Economic Analysis for In-Situ Resource Utilization on Mars in Support of the Generation of Rocket Fuel and Potable Water

A Discussion of the Socioeconomic and Political Obstructions to Water Purification Technologies in China

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By

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction

In 2010, the UN General Assembly recognized access to clean water as a human right. This meant that every human has the right to "sufficient, continuous, safe, acceptable, physically accessible, and affordable water for personal and domestic use" (*Drinking Water*). But in developing nations, access to clean water is not reliable or accessible to both urban or rural households. According to the United Nations (UN), 2.3 billion people live in water-stressed countries, with 733 million of them living in critically water-stressed countries (UN-Water). Access to safe and potable water is pivotal to the health, stability, and growth of a country and its people.

Socioeconomic and cultural inequalities exist in both urban and rural areas, serving only to promote further water quality and accessibility disparities. Without access to clean water, large amounts of time is spent making the effort to physically obtain it. Oftentimes, especially in rural areas of these developing nations, women and children are sent to obtain water from their usual water source, meaning they spend less time in school or at work, and more time making dangerous expeditions. Children are also particularly at risk of death from illness, with one dying every two minutes from water-born diseases (*The Water Crisis*). Better health, education, and economic prosperity can be achieved with access to clean water due to the increased quality of life that having it provides. These are just some of the reasons as to why the scarcity of such an essential resource can undermine the social and economic growth of these developing nations.

Organizations and private corporations alike have risen to tackle this problem through the innovation and establishment of on-site water purification technologies. Lifestraw, for example, has collaborated with Kenya's Ministries of Health and Education to produce sustainable water purification systems and employ over 40 local full-time staff members (Lifestraw). These

technologies are often community efforts though, and heavily rely on their compatibility within the communities' economic, social, and political situations, making it difficult to establish a strong case for a business or organization that seeks a return on its capital investment (Johnson et al., 2008). As climate change continues to cause irreversible damage to the environment, we need to be willing to consider new ideas and innovations that would improve the quality of life of those most affected by it. This paper aims to analyze the political and socioeconomic obstacles that stand in the way of the implementation of these innovative technologies.

Literature Review

Framing:

I will attempt to analyze the political and socioeconomic obstructions to the implementation of water purification technologies in a developing country through the lens of the Multilevel Perspective (MP). The framework of the MP can be broken into three sections: the niche, the regime, and the landscape (Sovacool & Hess, 2017). According to Hess and Sovacool, the niche refers to an innovation that is beginning to become viable in the market (2017). In regards to my research paper, the niche will be the innovations and products that will be focused on in the case studies. The regime is the sociotechnical system that the niche seeks to affect. The regime of these water purification technologies will be the current ways of water collection in the developing nation, as well as the political, economic. and social constructs that exist to keep them in place. The landscape refers to the events that put pressure on the regime, and create opportunities for the niche to penetrate the market (2017). The landscape of this paper will vary with the case study, since environmental, political, economic, and ideological events will depend on the nation that is being discussed.

Methods and Sources:

In order to analyze this issue, I will be collecting data in two main steps. By following a process similar to Johnson et. al, socioeconomic and political data will be collected from various sources with the final goal of performing a case study to analyze the feasibility of adoption of new water purification technologies in a developing nation (2008). Socioeconomic statistics such as population growth, poverty and literacy rates, and GDP will be sourced from the UN Department of Economic and Social Affairs Population Division. Water resource supply and usage data will be collected from the United Nations World Water Development Report. Data from the Worldwide Governance Indicators (WGI) project will also be used to determine the political and governmental environment of each country. Using this data, along with the UN's definitions of developing nations and water-stressed nations, I will choose a country to perform case studies on. Where this paper differs from Johnson et. al will be in the case study itself. Instead of analyzing the countries from the point of view of feasibility of business opportunities, I will analyze the water purification technologies that are most suitable for introduction to this developing nation. In order for the adoption of these technologies to be feasible, they must sufficiently purify unclean water, be affordable enough for domestic consumption, and socially and culturally appropriate. In addition to these conditions, the technologies must be able to be operated and maintained by the local people. Based on this criteria, media filtration, reverse osmosis, and flocculation/coagulation technologies will be used as the basis for conducting the case studies.

Data and Analysis

Country selection

A similar set of variables used by Johnson et. al were used to narrow down a country to be selected for a case study. Variables like literacy rates, government effectiveness ratings, population, GDP, and political stability were used to determine the country to be analyzed. Unlike Johnson et. al, this paper will only focus on one country, and dive deeper into the resisting factors to the adoption of new water purification technologies. This country will be China. China was chosen as the country of interest due to its relatively favorable conditions for new technology adoption. Its growing GDP and political stability creates an interesting environment for these new technologies, allowing for discussion of the feasibility of its adoption. Key data used in making this decision is listed in Table 1 below.

Table 1: Key variable data for China

Variable	**Data with Units**
Gross Domestic Product per Capita	10430.73 USD
Political Stability	-0.29
Government Effectiveness	0.65
Population	1410.93 (in millions)
Literacy Rates	96.84%

Sources: (*World Bank Open Data*) and (*UIS Statistics*)

Landscape

Human society and the development of countries depend on the people's access to clean and potable water. But with water demand increasing globally, water scarcity is increasingly affecting areas where water resource allocation was already sparse. This is especially true in China, where the available water per capita is only one fourth of the world average (Ma et al.,

2020). This water scarcity is not evenly distributed throughout China's provinces and regions, though. North China, which is composed of mainly rural areas, suffers from "both insufficient water quantity and inadequate quality throughout the year", whereas South China, which is more urban and houses most of the population, " is subject to seasonal water scarcity mainly due to water quality degradation" (Ma et al., 2020).

Natural monsoons put stress on the regime through the creation of additional water scarcity. Monsoons and other natural phenomena impact the quantity and quality of water, with most of their effect being seen in the more agricultural Northern China. Water scarcity increases during the dry seasons between March and May, which is the cause of the greatest regional water resource inequality annually, since industrial water requirements are often prioritized over agricultural (Ma et al., 2020). The monsoons present an interesting landscape in the framework of the MP, because they are not human causes, but natural occurrences that can influence the adoption of the niche.

But not only does China suffer from water scarcity, they also suffer from inadequate water quality. Poor water quality impacts availability even in Southern China, where resources are more plentiful. This insufficient water quality was likely caused by the rapid increase in urbanization and population growth in these areas. China's urban population has more than doubled in less than 25 years, with pollution-degraded water resources reaching 537 million cubic meters in 2020 (Jiang Y., 2009). This increase in urbanization, industrialization, and population growth leads to an increase in the pollution, which ultimately affects water quality and accessibility. This decreased water quality has had real consequences on the development of the nation, with poor water quality being attributed to a 1.16% decrease in GDP in 2003 (Jiang Y., 2009). Because of this decrease in economic activity, the issue of water scarcity is on the

Chinese government's radar, and may serve to aid in the adoption of water purification technologies.

Regime

The industrialization and urbanization of China encapsulates the socioeconomic regime. China is one of the fastest growing economies in the world. It has seen a 2.35% increase in real GDP in 2020 and ranks #17 in economic growth that year (*World Bank Open Data*). It has experienced this growth through its industrialization and urbanization, but as previously mentioned, this growth has caused water quality and accessibility issues. In these areas, the predominant land type has switched from natural vegetation to constructed surfaces, which increases runoff and has changed stream channels (Luo et al., 2018). This runoff has the potential to lead to severe pollution of the aquatic environment (Ma et al., 2020). This decrease in water quality and quantity has impacted the productivity of the country, but it is seen as a lesser evil, since GDP, employment, and literacy have been on the rise. China continues to choose to boost its socioeconomic status over its water quality because of these reasons, which lends to the idea that they may invest in water purification technologies down the line. Their socioeconomic actions in the present and past will inevitably catch up to them, and with their booming economy and educated populace, China seems favorable for the adoption of these novel technologies.

China's political regime is likely the largest supporter of the adoption of water purification technologies. In 2002, the Chinese Ministry of Water Resources initiated the China Water Resources Master Plan (CWRMP). The CWRMP was created to address China's water issues through the research and understanding of climate change conditions, construction of an effective information and metering system, and to finally deploy a strategy for the future. In

conjunction with this plan came the “three red lines” plan, which tackles water issues through the limiting of water use, water use efficiency, and water pollution (Xia, 2012). The three red lines take into account the available water resources and reflect the scale of socioeconomic development. Through these plans, the Chinese Ministry of Water aims to pinpoint areas of wasteful water use, and crack down on the perpetrators with fees and fines (Dajun et al., 2015). Also, by monitoring the water usage, efficiency, and pollution, they could make more informed decisions on which water purification technologies to implement into certain regions.

Although the Chinese government has made serious efforts to reform their water resource management, these attempts have not come without controversy. A recent project being undertaken by the Chinese government is the South-to-North Water Diversion Project (SNWDP). The SNWDP is the largest water diversion project of its kind in Chinese history, even larger than the Three Gorges Dam. As mentioned previously, the northern areas of China have struggled with both water quality and water quantity issues, unlike southern China which only suffers from water quality issues. For this reason, chairman Mao Zedong first proposed the idea in an attempt to ease water shortages in northern regions in 1952. It took 50 years of research, planning, and debate, before the plan was approved by the State Council in 2002 and construction began in 2003 (*South-to-North Water Diversion Project*). There were many debates about environmental and budget concerns, as the plan would cost almost 60 billion USD and expand over thousands of kilometers. This project encapsulates the political regime within the MP framework, because the debates around it emphasize the resistance to change.

Niche

Many designs for point of use water purification techniques exist today, with many ranging in complexity and cost. As mentioned above, the following technologies were determined to be suitable for China: media filtration, flocculation/coagulation, and reverse osmosis.

Media filtration is by far the simplest of the techniques, which flows water through a granular bed at a low speed to leave particulate matter behind while allowing for pure water to pass and be collected. This process is usually performed multiple times to ensure the removal of unwanted impurities. The filtration medium can range wildly, from expensive professional filters, to washcloths. Media filtration is great for separating solid impurities from water streams, but lacks the ability to disinfect the water going through it. This technology would be most suitable for the rural northern regions of China, as it is low maintenance and can be low cost.

Flocculation/Coagulation has a similar result as media filtration, just achieved in a different way. Coagulation and Flocculation often occur successively, although they can be performed individually. Coagulation is the collection of suspended solids in a water sample to a single particle through use of a charge attraction. This is usually done using a chemical coagulant. Flocculation is a gentle mixing stage that serves to effectively ‘clump’ up the particles to allow for easy separation from the water. This technique can also effectively remove large organic and inorganic polymers (Auerbach, P. S., 2017). Flocculation and Coagulation is a well researched and low cost technique and

Reverse Osmosis (RO) is another well documented water purification technology. Reverse osmosis pushes water through a selective membrane using a pressure differential to separate the water from its contaminants. This technique is roughly 95% effective at separating dissolved solids and also removes most bacteria, viruses, and other organic substances (*Reverse*

Osmosis., 2014). Reverse Osmosis, though, is fairly energy intensive and requires fair amounts of maintenance and upkeep. RO is a plausible option in southern China, since it is a more urban and industrialized region and would likely have the infrastructure necessary to support such a complex and energy intensive technology.

Conclusion

Access to safe and potable water is pivotal to the health, safety, and growth of a country and its people. Existing socioeconomic and cultural inequalities exist in both urban and rural China, promoting water disparities that already harm these communities. For these reasons, water purification solutions should be region specific, with thought being put into the specific political and socioeconomic landscapes of the region in question. Due to the agricultural regime of northern China, a niche that is low cost and can aid in irrigation and water diversion would be the most beneficial, since natural disasters and dry months cause the most harm to their water supplies. On the other hand, water quality poses more of an issue to the industrial and urban regime and landscape of southern China, suggesting that these areas should tackle their quality and pollution issues by implementing niches while also balancing their economic activities through regulations created by the Chinese Ministry of Water Resources. In conclusion, in the face of impending climate change and population increases causing increased water scarcity, policies and technologies should be adaptable, and implemented with consideration of the socioeconomic and political obstacles that stand in their way.

Resources

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