

A Novel Approach to a Sustainable
Waterjet Propulsion System
(Technical Paper)

An Assessment of Water
Systems and Policy
(STS Paper)

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Introduction

Why is freshwater so important to us? There are a multitude of ways that humankind use freshwater for across the world. These include, but are not limited to, recreational activities, crucial human consumption, farming, and manufacturing. Obviously, water is key to our survival as a species. Although water may seem infinitely plentiful in developed countries, demand is increasingly exceeding supply. This poses many concerns regarding how we behave around freshwater, and how we utilize it. Not only is water consumption an issue, but pollution also further limits the supply. Without understanding how to effectively manage our water sustainably, many of the world's metropolises will not be able to provide adequate supply for their continuously growing populations at an affordable price.

Technical Problem

With respect to the need for sustainability, my technical project involves configuring a battery-powered mechanical and electrical systems in order to add waterjet propulsion onto a commercial kayak. The development of a battery-powered system avoids the issues caused by gasoline-powered propellers that pollute freshwater bodies and are subject to environmental restrictions. It also is useful in shallow water, as it only drafts a few inches. Additionally, because this propulsion system keeps forwards momentum without the need for human-power paddling – as in a traditional kayak – this allows for an easier, less-strenuous means of travel upriver and against the current.

Through the use of computer-aided design packages and additive manufacturing, a waterjet, impeller and jet-housing units will be fabricated. From this point, they will then be mounted onto the back of the kayak and connected to rechargeable batteries. The final product resulting from this will be a functioning waterjet addition to a kayak, complete with electronic motor control systems for power, and steering. Once complete, this kayak

modification will be usable in freshwater bodies that are relatively shallow and feature environmental constraints.

The ideal result is to have a streamlined device that lays groundwork for an eventually marketable device. The goal is to have something that is more developed than a simple prototype, meaning that it functions well with highly refined controls systems. While it may never be used as a true business model, it is intended to be developed in a way where mass production of the device would become the next logical step.

STS Research

An assessment of water justice and equity in a world built on scarcity

While recreational activities that involve freshwater depend on the principle that there is enough water for its use, this begs the question: how much is at our disposal? It must be noted that less than 3% of the planet's water is deemed fresh, but 66% of that 3% is trapped in ice. This leaves less than 1% of the world's water accessible to humans; however through pollution, the actual volume of potable water is less than 1% (Rogers and Leal, 2002). The amount of usable water is scarce, but it may not seem obvious. In Latin American nations, water infrastructure is being developed to bring water to the people, but there are ingrained policy failures that change the definition of water accessibility, which ultimately commoditize it (Finnegan, 2002). Commoditization of water is when water transforms from being recognize as a public good to becoming a tradable commodity, which allows companies to profit over its management. This leads to the question: *In Bolivia and Mexico, why are the political agendas surrounding water management systems failing to provide systems of delivery that are both sustainable and able to accommodate human need?*

Background

Water is scarce, but it is something that everybody needs. It is very different from other scarce resources because without it, a person dies. Across the planet, there are instances

where available water cannot support the rapidly growing global population. There is a need to be efficient and effective with water consumption and delivery in order to ensure the longevity of humankind. The world's water infrastructure needs to be optimized, but it often isn't. Through an analysis of prior work, it can be seen that in Bolivia and Mexico there are failures in the political-economic, social and mechanical networks, and their ramifications need to be understood in order to find the best way to manage water.

Throughout Latin America towards the end of the twentieth century, nations began to employ neoliberal agendas. This political ideology places an emphasis on market-regulated devolution from federal control to either private holding or lower government levels (Harris and Roa-García, 2013). In the 1990s, governments began to devolve their national enterprises – whether it be water, mining, railroads, or electricity. This change of management pushed the change from an equal-access ideology (with respect to water) to a commodity-driven one (Perrault, 2006).

Typically, when water services are devolved, it leads to accelerated improvement of the system to try so that more customers can be reached. In some places, like Argentina, which experienced an overall increase in public health and welfare after water privatization in the 1990s, the change worked (Galiani, Gertler and Schargrotsky, 2005). However, government devolution in Latin America has been seen to, and continue to, cause significant sociopolitical unrest.

The Bolivian Water Wars

One of the greatest example of a lack of social consideration while devolving public water authority is the Bolivian “Water Wars” that began in 2000. For the city of Cochabamba, the neoliberal Bolivian federal government hastily passed Ley 2029, which gave a private company, Aguas del Tunari, a subsidiary of the American company Bechtel,

exclusive access to all of the water (groundwater, well water, rainwater, etc.) in the Cochabamba metropolitan region (Perrault, 2006).

Before privatization, there was intrinsic liberty in how citizens would obtain water, following a traditionalist Quechua style of the indigenous people (Perrault, 2006). Many would dig private wells to access “free” groundwater while others would use ancient irrigation systems; once the law was passed in the Bolivian legislature, the government gave all water jurisdiction to the single enterprise creating a monopoly. This doctrine also gave Aguas del Tunari jurisdiction over once private wells and irrigation channels, allowing a new avenue of exploitation. (Perrault, 2006, Spronk and Crespo, 2008).

Through what was billed as a method to modernize the water infrastructure for a rapidly-growing metropolitan population, Aguas del Tunari was, through their government-sanctioned charter, able to raise water fees by up to 35 cents, which made up a quarter of an average worker’s monthly salary. Despite this figure, the price was found to have increased by 200 cents locally (Finnegan, 2002, Spronk and Crespo, 2008). What happened in Cochabamba was that the water became commoditized, and the ability to have water to survive had a high price tag.

What did this mean for the people in and around Cochabamba? It meant fear and a lack of trust in the government. The Bolivian government has always struggled to maintain national support among its people. Once the people realized that their liberty and livelihood were at stake, they protested (Spronk and Crespo, 2008). Their demonstrations against the neoliberal agenda were occasionally violent, but very powerful. After a series of national strikes, the government was forced to act in April 2000 after months of unrest. Ley 2029 was changed, but at what cost? (Perrault 2006, Spronk and Crespo, 2008).

With this initial failure first being contained on paper, the state faced a crisis because of the convoluted wording of its laws. In a recent amendment to the Bolivian constitution,

there was a new clause that defined water accessibility was a human right. This was exciting news, but its interpretation was clouded by vague wording. Since the 2009 Constitution has over 400 articles, some articles tend to contradict others, so this specific amendment has questionable impact (Harris and Roa-García, 2013).

What does all of this show of the neoliberal movement to privatize industries, and why did this fail so catastrophically in Bolivia? It shows that faulty management by the Bolivian government and lack of social awareness by Aguas del Tunari led to its own demise. As an American-backed water consortium, Aguas del Tunari failed to understand what the sentiment surrounding water in Bolivia was like. Aguas del Tunari did not understand what their modernization plan would do to the city and its people, and how their new jurisdiction over once-private sources would pose an existential crisis to the people (Spronk, et al, 2008). The government too failed in its due diligence by allowing Aguas del Tunari to manage the region's water supply. Their resolution to devolve power was hasty, and it did not take into account what the socio-political climate surrounding water was like in Cochabamba (Harris and Roa-García, 2013).

Mexican Water Devolution

Devolving complete infrastructure control to a private holder is one interpretation of neoliberal reform; another is devolving power from the national government to federated, levels of government. Like in the private holding, lower-level government officials also fail to provide adequate services for the populace. One such example is Mexico.

In 1992, the Partido Revolucionario Institucional (PRI) enacted a series of neoliberal reforms to devolve the power of water management to state and local municipalities (Wilder and Lankao, 2006). The rationale for this reform was to help improve the quality of life of each state by giving increased pluralism in legislation regarding water authorities. Local governments would have a more intimate relationship with constituents, which would allow

them to improve facets of the water infrastructure specific to a certain constituency (Wilder, 2008).

The idea had good pretenses, but many of the states were caught off-guard and found themselves unable to effectively transition, including the capital (Ciudad de México) and Sonora (the Northwest of Mexico along the United States border).

Mexico City, along with many other large cities in the nation, inherited dilapidated water systems that were ineffectively subsidized beforehand by the federal government and were approaching the end of usable lifespan. After priista devolution, the water of Mexico City fell under the management of the state entity Conagua (de San Miguel, Lambarry-Vilchis and Flores, 2019). Since the 1990's, the city has kept the service fairly cheap, but it has failed to factor in maintenance costs for the crumbling system. This has not been the only issue; the city has not had enough water meters installed. Because of this, they have not been able to charge people correctly for water. Additionally, with less capital and revenue than the federal government, there have been less funds to appropriate to fixing the system (Bauer, 2010). This system in particular has lost up to 50% of piped water to leakage. This has been especially troubling for Mexico City as most of the municipal water has been sourced from rapidly-draining aquifers under the city, which has caused the city to sink up to 9 meters a year (de San Miguel, et al, 2019). Mexico City has been rapidly running out of water. As more water is lost, the city comes closer and closer to a day where the taps no longer provide water. Here, the neoliberal reforms of the 1990s priista agenda have been unable to consider the needs of the constituencies before reforming policy.

Transitioning to the arid state Sonora, the local government has felt great strain as a result of water reform. Sonora has been in a drought since the mid-1990s, but it is one of the most demanding of water per-capita in all of Mexico (Wilder and Lankao, 2006). This is due to its advantageous location near the United States border. Numerous American corporations

own factories (or maquiladoras) in Sonora to utilize the cheaper labor. The entire manufacturing process is extremely water intensive, but this area is and has been dangerously dry (Wilder and Lankao, 2006, Wilder, 2008). This has put tremendous strain on the water supply, so much so that the increase of maquiladoras has forced *ejido* (common farmland) farmers to shorten their growing season, retire lands, close wells, or move away. (Wilder, 2008).

This has been challenging to traditional Mexican values. The Mexican Revolution was fought in the early 20th century to return *ejidos* to the common person after years of “Europeanization” under Porfirio Diaz (Matute, 2010). What has happened recently, though, is that the local government has given preferential treatment for water to factories in this drought-stricken region.

What is seen here is a lack of government understanding of the sociopolitical climate in Sonora. The concept of an *ejido* is ingrained in the blood, sweat, toil, and tears of the Mexican people. Despite this, the people have once again been losing their land as a result of a scarcity of water due to local government preference to manufacturing industry for international consumers.

The Bolivian scenario and the Mexican example both show different aspects regarding the failures that occur when a government fails to provide effective policymaking surrounding its infrastructure and resources. Whether it be through neoliberal agendas that devolve entire authority to a single, private entity or when a power is devolved to lower levels of government, there is a lack of mutual understanding between utility users and the policy itself. In order to provide a system that functions sustainably and effectively for all, there needs to be common ground on all fronts in order to manage effectively.

Data Collection and Analysis

In order to truly understand how these two went about making policy decisions to manage these systems, more research needs to be conducted in order to understand all perspectives and ideologies. In addition to scholarly reviews of the scenarios, reading first-hand accounts will be helpful to understand the points-of-view for the relevant social groups. This information will be categorized into three main buckets corresponding to the relevant social groups: policy-making groups, the management companies for the water services, public opinion from constituents and opposition agendas and reasoning. All of these sources will build a full understanding of the state-of-affairs in each region and why decisions were made in order to find where things went wrong.

Finding information specific to the actor network and mutual shaping of these two sociotechnical system will be helpful for finding and classifying specific factors that contributed to their shaping. Taking into consideration all of the social groups, beliefs and expectations, key events that influenced development can comprehensively be studied. Understanding the moments that defined the trajectory of the Mexican and Bolivian water sociotechnical systems can shed light on how these moments led to the political-economic failures. Seeing similar trends in both countries, as well as differences, in how these two systems were shaped can bring a better understanding of potential risks that are at stake in neoliberal political-economic environments when taking part in the shaping of water sociotechnical systems.

Conclusion

By the end of the technical design and research phases, there will be a greater understanding of water systems with regards to sustainability. For the technical design, the goal is to have a functioning, well-designed system that can serve as a model for a low-pollution method of watercraft propulsion. This can serve as an example on how to design large-scale systems that protect the world's water from petroleum-based pollutants.

In addition, the research will provide a better understanding of trends involved in neoliberal political-economic approaches to the mutual shaping of water sociotechnical systems. With obvious policy failures and faults in systems globally, it is crucial to understand where things can go wrong and whether or not they are commonly made

Overall, the end of these tandem initiatives will provide a greater understanding of what it means to protect and conserve the most crucial resource through management of how we use it and with what.

References

- Bauer, C. (2010). Market approaches to water allocation: Lessons from Latin America. *Journal of Contemporary Water Research & Education*, 144(1), 44-49.
- Finnegan, W. (2002). Leasing the Rain. *The New Yorker*. 78, 43-53
- Galiani, S., Gertler, P., & Schargrodsky, E. (2005). Water for life: The impact of the privatization of water services on child mortality. *Journal of political economy*, 113(1), 83-120.
- Harris, L. M., & Roa-García, M. C. (2013). Recent waves of water governance: Constitutional reform and resistance to neoliberalization in Latin America (1990–2012). *Geoforum*, 50, 20-30.
- Matute, Á. (2010). Los años revolucionarios (1910-1934). *Historia de México*. México: FCE, SEP, Academia Mexicana de la Historia.
- Perreault, T. (2008). Custom and contradiction: Rural water governance and the politics of usos y costumbres in Bolivia's irrigators' movement. *Annals of the Association of American Geographers*, 98(4), 834-854.
- Rogers, P. P., & Leal, S. (2010). *Running Out of Water: The Looming Crisis and Solutions to Conserve Our Most Precious Resource*. New York: Palgrave Macmillan.
- de San Miguel, J. A. S. R., Lambarry-Vilchis, F., & Flores, M. M. T. (2019). Integral Drinking Water Management Model in Iztapalapa, Mexico City. *Management of Environmental Quality: An International Journal*, 30(4), 768 - 782.
- Spronk, S., & Crespo, C. (2008). Water, national sovereignty and social resistance: bilateral investment treaties and the struggles against multinational water companies in Cochabamba and El Alto, Bolivia. *Law, Social Justice and Global Development*, 1, 1-14.
- Wilder, M., & Lankao, P. R. (2006). Paradoxes of decentralization: Water reform and social

implications in Mexico. *World development*, 34(11), 1977-1995.

Wilder, M. (2008). Equity and Water in Mexico's Changing Institutional Landscape. *Water, Place and Equity*, 1(1), 95-117