of Civil and Environmental Engineering

in partial fulfillment

of the requirements for the degree of Bachelor of Philosophy

University of Pittsburgh

2010

UNIVERSITY OF PITTSBRUGH

SWANSON SCHOOL OF ENGINEERING

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China's water quality, quantity, and environmental management issues and policies were analyzed through three lenses: environmental policy through regulations, policies and projects to increase water quantity, and water quality treatment and distribution methods pursued. Three issues, rather than one, were focused upon in order to enable a more holistic understanding of the political climate and the policy mechanisms employed by the Chinese government.

Concerning environmental regulations, current state of the art, as well as implementation issues were studied concerning Environmental Impact Assessment (EIA) in China. Additionally, China's surface water regulations were compared to the United States Environmental Protection Agency (USEPA) National Primary Drinking Water Standards in order to determine the level of stringency reached by Chinese standards. Though it was determined that Chinese standards are equally –or more strict –than the American standards, implementation and enforcement of regulations remains an issue.

The effectiveness of some water quantity solutions implemented by the Chinese government were explored as well, specifically, the effectiveness of the South-to-North water transfer project was analyzed by comparing the water gained from that project to the water saved if more efficient irrigation methods were installed under varying scenarios of acceptance for three study years. It was determined that the amount of water gained from the entire water transfer project was nearly equal to, or less than, the volume of water saved if more efficient irrigation methods were utilized. Additionally, further

development of rainwater harvesting program in Gansu Province was referenced as another means by which to increase the quantity of water available.

Government priorities concerning various methods of water treatment and distribution were addressed as well. Though the government has made major investments in the construction of modern treatment plants, requisite investments have not been made in the distribution system. Consequently, the collection rates in many areas are low. In order to bridge the gap between infrastructure construction and treated water demand, distributed treatment, or point-of-use treatment was also explored. However, it was determined that the barriers to entry of point-of-use treatment in China are high, and thus, it would be difficult to establish a treatment program.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

I. WATER QUALITY, QUANTITY, AND ENVIRONMENTAL MANAGEMENT ISSUES IN CHINA- AN INTRODUCTION

China occupies an area roughly the size of the continental United States and houses the largest population on Earth at 1.31 billion in 2008 (End-of-Year 2007) and 1.338 billion in 2009 according to respective Chinese and United States sources. [1][2] Since 1978, China's Gross Domestic Product has grown sixty-eight-fold [1] to become the third-largest economy[2] at $3.656 trillion in 2008[1] (End-of-Year 2007, assuming an exchange rate of 6.8249 RMB to 1 USD[2]), or $8.789 trillion PPP according to 2009 estimates.[2] However, China remains a nation in transition. The capitalistic model implemented and encouraged by Chinese leaders has caused an historic modernization of the country, yet the justice system still faces issues with corruption. [3]

The low value-added nature of agriculture[4] has resulted in the prioritizing of the industrial sector over the agriculture sector,[4] which will not only affect China's ability to remain self-sufficient, but will affect the many nations of the world[2] who import agricultural products from China as well. Industry and agriculture pollute China's water sources through the dumping of wastewater directly into water bodies and from the runoff due to increased fertilizer application, respectively. [4] The pollution of water bodies in China is already compromising China's economic gains; in 2007, economic losses attributed to poor

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[1] National Bureau of Statictics of China. *China Statistical Yearbook- 2008.* Date Accessed: 23 April 2010. http://www.stats.gov.cn/tjsj/ndsj/2008/indexeh.htm.

[2] CIA World Factbook: China. Date Accessed: 22 June 2009. https://www.cia.gov/library/publications/the-world-factbook/geos/CH.html.

[3] Becker, Jeffrey. *Tackling Corruption at its Source: The National Corruption Prevention Bureau.* Journal of Chinese Political Science, Vol. 13, No. 3. 2008.

[4] Jiang, Yong. "China's Water Scarcity." Journal of Environmental Management, 2009. p. 1-12.

water quality were at least 158 billion yuan[4] (20.78 billion USD based on a 2007 exchange rate of 760.4 RMB to 100 USD[1]). This economic loss represents 1.16% of China's annual GDP. [4]

In addition to economic losses, the degraded water quality in China is greatly impacting human health, especially in rural areas where according to the World Bank, more than 300 million people through the country consume unsafe drinking water. [5] Health effects stemming from the consumption of unsafe drinking water can be associated with higher cancer rates;[4] in China, "the rates of stomach, liver, and bladder cancers are highest in rural areas and the mortality rates of liver and stomach cancers in China are well above the world averages." [4] An ongoing World Bank study concluded that "(in China,) waterborne diseases, such as diarrhea, cholera, and typhoid…could be reduced by almost 50 percent by moving from heavily to moderately polluted water…"[5] The same study estimates that in 2003, nine million cases of diarrhea were due to water pollution.[5]

In general, China's environmental policies and associated actions can be viewed through three lenses: environmental policy as seen through regulations, policies and projects to increase water quantity, and water quality treatment and distribution methods pursued. This paper will focus on each of these areas in turn rather than focusing on one specific area; this is to enable a more holistic understanding of the political climate and the policy mechanisms employed by the Chinese government.

[1]National Bureau of Statictics of China. *China Statistical Yearbook- 2008.* Date Accessed: 23 April 2010. http://www.stats.gov.cn/tjsj/ndsj/2008/indexeh.htm.

[4] Jiang, Yong. "China's Water Scarcity." Journal of Environmental Management, 2009. p. 1-12.

[5]World Bank. "Discussion Papers: China- Water Quality Management and Institutional Considerations." September, 2006.

II. A GENERAL ANALYSIS OF THE CHINESE GOVERNMENT'S VIEW ON THE ENVIRONMENT THROUGH REGULATIONS

A. CASE STUDY: ENVIRONMENTAL POLICY INTEGRATION (EPI), ENVIRONMENTAL IMPACT ASSESSMENT (EIA), AND STRATEGIC ENVIRONMENTAL ASSESSMENT (SEA) IN CHINA

1. Introduction

China's fast-paced development that prioritized economic growth over environmental protection has led it to become the third-largest economy in the world;[2] however, China has become the world's largest emitter of CO_2. [6] Realizing that economic growth has come at the expense of the environment, the 11th Five-Year-Plan represents a strategic shift toward sustainable water resources development in China. [4] This approach comes under the umbrella of "a scientific outlook on development," [4][7] one of the main objectives of the current administration.[6] In order to help achieve this goal, the Chinese Ministry for Environmental Protection has been called upon to develop and refine Environmental Impact Assessment (in China called Plan EIA, or PEIA) as a capacity building tool for integrating environmental concerns into planning activities.[5][6]

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[2]CIA World Factbook: China. Date Accessed: 22 June 2009. https://www.cia.gov/library/publications/the-world-factbook/geos/CH.html.

[5]World Bank. "Discussion Papers: China- Water Quality Management and Institutional Considerations." September, 2006.

[6] International Energy Agency. *CO_2 Emissions from Fuel Combustion Highlights- 2009 Edition. OECD,* 2009.

[7] Bina, Olivia, et. al. *"Transition from Plan Environmental Impact Assessment to Strategic Environmental Assessment: Recommendations of the Project 'Policy Instruments for a Chinese Sustainable Future."* Stockholm Environment Institute. May 2009.

2. Current status of EIA/SEA in China (also known as PEIA)

The 2002 Environmental Impact Assessment (EIA) Law, which came into force in September 2003, requires the application of project and plan EIAs to ten categories of 'specialized plans.' [5][7] These plan categories include industry, agriculture, animal husbandry, forestry, energy, water conservation, transportation, urban construction, tourism, and natural resources development. [7] Additionally, EIAs are required for four 'comprehensive development plans,' including land-use, river basin, coastal, and regional development.[7] This comprehensive law, though entitled the "EIA Law," requires Strategic Environmental Assessment (SEA) for programs as well. [8]

Comparatively, in the United States, the 1969 National Environmental Policy Act (NEPA) requires federal agencies to complete a detailed statement on "the environmental impact of the proposed action, any adverse environmental effects which cannot be avoided should the proposal be implemented, alternatives to the proposed action, the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented." [9] This statement, which came to be known as an Environmental Impact Statement (EIS), must be included in every Federal action significantly affecting the quality of the human environment. [9]

While the EIA Law has been in existence for over five years, there have been difficulties with its continued and widespread enforcement. [5] According to Professor Wang Canfa of the China University of Political Science and Law (via Lin Gu), "the rate of China's environmental laws and regulations that are actually enforced is estimated to be barely 10 percent." [10] While the EIA compliance rate for medium- to large-scale projects was close to ninety percent by the late 1990s, the compliance rate for small, local projects is unknown (most likely lower due to corruption problems at the local level). [3][5][8] Enforcement

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[3]Becker, Jeffrey. *Tackling Corruption at its Source: The National Corruption Prevention Bureau.* Journal of Chinese Political Science, Vol. 13, No. 3. 2008.

[5]World Bank. "Discussion Papers: China- Water Quality Management and Institutional Considerations." September, 2006.

[7]Bina, Olivia, et. al. *"Transition from Plan Environmental Impact Assessment to Strategic Environmental Assessment: Recommendations of the Project 'Policy Instruments for a Chinese Sustainable Future."* Stockholm Environment Institute. May 2009.

[8] Glasson, John, et. al. Introduction to Environmental Impact Assessment, 3rd Ed. Routledge, 2005.

[9] United States Government. *The National Environmental Policy Act of 1969: Title 1- Congressional Declaration of National Environmental Policy.* http://ceq.hss.doe.gov/nepa/regs/nepa/nepaeqia.htm.

[10] Lin, Gu. *China Improves Enforcement of Environmental Laws*. China Features. 29 September 2005. http://www.chinese-embassy.org.uk/eng/zt/Features/t214565.htm.

of the EIA Law is a major issue;[5][7][11] however, the current issues with implementation and decreased effectiveness of EIAs are caused principally by lack of quality control and timing of the EIA,[12] stemming from a historic non-prioritization of the environment and environmental protection in favor of growth.[5][7][11]

3. Problems with Current EIA Practice

a. Critique of EIA- Water Supply and Wastewater Treatment Project in Fuzhou, China: In general, the quality of Chinese EIAs is inconsistent; typically the highest quality EIAs (leading examples) are conducted for the most high-profile projects where top officials are involved,[7] while the lower-quality EIAs come from less visible projects. These projects tend to be in the richest parts of China (the Eastern coast and the South)[11] and are in many cases done in cooperation with an international development organization, such as the World Bank, the European Union, or the Asian Development Bank. The EIA that is presented here as a case study was conducted for a water supply and wastewater treatment project in Fuzhou, China. [13] Fuzhou City is located on the Southeastern coast of China and is an autonomous economic zone,[13] indicating that it possibly is afforded higher privilege by the Chinese government. This EIA exemplifies both typical issues found in Chinese EIAs and atypical aspects that show a departure from criticized trends in Chinese EIA practice. The EIA cited herein was prepared for a project (three subprojects) that was funded by the Asian Development Bank; [13] thus, final approval of the EIA by an outside organization was a necessary part of the process in this case. [13] Consequently, producing a high-quality EIA that concluded that expansion of the infrastructure for this "regional center for business, commerce, and industry," will have either have no negative environmental effects, or that those effects could be mitigated, would have been a priority for the provincial government. [13]

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[5] World Bank. "Discussion Papers: China- Water Quality Management and Institutional Considerations." September, 2006.

[7] Bina, Olivia, et. al. *"Transition from Plan Environmental Impact Assessment to Strategic Environmental Assessment: Recommendations of the Project 'Policy Instruments for a Chinese Sustainable Future."* Stockholm Environment Institute. May 2009.

[11] Bina, Olivia. *An Environmental Policy Integration Perspective of the Weaknesses and Potentials of Current Chinese Practice*. Wuppertal Institute. 30 June 2009.

[12] Spengler, Laura. *Public Participation in Strategic Environmental Assessment in China.* Wuppertal Institute, European Union Asia Pro Eco II Programme. June 2009.

[13] Fuzhou Municipal Government, Asian Development Bank. *Summary Environmental Impact Assessment: Fuzhou Water Supply and Wastewater Treatment Project in the People's Republic of China.* May 1998.

The actual EIA was prepared by the Fujian Provincial Environmental Protection Research Institute for the Fuzhou Municipal Government. [13] In addition to review and approval by the Fujian Environmental Protection Bureau and the National Environmental Protection Agency, the EIA was also reviewed by Asian Development Bank (ADB) consultants. [13] The EIA was prepared according to both the government's requirements and the Bank's *Environmental Assessment Requirements and Environmental Review Procedures* (for Summary EIA). Unlike what is typical many construction projects that are not overseen by an outside funding organization, construction had not begun for the majority of the project components that were within the scope of the EIA. [5][12][13] However, construction was already complete for the remainder of the project not being funded by the Asian Development Bank. [13]

Though the EIA for the Fuzhou projects followed established protocol, some issues with the EIA remain. Though alternative scenarios are mentioned, these alternatives are not elaborated upon or fully developed; consequently, it is impossible to compare the alternatives with the planned scenario. [13] Additionally, no baseline alternative (the "do nothing" alternative) was mentioned for any project. [8][13]

The decision to locate the water treatment plant for Fuzhou in Yuanzhong village, which "compared with the urban area, has poorer education, culture, transportation, communication, and urban facilities" [13] demonstrates a general (worldwide) tendency to locate treatment plants in "less desirable" areas. Though no threatened plant or animal species live within the areas proposed for the projects, [13] the negative effects these projects could possibly have on residents living near the project sites are only briefly mentioned. Locating the wastewater treatment plant near a "popular scenic spot that attracts a large number of visitors" [13] will most likely affect the area's economy. Additionally, in each of the three projects, the resettlement of some number of households is necessary.[13] Though the water source and treatment project will only require the resettlement of ten households, the wastewater treatment plant project will "ultimately require the resettlement of about 1500 people," [13] or almost fifty percent of the village's total population. Interestingly, the EIA did not mention the investigation into any alternatives (i.e. alternative locations) that did not require the resettlement of *any* households, but rather, that the resettlement of these people would be "mitigated through compensation packages" and job training if necessary. [13] However, it is also important to note that the United States pursues the same course of action if resettlement of households is deemed necessary for development or environmental reasons under the Uniform Relocation Assistance and Real Property Acquisition Act of 1970.[14]

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[14]United States Government. *42 USC Chapter 61- Uniform Relocation Assistance and Real Property Acquisition*

The EIA for the Fuzhou projects is complete in many respects, including in the description of mitigation efforts and in outlining how workers' safety would be ensured during construction; [13] however, the public participation aspect that is crucial to EIA preparation is in some ways lacking.[12][13] Though the public was informed about the projects through village-level meetings and was able to express their concerns through surveys and questionnaires,[13] it is unclear from the EIA whether or any public concerns were addressed in the planning of the projects with the exception of concerns related to dust and construction noise.[13] Additionally, only the general results of the public surveys are mentioned, with each project receiving positive support from most respondents (including the aforementioned respondents concerned about dust and construction noise).[13]

It is important to note that some aspects of the project which are not funded by the ADB (and not part of the EIA cited herein) are expected to have environmental impacts as well. [13] A planned dam and hydroelectric power plant are part of the overall project, but because they were not financed by the ADB, they were outside of the scope of the EIA cited herein. The hydroelectric dam and power plant were already approved for construction by the local government (who is financing the project); however, it is unclear whether or not an EIA was completed for the project. The construction and operation of a dam and its corresponding hydroelectric plant, though, are known to have environmental impacts.[15]

b. Barriers to Effective Implementation of EIA: The barriers to effective implementation of EIA presented in the above case study for the water supply and wastewater treatment project in Fuzhou, along with general problems in Chinese EIA practice (that are typical but not found in the above EIA for Fuzhou) stem from a number of structural and cultural factors.

There is a lack of developed alternatives presented in Chinese EIAs, which is a typical weakness in EIAs conducted in countries throughout the world. [7][8] One issue in particular that is seen in China, however, is that many EIAs are initiated once a plan is already in its final stages of being drafted, after that plan has already been approved as is, or even after construction has already begun.[5][8][12] Thus, even if

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Policies for Federal and Federally Assisted Programs. http://uscode.house.gov/download/pls/42C61.txt.

[5] World Bank. "Discussion Papers: China-Water Quality Management and Institutional Considerations." Sept., 2006.

[8] Glasson, John, et. al. Introduction to Environmental Impact Assessment, 3rd Ed. Routledge, 2005

[12] Spengler, Laura. *Public Participation in Strategic Environmental Assessment in China.* Wuppertal Institute, European Union Asia Pro Eco II Programme. June 2009.

[13] Fuzhou Municipal Government, Asian Development Bank. *Summary Environmental Impact Assessment: Fuzhou Water Supply and Wastewater Treatment Project in the People's Republic of China.* May 1998.

[15] Pearce, Fred. *Pipe Dreams.* Conservation Magazine, Vol. 6, No. 1. January-March 2005.

alternative scenarios are created for the purposes of fulfilling EIA requirements, these scenarios will have little effect on the actual project design. Additionally, the "preferred option" is, in many cases, predetermined by a higher level official; lower level planning officials do not want to risk taking any initiative unless they are sure it will meet with the approval of their leaders.[7] Consequently, alternatives are not explored in great detail.

The importance of rank within the Chinese bureaucracy is at the heart of many of the issues that currently exist in China. The inseparability of authority from rank[7][11] is partly due to long-held cultural traditions, as well as the governmental (Party) power structure which reinforces those traditions.
In the governmental hierarchy, the environmental protection organizations have traditionally been viewed as the weakest.[7][11] In order to increase the power of the State Environmental Protection Administration (SEPA) and demonstrate a commitment to environmental protection, the Chinese leadership upgraded the Administration to a Cabinet-level ministry, the Ministry of Environmental Protection (MEP).[7] While this promotion seems like a positive move, the MEP is still not considered "equal" among the ministries.[7] Additionally, even though the MEP presides over Environmental Protection Bureaus (EPBs) in each territory that are charged with enforcement of environmental law, those bureaus are also under the authority of the provincial (local) government.[7] The power structure is complicated further due to a long-held rule that binding orders cannot be issued between units of the same rank; thus Ministries cannot issue orders to (and thus have little control over) provincial governments.[7][11] Consequently, it is difficult to enforce proper completion of EIAs, especially on the local level, unless the higher-ranking provincial government has a vested interest in environmental protection.
In environmental policy implementation (specifically in completing EIAs), the lack of integration between bureaus and the lack of integration between project planning and environmental assessment is a common problem.[5][7] According to the Stockholm Environmental Institute, which conducted a two year long European Union (EU)-supported project with research institutions in China involved in environmental protection and planning, "fragmentation (in sectors of government)…is partly explained by the strict division of power according to rank, and the pervasive culture of avoiding conflict with higher-ranking officers and organizations." [7]
A further issue with the bureaucratic structure comes not with the organization of the hierarchy itself, but with the incentives for promotion of Party cadres. Since the beginning of China's transition to a more capitalist-style economy, the highest priorities (and thus the criteria upon which promotions are based) have been economic gains and "social stability." [11] According to Chinese thought, social stability

itself is dependent primarily on economic gains; ironically, the rate of economic growth has been compromised by the degradation in air and water quality caused by prioritizing economic growth over environmental health. [4][7] Thus, a change in how promotions are incentivized in the system may contribute a great deal to increasing the rate of EIA compliance, accompanied by an improvement in environmental quality.[7][11]

Another primary issue that decreases the effectiveness of EIAs lies not in the governmental hierarchy, but in the fact that social impacts, which describe the interaction between society and the environment (human health and social justice) are often left out.[7][8][12] This lack of consideration of social impacts is not a distinctly Chinese phenomenon but rather, is a general issue with EIAs due most likely to the subjective (and qualitative) nature of social impact assessment. [8] Nonetheless, social impacts, as well as other environmental impacts can be more accurately predicted if the public is included in project scoping and planning. [5][8][12] While other nations have increased the utilization of public input in EIAs,[8] Chinese EIAs still demonstrate a lack of public participation, [5][12] and even the participation of other bureaus despite the fact that a section on public participation is required in EIA reports. [12]

Public participation, if used to mean the "stakeholders" in a project, "may refer to the involvement of everyone whose interests may be beneficially or adversely affected by a proposal, including authorities, experts, concerned and interested citizens, enterprises, non-governmental organizations (NGOs), and other stakeholders." [12] Essentially, "public representation" is represented by three basic categories of people: the authority, the experts, and the general public.[12] If any of these three groups are consulted, it is typically either the authority or a group of experts.[7][12] According to an interviewee quoted in the Stockholm Environmental Institute's final report on SEA and EPI in China, "current practice resembles…the following: the draft plan document is presented to the other actors during a single meeting, where they are given a few hours to discuss and comment. The document is often considered 'secret' and will not be available outside the meeting, making it very difficult to make meaningful and informed suggestions…" [7] "Public participation" in Chinese EIA usually occurs in the following ways: lack of consultation, consultation is requested but is limited in some way to specific groups, consultation is requested after the plan has been approved or construction has already begun, or in some cases, public participation tools are used to manipulate, rather than to inform.[7][12]

In her study of public participation in Environmental Policy Integration (EPI) in China, Laura Spengler of the Wuppertal Institute analyzed SEAs completed for highway and road network projects in Heilongjiang, Henan, and Shaanxi provinces. [12] Though each SEA contained the required public participation section, Spengler found striking similarities between those sections, even though the proposed projects comprised different plans to be constructed in different provinces.[12] Writes Spengler, "…the chapters on public participation in the reports are very similar. The wording is mainly the same, and even the numbers in the evaluation table of a questionnaire handed out to government officials are identical. Thus, it must be assumed that consultation…was realized only in one of three cases and the results were copied into the reports on the other SEA studies." [12] These were subsequently approved, sending the message that neither the public participation aspect of the EIA process nor EIAs themselves are rigorously analyzed.

Though in many cases EIAs are (at least in part) available for comment, both the announcement informing the public that the document is available for comment and the commenting mechanism itself is through the internet; [12] thus, the ability of the common people to make their opinions heard is very limited. [12] Additionally, if the request for comments from the public (and the completion of the EIA) comes after the project has already been approved, the EIA will have little, if any impact on the plan. In one EIA conducted by the World Bank on tourism development in Guizhou, the master plan had been approved in 2003, yet the required SEA wasn't completed until 2007. [12][16] Consequently, concerns presented by the public could only have minor impacts on the project.

In general, Spengler determined through her analysis that "the current participation procedure in the Chinese SEA process is totally ineffective for involvement of the general public." [12] Due to aforementioned factors such as lower-ranking officials who will not offer alternatives to a decision handed down by a higher ranking official[7] and the weakness of the MEP in the governmental power structure,[7] "agencies lack the motivation and capacity to implement public participation dedicatedly." [12] What results is that public participation procedures only meet the minimum requirements and are conducted mainly as an exercise in compliance with regulations. Consequently, the needs of the people affected by a plan or project may not be fully addressed.

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[5]World Bank. "Discussion Papers: China- Water Quality Management and Institutional Considerations." September, 2006.

[7]Bina, Olivia, et. al. *"Transition from Plan Environmental Impact Assessment to Strategic Environmental Assessment: Recommendations of the Project 'Policy Instruments for a Chinese Sustainable Future."* Stockholm Environment Institute. May 2009.

[12] Spengler, Laura. *Public Participation in Strategic Environmental Assessment in China.* Wuppertal Institute, European Union Asia Pro Eco II Programme. June 2009.

[16] World Bank. *Strategic Environmental Assessment Study: Tourism Development in the Province of Guizhou, China.* 25 May 2007.

Though the aforementioned issues concerning the timing in conducting EIAs and a lack of public participation, as well as implementation of EIAs were discussed concerning China, these issues exist in the United States as well. [17] The Council of Environmental Quality (CEQ) conducted a study on the effectiveness of NEPA in the United States, [17] and though it was concluded that NEPA was a success, "NEPA's implementation at times has fallen short of its goals. For example…agencies may confuse the purpose of NEPA. Some act as if the detailed statement called for (*the EIS*) is an end in itself…as a consequence, the exercise can be one of producing a document to no specific end."[17] Additionally, in some cases consultation was only sought after a decision had already been made, [17] causing the public to believe that their concerns have not been heard. [17] Consequently, the EIS sometimes becomes more about litigation, whereby the public opposes the plan not because it is not environmentally sound, but because they feel as if they have no representation in the plan.[17] Thus, in the United States as well as China, a full range of alternatives may not be explored,[7][17] and the document produced may not always be high-quality.[17]

A separate issue in the implementation of EIAs practice is a lack of reliable data. [5][7] Reliable quantitative data is difficult and costly to obtain (usually requires favors).[7] However, Chinese officials place little trust in qualitative assessments,[7] making the completion of a comprehensive EIA difficult. Quantitative data, upon which more accurate predictions of future growth and consequently environmental impacts are based,[7][8] cannot be accurate without reliable methods of data collection.[7] In recent years, China has received some criticism for reporting possibly inaccurate or questionable data to the international community. [5][18] Access to data is conditional upon political influence and rank;[7] thus it is difficult for the comparatively weaker environmental agencies to procure the data necessary for EIA reports.[7] However, both the encouragement by the international community for China to establish a better data collection system and the agreement the Chinese government has entered into with the United States Environmental Protection Agency (USEPA) to cooperate on data collection should provide a stimulus to increase both access to data and quality control of data. [18]

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[5]World Bank. "Discussion Papers: China- Water Quality Management and Institutional Considerations." September, 2006.

[7]Bina, Olivia, et. al. *"Transition from Plan Environmental Impact Assessment to Strategic Environmental Assessment: Recommendations of the Project 'Policy Instruments for a Chinese Sustainable Future."* Stockholm Environment Institute. May 2009.

[17]Council on Environmental Quality. *National Environmental Policy Act: A Study of its Effectiveness After Twenty Five Years.* January, 1997.

[18]Eliperin, Juliet. *"U.S. and China reach accord on data collection."* The Washington Post. 19 November, 2009. http://www.washingtonpost.com/wp-dyn/content/article /2009/11/ 18/ AR2009111803058.html.

4. How Chinese Environmental Policy (Concerning EIA practice) Affects Water Quality Improvement Initiatives

Water and wastewater infrastructure-related projects are considered to be a high enough priority by the Chinese government that this category is included in the list of projects requiring an EIA.[7] Though these projects are seen as important, it can be hypothesized that the general patterns seen in EIA practice for other, similarly essential projects are reflected in plans for water and wastewater supply and treatment infrastructure. As evidenced by the aforementioned EIA of a water supply and wastewater treatment project in Fuzhou,[13] greater average wealth (typically located in Southern and/or coastal areas, of which Fuzhou is both) is associated with more attention paid to the environment.[7] More complete EIAs are usually conducted in areas like Fuzhou where there is a greater economic base due primarily to the fact that basic needs are fulfilled, enabling residents to concentrate on higher-level issues such as environmental protection.[7] Additionally, since the Southern and coastal cities are centers for commerce and technology in China,[7][13] there is a greater vested interest in those cities' continued prosperity. Though this attention paid to the environment indicates that sound EIA practice, leading to greater compliance with environmental policies does exist in China, it suggests that sound practice is more prevalent in affluent provinces.[7] Therefore, it is very possible that areas that would benefit most from more environmentally sound measures may not be helped, and in fact, may not be in compliance with EIA laws due in large part to insufficient funds.[5] Consequently, some areas with poor water quality and little infrastructure may not see much improvement unless a strong, influential leader (Party official) is present.[7]

The common issue previously mentioned concerning a lack of well-developed alternatives in Chinese EIAs was further explored by the Stockholm Environmental Institute in its final report on Environmental Policy Integration (EPI) and Strategic Environmental Assessment (SEA) in China.[7] **Table 1** (next page) is an adaptation of the "Types of Alternatives"[7] table generated by the Stockholm Environmental Institute for use as a tool for Chinese environmental planners to better develop alternative scenarios. Though the table in the Institute's report specifically addresses the energy and transportation sectors,[7] Table 1 is an exercise in generating questions to create alternatives for a theoretical water and/or wastewater supply and treatment infrastructure-related project.

Table 1: Considerations in Proposing Types of Alternatives for Water and Wastewater Supply and Treatment EIA

Level of Decision	Definition/Guiding Questions
	Water/Wastewater Supply and Treatment
Need or Demand	Is it necessary?
	Is the demand necessary or can it be met with more efficient use of water? Can increasing the price of supply/treatment decrease demand? Can the demand be met without new infrastructure?
Input and Supply	Can we use what we have now?
	Can the current water supply be augmented by rainwater harvesting? Can the current infrastructure be expanded rather than building a new treatment plant?
Mode or Process	How should it be done?
	Which type of disinfection should be utilized, keeping in mind the environmental and health effects of DBPs? Should energy-saving technologies be employed (higher initial cost but saves money in the long term)? If using activated sludge, how will the biosolids be handled? Will biosolids be used in land application? Does the treatment plant need to be equipped to handle stormwater flows?
Location	Where should it go?
	What site location will ensure that resident displacement is minimized (ideally none)? How can the site be located to address possible concerns of noise, odor, and aesthetics? How can the treatment plant be located to best neutralize the threat of an upset (i.e. maximize distance from a chemical plant)
Detail	Timing and detailed implementation
	When should the plant be built to meet the demand? What growth in demand (capacity) should be included in the design to account for low-, medium-, and high-growth scenarios? If expansion of water and wastewater treatment infrastructure (i.e. new treatment plants) is needed, in what sequence should they be carried out?

*adopted from [7], Annex: Table F

5. Suggestions for the Improvement of EIA Good Practice

Increasing public participation in EIAs will allow for a greater understanding of the social impacts of a project;[5][7][12] however, it is important to educate the public on the importance of environmental preservation (and the consequences of prioritizing economic gains while overlooking environmental effects).[5][7][13] Currently, China's main way of disseminating information (through "campaigns") does not translate into long-term sustainable uptake and implementation of an idea.[11] Thus, in order to spread environmental ideas, increasing the *quality* of education, rather than the *quantity* of people reached, should be the new goal.[11] If the public is able to gain greater knowledge on the environment, they will be more likely to comment on future EIAs, and those comments will be informed and thus more useful to the organization conducting the EIA.

Additionally, incorporating EIA and EPI thought into the training of party officials, [11] as well as using the completion of high-quality EIAs as a criterion in Party leaders' annual performance evaluations [11] will incentivize the consideration of environmental impacts. If there is an impetus to compose higher quality EIAs, then it is expected that there will be a corresponding increase in the quality and amount of data being collected, as well as a greater sharing of data. However, in order to increase the accuracy of predicted environmental impacts, the use of computer modeling is necessary.[7] Conducting sensitivity analyses using reliable data in order to decrease uncertainty is essential in forecasting the effects of different levels of growth.[7] Increasing the accuracy of EIAs will further increase their use in design, especially at the more preliminary stages.

Finally, the Chinese government can help to ensure a greater completeness of EIAs by making its practices more transparent [5][7] to the international community, who can act as a quality control watchdog. [18] Already, China has cooperated with many different international bodies on development projects, including the World Bank,[5][16] the Asian Development Bank,[13] the EU,[7][11][12] and various sectors within the United States Government.[18][19] The US Department of Agriculture and the US

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11 Bina, Olivia. *An Environmental Policy Integration Perspective of the Weaknesses and Potentials of Current Chinese Practice*. Wuppertal Institute. 30 June 2009.

12 Spengler, Laura. *Public Participation in Strategic Environmental Assessment in China.* Wuppertal Institute, European Union Asia Pro Eco II Programme. June 2009.

13 Fuzhou Municipal Government, Asian Development Bank. *Summary Environmental Impact Assessment: Fuzhou Water Supply and Wastewater Treatment Project in the People's Republic of China.* May 1998.

19 The White House-Office of the Press Secretary. "*US-China Joint Statement.*" 17 November 2009. http://www.chinafaqs.org/files/chinainfo/US_China_Joint_Statement_White_House_Nov_17.pdf.

Environmental Protection have both been working with the Chinese government in the areas of agriculture and environmental law (and enforcement), respectively. [20] Specifically, the USEPA is assisting China in increasing its data collection efforts,[20] which would serve to not only increase the quality in China's currently available data, but would also improve the effectiveness of the estimates upon which EIAs are based. In general, the opening up of China's EIA process will help encourage the process to become more representative of the needs of both the common people and their environment and thus, more democratic.

B. CASE STUDY: A COMPARISON OF DRINKING WATER REGULATIONS IN CHINA AND THE UNITED STATES

In addition to the EIA law, there are a number of other environmental laws in place. China's "Fifteen Small Shutdown Policy"[5] has caused the closure of enterprises in the fifteen most polluting industries, and its promotion of the use of Environmental Impact Assessments[5][7][11][12][13][16] for new construction and ISO14000 certification demonstrates a desire to become a world class competitor.[5] China's water regulations[21] are equally as strong as those found in the United States[22] as depicted by **Tables 2** and **3** below, which compare some of China's basic standards for surface water quality[21] with the EPA's National Primary Drinking Water Standards. [22]

[20] USEPA. *China Environmental Law Initiative Homepage*. Updated 10 December 2009. http://www.epa.gov/ogc/china/initiative_home.htm.

[21] Ministry of Environmental Protection, People's Republic of China. http://english.mep.gov.cn/standards_reports/standards/water_environment/quality_standard/200710/W020061027509896672057.pdf.

[22] USEPA. List of National Primary and Secondary Drinking Water Contaminants. http://www.epa.gov/safewater/contaminants/index.html#organic.

Table 2: MEP (China) Surface Water Regulations *(left)* [21]
Table 3: USEPA (US) National Primary and Secondary Drinking Water Regulations *(right)* [22]

Basic Standards and Limits						Primary Std.		Notes	Sec. Std.
	Class I	Class II	Class III	Class IV	Class V	MCL	MCLG		
pH			6~9			NL*	NL*		6.5~8.5
DO	7.5	6	5	3	2	NL*	NL*		NL*
permanganate index	2	4	6	10	15	NL*	NL*		NL*
COD	15	15	20	30	40	NL*	NL*		NL*
BOD5	3	3	4	6	10	NL*	NL*		NL*
ammonium nitrate (NH_3-N)	0.15	0.5	1	1.5	2	10	10	(nitrate as N)	NL*
total phosphorous	0.02	0.1	0.2	0.3	0.4	NL*	NL*		NL*
total nitrogen	0.2	0.5	1	1.5	2	1	1	(nitrite as N)	NL*
copper	0.01	1	1	1	1	action level=1.3	1.3		1
zinc	0.05	1	1	1.5	1.5	NL*	NL*		5
fluoride	1	1	1	1.5	1.5	4	4		2
selenium	0.01	0.01	0.01	0.02	0.02	0.05	0.05		NL*
arsenic	0.05	0.05	0.05	0.1	0.1	0.01	0		NL*
mercury	0.00005	0.00005	0.0001	0.001	0.001	0.002	0.002		NL*
cadmium	0.001	0.005	0.005	0.005	0.01	0.005	0.005		NL*
chromium	0.01	0.05	0.05	0.05	0.1	0.1	0.1		NL*
lead	0.01	0.01	0.05	0.05	0.1	action level= .015	zero		NL*
cyanide	0.005	0.05	0.2	0.2	0.2	0.2	0.2		NL*
volatile phenols	0.002	0.002	0.005	0.01	0.1	0.001	zero	penta chloro phenol	NL*
oils	0.05	0.05	0.5	0.5	1	NL*	NL*		NL*
surface activity-anions	0.2	0.2	0.2	0.3	0.3	NL*	NL*		NL*
sulfide	0.05	0.1	0.2	0.5	1	NL*	NL*	sulfate	250
total/fecal coliforms	200	2000	10000	20000	40000	5% TC pos/mth	0 ppm		NL*

*NL= not listed

While many positive changes have been made in pollution prevention regulations, issues still remain. China passed its Prevention and Control of Water Pollution law 1984[5] and its latest water quality regulations in 2002, [5] yet there remains a dramatic difference in China's water quality and that of the United States.

A number of factors have contributed to the lack of improvement in China's water quality. As with the implementation of EIAs, the way the Chinese bureaucracy is organized results in "a lack of horizontal and vertical coordination, and inter-agency communication is generally poor. Agencies often duplicate tasks and responsibilities, which is not only inefficient, but also results in inconsistencies." [5] This problem is exemplified by the Ministry of Environmental Protection (MEP) and the Ministry of Water Resources (MWR). The roles and mandates of these two organizations in water treatment and pollution control are often unclear, causing overlap in some areas while neglecting others.[5] Figure 1 below depicts the bureaucratic hierarchy for the different branches of the government involved in water quality and pollution management.[5]

Figure 1: Ministries and Authorities at the National Level Involved in Water (Quality and) Pollution Management [5]

Additionally, the role of the central government is often overemphasized and "the regulatory system is incomplete and complicated, which results in lack of integration and efficiency in implementation and enforcement." [5] Regulation is typically not market-based; thus many government agencies have problems enforcing environmental laws when they conflict with local development plans, especially if those plans have strong political backing.[5] Writes Cai, "For local governments, the strong wish for economic development always overrides the responsibility of environment protection."[23] This issue would be alleviated if the government would seek more private investment in dealing with pollution

[3] Becker, Jeffrey. *Tackling Corruption at its Source: The National Corruption Prevention Bureau.* Journal of Chinese Political Science, Vol. 13, No. 3. 2008.

[4] Jiang, Yong. "China's Water Scarcity." Journal of Environmental Management, 2009. p. 1-12.

[11] Bina, Olivia. *An Environmental Policy Integration Perspective of the Weaknesses and Potentials of Current Chinese Practice*. Wuppertal Institute. 30 June 2009.

[23] Cai, Ximing. "Water stress, water transfer and social equity in Northern China- Implications for policy reforms." Journal of Environmental Management, No. 87, p. 14-25. Available 6 March 2007.

control, which it has begun to do under the 10th Five-Year-Plan (2001-2005).[5] One other related issue, as discussed above, is the government's "close-down policy." This policy applies to industries as well as to non-compliant water treatment plants; firms that are highly polluting are given a warning to comply with standards or they are faced with closure. However, "application of the close-down policy is closely linked to local development policies…regulators are less likely to enforce closure in areas where local economic development is weak." [5][11]

Corruption within the system has hampered the enforcement of regulations as well. [3][11] Writes Cai, "Current water transfers follow the priorities of local government that are often driven by short-sighted economic profits." [23] Additionally, the Fifteen Small Shutdown Policy began a restructuring of priorities, where rather than investing in necessary infrastructure repair and modernization, industries and water/wastewater treatment plants alike that failed to meet effluent standards were shut down. This threat of shutdown in turn can cause a misreporting of data by managers who want to remain in operation. [24] Additionally, decreased economic growth in locations where industries have been closed has resulted in the re-opening of those industries, nullifying the previous decreased pollution load. [5]

Water pollution is seen as a major issue internationally, and the Chinese government has made a distinct shift in their rhetoric[[4][7][11] towards a greater prioritization of the environment, sustainable development, and water pollution control. However, how the State allocates its spending indicates a lower prioritization for two areas that could greatly contribute to an increase in water quality: environmental protection and education. "In the past three decades, investments in environmental protection accounted for only 0.68%, 0.81%, and 1.19% of China's GDP." [4] In 1999, China spent only 1.9% of its GDP on education [2]; in comparison, the United States spent 5.9% of its GDP on education in 2009.[2] The small percentage of GDP allocated to education spending may play a role in the general lack of knowledge concerning water quality issues.[5]

The issue of education, especially environmental education of both company managers and local people in general cannot be overemphasized. [5][7] "Both enterprise management and environmental management awareness levels are low." [5] Thus, it can be difficult to convince firms to comply with voluntary initiatives, such as ISO14000, or at least to view complying with regulations as a priority. As mentioned above, the Chinese government spends a very small percentage of total GDP on education,

[24] Gao, Di. Personal Interview. 5 June 2009.

and if that trend does not change, the country will not be able to achieve the goals set by both the Chinese government itself and by the United Nations (Millennium Development Goals).[25]

Furthermore, the majority of the population does not believe that their water is in great need of treatment,[24] mainly due to 水土不服 (shuǐ tǔ bù fú), a commonly held belief that drinking water from a different area of China from ones' own will make one sick due to one *not being acclimated to that environment yet*. [24][26] This belief has contributed to the lack of a *discerned public need* for an increase in the availability of higher-quality drinking water. [24] In order to create recognition in the public mindset concerning the importance of environmental protection, specifically dealing with water, the recommendations of the World Bank in their 2006 study[5] should be followed. "In order to effectively manage its water resources and reduce pollution levels, the Government of China must generate a greater level of environmental awareness and sense of responsibility among the general public. This will require environmental education initiatives and more transparent information on emissions and water quality." [5]

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[2]CIA World Factbook: China. Date Accessed: 22 June 2009. https://www.cia.gov/library/publications/the-world-factbook/geos/CH.html.

[5]World Bank. "Discussion Papers: China- Water Quality Management and Institutional Considerations." September, 2006.

[7]Bina, Olivia, et. al. *"Transition from Plan Environmental Impact Assessment to Strategic Environmental Assessment: Recommendations of the Project 'Policy Instruments for a Chinese Sustainable Future."* Stockholm Environment Institute. May 2009.

[25]UN Millennium Project 2005. "*Health, Dignity, and Development: What Will it Take?"* Task Force on Water and Sanitation, 2005.

[26] Li, Zhaoguo. "Zhong Xi Yi Jie He Xue Bao (中西医结合学报)." Journal of Chinese Integrative Medicine,Vol. 7, No. 4, p.383-388. Published online 15 April 2009.

III. AN ANALYSIS OF THE EFFECTIVENESS OF CURRENT SOLUTIONS TO WATER QUALITY AND QUANTITY ISSUES IMPLEMENTED BY THE GOVERNMENT

A. COMPARISON OF THE SOUTH-NORTH WATER TRANSFER PROJECT WITH INCREASED IRRIGATION EFFICIENCY

Water quality is a major issue in China, but a scarcity of water resources represents the other major water issue China faces. According to Jiang, "in normal water years, among 662 cities, 300 will have insufficient water supplies and 110 will experience severe water shortages; 30 out of 32 metropolitan areas with populations of more than 1 million people will struggle to meet water demands." [4] This lack of water is due in large part to the geographical layout of China; while Southern China enjoys a water surplus, Northern China is mainly comprised of arid and semi-arid lands.[4] Specifically, "average annual precipitation gradually decreases…from more than 2000 mm at the southeastern coastline to usually less than 200 mm at the northwestern hinterlands." [4] Consequently, the water quality in the South is typically better than that in the North, mainly due to the dilution of pollutants by a larger quantity of water (see **Figure 2**, next page).[5] As **Figure 2** demonstrates, the proportion of higher quality water bodies is much greater in the South than in the North.[5]

Figure 2: A Comparison of Water Quality in Water Bodies in Southern and Northern China, 1991-2005 [5]

Additionally, there is a lack of a system of both legally enforceable water rights and economic restraints in place to regulate the demand for water (water resource allocation is controlled on the supply side).[4] As industry in Northern China continues to grow and compete with agriculture for a dwindling supply of water, the pumping of water from deeper and deeper wells is resulting in the depletion of aquifers under cities,[4] land subsidence,[4] and salinization[4] of freshwater resources. Increasing water efficiency, desalination, piping in water from remote locations, and rainwater harvesting are all methods that the Chinese government is currently employing to some degree in order to alleviate its water crisis. While these methods vary in their environmental impacts and the degree to which they are sustainable, three methods in particular will be focused upon below: long-distance water transfers, increasing water efficiency, and rainwater harvesting.

In order to help solve both the water resources issue and the water quality issue in Northern China, in 2003, a massive engineering project was undertaken to build a pipeline from the Yangtze River in the south to Beijing in the North. This project, called the South-to-North Water Transfer Project, is expected to cost at least 62 billion RMB (9.084 billion USD based on an exchange rate of 6.8249 RMB to 1 USD[2]).[4] Writes Fred Pierce, "the first Yangtze water should be flowing north along a canal…in 2008. The canal will be 60 m wide and as long as France, crossing 219 rivers, 500 roads, and 120 railway lines as it takes some 12 km^3 of water a year…to Beijing."[15] Additionally, China plans to build two more pipelines; one diverting water to Eastern China, and another diverting water west to Tibet.[4][15] The entire project is expected to take about twenty years to complete and will divert an amount of water northward comparable to the current flow of the Yellow River, which has been over-used and heavily polluted by Northern industries and residents (**see Figure 3**, below).[15]

Figure 3: Map of the South-to-North Water Transfer Project [4]

While this project will provide the North with much needed water, it is receiving criticism from some environmentalists, who see the project as solving one problem while creating a whole host of new issues. Dams have already been shown to cause extensive damage to local ecosystems,[15] and drawing from that example, environmentalists believe that "transfers between basins will further destabilize ecosystems and shift predator species and diseases from one river system to another." [15] Instead, they argue that it is better to seek "soft solutions," the most appropriate being to engage in rainwater harvesting and better water resources management.[15] In agriculture, farmers could use drip irrigation and seeds that have been engineered to grow on less water, and the government could invest in finding and fixing leaks in their pipelines.[15]

The World Bank also notes that the pipelines will pass through some of the most heavily water-polluted areas in China which much be remediated through the course of the project;[5] as the pipelines are constructed, the average required improvement in water quality is between 82 and 99 percent for major pollutants like BOD, COD, nitrogen, and oils.[5] However, "China has no track record in cleaning up polluted rivers at this level." [5] Another concern is that the total cost of the project could drive the price of water high enough that many consumers could not afford the new supply,[5] those who the South-to-North Water Transfer project intended to serve would not be able to take advantage of the increased water supply.

While there are opponents of the South-North water transfer, advocates exist as well. [27] These advocates argue that the only way to satisfy the great water needs of Northern China is to divert water from the South.[27] Additionally, if the project is accompanied by a strong environmental protection plan, then the damage to ecosystems will be minimal. [27] In conducting a cost-benefit analysis of the South-to-North Water Transfer Project using Decision Support Systems, Feng concluded that "through an increment[al increase] of water supply by the S2N Project and proper policy-making, if a city such as Beijing pursues a sustainable development strategy, the gap between water demand and supply can eventually be closed." [27] However, this study only took into account Beijing itself without consideration of the rest of the North China plain,[27] and the needs of agriculture were only addressed in Feng's allotment of increased (treated) industrial sewage to agricultural use.

In order to ascertain the effectiveness of the South-to-North Water Transfer Project (in its entirety), a comparison was made between the water gained from the transfer project versus the water saved through installing more efficient irrigation systems. Agriculture was focused upon due to the fact that it is the industry with the highest water needs.[27] Irrigation efficiency in China is currently around .45,[4] while in developing countries, it is between .7 and .8;[4] thus, much improvement could be made in the area of water efficiency. **Table 4** (next page) depicts the inputs and assumptions used in the analysis, as well as the respective sources from which that information was gathered.

[27] Feng, Shan, et. al. "Assessing the impacts of South-to-North Water Transfer Project with decision support systems." Decision Support Systems, No. 42, p. 1989-2003. Available 1 January 2005.

Table 4: Inputs and Assumptions used in Analysis of South-to-North Water Transfer Project vs. Irrigation Efficiency

The given information was as follows:	The assumptions were as follows:
• irrigation efficiency in China: .45 [4]	• 1st part of South-to-North water transfer complete; adds 12 km^3 water [15]
• irrigation efficiency in developed countries: .7-.8 [4]	• no water from 1st part of South-to-North water transfer going to agriculture [15][27] (leaves 66% total for agriculture)
• amount of water used by agriculture (N. China): 185.7 billion m^3 in 2005 [4] projected: 210.5 billion m^3 in 2030 [4]	• most (2/3) water from pipelines going to municipal and industrial uses [4] (leaves ~20% for agriculture)
• amount of water diverted North for pipeline done in 2008: 12 km^3 [15][27]	• 13% increase in water use is spread out evenly over 25 years [4]
• amount of water diverted North for S2N water transfer: 45 billion m^3/yr [4][5]	• pipeline finished in 2008 cost 1/3 of projected total
• % of total water diverted going to agriculture: 20%* (see assumptions)	• 6% inflation rate/yr from 2008-2030
• water used by agriculture increases 13% from 2005-2030 [4]	• whole South-to-North water transfer project done by 2030 [15]*
• total cost of South-to-North water transfer project: 62 billion RMB (9.084 million USD) [4]	
• cost to install sprinkler irrigation: 3000 RMB per ha[28] (439.57 USD)	
• inflation rate: 6% (2008), 4.8% (2007) [2]	

*Note: Jiang gives an estimate of 2014 and 2050 for the completion of the second and third pipelines [4]

[2] CIA World Factbook: China. Date Accessed: 22 June 2009. https://www.cia.gov/library/publications/the-world-factbook/geos/CH.html.

[4] Jiang, Yong. "China's Water Scarcity." Journal of Environmental Management, 2009. p. 1-12.

[5] World Bank. "Discussion Papers: China- Water Quality Management and Institutional Considerations." September, 2006.

[15] Pearce, Fred. *Pipe Dreams.* Conservation Magazine, Vol. 6, No. 1. January-March 2005.

[27] Feng, Shan, et. al. "Assessing the impacts of South-to-North Water Transfer Project with decision support systems." Decision Support Systems, No. 42, p. 1989-2003. Available 1 January 2005.

[28] Lohmar, Bryan, et. al. "China's Agricultural Water Policy Reforms: Increasing Investment, Resolving Conflicts, and Revising Incentives." Market and Trade Economics Division, Economic Research Service, U.S. Department of Agriculture. Agriculture Information Bulletin No. 782. March, 2003.

The amount of water consumed by farmers per year was used to estimate the amount of water wasted by those farmers if there is no change in irrigation efficiency for three different years (2005, 2030, and extrapolated for 2008). The year 2008 was included in the analysis as it was the year the first pipeline was completed. The values calculated were compared with the amount of water wasted per year if 100% of farmers switch to seventy and eighty percent efficient irrigation equipment by the three scenario years. The difference between the amount of water wasted under the "do nothing scenario" and a change to a higher irrigation efficiency of .7 or .8 by each of the scenario years yields the amount of water saved per year by farmers in Northern China. The results of the water savings per year analysis are outlined in **Table 5** below. Some of the inputs, which were used in another analysis, are located in **Table 6**.

Table 5: Total Water Savings per Year Based on Various Scenarios for Adoption of More Efficient Irrigation Equipment

Scenario	no change to 70% irrigation efficiency (m^3)	no change to 80% irrigation efficiency (m^3)
100% adopt in 2005	46,425,000,000	64,995,000,000
100% adopt by 2008	45,555,924,000	64,415,616,000
100% adopt by 2030	38,985,000,000	60,035,000,000

It was concluded that a 100% adoption of 70% efficient irrigation equipment by 2005, 2008, and 2030 would result in a 46.4 billion m^3, 45.6 billion m^3, and 39 billion m^3 per year water savings, respectively. A 100% adoption of 80% efficient equipment by 2005, 2008, and 2030 would result in a 65 billion m^3, 64.4 billion m^3, and a 60 billion m^3 per year water savings, respectively. Thus, all of the values calculated for water savings per year under the various scenarios are greater than or equal to the entire per year projected amount of water received from *all three* pipelines, 45 billion m^3 per year. [4]

After verifying that the water savings from installing more efficient irrigation equipment could be greater than or equal to the water received from the entire South to North water transfer project, the cost to complete the remainder of the project was calculated based on an inflation rate of six percent per year. [2] Estimates of the total cost of the project [4] and the assumed cost of the first (finished) pipeline were utilized to approximate the cost of the project if finished by 2030 at 177.4 billion RMB. Using an inflation-adjusted cost of 3000 RMB (439.57 USD based on an exchange rate of 6.8249 RMB to 1 USD) per hectare to install a more efficient type of irrigation,[28] it was determined that the money earmarked for the remainder of the transfer project could instead be used to subsidize the installation of more efficient irrigation equipment on 13.8 million hectares of land. The results of each step in the calculation process are detailed in **Tables 6** (below) and **7** (next page). In addition to saving water through more efficient irrigation methods in the agricultural sector, the use of rainwater harvesting systems, discussed below, could provide yet another source of water for all of the major water-consuming sectors in China: agricultural, industrial, and municipal.

Table 6: Inputs in Water Savings per Year and Cost of South-to-North Water Transfer vs. Installation of More Efficient Irrigation Equipment Calculations

<table>
<tr><td>*percent per year increase in water use</td><td>0.52</td><td>irrigation efficiency China</td><td>0.45</td></tr>
<tr><td rowspan="2">*percent increase in water use by 2008</td><td rowspan="2">1.56</td><td rowspan="2">irrigation efficiency developed countries</td><td>0.7</td></tr>
<tr><td>0.8</td></tr>
</table>

Table 7: Cost of South-to-North Water Transfer vs. Installation of More Efficient Irrigation Equipment

Year	2005	*2008 (interpolated)	2030
amt used agr. (m^3)	185,700,000,000	188,596,920,000	210,500,000,000
amt farmers get from S2N trans.	0	0	6,600,000,000
cost S2N trans.	62,000,000,000[1]	24,614,330,667[2]	177,397,323,083[3]
no. ha subsidized to switch	20,666,666.67	6,888,888.89[4]	13,777,777.78
amt reaches crops no change	83,565,000,000	84,868,614,000	94,725,000,000
amt reaches crops .7	129,990,000,000	132,017,844,000	147,350,000,000
amt reaches crops .8	148,560,000,000	150,877,536,000	168,400,000,000
amt wasted no change	102,135,000,000	103,728,306,000	115,775,000,000
amt wasted .7	55,710,000,000	56,579,076,000	63,150,000,000
amt wasted .8	37,140,000,000	37,719,384,000	42,100,000,000

[1]reflects projected cost [4]

[2]reflects finished first pipeline cost

[4]reflects cost of first pipeline only

[3]remainder projected cost (inflation adjusted, assumes first pipeline done)

B. CASE STUDY: RAINWATER HARVESTING IN GANSU PROVINCE- A SUCCESS STORY

Though the Chinese government is still embarking on large-scale engineering projects, they have invested in rainwater catchment systems in limited areas as well.[29] Following the model set in Gansu Province,[29] rainwater harvesting is currently being employed in some rural areas, in order to help alleviate the water scarcity issues found in northern and western China. Gansu Province lies in a semi-arid region of China whose inhabitants are some of the poorest in the nation.[29] Rainfall is scarce and falls mainly between July and September, severely limiting the number and type of crops that can be planted.[29] The groundwater that is serves the region is of a poor quality, and the river water has a high salt content.[29] Additionally, because Gansu is mountainous, it is difficult to pipe water there from

[29] Zhu, Qiang and Li, Yuanhong. "Harvesting Water." LEISA Magazine, 2003. http://www.farmingsolutions.org/successstories/stories.asp?id=146.

nearby provinces.[29] All of these issues combined to make Gansu Province an ideal place to begin a rainwater harvesting program.

The Gansu Research Institute for Water Conservancy began its rainwater harvesting project in 1988,[29] and with the help of government subsidies, not only helped farmers install rainwater collecting tanks on their properties, but also educated them as to when the best time was to selectively irrigate crops.[29] The project proved to be very successful, and "by the end of 2001 there were 2.2 million new tanks making the irrigation of 236,000 ha of land possible. By this time, those benefiting from the…project had gone up to nearly two million." [29] The Chinese government has greatly expanded the rainwater harvesting project, which has not only greatly increased crop yields, but has also allowed the farmers of Gansu Province to plant crops that have higher water needs (i.e. tomatoes).[29] The ability to raise cash crops has thus greatly increased these farmers' income and stimulated the local economy.

Greenhouses have also been developed for this area, the roofs of which are used as additional catchment sources.[29] The utilization of greenhouses has enabled farmers to further diversify the crops that can be grown; farmers have reached the point financially that "investment [in the greenhouse] can be recovered in two to three years." [29] The success of this project can be attributed to several factors: individual (as opposed to state) ownership of the rainwater harvesting systems, affordability, easy acceptance by the farmers (already a traditional practice), and thorough preparation and good project management by the Gansu Research Institute for Water Conservancy. [29]

C. FACTORS THAT HINDER THE SUCCESS OF THE VARIOUS SOLUTIONS ANALYZED

The pressure placed on China's water resources by the expanding industrial, municipal, and agricultural sectors [4][5] is further complicated by China's lopsided rainfall pattern that runs counter to its agricultural needs. "In most areas of the country, precipitation within four consecutive months…accounts for 70% of annual precipitation. This…pattern of precipitation leads to a serious risk of flooding as well as drought, especially in northern China. Runoffs of the Hai and Huai rivers fall to 70% of their averages every four years and to 50% every 20 years." [4] Even though many areas in Northern China are water-starved and water is wasted through inadequately maintained infrastructure (specifically in irrigation), farmers have little incentive to save water.[4][5] According to Jiang, "It is estimated that current household expenditures for water only account for about 1.2% of disposable income. This percentage is lower than the 2% level that stimulates water-saving behavior and is much lower than the 4% in developed countries." [4]

Though the South-to-North water transfer could bring much needed relief to the North,[27] the environmental effects that will occur during construction, as well as the ecosystem damage that comes from transferring water between two vastly different environments render the project unsustainable.[5][15] Invasive species have already caused massive amounts of damage in the United States and could greatly harm species diversity in China as well. Additionally, as discussed above in **Section III. A.**, the water savings gained from increasing irrigation efficiency in agriculture are greater than the amount of water Northern China would receive from the South-to-North water transfer. Increasing the price of water and forgoing the completion of the South-to-North water transfer project could help to both subsidize and incentivize water efficiency.[4] If government programs to develop rainwater harvesting and install more efficient irrigation equipment are successful in the agricultural sector, they could be pursued in the industrial sector as well.

IV. A COMPARISON OF CENTRALIZED WATER TREATMENT VERSUS POINT-OF-USE WATER TREATMENT INITIATIVES

A. GOVERNMENT PRIORITIES

The Chinese government has been dramatically increasing its investment in the construction and expansion of centralized water and wastewater treatment since 1998. [5] While this is an important step in supplying the nation with clean water, there are some issues that arise when focusing on only one solution. Though there is an urgent need to develop treatment infrastructure,[4][5] the construction of permanent solutions can be both costly and time-consuming. According to the World Bank, between 1998 and 2004, investments in municipal and industrial wastewater treatment plants and sewage systems in the fourteen provinces and cities in Northern China totaled about 49 billion yuan and have been steadily increasing over the study period. In fact, between 1998 and 2003, annual investment in sewers (in northern regions) increased 272 percent. [5] However, as previously mentioned (see **Section II.A**), investment primarily flows to more developed areas.[5][7] On average thirty percent of the country was served by centralized wastewater treatment in 2003, yet the average served in Beijing was up to fifty percent. [5] In northern Hubei province, conversely, the number served was as low as fifteen percent. [5]

According to the World Bank, "in order to achieve a centralized wastewater treatment rate of 60 percent, it is estimated that a total investment of around 14 million RMB (2.05 million USD based on an exchange rate of 6.8249 RMB to 1 USD) will be required between 2003 and 2010. Investments of 5.6, 7.6, and .65 million RMB (.82, 1.11, .095 million USD) are required for wastewater treatment plants, sewer networks, and sludge handling facilities respectively." [5] Financially, that 14 million RMB (2.05 million

USD) represents a yearly investment of 1.75 million RMB (.256 million USD), an amount that corresponds to approximately .005% of China's GDP (based on a 2009 GDP of $4.758 trillion and a 2009 exchange rate of 6.8249 RMB per dollar[2]). Though China has the funds to easily meet the necessary monetary investment, the time necessary to construct quality infrastructure represents a great obstacle to serving sixty percent of the country through centralized treatment in the near future.

In its 2006 study of water issues in China, the World Bank reported that China's 9th Five-Year Plan, which was in effect from 1995-2000, required fifty-two wastewater treatment plants to be built in the Huai River basin, one of the most polluted parts of (Northern) China.[5] However, only thirty plants were complete or under construction by the time the report was released,[5] over five years after the conclusion of the 9th Five-Year Plan. Furthermore, "progress…has been much slower than planned, and established units cannot run at full capacity due to a lack of complementary sewer networks." [5] This delay in establishing necessary water and wastewater treatment infrastructure is reflected in a World Bank case study of Lake Dian, a large shallow lake in Yunnan Province that suffered from severe pollution, resulting in high levels of eutrophication.[5] According to the World Bank, sixty five treatment plants were completed in the area during the 9th Five-Year Plan, including four large wastewater treatment facilities with a combined capacity of 365000 tons per day.[5] However, inadequate investments in the collection system have resulted in collection rates around 33 percent.[5] Consequently, even though a large number of treatment facilities were constructed, many of them are either closed or only partially operational.[5] Additionally, the lack of an expansion of the collection system has prevented many other previously planned projects (12 projects, 1.29 billion RMB,[5] .189 billion USD) from being completed prior to the end of the 9th Five-Year plan, resulting in unmet water quality goals. [5]

Pollution control projects have shared a similar fate;[5] though "a major feature of the 10th Five-Year Plan," [5] a majority (greater than fifty percent) of the projects were not completed within the five-year plan period.[5] This delay is partly due to the fact that the cost of extending collection and distribution systems into certain areas, such as older areas of a city or more rural areas can be prohibitively high.[5] The high cost of expanding centralized treatment into some areas coupled with both the large time investment and the pattern of delays in constructing treatment infrastructure necessitates the implementation of a temporary, yet possibly effective solution: distributed (point-of-use) treatment.

Point-of-use treatment has been employed throughout the world where the construction of centralized treatment infrastructure has lagged behind the demand for clean water.[25] According to the United Nations (UN) Millennium Project Task Force on Water and Sanitation, the improvements in water quality that would come with the implementation of a point-of-use water treatment program "would decrease diarrheal episodes by 45 percent." [25] While a variety of methods exist, each has been proven to reduce or eliminate a variety of contaminants in field studies throughout the developing world. Solar disinfection (SODIS) was shown to reduce the incidence of diarrhea in children under the age of five by 16-24%[30] and a reduction in cholera cases of 86%[30] among the Maasai people.[30] In Bolivia, the use of SODIS reduced the incidence of diarrhea in children under five years old by more than 35%;[30] in Tamil Nadu, the risk of diarrhea for similar subjects who utilized SODIS was reduced by 40%.[30] Similar results have been reproduced for a number of other field studies by the same research group. [30] Potters for Peace, an international NGO teaches local craftspeople the art of making silver-impregnated filter pots. [31] These water filters, which have also been used in many nations worldwide, have been shown to deactivate bacteria present in drinking water. [32] **Figure 4** below shows the prevalence of solar disinfection (SODIS) users through the globe.[30]

Figure 4: Geographical Distribution of Solar Disinfection (SODIS) Users Worldwide [30]

Though **Figure 4** demonstrates the prevalence of solar disinfection (SODIS) use throughout the developing world,[30] it is important to note the locations that are not currently utilizing this treatment method, specifically China. Even though parts of China have the ideal climate for water treatment by SODIS,[30] that method is not currently being implemented anywhere in China according to the **Figure**. Other point-of-use water treatment methods have met a similar fate;[33][34] while readily accepted throughout the world,[30][31][32] China remains an essentially closed market. Two case studies, one from

[30] Meierhofer, R. and Landolt, G. "Factors Supporting the Sustained use of Solar Water Disinfection-Experiences from a Global Promotion and Dissemination Programme." Desalination, vol. 248, p. 144-151. Accepted 15 May 2008.

[31] Potters for Peace homepage. Accessed 16 April 2010. http://www.pottersforpeace.org/.

[32] Oyandel-Craver, Vinka A. and Smith, James A. "Sustainable Colloidal-Silver-Impregnated Ceramic Filter for Point-of-Use Water Treatment." Environmental Science and Technology, vol. 42, p. 927-933. Accepted 12 November 2007.

[33] Gately, Michael via O'Callaghan, Kevin. E-mail correspondence. 18, 19 October 2009.

[34] Zhang, Jack. Personal Interview. 2 November 2009.

Medentech,[33][35] a multinational firm headquartered in Ireland and one from PATH China,[34][36] the branch office of a global NGO provide some possible insight into why the barriers to entry for point-of-use water treatment are high in China.

B. POINT OF USE WATER TREATMENT AND ITS BARRIERS TO ENTRY IN CHINA

Medentech produces Aquatabs,[35] chlorination-based water purification tablets that have been employed in both disaster relief situations and as part of a regular treatment regiment where adequate infrastructure is not in place.[35] Having an interest in entering the untapped Chinese market, Medentech conducted a market assessment,[33] the conclusion of which were that it would not be profitable for Medentech to pursue sales of Aquatabs or any of its other products in China.[33] Medentech's informal study of Chinese citizens determined that people expected the central government to provide safe water as a service[33] (Gately calls this expectation the "old Communist mentality" [33]). Additionally, people felt that they should not have to pay for clean water;[33] consequently, willingness to pay for point-of-use water treatment was low.[33] Finally, since boiling water is a common practice[33] (common to drink hot water or tea), people did not feel that there was a need to disinfect their drinking water.[33]

PATH is a global Non-Governmental Organization (NGO) [36] that has implemented point-of-use water treatment projects (the Safe Water Project[36]) in developing countries including India;[36] however water treatment has not been on PATH China's list of priorities.[34] No dedicated program office is currently working in that area (water treatment) in China according to Mr. Jack Zhang, head of the PATH China.[34] Though Zhang believes that there is probably a need for point-of-use water treatment in the countryside, [34] his team has not been able to discern whether there is a *general* need for that type of project in China.[34] Additionally, Zhang is unsure if they can get support from the government to develop a point-of-use treatment program.[34] Furthermore, Zhang notes that one of the key factors of success in China is having the cooperation of state-owned companies and the local government;[34] it is very difficult to implement any program without the support of the Chinese government.[34] PATH has been in China since the early 1980s[34] and established an office in Beijing in 2003;[34] even with years of NGO experience in China, Mr. Zhang doesn't see any opportunities or a need to work on water treatment.[34]

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[35] Medentech homepage. Accessed 2 April 2010. http://www.medentech.com.

[36] PATH. "Quenching the Thirst for Safe Water: Using Market Forces to Fulfill a Universal Need." Date Accessed: 2 April 2010. http://www.path.org/projects/safe_water.php.

It would seem that both a lack of a very visible public need[24][26] (**see Section II.B.**) and lack of government support[34][combine to create the largest barriers to entry for the development of point-of-use water treatment, especially in the rural (and poorer) areas where the need is greatest and investment is typically minimal.[5][7]

An additional barrier to entry of distributed treatment arises due to the fact that mechanisms for private investment are not in place.[5] Mainly, there is a lack of an adequate system in place for loan repayment. Consequently, the government remains as the main source of funding and contribution from other sources is minimal. [5] This issue thus reinforces the previous conjecture that a project will not be successful without (financial) support from the government.[34] Furthermore, as is the case with the agricultural sector, there is little incentive for individuals to invest in point-of-use water (and wastewater) treatment due to the low price of water and sewage treatment and distribution.[4] Raising the price of treatment and distribution to more accurately reflect the costs of providing those services (and the environmental and health consequences that result from a lack of treatment) will not only raise funds to expand infrastructure, but provide the impetus for individuals to use water more efficiently. Further implementation of education programs to demonstrate the importance of drinking treated water[5] will help foster an increased demand for water treatment including temporary (point-of-use) solutions where construction of centralized infrastructure has not yet been completed.

V. GENERAL CONCLUSIONS AND RECOMMENDATIONS

Though some hurdles –political, social, and environmental- must be overcome, China's water crisis can be averted if the government makes adjustments (in some cases, more drastic adjustments) both structurally and policy-wise. A tabular breakdown of recommendations by category is detailed in **Table 8** (next page).

Table 8: Recommendations for Successful and Sustainable Implementation of Water Quantity and Quality Solutions

Structural Recommendations	• Consolidate the organizations that oversee water pollution control and clearly define the mandate of those organizations.[5]
	• Employ greater policing to see that regulations are followed corruption-free.[3]
	• Increase the power of the MEP with respect to other cabinet ministries and include EIA and other related subjects in the training and promotion criteria of party cadres.[7][11]
Law-Based Policy Recommendations	• Revise the Water Law to allow for individual ownership of water rights and establish market-based pricing of water that reflects its' actual value.[5]
	• Establish (economic) incentives to encourage water saving and counter the (economic and political) incentives that can result if regulations are ignored.[5]
	• Develop mechanisms into place to protect and foster private investment.[5][7]
Citizen- Focused Policy Recommendations	• Give a higher priority to environmental protection (and following regulations) in future policies and remove enforced targets that monitor economic growth solely in percentages.[5]
	• Further develop rainwater harvesting programs that include education of farmers on more responsible water use.
	• Emphasize the importance of environmental protection and the health consequences of consuming water of poor quality through education.[5]
	• Encourage the adoption of water saving irrigation equipment through subsidies and education programs.[28][29]

China has developed and modernized at a pace unmatched by any other nation to attain an economy that is the third-largest[2] and a population that is largest[2] in the world, respectively. If the Chinese government can reinforce in deed their rhetoric that environmental protection and pollution reduction are high priorities,[4][5] and open themselves to more foreign investment and influence,[18][19][20] then China will be able to remedy the environmental issues it currently faces with the help of the international community. The one certainty is that the world will continue to be fixed on China is it pursues its unique path of development into a First World nation that could quite possible surpass the United States in a only a short span of time.

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