Challenges and Opportunities from the Rural Drinking Water Supply in China

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Abstract

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Water, contrary to its importance and necessity to human health and economic development, has long been an undervalued investment focus, especially of private investors, whose investment in water has been modest relative to the growing investment in telecommunications, energy, and other high-margin sectors. This is particularly the case in low-income regions of developing countries, where the investment in water is most needed.

In this article, I examine current Chinese rural drinking water policies and situations. As the country with the largest global population, of which almost 50% live in rural areas, China is facing the huge challenge of providing safe drinking water to everyone. In addition to its scarce water resources per capita, both ground- and surface-water sources are being heavily polluted. At the same time, the BOP (Bottom of the Pyramid) business model is playing an increasingly critical role in tackling the drinking water issues in other developing countries. Potentially, BOP business can bring down the technology cost, engage closely with local communities, and stimulate innovation. Three BOP businesses are introduced in this article and their experiences and challenges are summarized. A general feasibility study replicating this business model in China is also conducted. The analysis suggests that although China has a huge demand, there are also some significant barriers and obstacles to tapping the enormous market potential.

Challenges and Opportunities from the Rural Drinking Water Supply in China

In China, roughly 50% of its current population lives in rural areas, with an average annual income per capita of around RMB 6,977 ($1073). This annual income almost doubles the income rate of 2005, but there are still 90 million people living below the poverty line in China. Coupled with increasing its income and living standards, China has accomplished part of its UN Millennium Development Goals (MDG) target, which is to "halve, by 2015, the proportion of the population without sustainable access to safe drinking water" (China Water 2011, 1-83). However, as a necessity of human health and economic growth, safe drinking water still remains a challenge for China. Having access to safe drinking water is also closely associated with seven other MDGs, including achieving gender equality, combating extreme poverty, providing primary education, and so on. In 2010, there were still 150 million people among the 715 million rural inhabitants without access to secure drinking water.

With the fast economic growth and industrialization of recent years, new water issues are also emerging. In addition to having an already low water resource per capita (one-quarter of the world average level), an increasing number of rural areas are now being heavily polluted by industrial and human wastes. Frequent extreme weather conditions, such as droughts and floods most likely triggered by climate change, are affecting the southern and northern agriculture areas and have severely damaged agriculture production and threatened national food security. China still has a long way to go to achieve its goal of drinking water security, which is to have drinking water accessible in every home. Given the importance of providing safe drinking water in rural areas and its priority among China's national policies, an exploration of the water supply and water technology market could be a major potential investment opportunity for private investors and operators.

This article is organized as follows:

- A brief analysis of water supply and demand situations in China's rural areas is presented in order to understand the issues.
- Case studies of three international companies introduce Bottom of the Pyramid (BOP) business models of rural water supplies.
- A feasibility study compares the key variables and other important factors of selected China provinces with those of the countries where the BOP businesses were carried out.
- The opportunities and challenges that confront businesses interested in investing in China's rural water supply are summarized in the conclusion.

Current China Rural Drinking Water Supply Situations

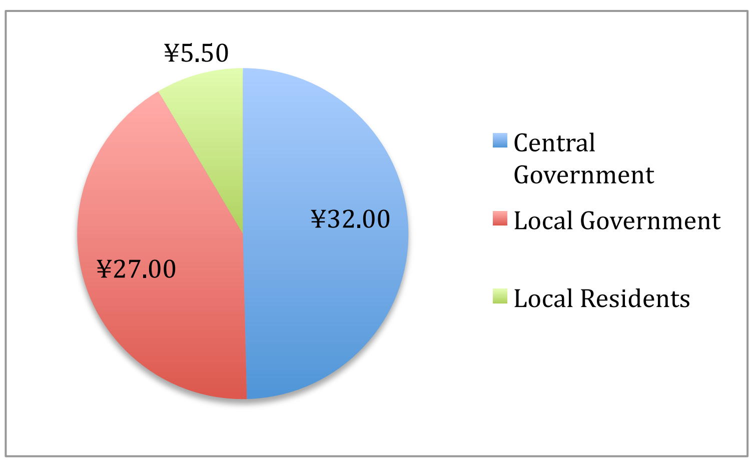
Providing safe drinking water in rural areas has been an important component of the Chinese government's poverty alleviation policies, therefore a comprehensive overview of current and past government strategies for rural drinking water is key to understanding the current rural drinking water supply situations in China. Additionally, a brief introduction to NGO and private investment roles is included because of their increasingly important role in this sector.

Government Strategies

The government of China is currently the dominant player in solving the rural drinking-water supply problems (Figure 1). Thanks to its strong and ambitious poverty alleviation policies, the population with insecure drinking water dropped from 311.76 million in 2005 to 200 million in 2008 according to the "11th Five-Year Plan on Rural Drinking Water Report" (China Water 2011, 1–83). It is estimated that by the end of 2010, this number dropped further to the level of 150 million. The projected total investment in the 11th Five-Year Plan was 64.5 billion RMB, but the actual investment during 2005–2010 amounted to approximately 100.9 billion RMB (China Water 2011, 1–83).

Figure 1. Breakdown of Total Investment (Planned) in Rural Drinking Water Supply Projects during 2006–2010 (in Billions)

The five-year (2006–2010) national investment plan for the rural drinking water supply projects is shown on the right.



Source: The author.

According to the "Decisions on Investment Institutional Reform," government spending should focus on national security, fixing market inefficiency in economic and social areas by providing public goods, and constructing basic rural infrastructure. Various other national policy documents further emphasize the importance of rural water safety. As a result, about 58.5% of the total investment made during 2005–2010 was from the central government, 35% of the investment was financed by the provincial and local government, and the remaining 6.5% was expected to be provided by the rural villagers who benefited. The exact ratio differs according to the local economic situations, with a higher ratio of government spending occurring in less developed areas.

One very important factor that contributes to China's success in achieving the MDG is its political structure. The central government sets a target in the rural water sector for the provincial government. The performance of local government in solving rural water problems is sometimes closely bound to the annual evaluation of the local officials. This approach is unique to the Chinese model and has been deployed during the past 30-year economic development. In this model, the central government sets the economic growth targets and disaggregates to the provincial level and subsequently the city level; the evaluation of the local officials will be highly dependent on the GDP growth. Although economic growth is weighed much more heavily than achievements in water supply in such an evaluation, with the recent circular economic strategies from the central government, the emphasis on sustainable development, environmental performance, and the quality of rural life are becoming increasingly important.

The water supply projects constructed in recent years can be roughly summarized into three categories: centralized water supply, decentralized water supply, and water shortage and pollution control projects.

Centralized Water Supply. By the end of 2004, about 362 million people (38% of the rural population) had access to centralized water supply systems, with each system supporting at least 200 people or providing $20m^3$ of water every day (China Water 2011, 1–83). During 2005–2010, there were more than 200,000 additional centralized water supply systems built around rural China. The rural centralized water supply systems are generally small. Only about 13% of them supply more than $200m^3$ water per day (China Water 2011, 1–83). Ninety-one percent of them are village-based, with underground water and streams as their water sources. Many projects were contracted to the local villagers and charged on the basis of headcounts or the quantity of water consumed. Among all centralized water supply systems, the majority of them are simply composed of water resources and pipelines; only around 8% of them are equipped with water treatment and quality monitoring systems. Additionally, local community members' behavior is a barrier to achieving safe drinking water objectives. The water supply capacity far exceeds the water demand in many cases because villagers with lower income often choose to pay only for drinking and cooking water and fall back to old free water sources for other water uses (Lin and Zheng 2009, 81–86). In some remote regions where education levels are low, villagers seem uninterested in the quality of the water. It was found in one NGO project that even though there were pigs wading at the source of a gravity-fed pipeline, local villagers still used it for their drinking water needs (Geoffrey 2011, 1–101). In other cases, local villagers just don't have a clear concept of water quality; they merely consider clarity as the standard for potability and believe that disinfection is an unnecessary process (Junling et al. 2009).

Decentralized Water Supply. Forty-nine percent of the rural population uses decentralized water supply systems. Most of the systems are built and managed by the households themselves and generally lack water quality monitoring systems (China Water 2011, 1–783). Sixty-seven percent of the decentralized water systems are shallow wells with hand-pumps or electric pumps that are distributed in the villages where underground water is easily accessed. Nine percent are from stream water diversion and three percent are from rainwater harvesting (China Water 2011, 1–83). Water quality remains the main challenge for the decentralized water systems and is generally worse than that of centralized water systems. Wastewater treatment capacity is extremely low in rural areas or even missing in most places; livestock manures, toilet water, and sewages are often directly disposed without any penetrating treatment and pollute the shallow underground water. In Si Chuan province, almost all of the 4,427 towns did not have wastewater treatment plants in 2009. More than 10 billion tons of wastewater and sewages were disposed directly into the environment (Wenguo and others 2012, 109–115). Fertilizer from agriculture is another important groundwater pollution source. Because of decreasing underground water resources and pressures from industrial or domestic pollutions, these decentralized water supply systems are becoming less and less reliable and sustainable.

Water Shortage and Water Pollution Control. According to a survey on rural drinking situations in China conducted in 2004, 90 million people in rural China—or 30% of the population facing insecure drinking water—don't have sufficient and accessible water resources (China Water 2011, 1–83). Some of them have no water supply system or have dysfunctional water systems; the rest are simply living in water- stressed areas. They have to walk long distances daily to fetch water directly from rivers, streams, ponds, or other villages. In some western provinces such as Qinghai, Guizhou, Guangxi, Shaanxi, and Chongqing, the number of people without sufficient safe drinking water even reached 40% of their total population during some drought periods (China Water 2011, 1-83). Some of the seasonal drought became even more severe, probably due to the climate change in recent years.

The other 70% of the population affected by water insecurities face various water pollution issues such as from fluorine, arsenic, and industrial pollution. These water shortage and pollution problems cannot be solved by simple centralized or decentralized water supply systems. They requires holistic drinking water solutions, ranging from consistent water quality testing to local community education and engagement.

International Organizations and NGOs

Several major philanthropic contributions from international organizations have been made in China during the past two decades. Since 1985, the World Bank loaned a total of $370 million to the National Public Sanitation Agency and some local governments to implement "China rural water supply and environmental health projects," providing 24.37 million people with safe drinking water (China Water 2011, 1–83). Since 1991, UNICEF, the Ministry of Water Resources of China, and local governments cooperated on three phases of rural drinking water projects. Other major philanthropic projects included rural water supply and sanitation projects that are cooperating with the Department for International Development (DFID) from Britain and technical support from the National Land Resource Department. The role of the international organizations is still limited to the scope of financial assistance.

China does not have a very long history of NGO activities. The projects with influence include donation activities organized by the All-China Women's Federation that raised more than RMB 150 million and water and sanitation projects implemented by Singapore NGO Lien Aid (China Water 2011, 1–83; Lien Aid 2012). There are other active domestic or international NGOs, but the scale is relatively small and the focus is narrowed down to only several local villages (Geoffrey 2011, 1–101).

Private Investment

The 11th Five-Year Plan expected that 6%–9% of financial resources would come from the private sector, which would include tariffs from the benefited villagers and investments from the private operators. There is a very limited amount of published research on the topic of rural water privatization, but existing research has shown the importance of private players in the rural water supply market. A 2008 case study from Shandong Province proves the feasibility of employing the market mechanism in providing a rural water supply. The centralized water supply projects run by the local villagers had both good financial and good project performances. Local governments provided various financial incentives to cover a large portion of the facility cost. Many other rural places in China have given the private sector permits to run the water supply business as well (Lin and Zheng 2009, 81–86). However, the study also suggests that the market is still under the constraints of government planning, business permits, tariff regulations, and so on. There is no general management process that can be applied nationally, and the villagers have lower water consumption per capita; thus, it is difficult for operators to realize economies of scale by expanding rapidly into other locations. The town in the case study is among the top 100 wealthy towns in China. This easy access to financing is not common in other parts of China. Additionally, the cost of financing for private operators can be as high as 9%–13%, which is higher than the return on investment. The last but not the least challenge for the local water business operator is the high cost of operation and maintenance, which is also another important cause of many NGO project failures (Geoffrey 2011, 1–101).

The BOP Business Model—The Need for Safe Drinking Water as a Market Opportunity

During the 6th World Water Forum in Marseille, March 11th–17th 2012, three companies that are exploring the market potential by solving the demanding rural drinking water challenges through various innovative business and technological models were interviewed. They are all large multinational companies: Schneider Electricity, Shikoku Chemicals, and Grundfos. Their projects target the poor people in remote rural villages who cannot afford to pay for connection to a conventional centralized water supply system. Water supplies are usually community-based. Following are brief introductions to the business models of the three companies:

> **Schneider—**Schneider started and self-funded their BipBop Program to bring rural people electricity. Access to water was just included in the program in 2007, because it was found that water and energy are very often closely interrelated; people are sometimes either paying a lot for electricity use to pump underground water or fetching unsafe drinking water from other resources. An innovative solar-powered pumping system will enable local villagers to have access to safe drinking water without dependence on grid electricity. Currently, revenues are mainly from product sales, just enough to cover costs, but the company expects to create more social and economic value by scaling up this business model in other regions of Africa and Asia in the future.
>
> **Grundfos—**Grundfos is one of the world's largest pump manufacturers. The safe drinking water program was conducted as a CSR activity in Kenya, and included 38 projects serving 100,000 people with safe drinking water by solar-powered pump. Safe drinking water is sold at the pumping stations. The company runs the full package of the project all by themselves, including the pump manufacture, project design, mobilization of the community to adopt their system, technical training, maintenance, and so on. Initial funding was primarily from donations by Grundfos worldwide

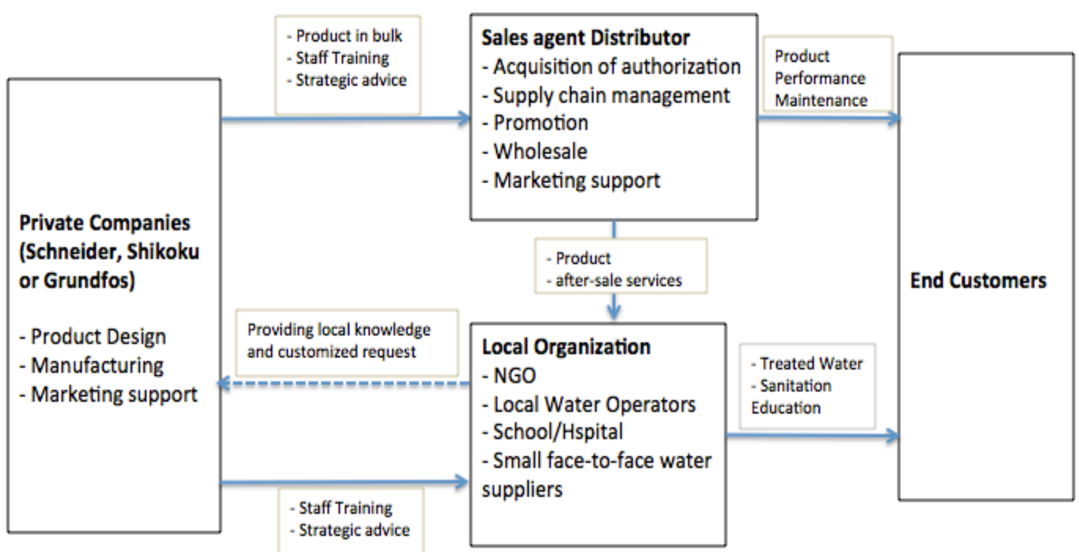
employees. The project shows that the water revenue can cover the maintenance cost, but an assessment of the population's willingness and capacity to pay should be conducted before implementing the project. The payback period is expected to be around five years for such projects.

One unique innovation from the company is their water tariff payment method. Villagers will be charged by the quantity of drinking water they collected at the water supply points and pay the water tariff by their cell phone.

SHIKOKU—Shikoku Chemicals Corporation is a giant chemical company, established in 1947 and based in Japan. The projects conducted by the company were supported by the Japanese governmental agency, the Japan International Cooperation Agency (JICA). The company developed a wide range of chemical products that purify water and has been supporting Indian NGOs who are actively involved in and experienced at supporting community efforts to improve the quality of life for children and women. The main activity of Shikoku Chemicals Corporation has been to help provide customized safe drinking water treatment and sanitation methods. Currently, it is actively conducting a feasibility study of its BOP business model for application in several other developing regions.

Although the technologies and business models employed by these three companies vary in their specifics, they operate within the general BOP business model (Figure 2).

Figure 2. BOP Business Model in Rural Drinking Water Supply Sector



Source: Created from Caterina Fonseca's data in "Briefing Note 1a—Life-cycle cost approach."

In addition, the challenges they face are very similar. A study from the World Health Organization summarizes these challenges: the three biggest barriers to investment flows to the low-income community drinking water areas are attributed to the problems of "Market Creation," "Distribution," and the "Financing Model" (Allen, James, and Francisco 2009).

Market Creation

All of the three companies mentioned the difficulties in and importance of understanding the local need for safe drinking water and its implications for customized technologies and business solutions. Learning of the actual situations—water resources, climate pattern, consumer preferences for the tastes, convenience, and prices—is time-consuming and requires engagement with local communities. Product designs that cannot fit the local circumstances will very likely fail.

On the other hand, the company needs also to create a market by raising local villagers' awareness of the link between health and safe drinking water. There are some cases in which NGOs and businesses can cooperate to create a hybrid organization—by focusing on the society's welfare and making a profit (Allen, James, and Francisco 2009). However, finding the right NGO to partner with is not always easy. NGOs usually operate at a slower pace than private companies, and the mutual trust needed between NGOs and the private sector is usually missing, according to the interview with Schneider and Grundfos.

Distribution

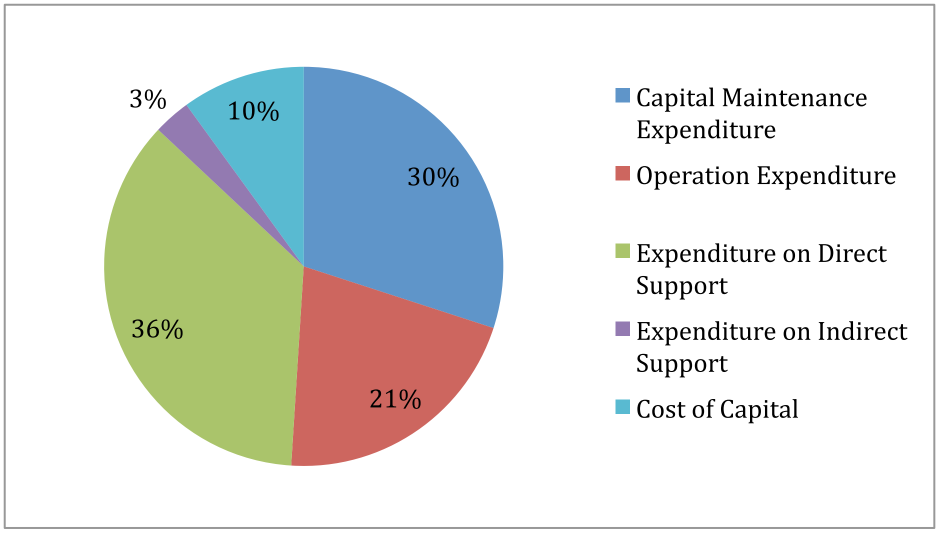
Due to the undeveloped basic infrastructures, setting up a reliable distribution channel remains a big challenge for Schneider and SHIKOKU, whose businesses generate revenue through selling equipment and chemicals. Additionally, business development people need to go to the sites in different villages to talk with local people repeatedly to sell the product or to finalize a project.

Financing Model

The financing model is very similar among the three companies. Parent companies cover the upfront investment in the technology and project development. Cost can be almost covered by sales and tariffs for Grundfos and Schneider. However, the human capital cost of the project conducted by Grundfos was covered by in-kind contributions from their employees. Staff-hours were therefore not included in the project analysis. According to the project manager, the full cycle of the rural water supply project requires a lot of staff-hours and expertise from various backgrounds. The human resource costs to keep the project running would be a huge barrier for such projects to scale up in other developing countries.

The cost of keeping rural drinking water projects functioning permanently is summarized by a life-cycle approach conducted by WASHcost project (Fonseca et al. 2011). Their findings illustrate the challenges faced by Grundfos (Figure 3).

Figure 3. Cost Structure of a Water Supply Project



Source: The author.

The cost of direct support, which accounts for 36% of the total cost, was rarely included in the rural water and sanitation estimates. It includes the cost of ensuring that local governments have the capacity to plan and implement the project, manage contracts, and respond in the case of system breakdown. The cost of monitoring a private or public service provider's performance is also included in this category. The expenditures made on maintenance and operations account for more than 50% of the total cost. Most rural water projects are difficult to sustain because local communities cannot afford this portion of the cost by themselves. According to the study conducted by WASHcost, when the coverage rate of safe drinking water reached 40%–80%, it is the maintenance and operations costs that cause the project failures (Fonseca et al. 2011). Therefore, for companies and small operators to run drinking water businesses in rural areas, both upfront investments and operation/replacement costs are important factors to consider.

According to the interview with Schneider, it is very difficult for companies selling equipment and products to persuade the local villagers or operators to make the large initial investment, especially in regions where the cost of financing is high and local villagers have very limited sources of financing.

In summary, the BOP business model has important advantages over the conventional water supply projects in terms of project performance:

a. One common advantage is their advanced technologies. The big international companies can provide tailored solutions and advanced technologies that meet the customized demands and solve the problems and challenges that the NGOs and local governments have been facing for years. One example would be the innovative water tariff payment method developed by Grundfos.

b. The projects are more sustainable. All three companies expressed their concern that if the projects failed in providing high-standard water services it would affect their reputations. Since the companies charge the local communities and put their company name on the water supply equipment, the public and local governments will scrutinize them; therefore, they are more motivated to maintain the water quality and services.

Other advantages include creating job opportunities, enhancing investment and operational efficiencies, and speeding up the provision of safe drinking water in rural areas.

Feasibility Study in China

In order to evaluate the feasibility of the BOP business model in China's rural water market and the opportunity to tap that huge market, several key variables (including GDP, etc.) of selected provinces in China were compared with those of the countries where the

BOP business case studies discussed previously took place (Senegal and Kenya) (Figure 4).

Figure 4. A Summary of Key Variables Comparison

Variables	Kenya	Senegal	Sichuan	Shaanxi	Guangxi	Yunnan
GDP per capita ($ US)	760^{2009}	$1,090^{2010}$	$4,227^{2011}$	$5,269^{2011}$	$4,038^{2011}$	$3,029^{2010}$
GDP annual growth rate (%)	2.6^{2009}	1.4^{2010}	15	13.9	12.3	12.3
Dealing with Construction Permits (Ranking)	37^{2012}	125	179	179	179	179
Starting a business (Ranking)	132^{2012}	93	151/19[a]	151/25	151/28	151/23
Total population (millions)	39.8	12.4	80.4	37.3	46.1	45.96
Percentage rural (%)	78	57.1	59.82	52.7	58.2	64.8
Literacy rate (% population over age 15)	87	49.7	94.56	96.26	97.29	93.97
Average household size (# person)	4.6	9	4	3.8	4.2	3.53
Water usage per capita (m^3)	605	202	80.55	223	660	328
% of rural population with access to improved water	52	52	64[11]	53^{2005}	57.1	58
% of urban population with access to improved water	83.82	91.4	92	92	88	88

Sources of data: (Guangxi Bureau of Statistics 2012; Rural Poverty Portal 2011; Shaanxi Bureau of Statistics 2012; World Bank 2012; World Bank 2011; World Bank 2010; Yunnan Bureau of Statistics 2012).

a. The number 151 is the rank of China and the following number is the rank of the province within China.

Economic Background

The four provinces in China have a relatively stronger economy than Kenya and Senegal. There is a huge water technology market based on the amount of investment in China's rural water sector during the five-year period of 2006–2010, which was about $16 billion.

The investment in the rural water sector will only increase during the next five years according to the 12th Five-Year Plan.

At the same time, the exchange rate of the Chinese Yuan to the US dollar has decreased from 8.3 to 6.3 during the past two years, which is favored by business exporting to China. Water giants Veolia Water and Suez Environment have already invested aggressively in China's urban water systems, anticipating the fast economic growth and urbanization process in China.

According to a World Health Organization (WHO) estimate, a household should spend 3.5% of its income for its basic water supply (Johnsona et al. 2007, 416–427). Based on the past experiences, rural villagers have a much lower level of water demand (Johnsona et al. 2007, 416–427). It might thus be difficult for business and water operators to profit in most of the towns and villages. Nevertheless, user financing for rural water projects has been in place for many years, and the strong economy indicates a higher financial capacity to pay for safe drinking water from both customers (Figure 5) and the government (Johnsona et al. 2007, 416–427).

Figure 5. Summary of the Annual Rural Income per capita in Four Provinces of China

Province	Sichuan	Shaanxi	Guangxi	Yunnan
Rural income per capita ($)	$972.7	$798	$830	$627

Source: The author.

Water Demand from Rural Residents

The percentage of rural people with access to improved water resources in the four provinces is as low as it is in Kenya and Senegal. The main challenge to improving water supplies in most cases comes from water resource contamination (China Water 2011, 1–83; Lien Aid 2012). Research shows that most villages' underground water supplies in Beijing rural areas were exploited until 2011 and, as a result, 97% of the surface water across those villages has been contaminated (Junling et al. 2009). Most of the current rural centralized water supply systems don't even have a basic water treatment capacity. Among the 3.6 million rural residents in JinHua city of ZheJiang province, one million residents are still drinking water from contaminated springs and other water sources (Junling et al. 2009). In order to meet this water quality challenge, investment in and implementation of advanced designs, monitoring systems, and affordable water purification technologies are required. In addition, a generally higher literacy rate indicates a higher awareness of hygiene and sanitation. Local people might be more willing to pay for safe drinking water and be more comfortable with new technology, as their literacy rate has increased.

Government

The government has put rural water safety as a high priority and has spent billions of dollars in building the water supply infrastructure and other basic infrastructures, but the rate of access to tap water is still low. Evidence shows that the investment is not very efficient, with some water supply systems exceeding the water demand. The main reason for this inefficiency is the strategy implemented by the central government. The central government granted funds, specified project requirements, and even material selection guidelines for the provincial and local governments, who will eventually implement the projects. As a result, the options available to solve the local water problems became very inflexible and such projects may not fit the local circumstances very well.

The government has encouraged and helped local businesses to step into the rural water supply market. Local government and people are generally continuing to welcome the investment from private and international investors. However, China ranks 151st and 179th out of 183 countries in "starting a business" and "dealing with construction permits," respectively. The time, procedures, and costs associated with starting a business and dealing with construction permits are generally much higher in China than in Kenya and Senegal according to the study from World Bank. In addition, the business will face similar risks from government regulations on water tariffs, importing technology, and so on. And the enforcement of intellectual property protection is still particularly difficult in China, which poses another risk for foreign companies doing business here.

The Operational Environment and Competition

Establishing a strategic partnership with the local governments, communities, and NGOs is a critical success factor for Grundfos in Kenya and Naandi Foundation in India. However, local NGOs and social enterprises are not well established in China. As a result, operations in China might not be able to receive support from local communities and NGOs. At the same time, thanks to the government's significant investments in the rural water sector in China, many domestic water purification and pumping technology suppliers have emerged in recent years. Compared to foreign investors, they have the advantages of offering a lower manufacturing cost and a closer connection to the local government and households. However, the BOP business model from international companies is more technically capable of providing integrated and customized solutions, rather than just technologies.

Conclusion and Recommendation for Future Research

This article introduces the idea of using the BOP business model in the rural drinking water sector and discusses the opportunities and challenges of applying it in China. With strong government support, fast economic growth, and the pressure of increasing ecological problems, there will be a huge market for such bottom-up solutions to rural drinking water issues. A comparison of the China rural market with those in Kenya and Senegal reveals the challenges and barriers, which include government intervention, lack of financing sources, and understanding the local needs.

Due to the constraints of time and resources, this article covered only three types of companies and technologies. Other technologies, such as for water purification, water storage, and rainwater collection, are already rolling-out in the market. A more comprehensive study on successful cases of these technologies and businesses should be conducted to understand the available options.

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Biography

Zhan Zhou is a second-year master student of Environment Studies at the University of Pennsylvania, with a concentration in environmental policy. He has keen interests in business sustainability and clean technology development, and has been focusing his research primarily on opportunities for using private investment and market-based solutions to improve environmental performance. As the main objective of his master capstone, he is helping establish the first U.S. industry-wide vinyl flooring recycling program by exploring opportunities from industrial ecology and utilizing technology such as ArcGIS. Throughout his graduate studies at Penn, he was very fortunate to participate in various clean-tech and social impact projects, including DOE Electric Vehicle Public Charging Business Plan competition and organizing Wharton Social Impact Conference and utility-scale solar project evaluation for GreenWorld Capital. Before coming to the U.S., Zhan graduated from Nanyang Technological University in Singapore with BEng (Honors) in Materials Engineering. During his undergraduate studies, he spent six months in France doing research on nano-material synthesis for 3rd Generation solar cell and his final year doing research on CIGS thin-film solar cell.