Hydroponics: Assessing the Sociotechnical Implementation of Clean Water Resources in the Middle East

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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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STS Research Paper

Introduction

Middle East is the most water-scarce region of the world. Home to 6.3 percent of the world's population, the region contains only 1.4 percent of the world's renewable fresh water (Roudi-Fahimi & Creel, n.d.). Without assessing the sociotechnical implementation of clean water resources, the region risks facing public health crises, social unrest, and potential conflict over water. Firstly, water scarcity is a critical issue in the region, and inadequate access to clean water resources can lead to a host of problems, including public health crises and social unrest. Secondly, the successful implementation of clean water resources involves the integration of social and technical factors, such as community engagement, infrastructure development, and water treatment technology. Without considering these factors, the implementation of clean water resources may not be sustainable or effective in addressing water scarcity issues. Thirdly, the Middle East is a region with a complex geopolitical landscape, and water resources can be a source of conflict between nations or communities. Therefore, assessing the sociotechnical implementation of clean water resources can help ensure that water resources are managed in a way that promotes cooperation and peace in the region. The purpose of this study is to assess the implementation of hydroponics technology in the Middle East using the STS framework of Social Construction of Technology (SCOT).

Methods

The question that guides this research study is, "What is the sociotechnical process of implementing hydroponics technology in the Middle East?" To determine if the implementation

of hydroponics in the Middle East will offer a solution for farmers to continue to grow food with diminishing supply of clean water, a case study methodology is utilized. The keywords guiding the research are “Hydroponics,” “Public perception of hydroponics in Iran,” “Public perception of hydroponics in the Middle East,” “Hydroponic innovators,” “Middle Eastern social economic crisis,” and “Middle Eastern government response to technology.” The discussion analyzes a case study of hydroponics implementation in Iran to understand the sociotechnical relationship of this technology. This geographic study offers insight into the sociotechnical response to this technology, which allows a strong basis to analyze the response of hydroponics technology in the Middle East.

Background

The Middle East is home to the earliest developed regions in the world, home to rich cultures and beauty. However, these countries face a major issue, an ever-increasing lack of fresh water. This scarcity has significant impacts on the populations in these areas, which ultimately spread to the rest of the world. Climate change and population growth are two major factors causing issues such as longer droughts, more variable flooding, increased probability of desertification, and lower water quality (Sowers et al., 2011). The poorest countries and populations will feel the greatest costs of climate change, and this is not the only impact. The oil-exporting states have already exceeded their freshwater resources and rely on other techniques such as groundwater and desalination. About 780 million people around the world do not have access to clean drinking water, a statistic that is clear in areas such as the middle east (Salaam-Blyther, n.d.). With these areas constantly coping with polluted water or only have access in certain intervals of the day. The lack of fresh water supply in turn makes water usage for farming extremely difficult, especially since some farming methods such flood irrigation has up to 50%

water loss (*Why All Farms Don't Use Drip Irrigation*, n.d.). The lack of basic needs can lead to violence and psychological stress, which is already seen in this region, as well as in other parts of the world. Water scarcity can lead to mental illnesses such as depression, anxiety, solution isolation, etc. (Ženko & Menga, 2019).

Population growth is another significant factor that exacerbates water scarcity in many parts of the world, including the Middle East. As the global population continues to increase, the demand for water resources also rises. Rapid population growth in arid regions with limited water resources results in increased competition for scarce water resources, leading to water scarcity. The population growth also leads to urbanization, which puts additional pressure on water resources. As more people move to urban areas, the demand for water increases for domestic, industrial, and agricultural use. Therefore, population growth is likely to intensify water scarcity in the Middle East and other regions of the world, calling for sustainable water management policies to ensure that the water supply meets the growing demand. Less freshwater availability means less water available to grow food. Population increases currently on the rise every year was predicted back in 2000 to reach 651 million people in 2030 (Sowers et al., 2011). Currently in 2022 estimates are 472 million people and trends show no sign of any sort of plateau coming soon (*Population, Total - Middle East & North Africa | Data*, n.d.). Many countries in the Middle East rely on imports for food, but with the population growth this pattern will not be sustainable. While nothing can stop the effects of climate change and population rise, technologies such as hydroponics can offer support to help these vulnerable populations until climate change can be addressed properly.

Hydroponics is a sustainable agricultural technique that has the potential to address one aspect of the water crisis issue. Unlike traditional farming, which requires large amounts of water

to grow crops, hydroponics relies on a water-efficient system that recirculates water and nutrients to plants in a controlled environment. This closed-loop system uses up to 90% less water than traditional farming and reduces the amount of runoff and pollution that can contaminate water sources. Additionally, hydroponics can be implemented in urban areas where access to clean water is limited, providing a source of locally grown produce that is free from harmful chemicals and pesticides. With the increasing demand for food and shrinking water resources, hydroponics can help alleviate the pressure on water supplies while providing a sustainable source of fresh produce (Jensen, 1997).

The social influences on technology in the Middle East are complex. Culture, public perception, and religion are all factors that shape the adoption and use of technology in the region. In many Middle Eastern countries, religion plays a significant role in society, and this can influence attitudes towards technology. Specifically Islam is the dominant religion in the Middle East and North Africa, with 93% of the region identifying as Muslim in 2010 with the numbers only expecting to increase in the future (Wormald, 2015). For example, some Islamic countries have restrictions on the use of water, such as some Islamic countries do not condone grey water usage (Ahmad, n.d.; "Water Supply, Sanitation, Hygienic Considerations and Practices in Muslim Civilizations," 2021). Islamic countries also have a practice of cleaning themselves before prayer called Wudu, which is a purification ritual requiring that they wash their faces, hands, arms, and feet using only clean water (adesanyai, 2016; *BBC - Religion & Ethics - In Pictures: Wudhu Ablution*, n.d.). Since most of the population is performing this ritual, rationing is put in place to ensure water availability and prevent negligent water loss. Overall, a deep understanding of the social and cultural factors that shape the use of technology is essential for effective technology implementation and adoption in the Middle East.

STS Framework

The Social Construction Of Technology (SCOT) framework is a sociotechnical theory that explains how technological artifacts emerge and evolve over time in response to social and cultural influences. The SCOT framework was first developed by a group of sociologists and historians of technology in the 1980s. The key contributors to the development of SCOT are Wiebe Bijker, Thomas Hughes, and Trevor Pinch (Pinch & work(s):, 1984). The SCOT framework argues that technologies are not determined by their inherent technical properties, but instead are shaped by the social and cultural contexts in which they are created and used. The framework identifies four main components that shape the social construction of technology: interpretive flexibility, relevant social groups, closure and stabilization, and wider context. Interpretive flexibility refers to the multiple meanings that can be attached to a technology, depending on the social and cultural context in which it is used. This flexibility allows for different interpretations of a technology, which can influence its adoption and evolution. Relevant social groups are the stakeholders who have a vested interest in the development and use of a particular technology. These groups can include manufacturers, users, policymakers, and social activists, among others. Relevant social groups refers to the way that a technology is presented and understood by specific groups. The way a technology is framed can shape its adoption and evolution, and different groups may frame a technology in different ways depending on their interests and goals. Closure and stabilization refers to the point at which a technology becomes accepted within a particular social and cultural context. This process is influenced by a variety of factors, including technical considerations, economic factors, and cultural norms. The last component wider context refers to the wider social-political milieu in where the technology development occurs. Wider context includes background conditions of

group interactions, such as their relationship with other, the rules which govern their interactions, factors that contribute to differences in their power (Klein & Kleinman, 2002).

Although the SCOT framework has been widely used and is influential in the field of Science and Technology Studies, it has also been subject to criticism. The main critics of SCOT were Langdon Winner, Stewart Russell, and Klein & Kleinman (Klein & Kleinman, 2002; *The Social Construction of Artefacts: A Response to Pinch and Bijker on JSTOR*, n.d.; *The Social Construction of Artefacts: A Response to Pinch and Bijker on JSTOR*, n.d.). One of the main critiques of the SCOT framework is that it tends to overemphasize the role of social groups in shaping technology, while underemphasizing the role of larger structural factors such as power relations, economic interests, and political institutions. Critics argue that the framework does not fully account for the ways in which technologies can reinforce existing power structures. Another criticism of the SCOT framework is that it may be too focused on the early stages of technology development and may not be as useful in understanding the later stages of technology implementation and use. Additionally, critics have pointed out that the framework may be limited in its ability to capture the full range of social and cultural factors that influence technology, such as gender, race, and class. Finally, some critics argue that the framework is too focused on the Western world and may not be as applicable to non-Western contexts where different cultural and social factors come into play.

Even with these critiques in mind, the SCOT framework provides a useful view for understanding how technology develops in response to social and cultural factors, and how different groups shape the meaning and use of technology. It can be applied to a wide range of technological artifacts, from simple tools to complex systems, and is useful for analyzing the social and cultural dimensions of technological change. Hydroponics is a new and emerging

technology that has the potential to cause major change in the middle east. That, however, depends on the acceptance and use of hydroponics technology. SCOT is applied to this analysis because it provides a look into how social factors affect the implementation of a technology and can provide insight into how hydroponics will fare in this region.

Results and Discussion

Analysis of Iran Case Study

To begin, this analysis will start with the results of the case study and then discuss the application of the SCOT framework. The main case study presentation comes from an Iranian study from the paper, *Understanding farmers' intention and behavior regarding water conservation in the Middle-East and North Africa: A case study in Iran* (Yazdanpanah et al., 2014). Along with other Middle Eastern countries, Iran is at a high risk of serious water shortages which could bring challenges such as rising water demand and shortage, declining groundwater levels, deteriorating water quality, and increasing ecosystem losses (Madani, 2014). The paper, written by researchers from countries around the world, including the United States, Iran, and Australia, analyzes the behavior and intention of farmers in conserving water in Iran. Specifically, the people in Iran were in the Boushehr province, an area in the south region of Iran, and data from the interviews was gathered in the summer of 2011. The farmers in this region generally believe that a water crisis risk is high and understand that it is important to be conservative in water usage. However, the study outlines that water conservation is also a moral issue, such that farmers may believe they should act a certain way to uphold their moral beliefs, but still end up acting in a contradictory fashion. For farmers to use water conservation strategies then they must put themselves at a disadvantage, which can make farmers less inclined to switch to this new technology even if they may know it is the better choice. This moral conflict brings a

great threat to introducing new technologies because regardless of how they feel about the crisis if farmers do not actually change their actions, then it will never get implemented. Now that a little background of the paper has been introduced, an analysis of the study will begin.

Currently the government in Iran has been looking to mitigate climate change impacts. The government is adapting in three ways adapting based on current technology, strengthening research and development for new, technologies and making changes in the institutional environment (*Climate Change and Agriculture*, n.d.). Adapting existing technologies requires spreading information through extension systems to farmers for them to be able to use the technology. Currently, there is a deficit of these extension systems while results in a lack motivation for farmers to implement these existing technologies. The government also seeks to strengthen research and development of new technologies mainly by introducing new crop seeds and shifting planting dates. However, government bodies are currently not involving major investments in new technology. The last strategy the government is currently doing is adapting government policies, such as policies that improve climate monitoring and early warning, along with a strategies to implement regional adaptation plans and to spread information more effectively. Iran's government is increasing water supply in agricultural regions by changing the policy to manage water demand. Increasing treatment in wastewater and desalination is prioritized instead of construction of dams and the exploitation of groundwater aquifers. Farmers have responded to the crisis as well, but their adaptation is not well documented. Their response mostly involves diversification of crops, adoption of insurance, changing planting strategies, and increased investment in irrigation infrastructure. Wealthy farmers are mainly the ones adapting to these changes and benefiting from the investments and policies. The poor farmers often suffer

more from drought and do not have the fund to adapt as easily as the rich or more well off (*Climate Change and Agriculture*, n.d.).

The SCOT framework states there are four basic components, interpretive flexibility, relevant social groups, closure and stabilization, and wider context. In SCOT, there are usually two categories of social groups, the producers of the technology and the users. For this analysis, there are three primary social groups, the Iranian farmers (direct users of the hydroponics technology), the Iranian government (the group implementing hydroponics technology), and the developers of the hydroponics technology. The Iranian farmers, like most of the world have used traditional methods of farming for thousands of years. One of the key factors is the moral conflict that farmers face when considering water conservation strategies. Although they recognize the importance of conserving water and understand the risks of a water crisis, they may still act in contradiction to their moral beliefs due to the disadvantages they face by implementing these strategies. The government and producers of hydroponic technology on the other hand are pushing more towards implementing the new technology because of their view of the bigger picture. These two viewpoints show the interpretive flexibility of technology because while the government and the producers of the technology believe that hydroponics can make the area prosper, the farmers are hesitant and are leaning towards their traditional farming techniques. These viewpoints highlight the importance of understanding the values, beliefs, and norms of the society in which technology is being introduced. Another factor that affects the adoption of technology in the Middle Eastern region is the lack of extension systems, which are critical for spreading information about new technologies to farmers. This deficit results in a lack of motivation for farmers to implement existing technologies, which highlights the importance of providing adequate resources and support to farmers in the region. The government's response to

the water crisis in Iran also reveals the influence of political and institutional factors on technology adoption. The government's focus on adapting existing technologies rather than investing in new ones suggests that there may be limited resources and funding for technological innovation in the region. Additionally, the prioritization of increasing treatment in wastewater and desalination over the exploitation of groundwater aquifers reflects a shift in government policy that is influenced by societal values and beliefs regarding the importance of environmental sustainability.

With respect to closure and stabilization, there is no clear outcome that can be predicted at this time because hydroponics is still new and currently being implemented in the region. Currently the region has not adopted widespread use of hydroponics, since this is still early in the process there needs to be more time to develop a conclusion on whether stabilization has occurred. However, if hydroponics is introduced correctly and the region has a large use of this technology, there is the potential for a plethora of benefits. Food security would increase to help with hunger problems and malnutrition. Economic growth and development which could create new jobs and opportunities for farmers and other related industries. The increased food supply and less water usage would contribute to social stability and could resolve conflicts over food and water shortages.

Discussion

Hydroponics is still a new technology, and unlike traditional farming that has been around for thousands of years, farmers and scientists are still exploring what the large-scale implementation of this technology looks like. Hydroponics has potential to help aid areas that are experiencing water crises, and the data shows that hydroponics could very well change the sociotechnical nature of the Middle East if introduced in the correct way. Hydroponics as a

technology is not well funded, and a critical social group, namely farmers, are not educated on the ways in which this technology could help food production practices. Additionally, other cultural factors such as gender roles and societal norms can impact the use of technology, particularly regarding women's access to technology. Finally, general public perception of hydroponics technology is also important, as it can influence the willingness of individuals and organizations to invest in and adopt new technologies.

Limitations and Future Research

In the conversation of wider context, future work requires this same research question should be applied to other regions in the area, such as Northern Africa. Northern Africa similar social considerations as the Middle East, as well as the same conditions of an impending water crisis. Northern Africa could benefit from the implementation of hydroponics and an analysis like this could prove useful in determining how it should be implemented. Another aspect of future work is the continuation of this paper after more time has passed to determine closure and stabilization component of SCOT. As Klein and Kleinman state in their criticism, SCOT fails to take account the systemic factors already at place, such as a corrupt government or the lack of power of the farmers. (Klein & Kleinman, 2002). A deeper analysis of the structural factors would be beneficial to the topic and should be considered for future work.

Conclusion

In conclusion, the implementation of clean water resources, particularly hydroponics technology, in the Middle East is crucial due to the region's water scarcity, the potential social and technical benefits, and the need for potential conflict resolution. The Middle East is the most water-scarce region in the world, with limited access to renewable fresh water despite its

growing population. Insufficient access to clean water resources can lead to public health crises and social unrest. By integrating social and technical factors, the implementation of clean water resources can effectively address water scarcity issues. Moreover, considering the sociotechnical aspects can promote cooperation and peace in a region where water resources can be a source of conflict. The SCOT framework provides a valuable lens for understanding how technology develops and is influenced by social and cultural factors. The case study analysis of hydroponics implementation in Iran reveals the moral conflicts faced by farmers in adopting water conservation strategies. It also highlights the role of relevant social groups, such as farmers, the government, and technology developers, in shaping the implementation of hydroponics. However, it is important to acknowledge the limitations of the SCOT framework, such as its potential overlooking of larger structural factors and its Western-centric focus. Nevertheless, hydroponics technology offers a promising solution to water scarcity in the Middle East, reducing water usage, providing sustainable agriculture, and potentially improving the overall well-being of the population.

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