Access to Water for Human Consumption in Lima, Peru: An Analysis of Challenges and Solutions

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Lima, Peru is one of the driest cities in the world and has grown immensely in the last 40 years, mostly by informal settlements outside the original city limits. This investigation and literature review, conducted from August-December 2019, is directly related to the conference theme of challenges of urban sprawl and sub/urban zones, informal settlements and slums. Our study analyzed access to potable water in Lima, focusing on the informal settlements outside the city and Lima's most vulnerable populations. Through analysis of various technical and political solutions, we advise further research solutions that include (1) a faster formalization of the water system, (2) better organization of scare water between human consumption and other use, (3) increasing political will and creating a culture that discourages water waste, and (4) testing innovative water conversion methods. Finally, the paper emphasizes the urgency of increasing access to potable water for economic development and public health, especially as the country battles the pandemic of COVID-19.

1 INTRODUCTION

Water is an indispensable resource for human life, for this reason, access to potable water is considered a human right that States are obligated to provide by international norms (ANA, 2019). Access to water resources is necessary for socio-economic progress and for the overall sustainability of a country. This importance for development is further confirmed by the Sustainable Development Goals (SDGs). Access to potable water is directly tied to SDG 1, which refers to ending poverty; SDG 3, which discusses health and wellbeing; SDG 6, which concerns clean water and sanitation, and SDG 11, which interests the creation of cities and sustainable communities.

Despite the fact that South America contains the most freshwater resources of the regions of the world, access to potable water is not secure. In Peru, approximately 10% of the population does not have access to potable water, according to the National Institute of Statistics (INEI). This deficiency constitutes a burden to development for the country, since it detriments the quality of life of Peruvians

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and has a significant effect on public health. Access to potable water is the most challenging in the capital city, Lima. In this lens, this work investigates the situation of water access in the city of Lima, the challenges to improving access, and potential solutions.

2 BACKGROUND

2.1 Current Situation in Lima

In order to begin to explain the current situation regarding access to potable water in Lima, it is important to consider that Law No. 30588 (2017) incorporates Article 7-A into the Peruvian Constitution, which states that "the State recognizes the right of every person to have progressive and universal access to drinking water. The State guarantees this right by prioritizing human consumption over other uses" (Congreso de la República, 2017). In addition, Peru ranks 20th in the world in terms of water availability. Despite this fact, there are significant problems related to water distribution, since 70% of the population resides on the desert coast, where only 2% of Peru's total water availability can be accessed (Burstein-Roda, 2018). In fact, the city of Lima is the second capital in the world to be settled in a desert, and it only rains 9 millimeters a year (Peru Oxfam, 2019). In addition, the demand for water is increasing, but the scarcity of freshwater is worsening. Currently, the number of people without access to drinking water or the sewage system is about 1.5 million in Lima (Peru Oxfam, 2019). In addition, almost 9% of households depend exclusively on tanker trucks for water supply. According to the World Health Organization, a person needs a minimum of 50-100 liters daily to cover their basic needs, but certain neighborhoods in the capital only have 15 liters per day on average.

2.2 3 Main Elements

Various factors that have contributed to the lack of access to potable water that affects about 1.5 million people in Lima. The major factors that have stood out are the capacity of the state, informal settlement, lack of efficiency in hydraulic planning and lack of efficiency in urban planning.

2.2.1 Capacity of the State

As water provision is considered a human right to be provided by States and a public good (ANA, 2019), the capacity of the government to provide water is a major determinative factor in water provision and access. One of the main reasons people will have unreliable water access is if there is weak state infrastructure, financial resources and/or political will to service water to all parts of the population. Although water and sanitation have become much more of a political action item in the last two decades, persistent constraints remain and progress at extending the water network has been gradual at best (Criqui, 2020; Ioris, 2012). Despite annual and incremental improvements in the water and sanitation network, the State is not effectively capable of guaranteeing that SEDAPAL, the major water utility in charge of managing the infrastructure for access to water resources, can provide access to all citizens. This is the main reason that around 1 in 10 *Limeños* does not have reliable access to water.

2.2.2 Informal Settlements

Informal settlements and construction, often called *barriadas, nuevos pueblos* or *nuevos Limas* is a crucial element of the lack of access to water. Peru faced a variety of socio-economic and political crises in the later half of the 21st century- leading to mass migration waves from rural areas. People forced to migrate from rural areas often did/do not have the monetary resources to settle in the city and resorted to building their houses in places that were not intended for living, including hillsides on the peripheries of the original center of Lima (Falconi, 2016). The capital of Peru experienced exponential growth beginning in the 1970s through slums and informal settlements (Falconi, 2016). As a result, there is no formal public water network in these territories, which generally extend to the North and South and along the Rimac River (Mesclier, Piron and Gluski, 2015). Introducing the water network after the territory is informally settled is often complicated and costly, and "intense urban growth" is the main driver of lack of access to water and sanitation, with a few exceptions (Ioris, 2012; Ferguson and Navarette, 2003; Mesclier et al).

Pamplona Alta, a settlement outside Lima that lacks secure water access. Source: Author, 2019.

2.2.3 Lack of Efficiency in Hydraulic Planning

Hydraulic planning also plays a very important role in water provision, especially in different dry climates such as Lima, because limited resources require efficient planning and balance between water demand and sustainable use of water resources. Even if the water infrastructure is extended to all the population, hydraulic planning must ensure the ability to distribute water to 100% of citizens. In the case of Peru, although it has a policy and regulatory framework that focuses on sustainable water management, gaps in access to water in terms of quantity and quality still prevail (Burstein-Roda, 2018). Oftentimes potable water may be used for non-human uses, further exacerbating the problem of limited water access. Unfortunately, water mismanagement often falls along the divisions of wealth, “considering that richer areas of the city fill rooftop pools, and over-water big parks and golf courses, sometimes with drinking water” (Hommes and Boelens, 2016; see also Ioris, 2012, 2016; Miranda et al., 2016). This demonstrates the lack of effectiveness of hydraulic planning to utilize the scare resource in world’s second-largest desert city.

3 METHODS

This paper reviewed a wide variety of literature, government data, and gray literature to investigate the situation in Lima with regards to access of potable water. The first search was aimed at further knowledge about the historical context and consequences of limited water access. Search terms included "consequences of lack of water in Lima" "poverty and lack of water access in Lima," "water access in Lima", "SEDEPAL", "informal settlements and water". The review also conducted a limited sweep of the publications of the government, local non-governmental organizations, (NGOs) and the publications of international organizations. These searches were conducted in Spanish, English and French. The first set of results describes the consequences of lack of access to water in Lima, with special attention drawn to health, socioeconomic, and environmental consequences. This review is needed in the context of Lima, since lack of water access is often seen as a consequence of poverty, but not a driver of poverty. Furthermore, building on the discussion is helpful, as comparatively little is written on this topic, especially with regards to the past five years.

The second literature sweep was aimed at potential solutions. Search terms included those above along with "Agua para todos[5]," "water projects in Lima," "water extension in Lima," "water NGOs in Lima", "improving water access in deserts," "improving water access in informal settlements" as well as a sweep of academia, the publications of local non-governmental organizations (NGOs) and the publications of international organizations. The second set of results reflects the investigation of the proposed solutions to limited water access, especially focusing on investment in the formal water system and financing of the investment needed. The paper examines current domestic efforts to improve access as well as political and technical solutions implemented in other areas of the world. The paper also investigates non-traditional, alternative solutions to expanding the formal water system.

4 RESULTS: CONSEQUENCES OF LIMITED WATER ACCESS AND CHALLENGES

4.1 Consequences of Limited Access to Water

A major theme arising from the literature search was the significant socioeconomic consequences drawing from lack of access to water in Lima. Although lack of water access has traditionally been seen as an unequal feature of poverty in Peru which politicians have attempted to rectify (Ioris, 2014; Criqui, 2020), recent research has added to the understanding of water as essential to any economic and social development. Additionally, lack of water access exacerbates economic inequality and poverty. Decoupling of water with other development objectives is not possible: critical consequences for human and societal development occur as a result of limited water access, including poor public health, socio-economic barriers, and environmental problems.

Primarily, the lack of access to clean water is closely linked to health problems, diseases and personal hygiene. The problem is not only caused by the lack of facilities in disadvantaged neighborhoods, but also by the age of the facilities (ECLAC, 2010, p. 64), which affects their functionality. According to the Economic Commission for Latin America and the Caribbean, in the settlements around Lima, waterborne diseases and dehydration has led to population loss. Lack of hydration was observed more frequently during the summer months, from December to March, where there is a greater likelihood of dehydration due to high temperatures. The situation is made more serious by the fact that tap water in Lima is not potable and can spread water-borne diseases if consumed without filtration. According to

[5] *Agua para todos* is the most recent campaign of the Peruvian government regarding water access

the report, wastewater transmits diseases such as cholera, diarrhea, parasites and typhoid (ECLAC, 2010, p. 64). Moreover, water scarcity is directly related to hygienic practices: after provision of water and sewerage connections in informal settlements of Lima, “mothers were approximately two times more likely to be observed washing their hands within a minute of defecation, compared with when they relied on shared, external water sources and non-piped excreta disposal” (Oswald et al, 2014). Recent circumstances of the pandemic of COVID-19 have also had drastic effects on the population without water- as the lack of access to water has been one of the driving factors in Peru’s battle with COVID-19 (Taj and Kurmanaev, 2020). The death rate in Peru has doubled this past year, and lack of access to sanitation and handwashing is of major concern to stop the spread of the virus (Taj and Kurmanaev).

Issues with water access have not been evaluated sufficiently for their true economic impact. Lack of water access has the strong economic impact and extreme consequences for economic inequality: not only is it more costly to buy drinking water when the public network is not available, but the labor productivity is compromised. The economic consequences have exacerbated the economic inequalities that already normally face the citizens who do not have public water access, as lack of water access is often a trait of informal, poorer and marginalized areas. In depth geographic analysis reveals that around 30% of household characterized as economically “disadvantaged” do not have access to water; however, the analysis cautions against a simple causal link, as there are also well-connected poor areas and poorly-connected wealth areas (Mesclier et al, 2015). Tanker trucks supply those without access to the drinking water grid, and this type of supply, for the most marginalized population, is by far the most expensive. There is significant evidence that without easy access to clean water, many communities are prescribed to poverty (Peru 21). A study conducted by the National Superintendence of Sanitation Services (SUNASS) showed that *Limeño* households without access to water need to spend six times more (about 90 soles per month) than those with public water access. The economic cost of water is directly related to the subsequent consumption of water: "the average consumption in the district of *Lurigancho-Chosica* [one of the poorest areas] was 15.2 liters (per person) in 2011, in *San Isidro* [one of the richest districts] consumed 447.5 liters” (RPP, 2017). It should be added that the United Nations Development Programme (UNDP), "says that Peru is the Latin American country with the highest levels of inequality in terms of access to drinking water in the home” (RPP, 2017). These inequalities may also exacerbate deaths by the COVID-19 pandemic, as handwashing and sanitation are compromised in these areas from lack of water access.

Recent literature in the water space further confirms the necessity of water access for achieving development goals. Economic growth depends on proper water access and sanitation: the estimated benefit-to-cost ration for interventions to improve sanitation is 7.7 for Latin America, meaning the economic return is $7.7 for every dollar invested (Hutton, 2012). Similar estimates show that every $1 invested in water and toilets returns an average of $4 in increased labor productivity (Hutton). Moreover- water access and handwashing in schools is a major factor in child survival and school retention. Three in 10 schools in Peru have no drinking water nor sanitation facility in the school building (Steele and WHO/UNICEF, 2018). These insights further emphasize that economic development programs cannot be decoupled with water provision and access.

Limited access to water is also related with poor water management, which has damaging effects on the environment. Currently, the age of the facilities and poor usage practices mean that there is a lack of wastewater treatment in neighborhoods without access to water. The current situation in Peru regarding wastewater treatment is worrisome, as informality often leads to contamination. According to data published by ECLAC, only 29% of the sewage is treated, and within the 143 plants operated by the EPS, many of "these plants are not managed efficiently because the providers allocate insufficient resources for operation and maintenance" (ECLAC, p. 65). Of the 143 existing plants, 61 are for agricultural use, 12 use their effluents for "watering green areas", 70 discharge their effluents into rivers, lakes or the sea, and only 3 of the 143 plants are for water recycling, which creates a large waste problem in a desert city like Lima.

Consequently, the inefficiency of water treatment means that considerable waste is pumped into the surrounding river and sea. Lima is a megacity with over 9.8 million inhabitants, and the massive waste generates damages aquatic ecosystems and wildlife and creates toxic environments (ECLAC, 2010). Currently, for the population of Lima and Callao, the Rimac River is the main water supplier and simultaneously is the most deteriorated basin in environmental terms (Oxfam Peru, 2019). This increases the possibility of spreading diseases, due to the proliferation of toxins and mosquitoes (ECLAC, p. 65).

5 RESULTS: CURRENT EFFORTS AND POTENTIAL SOLUTIONS

5.1 Desired Outcomes

By measuring potential solutions against an ideal situation, we attempt to conceptualize the investment required in Lima’s water system. As revealed in the first literature sweep, water is considered a human right and essential to economic development and human life. Therefore, in the ideal situation, all citizens of Lima would have access to potable drinking water the public water system in their place of residence. To analysis potential solutions, water management and hydraulic planning must be imperatively considered, taking into account the contamination and lack of water in Lima. There are many important elements needed to implement universal water access, therefore we organize them in three areas: (1) investment in the formal system, (2) financing investment in the system, and (3) treatment and maintenance of this system.

5.1.1 Investment in the Formal Water System

The severe consequences of limited water access have driven political momentum to increase water access, but further investment is clearly necessary to guarantee full access, public health safety and increased economic activity. First of all, the cholera epidemic in 1991 in Peru signified a warning signal to government authorities. Consequently, the government increased investment for new installations for water between 4-18% annually from 1990-1999, but mostly in rural areas (ECLAC, 2010, p. 15). During this period, the total investment reached 430 million US dollars, including the investment from all government entities (FONCONDES) and non-governmental organizations (ECLAC, p.15). Political interest in the matter further crystalized with the second presidential campaign of Alan Garcia, who ran on a platform with water and sanitation as a main tenant and launched the *Programa Agua para Todos* (Water for All Program) which focused on systematic provision of traditional water infrastructure (Criqui, 2020). Today, the issue is still very politically relevant, as SEDAPAL, the public water utility in Lima, has recently established a contingency plan and established 240 cisterns to increase the availability and distribution of potable water in Lima and Callao (Gestión Perú, 2019). The need for water has even pushed some businesses and private entities to become involved or increase visibility in the matter. For example, Caja Piura, a private bank, has established microfinance products such as Aqua Crédito, which includes access to water and a bathroom, with the intent to improve the quality of life of low-income families in vulnerable situations (PQS, 2019). Some may argue, however, that interest of the private sector has been fueled by neoliberal privatization/commercialization of the water sector and other public services (Ioris, 2012). All things considered, despite increased political action, the investment in water provision and sanitation is still much below what is needed for secure access. According to most recent figures from SEDAPAL, the government of former President Pedro Pablo Kuczynski estimated the total cost to provide a safe water supply throughout Peru is $15.8 billion in investments (RPP, 2017).

The government’s most recent strategies: *Agua para todos* program from 2007-2011 and currently the project *Agua segura para Lima y Callao* (“Secure water for Lima and Callao”) have been focused on extending traditional water infrastructure and the grid as the main strategy (Criqui, 2020). These recent strategies differ from previous programs: funding is purely domestic, and conventional infrastructure is pursued with subcontracting of construction companies (Criqui, 2020). The current strategy first identifies areas that need investment and then extending the water network gradually to the identified areas. In the *Agua para todos* cumulative report, the data shows an increase of coverage of the drinking water network in urban areas between 1.4-3.1% of the population of Lima each year (Ministry of Economy and Finance, 2009, p. 23).

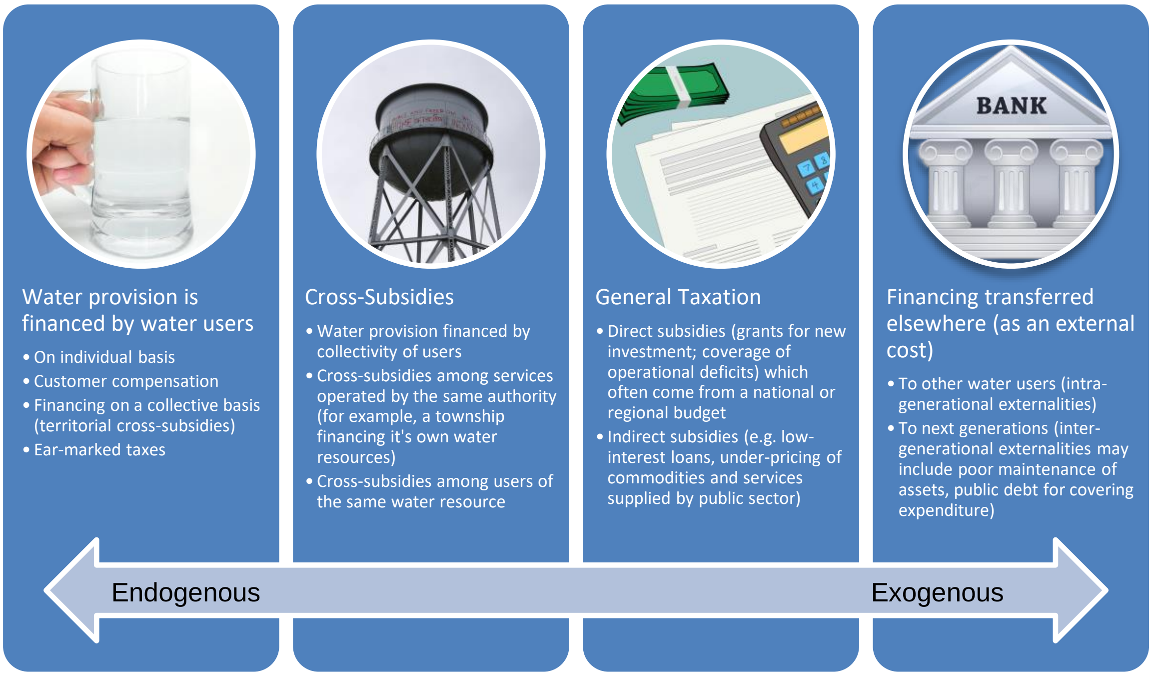
Eight years after the *Agua para todos* project and investment strategy began, the situation in Lima is still dire-the city still needs a large-scale investment, and improvements in efficiency and efficacy. At least 10% and up to 18% of the population continues to live without reliable access to potable water at any given moment. Better formalization and faster organization of the water system is evidently necessary. The next sections will discuss the financing options and management required to continue along the current strategy of improving traditional water infrastructure and the water grid while considering the harsh constraints facing Lima.

5.1.2 Financing Investment in the Water System

Research of other areas in the world that share similar difficulties as Lima, such as large informal settlements and limited financial capacity, has revealed a set of options to finance the investment in the water system required. In recent years, economic and financial understanding about how to finance such projects has greatly improved. Unfortunately, the introduction of the water network into informal settlements and slums can cost up to three times more than introduction into planned urban areas and formal settlements, which poses as significant challenge for policymakers (Ferguson and Navarette, 2003). That said, there are financial options that prioritize equity in the investment.

Equitable and feasible financing of the water system can include a payment system that stretches over long periods of time, to reduce the initial cost, and convince homeowners to invest in formalizing their water by levels of income. As recognized by studies by the OECD, appropriate financing must include the “three T’s”- tariffs, taxes and transfers (SWITCH, 2011, p. 51). This research outlines a range of financing sources ranging from endogenous to exogenous sources. Endogenous financing is defined as financing directed towards water users, which can include direct payments for water or water investment, and direct customer compensation (SWITCH, 2011, p. 52; INECO, 2009). Exogenous financing transfers water financing costs on external sources, often by way of long-term, inter-generational financing measures (SWITCH, 2011, p. 52; INECO, 2009). In the spectrum, there are various financing schemes, from cross-subsidies to general taxation, that are neither purely exogenous nor endogenous. All countries strike a balance of financing between endogenous and exogenous financing as described, depending on the particular constraints, public investment and spending decisions, and water rights defined in law. In a developing country such as Peru with a large informal economy, financing the water system will also have to strike a balance between endogenous and exogenous financing sources to capture unique constraints. To be clear, this research does not advocate exogenous nor endogenous sources of financing as “better” or more “efficient,” as the unique landscape of each water system will affect these decisions.

That said, attention must be paid to the social structure of those who tend to lack water in Peru to advise just and equitable financing structures. The appropriate balance must be struck to secure the finance needed to increase the water network, as it must consider the limited state resources from a weaker tax base, while simultaneously avoiding over-burdening financing investment from water users who lack water, who are often the most economically marginalized sector of the population.



Source: Graphic adapted from SWITCH, City Water Economics Manual, 2011, p. 52; INECO, 2009. All information from SWITCH, City Water Economics Manual, 2011, p. 52

In particular, two examples of water financing projects in Alexandria, Egypt, and Accra, Ghana, are useful to study with regards to Lima, because of similarities in climate and informal settlement patterns. In Alexandria, Egypt, another desert climate, new tariffs will be implemented according to level of income in order to finance the investment needed in the public water system. The National Technical University of Athens for the Sustainable Water Management in the City of the Future (SWITCH) Project analyzed 3 potential tariff schemes, which could also be options for financing in Lima. All tariff schemes targeted 100% recovery of costs for operation and maintenance and 65% for investment costs (the remaining 35% is state funded). The schemes are described as follows (SWITCH, CWE Manual, p. 92):

- "Scheme #1, 'Adjustment of volumetric rates for improved cost recovery', concerned the increase of volumetric rates preserving the current consumption blocks, in order to achieve the set cost recovery targets.

- "Scheme #2, 'Change in block tariff structure', included the introduction of two additional consumption blocks and higher variation of the volumetric rates, to achieve a more equitable distribution of costs and preserve affordability of charges faced by low income groups. It further included a fixed charge, to recover 50% of capital costs. To further simplify billing processes, the invoicing period was set at 4 months (instead of monthly) to potentially decrease administrative costs."

- "Scheme #3, 'Seasonal rates' included the additional introduction of seasonal rates for each 4-month period, to account for the large variation between summer and winter water consumption, which requires the development of additional infrastructure 9and thus potentially entails higher costs) to cope with peak demands."

All schemes are aimed at improving cost recovery, enhancing incentives, affordability, ease of implementation and enhancement of revenue stability. Similar analysis could be conducted on a financing scheme for Lima. Examining the results of Alexandria's change in tariff structure could help to guide Lima in choosing financing options.

In Accra, Ghana, where only 40% of the population has access to the water network, the case is more severe. In this case, the researchers created a 15-year tariff plan that would cost no more than 6 percent of the average annual income of low-income people. However, it is necessary to take into account that for people in extreme poverty, the rate could be as high as 15% of annual income (SWITCH, CWE Manual, 2011, pg. 105). Observing the results of these other cities could help Lima to formulate a financial investment plan that is socially equitable and efficient.

Microfinance options could also aid financing and construction of the formal water system. Bruce Ferguson and Jesus Navarette's influential article titled *A financial framework for reducing slums: lessons from experience in Latin America*, introduces various housing microfinance options. A microfinance or financial institution can offer housing microfinance to the general public, for which a homeowner can opt to "formalize" their property and help increase access to water or sanitation (Ferguson and Navarette, 2003, p. 214). These ideas have been tested in Venezuela and Nicaragua, but implementation must be paired with strict prevention of predatory lending. That said, housing microfinance could offer a way for communities to work together to directly resolve and invest in their properties through collective action and financing.

Without question, water access is a human right. The Peruvian government should utilize low interest rates and need for employment to invest in the human health of its citizens. These financing options can be useful for the government to reform the current water system and create a formal and accessible water system for Lima's residents.

5.1.3 Treatment and Maintenance of the System

Recognizing that Lima is in a desert, treatment and maintenance of the water system are imperative elements of successful expansion of the water network. In the case of Lima, improving the organization of the water resources is required; unfortunately, poor organization of the resource leads to potable water being used for non-human use such as irrigation of green public spaces (Castro et al., 2010). Any potable water in Lima should be designated for human consumption, considering the dry climate and lack of water access.

Examining other cases provides policy options to better conserve water. In Northern California, there was a successful policy during the extreme drought in 2014 that led to better conservation of water. During the drought from 2011-2019, the California state government implemented a series of policies in order to influence residents to not waste water. For example, the use of water for lawns and gardens incurred fines, especially in wealthy areas (California Water Boards, 2018). Although the drought has now ended and the restrictions loosened, this period improved efficiency of water use enormously and has reduced the waste of water in California. Similar policies could be very useful in Lima, as generally there are low available water sources. If the policies are designed in a way that takes into account social disparities, similar economic policies concerning water use could be beneficial for better organization of water resources in Lima.

In an ideal situation in Lima, a form of a "circular economy" could be implemented in terms of water use. Treated potable water should only be used for human consumption. Treated wastewater could only be used for watering gardens or urban agriculture. In Lima currently, less than 15% of parks and gardens in the city are watered with treated wastewater, and contaminated water from the river or potable drinking water is used to water over 1,200 hectares of green zones in the city (Castro et al., 2011). The city must implement systems that utilize all potable water for human consumption, and any treated wastewater for other necessities. Currently, the project SWITCH of the United Nations is working with politicians in Lima to change the inefficient organization of the water sources. To this end, SWITCH has implemented a program to convert treated wastewater for agricultural uses (Castro et al., 2011). With the management of SWITCH, the government has authorized the use of treated wastewater for non-human uses and is working to convert the water system in a more resourceful manner.

In sum, to convert the water system to the objective of providing potable water to all Lima residents, it is important to consider financing of investment and management of the water system to create sustainable and equitable solutions. With any public decisions, there must be communication and public dialogue in order to produce the best results and find equitable solutions for conversion of the water system.

5.2 Alternative Solutions

Although this paper considers investment in the public water system to be the most viable solution to the end goal of providing water to all of Lima's citizens, many alternative solutions in the literature could provide interesting ideas to solving Lima's unique and difficult challenges of providing water to a megacity in a desert. The NGO *Consorcio para el Desarrollo Sostenible de la Ecorregión Andina CONDESAN* proposes reusing a 1,500-year-old pre-Inca hydraulic system called "amunas" by Peruvian scholars. The complex mechanism consists of capturing rainwater in basins in the mountains, which are directly connected to the capital by subterranean stone canals. The water is filtered in the stone canals and rises to the surface weeks or months later. The NGO claims the water is sufficient to use all year round, and conserves water in cases of flooding. Restoration of the canals would require reinforcing the canals with cement. *CONDESAN* claims that putting 50 of the canals in service would increase water resources by 26 million cubic meters and reduce the water deficit by 60% during the dry season in Lima (Le Monde, 2015; CONDESAN).

Another alternative solution that is being developed plays to the fact that Lima, despite receiving very little rainwater, has a high humidity concentration in the air. The advertising agency Mayo Draft FCB has collaborated with Peru's University of Engineering and Technology (Utec) to develop an innovative way to bring fresh water to people on the outskirts of the city who have little access to drinking water: billboards that collect water from the air (Nicko, 2013). Despite receiving less than 13 millimeters of rain per year, the city has a high rate of atmospheric humidity (around 98%). The billboard panel absorbs this humidity thanks to 5 generators, which absorb the air, pass it through a carbon filter and through condensation obtain drinking water, stored in the lower part of the panel. This system produces 96 liters of water per day (Nicko, 2013). If expanded and made popular among the private sector, this system could help to resolve drinking water shortages on a small-scale for local workplaces and communities. Improving the technology and increased investment could also improve the efficiency of water collection.

Moreover, solutions may also lie in the strategies of the past. Laure Criqui, in her recent piece titled *Sociotechnical alternatives and controversies in extending water and sanitation networks in Lima, Peru,* mapped the major programs to improve water access over the past 30 years, and emphasized that certain benefits of the "condominial network" strategy of the early 2000s may have been overlooked in favor of traditional grid expansion during the *Agua para Todos* plan and beyond (Criqui, 2020, p. 171). This conventional network alternative, which is characterized by smaller, more flexible networks in smaller neighborhoods/units, was funded by the World Bank between 2003-2008, and connected up to 160,000 people (Criqui, 2020). This method of water expansion was eventually abandoned by SEDEPAL and the Peruvian government over inequity concerns (Criqui, 2020); however, the basis for these concerns may be more political than technical, as adoption and cost under the World Bank program was rather efficient and successful (Criqui, 2020).

Behavioral insights can help policymakers improve water conservation measures and water use efficiency. Water companies are accustomed to large construction sites: pumping stations, dams, water treatment plants or tunnels under the mountains. However, recent initiatives have found that part of their added value lies in "soft" investments: they can encourage water conservation and recycling; make ecological investments in upstream basins, working with farmers and herders; and improve water quality control with mining companies to protect this resource.

It should be added that for the first time in its history, the water utility SEDAPAL has approached NGOs to protect watersheds and groundwater. It is also beginning to raise awareness among consumers to reduce consumption per household, and to explore with the municipality solutions to use recycled water to irrigate green spaces. In addition, the water utility has also requested additional assistance from the World Bank, particularly to complement traditional physical investments. Engaging civil society was a major feature of early 2000s water access strategies; some suggest that the recent technocratic strategy of the past 10 years has unnecessarily moved away from community engagement beyond what is required (Criqui, 2020). Thus, further engagement with civil society actors, international organizations and the private sector is a promising path forward to increase capacity and investment in efficient solutions.

Conclusions and Recommendations

In conclusion, it is important to find short-term solutions to improve the quality of life and reduce health risks for the population without water access. However, it is more important to manage projects that propose long-term solutions to ensure the sustainability of society. As long as investment in ensuring access to water for all citizens is not a priority for current and future governments, Peru will not be able to fully develop. Inadequate and insecure access to water limits individual and collective progress, as it is a basic necessity for daily activity and health.

Through analysis of various technical and political solutions, we recommend further study into solutions that include (1) a faster formalization of the water system, (2) better organization of scare water between human consumption and other use, (3) increasing political will and creating a culture that discourages water waste, and (4) testing innovative water conversion methods.

The culture of water conservation must be introduced into Peruvian society, especially in Lima, since it is a desert territory that cannot afford to waste water as has been done in the *status quo*. For this reason, it is crucial for the State to focus more on this issue, since responsible water use is a very important factor for success in improving the water system and making the system sustainable. Education about water conservation is of utmost importance, especially in areas of the city with plentiful water supply.

Access to this resource is necessary for human life and should be a top priority of the Peruvian state, development agencies, and Peruvian society. Economic and societal development cannot progress without reliable water access, and the COVID-19 pandemic has highlighted and exacerbated the dangers of limited water and sanitation access. Providing water access has a positive economic development benefit. As highlighted by UNESCO, "Creating conditions to improve water productivity and favor the transition to green economies, and training qualified workers to respond to the growing demand for labor in the water sectors, are some of the points . . . [that] draw the attention of governments to respond to the demands of the sustainable development objectives set by the United Nations, in particular Sustainable Development Goal 6 on water and sanitation" (2016).

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