Universitat Autònoma de Barcelona

ACCESS TO WATER IN RAPIDLY GROWING CITIES OF THE GLOBAL SOUTH

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Ph.D. Dissertation
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Contents

Abstract

Ensuring universal access to quality drinking water remains a challenge in most cities around- the world, especially in the fast-growing cities of the Global South. Although reforms in the water sector and the intervention of international organizations in global water policies (Millennium Development Goals, Sustainable Development Goals, and the recognition of the Right to Water and Sanitation by the United Nations) have contributed to significant advances in water coverage and accessibility, one in three people in the world does not have access to drinking water. Furthermore, the lack of safe drinking water poses particular risks for the one billion people living in urban settlements in the Global South. Inequalities in access may be much more significant when considering other dimensions of water access such as availability, water quality, and service provision. For example, in the case of cities in the Global South, progress and success figures for water accessibility are often presented, but these figures say little about the availability of water in households 24 hours a day. While factors such as climate change and rapid urbanization have important implications for water access, this thesis argues that socio-spatial contexts of cities are to a large extent responsible for inequalities in accessibility, affordability, and service provision. This results in cities with a range of water access conditions, which tend to be very favorable for some and unfavorable for other social groups, especially low-income groups.

In this regard, the thesis explores how access to water, including affordability, water quality, and service provision, varies in the fast-growing city of Arequipa (Peru). Through surveys in the core and urban periphery of the city (N=721), semi-structured interviews with a set of key stakeholders, and review of secondary data, the work contrasts inequalities of water access in the fast-growing city environment of Arequipa that includes the core (commonly planned area) and urban periphery (partially planned area). The results show that increases in accessibility do not translate necessarily into affordability, quality, and service delivery, especially in the urban periphery. Also, the variety of small-scale providers fulfills an important role in urban areas without access to the public network, but challenges remain in other dimensions of water access. On the other hand, conventional top-down water management approaches are relevant, but their reach may be hampered by socio-spatial differences and the complexities of water supply. Bottom-up water management strategies for water democratization are also emphasized in the thesis such as the efforts made by (in)formal water providers and collective action to secure water supply, in the context of the health emergency caused by Covid-19. In Arequipa, the responses of (in)formal providers contribute significantly to alleviating the water access deficiencies, although some limitations of informal services are also underscored. In any case, greater attention to the functioning of existing networks and recognition of existing efforts can contribute to democratizing the provision of higher quality water for the Arequipa citizens.

Resumen

Garantizar el acceso al agua potable de calidad y de manera universal sigue siendo un desafío en la mayoría de las ciudades del mundo, especialmente en ciudades de rápido crecimiento del Sur Global. Si bien las reformas en el sector del agua y la intervención de organizaciones internacionales en políticas del agua mundial (Objetivos de Desarrollo del Milenio, Objetivos de Desarrollo Sostenible y el reconocimiento del derecho al agua y saneamiento por las Naciones Unidas) han contribuido en avances importantes en la cobertura y la accesibilidad del agua, uno de cada tres personas en el mundo no cuenta con el servicio de agua potable. Además, la falta de este servicio plantea riesgos particulares para los mil millones de personas que viven en asentamientos urbanos del Sur Global. Las desigualdades se podrían agravar si se considera otras dimensiones de acceso al agua como la asequibilidad, calidad del agua y la prestación de servicios. Por ejemplo, para el caso de las ciudades del Sur Global a menudo se presentan avances y cifras exitosas de accesibilidad al agua, pero estas cifras dicen poco sobre la disponibilidad en los hogares durante las 24 horas del día. Aunque algunos factores como el cambio climático y la rápida urbanización tienen importantes implicaciones en el acceso al agua, en esta tesis se argumenta que el contexto socioespacial de las ciudades representa las desigualdades de accesibilidad, asequibilidad, calidad y prestación de servidos. Esto da lugar a entornos urbanos con una serie de condiciones de acceso al agua, los que tienden a ser muy favorables para algunos y desfavorables para otros grupos sociales, especialmente grupos de bajos ingresos económicos.

En este sentido, esta tesis explora la forma en como varía el acceso al agua, incluido la asequibilidad, calidad del agua y la prestación del servicio, en la ciudad de rápido crecimiento Arequipa (Perú). Mediante encuestas en el núcleo y la periferia urbana de la ciudad (N=721), entrevistas semiestructuradas con un conjunto de actores clave y la revisión de datos secundarios, el trabajo contrasta las desigualdades de acceso al agua en el entorno de la ciudad de rápido crecimiento Arequipa, que incluye el núcleo (área comúnmente planificada) y la periferia urbana (área parcialmente planificada). Los resultados muestran que los aumentos de accesibilidad al agua no se traducen necesariamente en la asequibilidad, calidad y prestación de servicios, especialmente en la periferia urbana. Asimismo, la variedad de proveedores a pequeña escala cumple un papel importante en las zonas urbanas sin acceso a la red pública, aunque persisten desafíos en otras dimensiones de acceso al agua. Por otro lado, los enfoques convencionales de gestión del agua de arriba hacia abajo son relevantes hasta cierto punto, porque su alcance puede verse mitigado por las diferencias socioespaciales y las complejidades del suministro de agua. En la tesis se destaca las estrategias de gestión del agua de abajo hacia arriba, los que pueden ayudar con la democratización del agua, como los esfuerzos realizados los proveedores de agua (in)formales y la comunidad urbana para garantizar el abastecimiento de agua, especialmente en el contexto de la emergencia sanitaria provocada por la Covid-19.

En Arequipa, las respuestas de los proveedores (in)formales han contribuido significativamente en aliviar la deficiencia de acceso al agua, aunque también se destaca los desafíos que enfrentan los servicios informales. En cualquier caso, una mayor atención en el funcionamiento de las redes existentes y el reconocimiento de los esfuerzos existentes en la periferia urbana pueden contribuir con la mejora del abastecimiento de agua de mejor calidad para la ciudadanía arequipeña.

Resum

Garantir l'accés a l'aigua potable de qualitat i de manera universal sigue un desafío en la majoria de les ciutats del món, especialment en ciutats de ràpid creixement del Sur Global. Si bé les reformes en el sector de l'aigua i la intervenció d'organitzacions internacionals en polítiques de l'aigua mundial (Objectius de Desenvolupament del Mil·lenni, Objectius de Desenvolupament Sostenible i el reconeixement del dret a l'aigua i saneamiento per les Nacions Unides) han contribuït en avenços importants en la cobertura i l'accessibilitat de l'aigua, un de cada tres persones al món no compte amb el servei d'aigua potable. A més, la falta d'aquest servei plantea riesgos particulars per als mil milions de persones que viuen en assentaments urbans del Sud Global. Las desigualdades se podrían agravar si considera altres dimensions d'accés a l'aigua com a asequibilitat, qualitat de l'aigua i la prestació de serveis. Per exemple, per al cas de les ciutats del Sur Global a menut es presenten avenços i xifres exitoses d'accessibilitat a l'aigua, però són xifres que dicen poc sobre la disponibilitat en els hogares durant les 24 hores del dia. Aunque alguns factors com el canvi climàtic i la ràpida urbanització tenen importants implicacions en l'accés a l'aigua, en aquesta tesi es argumenta que el context socioespacial de les ciutats representa les desigualtats d'accessibilitat, asequibilitat, qualitat i prestació de serveis. Això dóna lloc a entorns urbans amb una sèrie de condicions d'accés a l'aigua, els que tendeixen a ser molt favorables per a alguns i desfavorables per a altres grups socials, especialment grups de baixos ingressos econòmics.

En aquest sentit, aquesta tesi explora la forma en com variar l'accés a l'aigua, inclòs l'asequibilitat, qualitat de l'aigua i la prestació del servei, a la ciutat de ràpid creixement Arequipa (Perú). Mediante encuestas en el núcleo y la periferia urbana de la ciudad (N = 721), entrevistes semiestructurades amb un conjunt d'actors clau i la revisió de dades secundàries, el treball contrasta les desigualtats d'accés a l'aigua en l'entorn de la ciutat de ràpid creixement Arequipa, que inclou el nucli (àrea comú planificada) i la perifèria urbana (àrea parcialment planificada). Els resultats muestran que els augments d'accessibilitat a l'aigua no es tradueixin necessàriament en l'asequibilitat, qualitat i prestació de serveis, especialment en la periferia urbana. Asimismo, la variada de proveedores a una petita escala complerta un paper important a les zones urbanes sense accés a la vermella pública, encara que persisteixen desafíos en altres dimensions d'accés a l'aigua. Per un altre costat, els enfoques convencionals de gestió de l'aigua de dalt cap a baix son rellevants fins al punt punt, perquè el seu alcance pot versar mitigant per les diferències socioespacials i les complexitats del subministrament d'aigua. En la tesi es destaca les estratègies de gestió de l'aigua de baix cap a dalt, els que poden ajudar amb la democratització de l'aigua, com els esforços realitzats pels proveïdors d'aigua (in) formals i la comunitat urbana per garantir l'abastiment d'aigua, especialment en el context de l'emergència sanitària provocada per la Covid-19. En Arequipa, les respostes dels proveïdors (in) formals han contribuït significativament en aliviar la deficiència d'accés a l'aigua, encara que també es destaca els desafiaments que enfronten els serveis informals. En qualsevol cas, una major atenció en el funcionament de les restes existents i el reconeixement dels esforços existents en la perifèria urbana poden contribuir amb la millora de l'abastiment d'aigua de millor qualitat per a la ciutadania arequipeña.

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Chapter 1

General introduction

1.1. Background

Although water represents 70 percent of the surface of planet Earth, not all of it is directly available to humans and most terrestrial organisms. 97.5 percent of the water on the planet is salty and of the total percentage of fresh water, only 0.3 percent remains easily accessible to humans (GRIDA, 2006). While the amount of accessible freshwater is significantly small, it is also unevenly distributed between and within different regions of the world, and between the seasons of the year according to different climatic zones. This means that water is physically abundant in some regions and very limited in others. However, the fact that the physical availability of water is limited in some regions does not mean that there is a shortage of water for human use. Likewise, abundant precipitation and river flows do not necessarily ensure sufficient and safe resources for local populations. In this sense, water availability is mediated by social, economic, political, technological, and cultural processes creating strong imbalances in reliable and safe access.

Latin America, which accounts for 8.6 percent of the world's population, concentrates 32 percent of the world's total water, making it the second most water-abundant region in the world after Asia. Although water resources are abundant in Latin America, water is unevenly distributed and used between and within countries, and in some, water use is already considered "unsustainable". For example, Peru, Mexico, Argentina, Chile, and Brazil display significant signs of water scarcity, especially in the Pacific basins of Peru; in Northern Mexico, and Southwestern Argentina (Mahlknecht & Pastén-Zapata, 2013). It is not surprising that these regions suffer water deficits since, for example, the Peruvian Pacific drainage basins only concentrate 2 percent of the total available water in the country but 70 percent of the population and 90 percent of economic activities, especially water-dependent export crops (Damonte & Boelens, 2019; Filippi et al., 2014). Agricultural export activity not only tends to increase water demand but is also responsible for water pollution due to the wide use of chemicals. Elsewhere, the northern part of Mexico, with 31 percent of the water resources of the country, concentrates 77 percent of the population and 87 percent of the GDP (Mahlknecht & Pastén-Zapata, 2013). Growing population (including changes in lifestyles), rapid urbanization, and the incorporation of new irrigated areas for agricultural production may stress existing water resources. Therefore, it can be stated that water scarcity either in Latin America and other regions of the world is not solely physical or natural, but the result of social, political, economic, and technological interacting with ecological processes, which configure and reconfigure the flows of the natural water cycle (Aguilera-Klink, 2012; Boelens et al., 2016; Kaika, 2003; Kallis, 2008; March & Sauri, 2009).

Water scarcity may be aggravated by the effects of climate change. For example, Stern (2007) points out that rainy seasons with frequent and intense precipitation events, lead to higher runoff volumes, and create more complex conditions for water storage. Longer periods of little or no precipitation reduce water availability while the contamination of surface and groundwater due to anthropogenic activities also reduce the availability, of the resource and worsens scarcity conditions (Schriks et al., 2010).

In this context, 4 billion people in the world experience severe water scarcity at least one month per year and 500 million people experience severe water scarcity throughout the year (Mekonnen & Hoekstra, 2016). Despite numerous reforms in the water sector (Bakker, 2007a, 2014) and the intervention of international organizations in global water policies (e.g., the Millennium Development Goals (MDGs) or the recognition of water as a human right by the UN and the UN Sustainable Development Goals (SDGs)), more than one billion people in cities in the Global South cannot access safe drinking water, especially in peripheral urban areas subject to rapid growth (Mitlin, 2020). Lack of access to water or limited ability to obtain water safely, reliably, and affordably poses a threat to public health and the overall well-being of individuals and households (Prüss-Ustün et al., 2014; Sultana, 2011). Also, the lack of access to water disproportionately affects poor households and marginalized groups especially in rural areas, as water collection practices generally fall on women and girls, increasing gender-related inequalities (Bisung & Elliott, 2017; Stevenson et al., 2016).

In cities of the Global South[1] , population growth and rapid urbanization exacerbate problems related to water access. The urban population of the Global South has increased from 306 million in 1950 to 1,9 billion in 2000, and this number is expected to increase to almost 3.9 billion people by 2030 (Cohen, 2006). Much of this population growth will occur in regions of Asia and Africa, where the effects of water scarcity already impact people's daily lives (Smiley, 2013; Sun et al., 2020). Similarly, rapid urban expansion has increased social inequalities and led to the formation of peri-urban areas or "informal" urban settlements that strive and develop outside the administrative boundaries of the planned urban area[2].

According to Bocquier (2005) and The World Bank (2018), approximately 30 percent of the Global South's population lives in informal urban settlements, a figure

1 Following to Mitlin & Satterthwaite (2012), we use the term Global South to refer to all nations classified by the World Bank as low- and middle-income that are located in Africa, Asia, and Latin America and the Caribbean.

2 According to Adell (1999), peri-urban areas are dynamic "transition" spaces that combine urban/rural characteristics and develop between the urban fringe and the rural hinterland of cities.

that may increase to 60 percent by 2050. Although informal urban settlements are a means by which low-income people may find a place to build their homes, residents in these areas are usually excluded from basic services (water, sanitation, transportation, energy, etc.), in part because local administrators and urban planners often characterize peripheries as "abnormal and temporary spaces" that must eventually disappear. This urban logic creates complex conditions for the expansion of conventional water and sanitation networks. These networks are concentrated in planned urban areas with higher economic incomes that obtain the best services, while households in informal urban settlements are excluded from drinking water networks, so residents must seek other alternative modes of access to water, such as tanker trucks, wells or public pylons, among other options (Kooy & Walter, 2019). Bakker (2003) uses the metaphor of "archipelagos" to highlight inequalities in access to water in cities in the Global South. Similarly, Graham & Marvin (2001), with the notion of "splintering urbanism", and Gandy, (2004, 2008) characterize such inequalities in access as part of "fragmented urban technological landscapes". While scholars use different metaphors to describe inequalities of water supply (and other basic services and infrastructures) in cities of the Global South, they agree that urban and basic service fragmentation is, in part, the result of liberal political and economic processes inattentive to the needs of the most vulnerable. It should also be noted that urban fragmentation and the fragmentation of basic services are related to historical processes of social differentiation and of unequal social, economic, and technological power relations (Bakker, 2003; Botton & Gouvello, 2008; Kooy & Bakker, 2008; Swyngedouw, 1995, 1997).

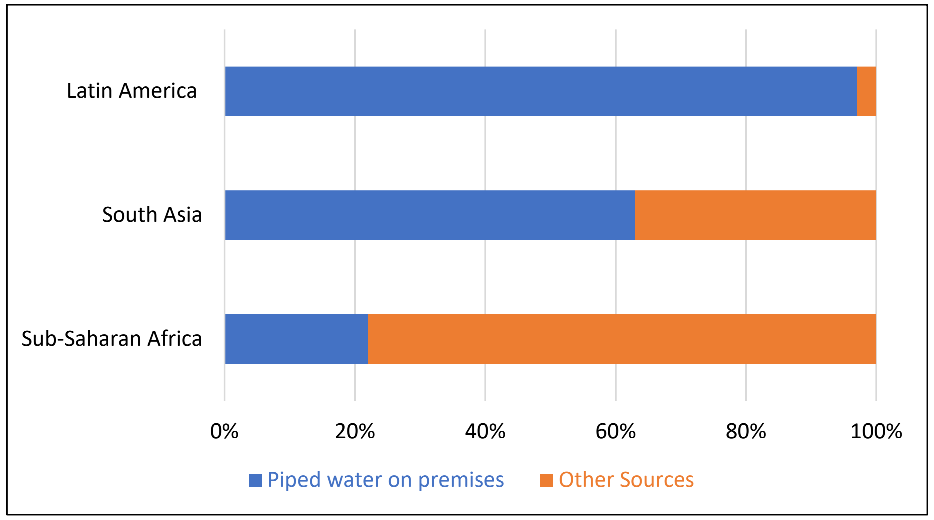
The metaphor of archipelagos to characterize urban water in the Global South reflects a variety of forms of water supply, especially present in marginal urban areas and producing both successes and major challenges in securing water. Liddle et al. (2016) and Pierce (2020) consider that the aforementioned informal water distribution options may be potentially favorable for service coverage and may even improve service in the short term in urban areas without access to water networks. However, water sources considered informal are marginalized by the formal water sector, as the latter advocates the development of modern water infrastructures. In any case, urban water policy based solely on drinking water networks can increase the risks of water insecurity (Bakker & Morinville, 2013) and of existing water access inequalities in cities in the Global South (Swyngedouw, 1995).

Access to Water in Rapidly Urbanizing Contexts of the Global South

Access to water was recognized by the United Nations as a human right in 2010 (UN,2010). This and other initiatives have facilitated progress towards reducing the

gap between water supply and demand. However, despite significant progress, the Joint Monitoring Programme (JMP) report (from WHO and UNICEF) shows that nearly 2.1 billion people in the world, many of whom live in cities in the Global South, do not have access to safe drinking water (WHO/UNICEF, 2017). The number of people without access could increase in the coming years due to population growth, pollution, and accelerated urbanization (Dos Santos et al., 2017). In most cities in the Global South, urban expansion has already outpaced the development of water infrastructure, increasing gaps in access (Mehta, 2010). Although it should be noted that access to water in cities of the Global South is significantly higher compared to rural areas, disaggregated data show that there are significant inequalities of access between cities in different regions (see Figure 1). Thus, while access to water in cities in Latin America is 97 percent (the highest figure), access to water in cities in Sub-Saharan Africa reaches only 22 percent of the urban population.

Figure 1. Access to water in cities in the Global South



Source: Adapted from Mitlin et al. (2019)

Although overall, Latin American cities are in a privileged position in terms of access to water compared to other urban areas of the Global South, there are also large disparities in water access between countries and cities in the region. For example, networked water access figures in Santiago (Chile) and Bogotá (Colombia) may reach 99 percent of inhabitants (IBNet, 2019), while in Port-au-Prince (Haiti) access is only enjoyed by 20 percent of the population (Patrick et al., 2017). Likewise, inequalities of access within cities are particularly pronounced. Residents of the urban cores tend to have better access compared to residents of the informal peripheries, often with lower economic incomes (Beard & Mitlin, 2021; Swyngedouw, 1995). However, the problem lies not only in whether urban residents have access to the public drinking water network, but also affects other issues, such as, for example, whether residents actually enjoy a reliable and safe service able to cover all their basic needs, especially in informal urban areas.

In Lima, for example, despite the 95.8 percent of networked water coverage figure recorded in 2020 that, in general, indicates extensive household connections, water allocation is not equitable among different households in the city districts. Water is abundant and cheap in higher-income districts (leading to higher water consumption), while residents of peripheral districts pay more for smaller amounts of water (Ioris, 2016; Miranda-Sara et al., 2017). In addition, drinking water may suffer from poor quality in Lima's urban peripheral districts (Boehnke et al., 2018). These differences reflect, in part, preferences to provide water to social groups that can pay for safe and reliable commercial connections.

In this context, a growing number of studies in the Global South have been interested in assessing water access inequalities between and within urban areas (Adams, 2018b; Martinez-Santos, 2017). Dos Santos et al. (2017) state that significant inequalities of access to water have been reported in urban centers, while these inequalities are greater in slum settlements in Global South cities (Adams, 2018a). Inequalities of access to water in the urban core, in general, appear to be related to the operation of the drinking water network and to socio-economic status (Wright-Contreras, March, & Schramm, 2017). The study by Mitlin, Beard, Satterthwaite, & Du (2019) for 15 cities of the Global South found that water from networks considered reliable often is supplied intermittently meaning that flows are not available 24 hours a day. Many households are then forced to seek for other sources of supply, often uncertain and at very high prices. Operational problems such as low system pressure or interruptions can have important implications on other dimensions of water access (water quality), and may force households to resort to other practices such as storing water in containers (Burt & Ray, 2014). Water access inequalities in the urban periphery are closely related, among other aspects, to socio-economic status and to the fragmented characteristics of these peripheries (Adams, 2018b; Angoua et al., 2018). Many residents of informal urban settlements are not commonly connected to the public drinking water network, so they are forced to obtain water from other sources, highly heterogeneous in terms of quantity and quality. According to Angoua et al. (2018), households in urban areas with access to a so-called "improved" water source often have to resort to unprotected sources. For example, in Abidjan (Ivory Coast), residents not connected to the drinking water network have access to a hand pump (considered as a "protected" or "improved" water source) but accessing this source requires significant physical efforts as it often lacks maintenance, forcing neighbors to access unprotected wells. Similarly, residents of Malawi's urban settlements rely on water resold in kiosks. However, this water is often unavailable due to the high rates of inoperability of kiosks and to the reduced number of kiosks in comparison with water demand (Adams, 2018b). These factors push residents (mostly women) to search for new water sources (Truelove, 2019). However, it should also be recognized that, in the informal urban settlements of the Global South, where access to the water network is insufficient, there are significant community efforts to improve access to water. The case of Dar es Salaam (Tanzania) shows that residents of the urban periphery, lacking connections to the drinking water networks, have self-organized to access, for example, water wells. This has made it possible to improve the living conditions of residents in these areas, especially the poorest segments (Kyessi, 2005; Smiley, 2020).

In addition to inequalities in access, an important aspect that should not be ignored by water managers in the Global South is non-revenue water or water not registered as used, which, on average, may represent up to 50 percent of distributed water (Zyoud et al., 2016). Network water losses are due to, among other factors, aging infrastructure, intermittent service (caused by low system pressure), or unauthorized and unregistered connections (Mutikanga et al., 2009). In some cities in the Global South, intermittent service is often considered as a strategy to reduce water demand. This strategy usually creates short-term advantages, but water demand usually increases significantly in the long term, as intermittency is the source of pipe breaks and water pollution (McKenzie, 2018). In any case, unaccounted water can increase cost recovery problems.

1.2. Objectives and research questions of the thesis

The main theme of this thesis is access to water supply in rapidly growing cities of the Global South. Working with the case of Arequipa, Peru, the thesis first systematically attempts to compare access to water supply in the urban core and in the periphery of Arequipa; second, the thesis examines the supply strategies most used in urban water management and the perception of these strategies by residents of the urban core and the periphery, and third, the thesis analyzes the responses that have emerged in the urban periphery to inequalities in access to urban water supply, including the responses of (in)formal water providers to guarantee access to water in the urban core and periphery of Arequipa during the sanitary crisis produced by Covid-19.

The main research questions addressed in this thesis are:

- How does access to water supply vary spatially in rapidly growing cities such as Arequipa?
- To what extent do strategies by the water company contribute to improve access to water supply in Arequipa?
- What role do informal supply systems and collective action play in access to water in Arequipa? To what extent the formal urban water sector in Arequipa cooperates with informal water source providers?
- In the context of the Covid-19 health emergency, how are formal and informal water providers, responding in Arequipa?

1.3. Case study: Arequipa, Peru

Arequipa (1.3 million inhabitants) is the second-largest city in Peru and one of the country's fast-growing cities. Due to its geographical location and connectivity with other regions, Arequipa, the main economic center of the Macro Southern Region of Peru (CAF, 2018), is located at the head of the Atacama Desert, 2300 meters above sea level. Rainfall in the city is very scarce contrasting with the higher values of the Andes of the Arequipa region, especially between December and March. Rainfall and the melting of snow in the Andes feed the Quilca-Chili River basin, which flows into the Pacific Ocean.

The city includes 20 districts of the 29 that constitute the province of the same name (Municipalidad Provincial de Arequipa, 2016). Arequipa's urban landscape includes the built environment and an agricultural area locally called the Campiña (see Figure 2).

The Chili River (Quilca-Chili basin) is the main source of water supply for urban and agricultural areas of Arequipa as well as for other economic activities. Since 1960 the flow of the Chili River has experienced reductions due to increasing demand. Diminishing flows have been enhanced with the construction of seven dams in the Andes mountains (at 6000 masl) (Andersen, 2016; Zapana, 2018), at the cost however of important social conflicts over water in rural areas (Paerregaard, 2013). While the water inputs from the dam network have kept the flow of the Chili River relatively stable between 10 and 13 meters cubic per second per year, current supplies are threatened by the retreat of snow-capped mountains caused by climate change; deforestation in the upper Chili River basin, and water pollution (Filippi et al., 2014; Veettil & Kamp, 2019). It is therefore not surprising that water managers and politicians in Arequipa are proposing new inter-basin water projects, as well as the construction of new dams.

Figure 2. The city of Arequipa and the Campiña

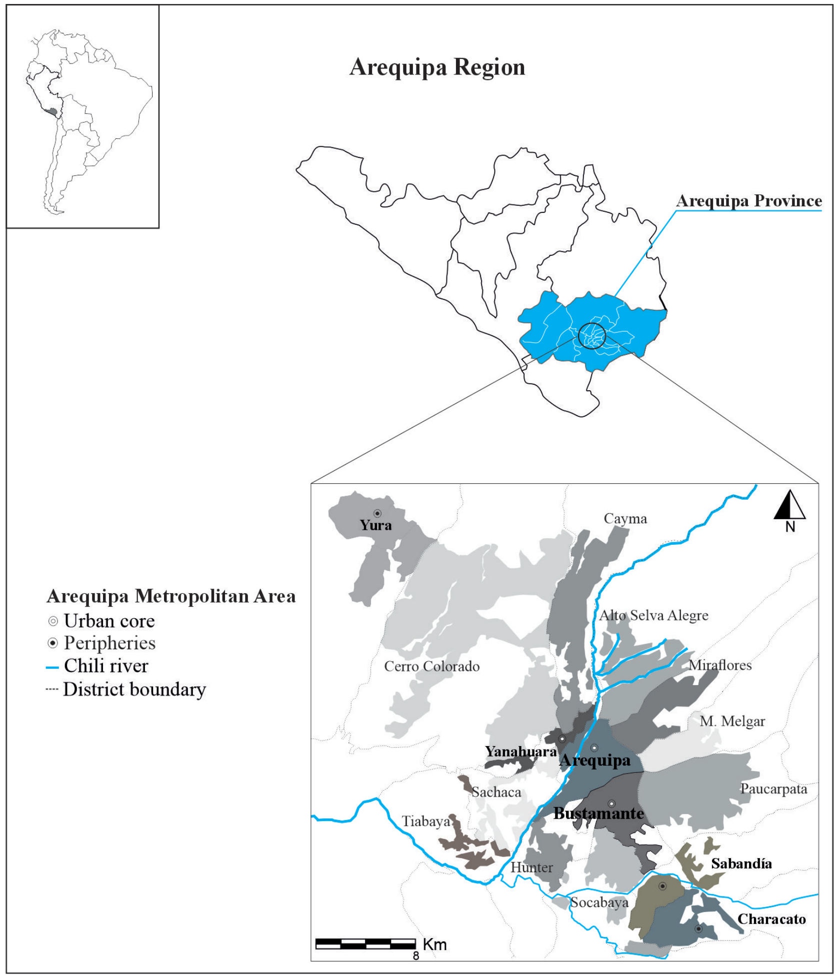
Source: Photo by Sandra Benavides

Figure 3. Location of the study area

Arequipa, like most cities of the Global South, is a spatially segregated city (with planned and unplanned or informal urban areas) (see Figure 3). The presence of planned and unplanned urban areas has been a peculiarity of Arequipa since the Spanish foundation in 1540. According to Belaunde & Mujica (1992), the urban layout was completed with important features of sociospatial segregation. While the planned urban core was occupied by the colonizers, the indigenous population was forced to live outside. Although in 1821 (in Lima) and 1825 (in Arequipa) independence from Spain was declared, the patterns of social and spatial segregation have been reproduced over time. In the contemporary context, migration from the countryside has played an important role in population growth and the urban configuration of Arequipa, especially since the early 1930s (Muñoz, 2018) (see Figure 4). Migration, both local and regional (from southern Peru) has therefore driven Arequipa's growth. However, the city has not been able to provide basic services (e.g. access to housing, health, transportation, drinking water, sanitation, etc.) for all its citizens (Pineda-Zumaran, 2016; Zapana-Churata, March, & Sauri, 2021). Hence, the unserved urban population has sought other strategies to access basic services. Historically, the newly arrived population has settled in informal areas, locally known as Pueblo

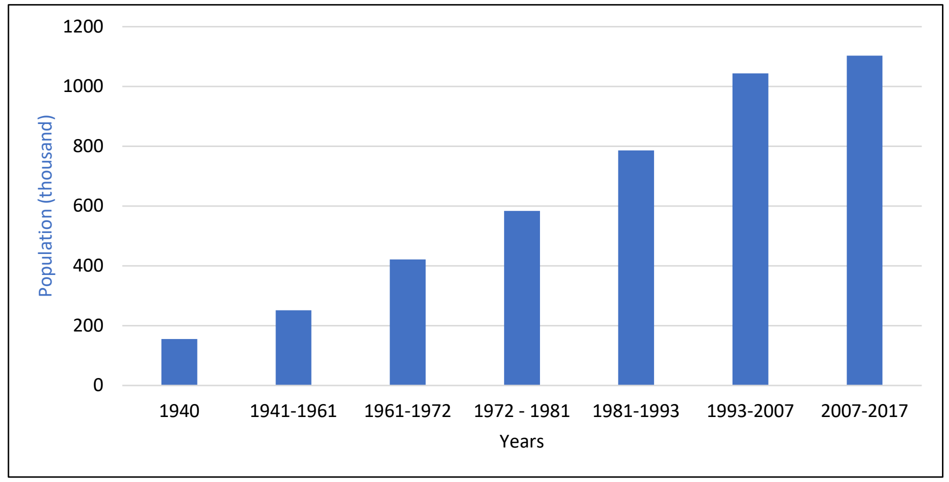
Joven. In 1932, migrants created the first of the many informal urban settlements in the city, which have expanded significantly decades later (Garden, 1989). However, it should be noted that the formation of urban settlements in Arequipa has not only been favored by historical processes of social segregation and migratory flows, but has been the result of earthquakes in the 1950s as well, when many residents of the urban core lost their homes and built temporal housing on the periphery of the planned urban core. Although these residents were relocated back to the planned urban area in the 1960s, informal settlements did not disappear; on contrary, their expansion kept increasing during the following decades.

Figure 3. Location of the study area



Source: Own elaboration

Figure 4. The population of Arequipa (1940-2017)



Source: Own elaboration based on INEI, 2009; BCR, 2016; UN, 2019.

Informal areas in Arequipa have grown due to a combination of laissez-faire urban policies and economic and industrial development transforming the city into an attractive space for local and regional migration. For example, President Fernando Belaunde in his second government (1980-1985) gave the responsibility of urban growth management to municipalities (which, however, lacked sufficient economic and technical resources to perform this task), even though the Instituto Nacional de Planification (INP) at that time had achieved significant results in land-use planning. However, the INP was dissolved in 1992 during the presidency of Alberto Fujimori (Muñoz, 2018). Although the mayors and officials of the municipality of Arequipa have prepared and launched urban development plans, these initiatives have generally failed, since informal urban areas did not conform to the technical-managerial regulations imposed by the municipality. Because of all these factors, the contemporary urban area of Arequipa includes districts of the planned urban core (see Figure 5) and districts of the partially planned urban periphery (see Figure 6), where informal urban settlements predominate (see Figure 3 and 6).

The polarized fragmentation of the urban area, therefore, significantly influences the development of water and sanitation infrastructures in Arequipa. While the drinking water network serves all districts of the urban core, in the urban periphery the service is partial. Most residents of the urban core have access to water and sanitation services. In contrast, for residents of the urban periphery, access to these basic services remains a challenge (RPP, 2017). Although the 2017 Annual Report of Arequipa's public water company (SEDAPAR) indicated that 90.27 percent of the popula-

Figure 5. The urban core of Arequipa

Source: Photo by Vougue (2020).

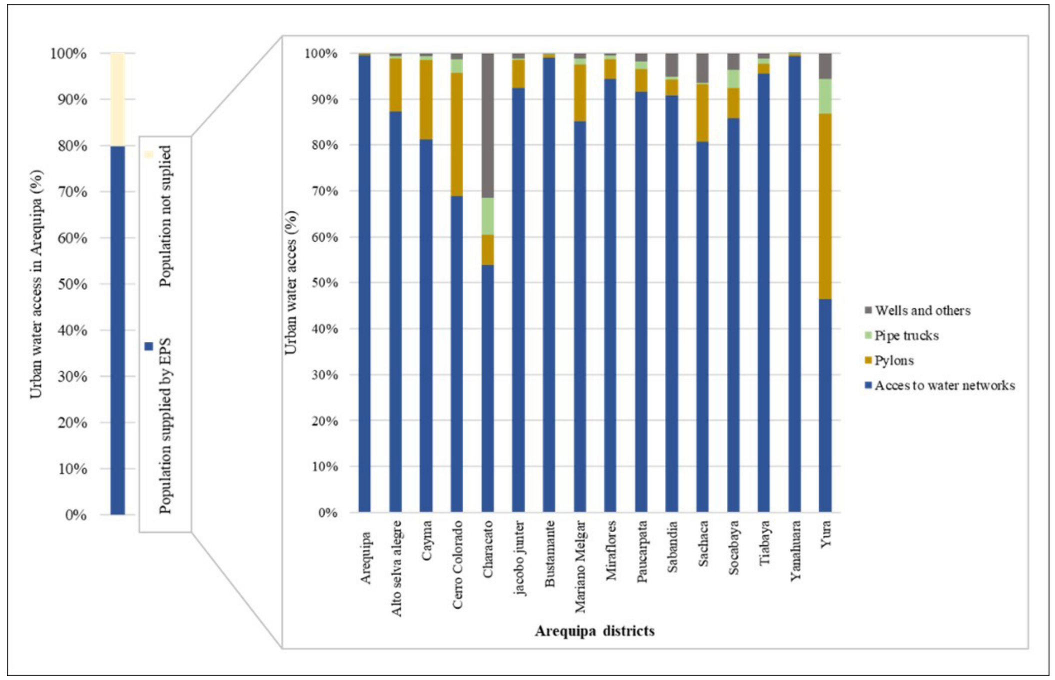
Figure 6. The urban periphery of Arequipa

Source: Photo by Luís Zapana

tion had access to drinking water, the National Census of the same year provided less encouraging results. According to the census conducted by Instituto Nacional de Estadística e Informática-INEI (2017), 79.88 percent of the urban population was supplied by the public drinking water company (SEDAPAR) and 20.12 percent was supplied through non-network supply sources (public pylons, tanker trucks, and others) (see Figure 7). An analysis with more disaggregated figures shows significant disparities in access to water, depending on the districts. For example, access to drinking water through the public network is almost universal in planned and higher-income districts such as Arequipa D.C, J.L. Bustamante, and Yanahuara, while in districts of

the urban periphery access to drinking water through the public network does not exceed 70 percent of households. Inequalities in access to water are often addressed in the local political sphere but administrators and politicians often ignore the other dimensions of water access such as affordability, quality, or service delivery. The sole purpose of the urban water sector is to increase water coverage through the expansion of drinking water infrastructures, but coverage alone does not address other important parameters such as water service interruptions, low system pressure, water shutoffs due to overdue water bills, inadequate water quality, etc., especially, but not only, in the urban periphery. These parameters can compromise, among other aspects, the health and wellbeing of the Arequipa population, especially residents in urban settlements, (Carpio & Fath, 2011).

Figure 7. Access to the water supply in the city of Arequipa



Source: own elaboration based on INEI 2017.

1.4. Theoretical frameworks

This section presents the conceptual frameworks used in the thesis that facilitate the understanding of socioecological processes related to the production of highly unequal urban environments with implications for water access. First, the thesis presents the conceptual framework of Urban Political Ecology (UPE) addressed to provide an interpretation of the fragmented urban landscape and the co-production of water services in the Global South. Second, insights from the literature on Fragmented urban water landscapes and the co-production of water services are introduced. Third, Water Demand Management (WDM) as the main strategy followed by the Arequipa water utility is presented. Fourth, the relationships between water supply and socio-spatial inequalities in times of Covid-19 are explored. It should be noted that the chapters of the thesis present an extensive literature review, which is related to the research questions. The different theoretical frameworks are briefly detailed below.

Urban Political Ecology (UPE)

Urban Political Ecology (UPE) attempts to provide tools for understanding how the interplay of social and ecological processes produce urban environments often highly uneven (Heynen, 2014; Keil, 2003, 2020; Swyngedouw & Heynen, 2003). From the UPE point of view, urban environments and all that is "contemplated" therein are historical outcomes of social and ecological processes. Swyngedouw (1996, 2006) states that, in cities, social (political-economic) and ecological (physical material) factors are closely intertwined, yet this "socio-natural" urban environment is full of contradictions, tensions, and conflicts. Swyngedouw & Heynen (2003) indicate that the degree of tensions, inequalities, and conflicts in urban environments depends, in part, on political-economic power and of specific characteristics, including ecological processes. Political-economic power, for example, decides who will have access to and control over environmental resources and who will be denied access (Heynen, 2017).

UPE conceptual stance and methodology are deeply influenced by the work of Marxist geographers such as David Harvey and Neil Smith. Their contributions take issue with conventional methods that separately analyze ecological and social processes (Heynen, 2006, 2014, 2016, 2017; Keil, 2020; Lawhon et al., 2014). For example, studies by Gandy (2004) and Kaika (2005) have suggested correcting the functional-linear methods of urban metabolism which ignore the intertwining of social and technological systems through hybrid and relational approaches at multiple socio-ecological scales. These authors point out that hybrid and relational approaches reveal ways in which nature is transformed and embedded in political issues and socio-economic practices, which in turn shape unequal urban landscapes. Similarly, Swyngedouw & Kaika (2014) note that the hybrid approach shows how certain types of natures are socially mobilized, economically incorporated (through commodification), and physically transformed to support the urbanization process. In any case, the process of commodification of nature benefits urban environments with higher economic incomes, to the detriment of other, less favored urban environments.

Kaika (2003) chooses water to explain the unequal effects of the socio-economic processes and political-economic reconfigurations in cities. Her work shows how water is domesticated and incorporated into urban society through socio-economic processes to satisfy first the needs of well-off households.

While the hybrid approach based on the intertwining of economic, political, social, and ecological processes that result in unequal urban environments (e.g. the construction of a safe and private "inside" is based on the exclusion of an unknown or undesirable "outside") has been the central theme of UPE analysis, a growing number of studies have suggested that UPE should move beyond the binary distinctions of an "inside" and "outside", an "urban core" and "urban periphery" (Connolly, 2019; Cornea, Véron, & Zimmer, 2017; Keil, 2018; Tzaninis, Mandler, Kaika, & Keil, 2020). Studies suggest that the division of "urban core" and "urban periphery", for example, should be understood as part of the same continuous process. In sum, a growing number of studies suggest that UPE should be anchored in the problematization of urbanization or sub-urbanization processes and governance issues (Amuzu, 2018; Cornea et al., 2017; Tzaninis et al., 2020; Wilson & Jonas, 2018).

Moreover, since UPE is a critical approach that explores the socio-natural construction of urban environments, the first studies emerged from inequalities of access and social conflicts over urban water which is a basic component of the urbanization process. In this sense, active literature highlights water inequities in cities of the Global North and South. Later the UPE approach was extended to the study of inequalities in other topics (Buzzelli, 2008; Coplen, 2018; Lawhon et al., 2014; Njeru, 2006).

Concerning water, the study by Swyngedouw (1995) in Guayaquil (Ecuador) shows how political, economic, and technological factors facilitate not only the capture and control of water but also its incorporation and commodification in the urban environment, which favors high-income households to the detriment of low-income urban sectors. The case of Guayaquil (Ecuador) illustrates how political, economic, and technological factors prioritize water supply for the urban elite, resulting in urban areas with abundant water, while poor urban areas suffer from water scarcity. Swyngedouw (1995) emphasizes that inequalities in access to urban water have served to legitimize the production logic of the Guayaquil water company and its political and economic representatives when in reality the problem is the unequal distribution or allocation of urban water. On the other hand, Aguilera-Klink et al. (2000), with a case study in Tenerife (Spain), reflect that the scarcity of water that the island has experienced is, to a large extent, the result of socioeconomic processes. The authors point that the notion of water as an economic good has led to the production of abundance and, at the same time, to scarcity due to the continuous overexploitation of the resource. In other words, growing water scarcities are socio-environmental phenomena, produced by environmental, climatic, hydrological, social, economic and cultural processes (Kallis, 2008). Similarly, Kaika (2003) demonstrates that water crises, in Athens (Greece) have not been caused by climate variability, but have been the result of historical interactions between water, the transformation of nature by society, economy, politics, and cultural values. The study by Domene, Saurí & Parés (2005) in Barcelona (Spain) reflects how socio-ecological processes produce new unequal suburban landscapes, for example, high-income areas with "Atlantic" type gardens with high rates of water consumption, and areas with "Mediterranean" gardens with lower rates of water consumption. On the other hand, the studies by Ioris (2012, 2016) show that unequal power relations (coupled with corruption) have profound implications for the often unequal distribution of water. Drawing on the cases of Lima (Perú) and the Baixada Fluminense, in the Rio de Janeiro region (Brazil), the author claims that power is exercised over water through selective public policies, leading to the allocation of abundant water for some urban sectors and persistent scarcity for others. Ioris (2012, 2016) also argues how the "scarcity" of urban water is a powerful discourse to justify new projects with economic interests of capitalist groups and the provision of more water for the urban elite. It should be noted that these critical contributions have not only improved the understanding of the production of inequalities of access to water as the result of social, political, economic, and ecological processes, but have also facilitated progress towards a more interdisciplinary UPE.

A growing number of UPE studies have been interested in inequalities related to affordability as well as in everyday life around water in cities of the Global South. It could be said that UPE's approach on inequalities in affordability and the diverse everyday practice around the water, for example, are initiatives addressing the claims made by Connolly (2019); Cornea et al. (2017); Keil (2018) & Tzaninis et al. (2020), suggesting that UPE should move beyond the conception that the "inside" is based on the simultaneous existence and exclusion of an unknown "outside". In any case, UPE studies on water quality and everyday life are presented as a relevant option to deepen the conceptions of socio-ecological inequalities. In cities in the Global South, rapid urbanization is often associated with a progressive decline in drinking water quality and an increase in communicable diseases (Carpio & Fath, 2011). However, the study by Rusca et al. (2017) in Malawi shows that urban water quality is also determined by power relations. The authors emphasize that power and politics influence the circulation of water through the networks, which determines the conditions of access and the quality of the water supplied. In other words, drinking water supplied by networks (which is theorized as "safe" and "reliable") may in practice be contaminated, especially in low-income urban environments. Staying in Malawi, the study by Price et al. (2021) on quantifying daily changes in water access and quality in an urban settlement reveals that household water quality changes on a daily basis. The study reports that while urban residents in Malawi relied on multiple water sources to meet their daily needs, samples obtained from these water sources revealed similar levels of E. coli. In urban settlements, water sources often remain outside households, forcing residents to transport and store water, making these factors the main entry point for contaminants. Similarly, in the context of urban settlements, the study by Karpouzoglou, Marshall, & Mehta (2018) in Ghaziabad (near Delhi, India) shows that residents mostly rely on groundwater. However, groundwater is contaminated by industrial waste discharged directly into the Hindon River. Continuing in the peri-urban settlements of Delhi, Truelove (2019b) highlights the daily practices of both residents and policymakers. Indeed, the study shows that everyday water control practices (e.g., by managers and operators of the informal water supply) enroll people in different environmental and social relationships. In other words, everyday resource control practices allow or limit forms of security and equitable distribution. Likewise, the study by Shields et al. (2015) in several developing countries highlights that water quality varies significantly between the source of origin and the water stored. These authors stress that there is a high probability that water quality will decrease after collection from a source free of contamination. This evidence, however, shows that access to a "protected" or "improved" water source (classified by JMP-WHO and ODS as safe water) is not always safe, but prone to contamination at any time. Therefore, a focus on the daily practices of either water control or access can reveal inequalities in water access, affordability, quality, and at the same time, help improve the monitoring of the Sustainable Development Goals (Llano-Arias, 2015; Truelove, 2019a).

Fragmented urban water landscapes and co-production of water services in the Global South

In most cities of the Global South, and following urban segregation processes mentioned previously, the urban water landscape is fragmented, meaning that residents of cities have access to water through a variety of sources (Wright-Contreras et al., 2017). While 83 percent of the urban population in the Global South, in theory, accesses water through physical networks fulfilling the "ideal of modern infrastructure" or water that takes no more than 30 minutes to collect, millions rely on alternative, "informal" options (tanker trucks, wells, public pylons, and other sources). According to the academic literature, there are two factors behind the fragmentation of the urban water landscape. The first factor relates to the processes of economic liberalization of water, energy, telecommunications, etc., and the development of new technologies (Graham & Marvin, 2001). The book Splintering Urbanism by Graham & Marvin (2001) indicates that the processes of privatization and economic liberalization have contributed to the emergence of "secessionist" spaces. The production of these networked secessionist spaces includes security, financial, infrastructural, and state urban design in combination, to separate the social and economic life of the rich from that of the poor (p. 222). In other words, liberalization in the water sector would have created favorable conditions favoring access to better quality water for social groups with higher economic incomes (access to the drinking water network), but with significant degrees of exclusion from access to the drinking water network for poor social groups (Bakker, 2010). Although water liberalization promised a series of benefits such as, for example, relieving governments of the burden of financing investments, allocating environmental goods more "efficiently" and providing water especially for the urban poor in the Global South, in practice the benefits have turned out to be largely a myth (Hall & Lobina, 2015; Swyngedouw, 2006b). For example, water network expansion for the poor has been disappointing (Bakker, 2007b; Budds & Mcgranahan, 2003; Castro, 2008). As Bakker (2013) points out, the expansion of water networks in developing cities has been carried out with investments from the public sector and not from private companies. Even in developed cities, water liberalization has not achieved benefits in social and environmental terms, because water (a vital resource for life) has turned out to be uncooperative vis-à-vis commodification (Bakker, 2005; Fletcher et al., 2018). Therefore, it is not surprising that the failure of water liberalization to deliver on numerous promises has led to major discontents and social mobilizations such as the "Water War" in Cochabamba (Bolivia) (Assies, 2003; Perreault, 2012). In any case, this thesis moves away from the dualistic public/private debates (in which much of liberalization is framed), because these debates often obscure the wide variety of management or water supply systems that operate markedly in cities of the Global South. Indeed, this misleading situation on the part of the public/private binary has been described by (Bakker et al., 2008) as "governance failures". Thus, to overcome governance failures, Bakker (2008) and Bakker et al. (2008) suggest certain water governance reforms, the purpose of which should not only be limited to network water supply but should include the variety of community or informal water management systems.

The second factor relates to the historical processes of water urbanization in the Global South. Several studies have argued that, historically, the supply of urban water would have been carried out through a variety of supply systems (wells, tanks, etc.), meaning that the urban water landscape was fragmented since the early days of urbanization (Botton & Gouvello, 2008; Coutard, 2008). Additionally, the historical

processes of urban (post)colonization, produced significant degrees of segregation and social differentiation, with important implications for the urban water landscape (Botton & Gouvello, 2008; Fernández-Maldonado, 2008; Kooy & Bakker, 2008).

In any case, the urban water sector in cities of the Global South has promoted the supply of the resource through the ideal of modern infrastructure, as a unique means to provide the distribution of quality water. This alternative promotes the commercialization of the resource and the expansion of state power (Meehan, 2014). While the formal urban water sector (based on network infrastructure) has registered significant progress in water coverage over the past two decades (WHO/UNICEF, 2017), it has not yet achieved its goal of universalizing the service (WHO/UNICEF, 2014). Moreover, this purpose, included in the 2030 Agenda is far from being a tangible reality (Nhamo et al., 2019; Parikh et al., 2020). Even though the "ideal of modern infrastructure" is, at least in the short term, an unrealized dream in most cities of the Global South, the dominant urban water sector still continues to recognize drinking water networks as the only and viable means of supply and ignores the role of other water sources, because it considers these sources as "traditional, temporary and incompatible within a "modern" urban water policy. This view, therefore, only increases the exclusion of people from access to urban water and reinforces the marginalization of water supply system conditions in "informal" areas, where most people live.

Networked water infrastructures are fundamental to providing water resources to urban populations, although the speed of their expansion remains limited or does not usually comply with technical regulations for installation, leading to multiple operational problems (Tiwale, 2015). Likewise, in most of the fast-growing cities of the Global South, drinking water infrastructures do not always operate smoothly and problems appear, related, among other aspects, to rapid urbanization, lack of land regularization, corruption, infrastructure deterioration as well as interruptions of service and water maintenance issues (Andreasen & Møller-Jensen, 2016; Bellaubi & Pahl-Wostl, 2017). It should be noted that service interruptions force users to seek complementary but problematic water sources, which could have important implications for the well-being of residents (Meehan, 2014). Similarly, inadequate functioning of water networks is related to declining water quality, which can compromise public health (Hunter et al., 2009). Pipe failures, on the other hand, can increase water losses (Lee & Schwab, 2005).

Since the "formal" urban water sector has not been able to extend networks universally, alternative informal sources (tanker trucks, wells, public pylons, and house storage devices among others) whether temporary or permanent, fill the void left by formal systems. It should be noted that informal sources are not contemporary practices. They have a long history of use in rural areas, which have been progressively adapted to urban environments. However, they have not been formally recognized and do not receive attention from public institutions, so that the provision of water through these sources may have important implications in terms of reliability, accessibility, and quality. As demonstrated in several case studies from the Global South, urban dwellers with access to unregulated alternative sources generally pay higher prices for smaller quantities of water, often of uncertain quality (Ioris, 2016; Swyngedouw, 1997).

In this context, numerous studies have highlighted that the legal recognition of informal sources can increase access and reliability of the water supply (Adams & Zulu, 2015; Marston, 2014; Narayanan, Rajan, Jebaraj, & Elayaraja, 2017). Other studies claim that these initiatives can help to improve sanitation systems in urban areas deprived of sewer facilities, an issue that is often overlooked (Van Dijk et al., 2014). Other authors such as Jaglin (2002) are skeptical of the operationalization of informal sources of supply because lacking sufficient economic resources to expand supply they may also fail in achieving equity in access. The author also points out that reliance on alternative sources can limit the expansion of networks in urban settlements and risk institutionalizing the service at two levels. In any case, a growing number of studies have reported that the strategy based on the co-production of water services between the formal and informal water sector (a hybrid service modality), including citizen participation, can help to improve service delivery in fast-growing cities in the Global South (Brandsen & Pestoff, 2006; Llano-Arias, 2015; Ostrom, 1996; Rusca et al., 2014). Co-production is the process by which professionals and citizens make better use of each other's assets, resources, and contributions to achieve better outcomes (Bovaird et al., 2015). Also, co-production implies that citizens can play an active role in the production of the public goods and services that matter to them (Ostrom, 1996).

In this sense, Liddle et al. (2016) indicate that sourcing practices in cities in the Global South that are typically categorized as "formal" and "informal", in practice interact through a set of social and material relationships to provide water. Therefore, co-production attempts to move beyond the conventional network-based supply towards the collaboration between citizens and public officials in developing other sources of supply (Ahlers, Cleaver, Rusca, & Schwartz, 2014). The study by McMillan et al. (2014) in Venezuela reflects that co-production between the State and citizens has not only improved water supply but also promoted citizen participation.

Nevertheless, in rapidly growing cities, water supply systems, including informal

water sources, may experience several difficulties in providing water to their users. It should be noted that cities comprise wide and varied socio-spatial realities and specific development trajectories, meaning that successful approaches to urban water in some of them may not work in other cases. In this sense, we can affirm that the preference for a specific, formal system within the urban water policies of the Global South may not be enough to meet the objectives of universal supply and access. Therefore, more context-sensitive and inclusive urban water policies are required, allowing the presence of certain informal water sources in water supply portfolios.

Water Demand Management (WDM)

Given that population growth, rapid urbanization, expansion of irrigated agriculture, development of new industrial activities, pollution, and climate change have important implications on limited water resources, water demand management (WDM) is shown as an alternative to improve the use of water in more sustainable terms. To ensure water supply in the future, WDM has emerged in the past decades as an essential complement of traditional approaches having to do with supply management also referred to as the "hydraulic paradigm" Kallis & Coccossis, 2003; Saurí & del Moral, 2001). While the hydraulic paradigm pursues increasing water supply through the "command and control" approach directed by the State, WDM focuses instead on water conservation. In this sense, WDM implies changes in individual and collective behavior towards more sustainable consumption patterns. In a more operational definition Brooks (2006) points out that WDM is any measure (administrative, economic, financial, technical-social) that attempts, at least to:

1. Reduce the quantity or quality of water required to accomplish a specific task.
2. Adjust the nature of the task or the way it is undertaken so that it can be accomplished with less water or with lower quality water.
3. Reduce the loss in quantity or quality of water as it flows from source through use to disposal.
4. Shift the timing of use from peak to off-peak periods.
5. Increase the ability of the water system to continue to serve society during times when water is in short supply. off-peak periods.

Therefore, reducing the levels of consumption or losses of water is the objective pursued by the WDM. This is especially important because decreasing water consumption in certain uses may translate into increasing water availability for other uses. WDM not only promotes water use efficiency but also tries to promote a more equitable distribution of water. Under this perspective, several academics and international institutions support the role of WDM in urban water management (Bates et al., 2008; Maggioni, 2015; Rockström, 2003). Maggioni (2015) and Rockström (2003) note that WDM approaches are adequate to address threats to water security. The IPCC has even described WDM as an unapologetic solution to addressing the future vulnerability of water supplies due to the impacts of climate change (Bates et al., 2008). In this sense, WDM generally adopts economic and technological strategies and awareness campaigns to achieve the objectives of sustainable water use (Sauri, 2003).

Economic strategies include prices, taxes, subsidies, or discounts. These strategies often receive special attention when it comes to promoting water sustainability and distributional water equity (Grafton et al., 2009; Griffin, 2016). The discourse that supports the implementation of economic strategies revolves especially around rate structures (volumetric rates, increasing block rates, etc.). Indeed, it is often considered that high tariffs stimulate users to use water “efficiently” and, at the same time, facilitate the recovery of investment costs (Savenije & Van Der Zaag, 2009). However, a more nuanced approach in this regard shows that the pricing strategy does not always increase water use efficiency (March & Sauri, 2017; Saurí, 2013). For domestic uses, it is important to recognize indoor and outdoor water use. For example, it is estimated that the pricing mechanisms are more effective to curb outdoor water uses (Arbués et al., 2004; Domene & Saurí, 2006) since indoor uses tend to be more essential for household activities. In other words, water consumption for indoor uses is inelastic concerning price, so initiatives that seek to increase water use efficiency through higher prices may not be effective and, in addition, may not be equitable. In contrast, outdoor water consumption is shown to be more price elastic (Renwick & Archibald, 1998), meaning that increasing the price may decrease water consumption as these uses are not considered essential.

Technological strategies include different types of water-saving technological devices such as dual flushing toilets, water-saving washing machines and dishwashers, faucets, and shower heads with restricted flow, etc. These devices can be implemented for different water uses in households. However, the amount of water saved may vary depending on the technical process for installing or replacing technology devices. The study by Inman & Jeffrey (2006), shows that the installation of new devices can reduce water consumption between 9 and 10 percent. Alternatively, the replacement of devices (for example, toilets and washing machines) with more efficient systems or models can reduce consumption by up to 50 percent. The latter offers greater advantages because replacing faulty devices with new and more efficient ones reduces water leaks.

Awareness campaigns are aimed at encouraging users to conserve water, especially during periods of drought (Saurí, 2013). They include announcements, public training programs, and other events to educate users about water conservation. Although awareness campaigns are important for water management in urban areas, empirical studies have shown mixed results regarding their effectiveness. Some studies have claimed that awareness campaigns have failed to conserve water (Olmstead et al., 2007; Renwick & Green, 2000). However, other studies have indicated that awareness campaigns have managed to reduce between 5 and 20 percent of water consumption (Zietlow et al., 2016). In any case, studies have reported that the success of awareness campaigns can be influenced by a variety of factors such as the intensity of the campaigns, the magnitude of droughts, or sociodemographic conditions among others (Inman & Jeffrey, 2006; March et al., 2015; March & Sauri, 2017; Saurí, 2003).

However, despite the promising benefits of WDM in urban areas, its implementation in cities of the Global South must be attentive to certain considerations such as, for example, sociodemographic conditions, population with access to different sources of water supply, different levels of water consumption, need to supply water of better quality, equity issues, traditional values of water, etc. Failure to take these considerations into account may generate unfavorable effects, especially for the poorest segments of the population. For example, the study by Whittington et al. (2015), shows that the implementation of economic strategies with subsidies (which in theory promotes equity) without considering household income in cities of the Global South, mainly favors households with higher economic incomes and high levels of water consumption. Regardless of economic measures, other WDM strategies such as water leakage control and management, as well as rainwater collection are achieving promising results (Amos et al., 2018; Domènech et al., 2012; UN-HABITAT, 2002).

Water supply and socio-spatial inequalities in times of Covid-19 emergency

At the end of 2019, Covid-19 was identified in Wuhan (China) and in early 2020 it was declared by the World Health Organization a global pandemic. WHO (2020) recommended several measures to mitigate the negative impacts of the pandemic. Among them, social distancing and hand washing were promoted to reduce the rate of infections. Social distancing, for example, is a relevant measure because it forces people to avoid physical contact since physical contact was a viable means of virus transmission. However, the objective of this measure has been almost unattainable for people who did not have homes or people who did not have housing conditions and basic water and sanitation services, especially, but not only, in peri-urban areas of cities in the Global South. On the other hand, handwashing has also been widely promoted as playing a key role in mitigating the spread of infectious diseases. The WHO recommended hand washing for 20 minutes 8-10 times per day, resulting in the need for an additional 8-10 liters of water (Staddon et al., 2020). Therefore, the action of "hand washing" requires that people always have enough water available. However, given that more than one billion people in cities in the Global South do not have water service (Zvobgo & Do, 2020), governments and water managers quickly launched a series of highly relevant measures to ensure water supply (AquaRating, 2020; Cooper, 2020). For example, among the most prominent measures we can cite the suspension of utility disconnections due to non-payment, the deferral of payment of customer bills (predictably until the end of the pandemic), the expansion of different water distribution points, and most especially the distribution of free water (Sanitation and Water for All, 2020; Smiley et al., 2020).

In any case, of all the measures implemented by governments and water managers in cities of the Global South, the distribution of free water has been the most relevant, because this measure was targeted at poor households that for various circumstances did not have access to piped water systems (The World Bank, 2020). Thus, free water was distributed by various water supply systems, including tanker trucks and new pipes (Amankwaa & Ampratwum, 2020). Free water distribution can help mitigate the negative effects of water scarcity affecting households in the urban periphery and help reduce not only Covid-19 infections but also alleviate populations from diarrheal and respiratory diseases. Although the distribution of free water in general terms has important social benefits, it may also have economic implications for the water companies, although this could be overcome by financial compensation from governments or external aid.

In any case, despite the potential of the "free water" measure, this measure has failed to complete its overall objective of free water distribution to the most vulnerable populations. In other words, the distribution of free water has been limited, among other aspects, by water supply problems and the very different socio-spatial realities in cities of the Global South (Bakker, 2003; Furlong, 2014; Wright-Contreras et al., 2017). For example, the free water that was supposed to be distributed through the new pipeline installations was hampered by intermittent and unreliable service, which is common in water distribution systems in cities in the Global South (Mitlin et al., 2019). Likewise, the amount of free water (e.g., 40 liters per household in sub-Saharan African countries) has been almost negligible for multi-family households (Parikh et al., 2020). Similarly, even though free water has been distributed in tanker trucks, it has not had either a large reach because of the limited number of trucks.

In summary, water managers have had very relevant initiatives that should be recognized, but it is also important to mention that managers have launched measures without recognizing the complexities of water supply and the complex urban typologies in the Global South.

However, although the measures implemented by governments and water managers have had limitations in the process of guaranteeing water supply, it is also important to mention the experiences of small-scale or informal water providers in supplying water in Covid-19 times. In fact, even though small-scale water providers have no legal responsibility for supplying the water, they have continued their water supply operations in times of Covid-19. For example, the study by Roca-Servat et al. (2020) shows that community providers have decided to provide water for all their users, regardless of whether the users had no income due to the loss of their jobs. Similarly, in Venezuela and Peru, the distribution of free water in tanker trucks has played an important role for households without connections, albeit with significant economic and water quality maintenance challenges (El Peruano, 2020; Mcmillan, 2020). In Nigeria, small-scale providers have continuously provided water to rural residents (Agada, 2020). However, it will also be important to mention some limitations of small-scale water distribution. For example, likely, water distribution is not equitable among its users. Small-scale water distribution is also likely to be a point of contagion due to crowding by receiving water from tanker trucks. Ultimately, water may not be sufficient for households in peri-urban areas, so it will be important for water managers to address improvements to the full range of supply systems that make up the urban water landscape.

1.5. Research methodology

This section presents the methodologies used to meet the objectives of the thesis and answer the research questions. The first part includes a brief description of data collection methods and secondary information for the city of Arequipa and most especially for the selected districts of the urban core and periphery. Secondly, included

data analysis. It should be noted that the methodological details of each case can be found in the respective chapters.

1.5.1. Data collection process: surveys and semi-structured interviews

This research combines quantitative and qualitative methods. One of the advantages of combining methods is that it facilitates the "triangulation" of multiple perspectives (e.g., comparison of results from surveys, interviews, documents, and publications, etc.), contributing to a better understanding of the problem at hand by increasing the reliability and validity of the research (Duffy, 1987). To a large extent the thesis feeds on surveys (Baxter, Hastings, Law, & Glass, 2008; Hernández Sampieri, 2006), interviews with officials of public institutions and representatives of housing associations (Kitzinger, 1995), and the analysis of secondary data (databases, official documents, and annual reports) provided by institutions such as the public water company SEDAPAR (Servicio de Agua Potable y Alcantarillado de Arequipa), SUNASS (Superintendencia Nacional de Servicios y Saneamiento, Arequipa), and AUTODEMA (Autoridad Autónoma de Majes) and the Municipality of Arequipa. The data collection is presented in the tables below (Table 1 and 2).

Surveys

A total of 721 surveys were conducted between September and November 2018 by a team of 6 people coordinated by the author of this thesis[3] .Six districts were selected out of the twenty districts that make up the city of Arequipa: three districts (Arequipa D.C., J.L. Bustamante, and Yanahuara) (n=354) belong to the higher income urban core, while the other three (Characato, Sabandía, and Yura) (n=367) are located in the lower-income urban periphery (see Table 1). Water in the districts of the urban core is supplied mainly by the public water company, while the districts of the urban periphery are supplied by both the public company and by other alternative water sources.

The three selected districts of the urban core (Arequipa D.C., J.L. Bustamante, and Yanahuara) have similar socio-spatial and economic characteristics. The development of the urban core has been the result of technical-managerial processes of urban planning. This is, therefore, a planned urban environment with very well connected and paved streets and roads, parks, shops, hospitals, schools, universities, the headquarters of national and international banks, and residential areas, where basic services such as water, sanitation, and energy, are provided by public companies. Most of the governmental institutions are in these districts, forming an environment generally preferred by people with higher incomes, whether from Arequipa or other cities in the country. About 58 percent of the inhabitants of the urban core have employment in the public and private administrations, and the rest of the inhabitants are merchants, farmers, construction workers, etc. Only 4 percent of the population of the urban core has been classified as “poor” (BCR, 2016).

3 The six people helped with the surveys in the city of Arequipa. The people who have collaborated with the surveys have not received financing, but they have received sufficient materials to carry out this task, for which we are infinitely grateful to them for their collaboration.

On the other hand, the three districts of the urban periphery (Characato, Sabandía, and Yura) also share similar socio-spatial and economic characteristics, quite different, however, from the urban core. For example, in these peripheral districts, only the central areas have been planned whereas a large part of the district has been occupied and developed outside the technical plan of “urban development” through informal urban settlements, which have progressively increased since 1940. Most of the informal urban settlements were incorporated into the Plan de Desarollo Metropolitano de Arequipa, which facilitated the expansion (although not universally) of basic services such as water, sanitation, energy, and telecommunications. However, more recently, informal urban settlements especially in the Yura district have been rapidly expanding (Muñoz, 2018), which calls into question not only the technical and economic capacity of the municipalities in charge of urban planning but the provision of basic services such as water and sanitation. About half of the residents of the three selected peripheral districts access the public water source (provided by SEDAPAR) while the rest access a variety of so-called “informal” supply sources. In these three selected districts of the urban periphery, about 7.5 percent of the residents are employees of public and private institutions, and about 50 percent are merchants and service workers, who generally tend to commute to the urban core for their daily work (INEI, 2017). According to BCR (2016), about 20 percent of the population in the districts of Yura, Sabandía, and Characato are considered very poor.

The surveys conducted in the six districts of the urban core and periphery were composed of a total of 29 questions with open and closed answers addressing a variety of urban water issues, including water accessibility, availability, quality of service, affordability, pricing, management models, water savings, and awareness campaigns. The surveys (see Table 1) were conducted using a systematic sampling method.

Tab

Districts		Number of surveys
Urban core	Arequipa D.C.	118
	J.L. Bustamante	184
	Yanahuara	52
Urban periphery	Characato	73
	Sabandía	40
	Yura	254
Total		721

Table 2. Stakeholders interviewed in the city of Arequipa

Entity/association	Abbreviation	Position	Phases of interviews	
			Year 2018	Year 2020
Servicio de Agua Potable y Alcantarillado de Arequipa	SEDAPAR	Planning and Business Development Manager	First	Second
Superintendencia Nacional de Servicios de Saneamiento, decentralized office in Arequipa	SUNASS	Decentralized coordinator in Arequipa	First	Second
Autoridad Autónoma de Majes	AUTODEMA	Autodema Executive Manager	First	Second
Regional Government of Arequipa	GRA	Advisor to the Regional Government of Arequipa	First	Second
Provincial Municipality of Arequipa	MPA	Urban Development Manager and others	First	Second
District Municipality of Characato	MD-Characato	Manager of Citizen Services		Second
Jardines del Colca Housing Associations	--	Association Representative	First	Second
La Victoria Housing Association	--	President of the Association	First	Second
Villa Tambo Housing Association	--	President of the Association	First	Second
Salud del Sur Housing Association	--	Members of housing association	First	Second
Juventud de Characato Housing Association	--	President of the Association	First	Second
Water Supply in Tanker Trucks	--	Tank Truck Operator	--	Second
Water Supply in Tanker Trucks	--	Tank Truck Operator	--	Second
Water Supply in Tanker Trucks	--	Tank Truck Operator	--	Second
Water Supply in Tanker Trucks	--	Tank Truck Operator	--	Second

Source: Own elaboration

Interviews

A total of 25 semi-structured interviews (face-to-face and telephone) were conducted in two phases. The first phase (12 semi-structured face-to-face and telephone interviews) was conducted between September and November 2018. In this phase, the interviews targeted representatives of government institutions and housing associations from the urban periphery of Arequipa (see Table 2). The main topic of the interviews was urban water management, with an interest in understanding, among other aspects, how those responsible for urban water management responded to the increasing demand for water in a context of rapid urban growth and what challenges they faced to guarantee universal access to water. The second phase of 13 semi-structured interviews was conducted between July and September 2020 exclusively by telephone since direct contact was not possible due to pandemic restrictions. These interviews targeted representatives of government institutions, housing associations in the urban periphery and water truck operators that deliver water to the urban periphery without access to the public network. With these interviews, the objective was to analyze the role of suppliers (including the public water sector and small-scale water providers) in providing and improving access to water in the urban core and periphery of Arequipa. Responses of "formal and informal" water providers in the context of the state of emergency in Peru caused by the spread of the Covid-19 pandemic were subject to special attention.

Secondary data collection

Secondary data analyzed in this research included databases and official documents provided by governmental institutions in the city of Arequipa after submitting the pertinent requests. Databases from SEDAPAR included historical consumption (of domestic, public, commercial, industrial, and social drinking water in Arequipa), drinking water and sanitation connections for each district, and historical production of drinking water and wastewater treatment. An extensive review of the annual reports of the public water company and some technical files was also carried out. Next, SUNASS documents related to the "Management goals, rate formula and rate structure for drinking water and sanitation services in Arequipa" were extensively reviewed. Likewise, the water supply data provided by AUTODEMA was also analyzed. Finally, in-depth reviews of the annual reports of the Municipality of Arequipa, the regulations of the Arequipa Metropolitan Development Plan, Municipal Ordinances, and Metropolitan Development Plan Plans were also made.

1.5.2. Data analysis

Data from surveys were first processed with descriptive statistical treatment. This operation made it possible to characterize the access to water supply (in terms of affordability, quality, service provision, etc.) and related perceptions on the part of water users in both the core and peripheral urban districts. Following this descriptive analysis, survey data were evaluated with Pearson's chi-square (X2) tests (Baxter et al., 2008; Hernández Sampieri, 2006). This test was especially used to find differences in access to water supply in the selected districts of the urban core and the urban periphery of Arequipa, allowing us to identify differences in water accessibility, availability, quality of service, affordability, price of water, etc. between the two district groups.

Interviews were recorded with the consent of the interviewees. The recorded data were transcribed and classified before analysis following the method of Classical Count Analysis, a method used by researchers to analyze blocks of texts, ideas, meanings, etc. (Fernandez-Nuñez, 2006). The data were classified according to the major themes addressed such as water management in Arequipa, water prices, water access difficulties, satisfaction with water services, measures to guarantee water supply in times of emergency, community participation in water provision, and collaboration among water providers to guarantee water supply, among others.

1.6 Thesis outline

The objectives of this thesis are addressed in chapters 2-5. These chapters have been published in or submitted to, international peer-reviewed journals, so their content can be read independently.

Chapter 2 offers a state of the art of access to water supply in rapidly growing cities of the Global South from the prism of Urban Political Ecology (UPE). In this literature review, the starting point is the fragmentation of the urban water supply in the form of "archipelagos" (Bakker, 2003). This analogy is meant to argue that in fast-growing cities, water is supplied by a variety of sources (including conventional water network systems and "community practices"). After explicitly addressing these inequalities in water supply and access, other dimensions of water access, such as affordability, quality, and service provision, are presented. It is observed that within fragmented urban water landscapes, there are inequalities with respect to affordability, quality, and service provision. Therefore, through the UPE prism, it can be argued that inequalities of inaccessibility (including affordability, quality, and service provision) increase with the peri-urbanization of cities in the Global South. This perspective is expanded in detail in the subsequent empirical analyses of the following chapters.

This chapter has been submitted to the journal *Documents d'Anàlisi Geogràfica* in October 2021 as:

- Zapana-Churata, L. Las desigualdades de acceso al agua en ciudades del Sur Global desde el prisma de la Ecología Política Urbana.
- Submission status: received by the journal

Chapter 3 characterizes access to water supply according to the urbanization process of the core and the urban periphery of Arequipa. The case study shows that there are improvements in the accessibility and availability of water in the core (planned area) and the urban periphery (partially planned), but the improvement of "accessibility", for example, does not always translate into equitable affordability, quality and the provision of service, since the tariff structure of water commercialization affects disproportionally households with the highest number of people and low economic income. This chapter also shows that there are service interruptions in the urban core and in the periphery, which calls into question the provision of services and the meaning of "safe water" in both environments.

This chapter is in the process of being published as:

- Zapana-Churata, L., March, H., Sauri, D. Las desigualdades en el acceso al agua en ciudades latinoamericanas de rápido crecimiento: el caso de Arequipa, Perú
- Sent to: *Journal of Geography Norte Grande*
- Submission status: accepted in 2020
- Date of publication: December 1, 2021

Chapter 4 presents an analysis of the more common urban water management strategies in Arequipa and their perception by residents of the urban core and the periphery. The Arequipa case study shows that urban water management attempts to increase water supply but that, following rapid urbanization and major droughts, experienced in the city, it has also promoted demand management. The study shows that while demand management strategies may be relevant to reduce "excessive" consumption, their implementation without taking into account the wider socioenvironmental context in Arequipa may produce disproportionate impacts on vulnerable populations, especially if these water demand management strategies rely strongly on economic instruments.

This chapter has been published in the journal *International Journal of the Water Resources Development* as:

- Zapana-Churata, L., March, H., Sauri, D. (2021). Water demand management strategies in fast-growing cities. The case of Arequipa, Perú. *International Journal of the Water Resources Development*
- Published in: *International Journal of the Water Resources Development*
- Available at: https://doi.org/10.1080/07900627.2021.1903401

Chapter 5 highlights the role of informal water providers that have emerged in the urban periphery of the city of Arequipa. Informal water providers supply approximately 15 percent of Arequipa's urban population, but these "bottom "up" water supply initiatives are not recognized in the political agenda of the formal urban water sector. Informal water providers and the neighbor's collective action (especially in housing associations) have scored some successes in the water supply but have failed to ensure water affordability and quality. In this sense, this chapter attempts to broaden the discussion on the efforts and challenges experienced by water suppliers in Arequipa, whether "formal" or "informal", and does so in the context of the sanitation crisis produced by Covid-19. The results show that formal and informal providers have implemented numerous measures to ensure water supply during the first wave of the pandemic. The chapter highlights the important initiatives that have emerged in the urban core and periphery, but also their limitations. Results can help improve the approach to urban water policies.

This chapter has been submitted to the journal *Water International* in March 2021 as:

- Zapana-Churata, L., Satorras, M., March, H., Sauri, D. Water supply in COVID-19 times: The role of public operators, housing associations and informal providers in Arequipa (Peru)
- Submission status: under review

Chapter 6 presents the discussions and conclusions of this dissertation. Overall, and building on the case of Arequipa, the thesis reveals significant inequalities in access to water in the fast-growing city environments of the Global South. While inequalities in access to water are usually reflected in analyses of urban-rural contexts or are often related to peripheral urban areas, this thesis attempts to move beyond this connotation and reveals that there are inequalities in access to water (in terms of affordability, quality, service provision) in both the urban core and in the periphery, although these problems of unequal access are larger in the urban periphery. On the other hand, the top-down approach of structural policies that advocate the development of water infrastructure as the only means of supply ignores, among other aspects, community water supply practices. This contempt places community practices in a much more vulnerable condition, possibly leading to negative impacts on the health of their users. Likewise, this chapter highlights bottom-up approaches that include community water supply practices, which beyond their conditions and limitations, are alternatives that require the attention of the formal urban water sector. Moreover, community practices can help democratize access to water in fast-growing cities.

1.7. References

Adams, E. A. (2018a). Intra-urban inequalities in water access among households in Malawi's informal settlements: Toward pro-poor urban water policies in Africa. *Environment Development*, *26*, 34–42. https://doi.org/10.1016/j.envdev.2018.03.004

Adams, E. A. (2018b). Thirsty slums in African cities: household water insecurity in urban informal settlements of Lilongwe, Malawi. *International Journal of Water Resources Development*, *34*(6), 869–887. https://doi.org/10.1080/07900627.2017.1322941

Adams, E. A., & Zulu, L. C. (2015). Participants or customers in water governance? Community-public partnerships for peri-urban water supply. *Geoforum*, *65*, 112–124. https://doi.org/10.1016/J.GEOFORUM.2015.07.017

Adell, G. (1999). *Theories and models of the peri-urban interface: a changing conceptual landscape. The Development Planing Unit*. London: University College London 9. Retrieved from https://discovery.ucl.ac.uk/id/eprint/43/1/DPU_PUI_Adell_THEORIES_MODELS.pdf

Agada, S. (2020). Nigeria's Informal Water Providers: Filling in the Public Gaps. In *Public Water and Covid-19: Dark Clouds and Silver Linings*. Retrieved from https://www.municipalservicesproject.org/sites/municipalservicesproject.org/files/publications/17-Nigeria.pdf

Aguilera-Klink, F., Pérez-Moriana, E., & Sánchez-García, J. (2000). The social construction of scarcity. The case of water in Tenerife (Canary Islands). *Ecological Economics*, *34*, 233–245. Retrieved from https://www.sciencedirect.com/science/article/pii/S0921800900001609?casa_token=gBcyeaaR-KUAAAAA:5vO6ZBP58sdUAFci68QibKe-KB6lhK_38uYzPS6Xkpdzj6YBiqP3uy2TV1T0b1y0-7EtC7Yu4vA

Aguilera Klink, F. (2012). Hacia una nueva economía del agua: cuestiones fundamentales. *Polis. Revista Latinoamericana*, (14).

Ahlers, R., Cleaver, F., Rusca, M., & Schwartz, K. (2014). Informal space in the urban waterscape: Disaggregation and co-production of water services. *Water Alternatives*, *7*(1), 1–14. Retrieved from https://www.water-alternatives.org/index.php/alldoc/articles/vol7/v7issue1/230-a7-1-1

Amankwaa, G., & Ampratwum, E. F. (2020). COVID-19 'free water' initiatives in the Global South: what does the Ghanaian case mean for equitable and sustainable water services? *Water International*, *45*(7–8), 722–729. https://doi.org/10.1080/02508060.2020.1845076

Amos, C. C., Rahman, A., & Gathenya, J. M. (2018). Economic analysis of rainwater harvesting systems comparing developing and developed countries: A case study of Australia and Kenya. *Journal of Cleaner Production*, *172*, 196–207. https://doi.org/10.1016/J.JCLEPRO.2017.10.114

Amuzu, D. (2018). Environmental injustice of informal e-waste recycling in Agbogbloshie-Accra: urban political ecology perspective. *Local Environment*, *23*(6), 603–618. https://doi.org/10.1080/13549839.2018.1456515

Andersen, A. O. (2016). Infrastructures of progress and dispossession: Collective responses to shrinking water access among farmers in Arequipa, Peru. *Focaal-Journal of Global and Historical Anthropology*, *3*(74), 28–41. https://doi.org/10.3167/fcl.2016.740103

Andreasen, M. H., & Møller-Jensen, L. (2016). Beyond the networks: Self-help services and post-settlement network extensions in the periphery of Dar es Salaam. *Habitat International*, *53*, 39–47. https://doi.org/10.1016/J.HABITATINT.2015.11.003

Angoua, E. L. E., Dongo, K., Templeton, M. R., Zinsstag, J., & Bonfoh, B. (2018). Barriers to access improved water and sanitation in poor peri-urban settlements of Abidjan, Côte d'Ivoire. *PLOS ONE*, *13*(8), 1–13. https://doi.org/10.1371/JOURNAL.PONE.0202928

AquaRating. (2020). TARIFAS: Algunas acciones sobre tarifas que han implementado algunos países - AquaRating. Retrieved September 1, 2020, from https://aquarating.org/resiliencia-adaptacion-y-esperanza-como-las-empresas-de-agua-estan-implementando-la-continuidad-del-negocio-durante-covid-19-2-2/

Arbués, F., Barberán, R., & Villanúa, I. (2004). Price impact on urban residential water demand: A dynamic panel data approach. *Water Resources Research*, *40*(11). https://doi.org/10.1029/2004WR003092

Assies, W. (2003). David versus Goliath in Cochabamba: Water rights, neoliberalism, and the revival of social protest in Bolivia. *Latin American Perspectives*, *30*(3), 14–36. https://doi.org/10.1177/0094582X03030003003

Bakker, K. (2003). Archipelagos and networks: urbanization and water privatization in the South. *The Geographical Journal*, *169*(4), 328–341. https://doi.org/10.1111/j.0016-7398.2003.00097.x

Bakker, K. (2005). Neoliberalizing Nature? Market Environmentalism in Water Supply in England and Wales. *Annals of the Association of American Geographers*, *95*(3), 542–565. https://doi.org/10.1111/j.1467-8306.2005.00474.x

Bakker, K. (2007a). The " Commons " Versus the Anti-privatization and the Human Right to Water in the Global South. *Antipode*, *39*(3), 430–455. https://doi.org/10.1111/j.1467-8330.2007.00534.x

Bakker, K. (2007b). Trickle Down? Private sector participation and the pro-poor water supply debate in Jakarta, Indonesia. *Geoforum*, *38*(5), 855–868. https://doi.org/10.1016/J.GEOFORUM.2005.11.011

Bakker, K. (2008). The ambiguity of community: Debating alternatives to private-sector provision of urban water supply. *Water Alternatives*, *1*(2), 236–252.

Bakker, K. (2010). *Provatizing Water: Gobernance Failure and the World's Urban Water Crisis*. New York: Cornell University Press. Retrieved from https://books.google.es/books?hl=en&lr=&id=qIMG3Ik6NXwC&oi=fnd&pg=PR6&ots=WISkAhqS2W&sig=VShLzGTl6xxVBN4r_7k4eN0A2us&redir_esc=y#v=onepage&q&f=false

Bakker, K. (2013). Neoliberal Versus Postneoliberal Water: Geographies of Privatization and Resistance. *Annals of the Association of American Geographers*, *103*(2), 253–260. https://doi.org/10.1080/00045608.2013.756246

Bakker, K. (2014). The Business of Water: Market Environmentalism in the Water Sector. *Annual Review of Environment and Resources*, *39*, 469–494. https://doi.org/10.1146/annurev-environ-070312-132730

Bakker, K., Kooy, M., Shofiani, N. E., & Martijn, E. J. (2008). Governance Failure: Rethinking the Institutional Dimensions of Urban Water Supply to Poor Households. *World Development*, *36*(10), 1891–1915. https://doi.org/10.1016/j.worlddev.2007.09.015

Bakker, K., & Morinville, C. (2013). The governance dimensions of water security: a review. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *371*(2002). https://doi.org/10.1098/RSTA.2013.0116

Bates, B., Wu, S., Kundzewicz, Z., & Palutikof, J. (2008). *Climate Change and Water*. *IPCC*.

Baxter, R., Hastings, N., Law, A., & Glass, E. J. . (2008). Social research methods. *Animal Genetics*, *39*(5), 561–563.

BCR. (2016). *Informe Económico y Social Región Arequipa*. *BCR*. Retrieved from https://www.bcrp.gob.pe/docs/Proyeccion-Institucional/Encuentros-Regionales/2016/arequipa/ies-arequipa-2016.pdf

Beard, V. A., & Mitlin, D. (2021). Water access in global South cities: The challenges of intermittency and affordability. *World Development*, *147*, 105625. https://doi.org/10.1016/J.WORLDDEV.2021.105625

Bellaubi, F., & Pahl-Wostl, C. (2017). Corruption risks, management practices, and performance in water service delivery in Kenya and Ghana: an agent-based model. *Ecology and Society*, *22*(2), 388–409. https://doi.org/10.5751/ES-09205-220206

Bisung, E., & Elliott, S. J. (2017). Psychosocial impacts of the lack of access to water and sanitation in low- and middle-income countries: a scoping review. *Journal of Water and Health*, *15*(1), 17–30. https://doi.org/10.2166/WH.2016.158

Bocquier, P. (2005). World Urbanization Prospects: an alternative to the UN model of projection compatible with the mobility transition theory. *Demographic Research*, *12*, 197–236. https://doi.org/10.4054/DemRes.2005.12.9

Boehnke, K. F., Brewster, R. K., Sánchez, B. N., Valdivieso, M., Bussalleu, A., Guevara, M., … Xi, C. (2018). An assessment of drinking water contamination with Helicobacter pylori in Lima, Peru. *Helicobacter*, *23*(2), e12462. https://doi.org/10.1111/HEL.12462

Boelens, R., Hoogesteger, J., Swyngedouw, E., Vos, J., & Wester, P. (2016). Hydrosocial territories: a political ecology perspective. *Water International*, *41*(1), 1–14. https://doi.org/10.1080/02508060.2016.1134898

Botton, S., & Gouvello, B. de. (2008). Water and sanitation in the Buenos Aires metropolitan region: Fragmented markets, splintering effects? *Geoforum*, *39*(6), 1859–1870. https://doi.org/10.1016/J.geoforum.2008.08.003

Bovaird, T., Van Ryzin, G. G., Loeffeler, E., & Parrado, S. (2015). Activating Citizens to Participate in Collective Co-Production of Public Services. *Journal of Social Policy*, *44*(1), 1–23. https://doi.org/10.1017/S0047279414000567

Brandsen, T., & Pestoff, V. (2006). Co-production, the third sector and the delivery of public services. *Public Management Review*, *8*(4), 493–501. https://doi.org/10.1080/14719030601022874

Brooks, D. B. (2006). An operational definition of water demand management. *International Journal of Water Resources Development*, *22*(4), 521–528. https://doi.org/10.1080/07900620600779699

Budds, J., & Mcgranahan, G. (2003). *Are the debates on water privatization missing the point? Experiences from Africa, Asia and Latin America* (Vol. 15). Retrieved from http://www.iied.org/urban/

Burt, Z., & Ray, I. (2014). Storage and non-payment: Persistent informalities within the formal water supply of hubli-dharwad, India. *Water Alternatives*, *7*(1), 106–120. Retrieved from https://www.water-alternatives.org/index.php/volume7/v7issue1/236-a7-1-7/file

Buzzelli, M. (2008). A political ecology of scale in urban air pollution monitoring. *Transactions of the Institute of British Geographers*, *33*(4), 502–517. https://doi.org/10.1111/J.1475-5661.2008.00316.X

CAF. (2018). *Vulnerabilidad y adaptación al cambio climático en Arequipa Metropolitana*. (CAF, Ed.), *CAF* (1st ed.). Caracas: CAF: Development Bank of Latin American. https://doi.org/scioteca.caf.com/handle/123456789/1181

Carpio, O. V., & Fath, B. D. (2011). Assessing the environmental impacts of urban growth using land use/land cover, water quality and health indicators: A case study of Arequipa, Peru. *American Journal of Environmental Sciences*, *7*(2), 90–101. https://doi.org/10.3844/ajessp.2011.90.101

Castro, J. E. (2008). Neoliberal water and sanitation policies as a failed development strategy: Lessons from developing countries. *Progress in Development Studies*, *8*(1), 63–83. https://doi.org/10.1177/146499340700800107

Cohen, B. (2006). Urbanization in developing countries: Current trends, future projections, and key challenges for sustainability. *Technology in Society*, *28*(1–2), 63–80. https://doi.org/10.1016/j.techsoc.2005.10.005

Connolly, C. (2019). Urban Political Ecology Beyond Methodological Cityism. *International Journal of Urban and Regional Research*, *43*(1), 63–75. https://doi.org/10.1111/1468-2427.12710

Cooper, R. (2020). *Water for the urban poor and Covid-19*. *Department for International Development*. Retrieved from https://theconversation.com/day-zero-is-meant-to-cut-cape-towns-water-

Coplen, A. K. (2018). The labor between farm and table: Cultivating an urban political ecology of agrifood for the 21st century. *Geography Compass*, *12*(5), e12370. https://doi.org/10.1111/GEC3.12370

Cornea, N. L., Véron, R., & Zimmer, A. (2017). Everyday governance and urban environments: Towards a more interdisciplinary urban political ecology. *Geography Compass*, *11*(4), e12310. https://doi.org/10.1111/GEC3.12310

Coutard, O. (2008). Placing splintering urbanism: Introduction. *Geoforum*, *39*(6), 1815–1820. https://doi.org/10.1016/J.GEOFORUM.2008.10.008

Damonte, G., & Boelens, R. (2019). Hydrosocial territories, agro-export and water scarcity: capitalist territorial transformations and water governance in Peru's coastal valleys. *Water International*, *44*(2), 206–223. https://doi.org/10.1080/02508060.2018.1556869

Domene, E., & Saurí, D. (2006). Urbanisation and Water Consumption: Influencing Factors in the Metropolitan Region of Barcelona. *Urban Studies*, *43*, 1605–1623. https://doi.org/DOI: 10.1080=00420980600749969

Domene, E., Saurí, D., & Parés, M. (2005). Urbanization and sustainable resource use: The case of garden watering in the metropolitan region of Barcelona. *Urban Geography*, *26*(6), 520–535. https://doi.org/10.2747/0272-3638.26.6.520

Domènech, L., Heijnen, H., & Saurí, D. (2012). Rainwater harvesting for human consumption and livelihood improvement in rural Nepal: benefits and risks. *Water and Environment Journal*, *26*(4), 465–472. https://doi.org/10.1111/J.1747-6593.2011.00305.X

Dos Santos, S., Adams, E. A., Neville, G., Wada, Y., de Sherbinin, A., Mullin Bernhardt, E., & Adamo, S. B. (2017). Urban growth and water access in sub-Saharan Africa: Progress, challenges, and emerging research directions. *Science of The Total Environment*, *607–608*, 497–508. https://doi.org/10.1016/J.SCITOTENV.2017.06.157

Duffy, M. E. (1987). Methodological Triangulation: A Vehicle for Merging Quantitative and Qualitative Research Methods. *Journal of Nursing Scholarship*, *19*(3), 130–133. https://doi.org/10.1111/j.1547-5069.1987.tb00609.x

El Peruano. (2020). MVCS distribuye agua potable en zonas de Lima que no cuentan con el servicio. Retrieved January 8, 2021, from https://elperuano.pe/noticia/93327-mvcs-distribuye-agua-potable-en-zonas-de-lima-que-no-cuentan-con-el-servicio

Fernández-Maldonado, A. M. (2008). Expanding networks for the urban poor: Water and telecommunications services in Lima, Peru. *Geoforum*, *39*(6), 1884–1896. https://doi.org/10.1016/J.GEOFORUM.2007.11.007

Fernandez-Nuñez, L. (2006). ¿Cómo analizar datos cualitativos? *Universitat de Barcelona*.

Filippi, M. E., Hordijk, M., Alegría, J., & Rojas, J. D. (2014). Knowledge integration: A step forward? Continuities and changes in Arequipa's water governance system. *Environment and Urbanization*, *26*(2), 525–546. https://doi.org/10.1177/0956247814539233

Fletcher, C., Heelsum, A., & Roggeband, C. (2018). Water privatization, hegemony and civil society: What Motivates Individuals to Protest About Water Privatization? *Journal of Civil Society*, *14*(3), 241–256. https://doi.org/10.1080/17448689.2018.1496308

Furlong, K. (2014). STS beyond the "modern infrastructure ideal": Extending theory by engaging with infrastructure challenges in the South. *Technology in Society*, *38*, 139–147. https://doi.org/10.1016/J.TECHSOC.2014.04.001

Gandy, M. (2004). Rethinking urban metabolism: water, space and the modern city. *City*, *8*(3), 363–379. https://doi.org/10.1080/1360481042000313509

Gandy, M. (2008). Landscapes of disaster: Water, modernity, and urban fragmentation in Mumbai. *Environment and Planning A*, *40*(1), 108–130. https://doi.org/10.1068/a3994

Garden, T. Van. (1989). Collective organization and action in squatter settlements in Arequipa, Perú. In F. Schuurman & T. Van Naerssen (Eds.), *Urban Social Movements in the Third World* (First Edit, pp. 27–44). New York: Routledge. Retrieved from https://books.google.es/books?hl=es&lr=&id=KFrRhIpzjzQC&oi=fnd&pg=PA27&dq=settlement+of+pueblo+joven+in+arequipa&ots=TSROaLMLcb&sig=U6hdg18ut6OG-SHGLCmnq-qsToA#v=onepage&q=settlement of pueblo joven in arequipa&f=false

Grafton, R. Q., Kompas, T., To, H., & Ward, M. (2009). *Residential Water Consumption: A Cross-Country Analysis*. *Research in Agricultural & Applied Economics*. Retrieved from https://ageconsearch.umn.edu/record/94823/

Graham, S., & Marvin, S. (2001). *Splintering Urbanism: Networked Infrastructures, Technological Mobilities, and the Urban Condition*. *Technology and Culture* (1st ed., Vol. 43). New York: Taylor & Francis. https://doi.org/10.1353/tech.2002.0124

GRIDA. (2006). A World of Salt | GRID-Arendal. Retrieved July 14, 2021, from https://www.grida.no/resources/5606

Griffin, R. C. (2016). Water Resource Economics, second edition: The Analysis of Scarcity, Policies, and Projects. Retrieved September 26, 2021, from https://books.google.es/books?hl=en&lr=&id=qUe6CwAAQBAJ&oi=fnd&pg=PR7&ots=L1v-hgbm92&sig=-9q9x3O_nAj06ndAljFGa3rd2hpM&redir_esc=y#v=onepage&q&f=false

Hall, D., & Lobina, E. (2015). *Pipe dreams: The failure of the private sector to invest in water services in developing counries*. *World Development Mo*. https://doi.org/10.1007/978-94-6209-944-9_5

Hernández Sampieri, R. (2006). *Metodología de la investigación*. *McGraw-Hill/Interamericana Editores, S.A.* Retrieved from http://encore.fama.us.es/iii/encore/record/C__Rb1750861__S*__Ff%3Afacetlocations%3Afee%3Afee%3AB C Económicas%3A%3A__Ff%3Afacetlocations%3Aeee%3Aeee%3AB Turismo y Finanzas%3A%3A__Ff%3Afacetavailability%3Atrue%3Atrue%3AEn la biblioteca%3A%3A__Ff%3Afacetmed

Heynen, N. (2006). Green Urban Political Ecologies: Toward a Better Understanding of Inner-City Environmental Change: *Envoronment and Planning A: Economy and Space*, *38*(3), 499–516. https://doi.org/10.1068/A37365

Heynen, N. (2014). Urban political ecology I: The urban century. *Progress in Human Geography*, *38(4) 598-*. https://doi.org/10.1177/0309132513500443

Heynen, N. (2016). Urban political ecology II: The abolitionist century. *Progress in Human Geography*, *40*(6), 839–845. https://doi.org/10.1177/0309132515617394

Heynen, N. (2017). Urban Political Ecology. *International Encyclopedia of Geography: People, the Earth, Environment and Technology*, 1–9. https://doi.org/10.1002/9781118786352.WBIEG1110

Hunter, P. R., Zmirou-Navier, D., & Hartemann, P. (2009). Estimating the impact on health of poor reliability of drinking water interventions in developing countries. *Science of The Total Environment*, *407*(8), 2621–2624. https://doi.org/10.1016/J.SCITOTENV.2009.01.018

IBNet. (2019). Countries - IBNet Tariffs Database. Retrieved September 4, 2019, from https://tariffs.ib-net.org/sites/IBNET/Wizard/Countries?regionId=4

INEI. (2017). Censo de 2017: abastecimeinto de agua en la vivienda. Retrieved February 1, 2021, from https://www.inei.gob.pe/estadisticas/censos/

Inman, D., & Jeffrey, P. (2006). A review of residential water conservation tool performance and influences on implementation effectiveness. *Urban Water Journal*, *3*(3), 127–143. https://doi.org/10.1080/15730620600961288

Ioris, A. A. R. (2012). Applying the strategic-relational approach to urban political ecology: The water management problems of the baixada fluminense, Rio de Janeiro, Brazil. *Antipode*, *44*(1), 122–150. https://doi.org/10.1111/j.1467-8330.2011.00848.x

Ioris, A. A. R. (2016). Water scarcity and the exclusionary city: the struggle for water justice in Lima, Peru. *Water International*. https://doi.org/10.1080/02508060.2016.1124515

Jaglin, S. (2002). The right to water versus cost recovery: participation, urban water supply and the poor in sub-Saharan Africa. *Environment & Urbanization*, *14*(1), 231–245. https://doi.org/doi.org/10.1177/095624780201400119

Kaika, M. (2003). Constructing scarcity and sensationalising water politics: 170 Days that shook Athens. *Antipode*, *35*(5), 919–954. https://doi.org/10.1111/j.1467-8330.2003.00365.x

Kaika, M. (2005). *City of Flows: Modernity, Nature, and the City*. New York: Routledge.

Kallis, G, & Coccossis, H. (2003). European Planning Studies Managing Water for Athens: From the Hydraulic to the Rational Growth Paradigm Managing Water for Athens: From the Hydraulic to the Rational Growth Paradigm. *European Planning Studies*, *11*(3), 245–261. https://doi.org/10.1080/09654310303633

Kallis, Giorgos. (2008). Droughts. *Annual Review of Environment and Resources*, *33*, 85–118. https://doi.org/10.1146/annurev.environ.33.081307.123117

Karpouzoglou, T., Marshall, F., & Mehta, L. (2018). Towards a peri-urban political ecology of water quality decline. *Land Use Policy*, *70*, 485–493. https://doi.org/10.1016/J.LANDUSEPOL.2017.11.004

Keil, R. (2003). Urban Political Ecology. *Urban Geography*, *24*(8), 723–738. https://doi.org/10.2747/0272-3638.24.8.723

Keil, R. (2018). The empty shell of the planetary: re-rooting the urban in the experience of the urbanites. *Urban Geography*, *39*(10), 1589–1602. https://doi.org/10.1080/02723638.2018.1451018

Keil, R. (2020). An urban political ecology for a world of cities. *Urban Studies*, *57*(11), 2357–2370. https://doi.org/10.1177/0042098020919086

Kitzinger, J. (1995). Qualitative Research: Introducing focus groups. *BMJ*, *311*(7000), 299. https://doi.org/10.1136/bmj.311.7000.299

Kooy, M., & Bakker, K. (2008). Splintered networks: The colonial and contemporary waters of Jakarta. *Geoforum*, *39*(6), 1843–1858. https://doi.org/10.1016/J.GEOFORUM.2008.07.012

Kooy, M., & Walter, C. T. (2019). Towards a situated urban political ecology analysis of packaged drinking water supply. *Water (Switzerland)*, *11*(2), 225. https://doi.org/10.3390/w11020225

Kyessi, A. G. (2005). Community-based urban water management in fringe neighbourhoods: the case of Dar es Salaam, Tanzania. *Habitat International*, *29*(1), 1–25. https://doi.org/10.1016/S0197-3975(03)00059-6

Lawhon, M., Ernstson, H., & Silver, J. (2014). Provincializing Urban Political Ecology: Towards a Situated UPE Through African Urbanism. *Antipode*, *46*(2), 497–516. https://doi.org/10.1111/ANTI.12051

Lee, E. J., & Schwab, K. J. (2005, June 1). Deficiencies in drinking water distribution systems in developing countries. *Journal of Water and Health*. IWA Publishing. https://doi.org/10.2166/wh.2005.0012

Liddle, E. S., Mager, S. M., & Nel, E. L. (2016). The importance of community-based informal water supply systems in the developing world and the need for formal sector support. *Geographical Journal*, *182*(1), 85–96. https://doi.org/10.1111/geoj.12117

Llano-Arias, V. (2015). Community Knowledge Sharing and Co-Production of Water Services: Two Cases of Community Aqueduct Associations in Colombia. *Water Alternatives*, *8*(2), 77–98. Retrieved from www.water-alternatives.org

Maggioni, E. (2015). Water demand management in times of drought: What matters for water conservation. *Water Resources Research*, *51*(1), 125–139. https://doi.org/10.1002/2014WR016301

Mahlknecht, J., & Pastén-Zapata, E. (2013). *Diagnóstico de los Recursos Hídricos en América Latina*. *Instituto Tecnológico y de Estudios Superiores de Monterrey*. Naucalpan de Juarez: Pearson Educación.

March Corbella, H., & Sauri Pujol, D. (2009). What lies behind domestic water use? A review essay on the drivers of domestic water consumption. *Boletin de La Asociacion de Geografos Espanoles*, (50), 297–314.

March, H., Hernández, M., & Saurí, D. (2015). Assessing domestic water use habits for more effective water awareness campaigns during drought periods: A case study in Alicante, eastern Spain. *Natural Hazards and Earth System Sciences*, *15*(5), 963–972. https://doi.org/10.5194/NHESS-15-963-2015

March, Hug, & Sauri, D. (2017). When sustainable may not mean just: a critical interpretation of urban water consumption decline in Barcelona. *Local Environment*, *22*(5), 523–535. https://doi.org/10.1080/13549839.2016.1233528

Marston, A. (2014). The Scale of Informality: Community-Run Water Systems in Peri-Urban Cochabamba, Bolivia. *Water Alternatives*, *7*(1), 72–88. Retrieved from www.water-alternatives.org

Martínez-Santos, P. (2017). Does 91% of the world's population really have "sustainable access to safe drinking water"? *International Journal of Water Resources Development*, *33*(4), 514–533. https://doi.org/10.1080/07900627.2017.1298517

McKenzie, R. (2018). Why intermittent supplies are no answer to cities hit by drought. Retrieved April 24, 2020, from https://www.thesourcemagazine.org/why-intermittent-supplies-are-no-answer-to-cities-hit-by-drought/

Mcmillan, R. (2020). DEFENDING PUBLIC WATER IN TIMES OF CRISIS: "POPULAR WATER GOVERNMENT" IN CARACAS, VENEZUELA. In *Municipal Service Project* (pp. 197–220). London.

McMillan, R., Spronk, S., & Caswell, C. (2014). Popular participation, equity, and co-production of water and sanitation services in Caracas, Venezuela. *Water International*, *39*(2), 201–215. https://doi.org/10.1080/02508060.2014.886844

Meehan, K. M. (2014). Tool-power: Water infrastructure as wellsprings of state power. *Geoforum*, *57*, 215–224. https://doi.org/10.1016/J.GEOFORUM.2013.08.005

Mehta, L. (2010). The social construction of scarcity: The case of water in western India. *Global Political Ecology*, *9780203842*, 371–386. https://doi.org/10.4324/9780203842249

Mekonnen, M. M., & Hoekstra, A. Y. (2016). Four billion people facing severe water scarcity. *Science Advances*, *2*(2), e1500323. https://doi.org/10.1126/SCIADV.1500323

Miranda-Sara, L., Pfeffer, K., & Baud, I. (2017). Unfolding Urban Geographies of Water-Related Vulnerability and Inequalities: Recognising Risks in Knowledge Building in Lima, Peru. *Future City*, *6*, 81–98. https://doi.org/10.1007/978-3-319-42686-0_6

Mitlin, D. (2020). Dealing with COVID-19 in the towns and cities of the global South | International Institute for Environment and Development. Retrieved August 23, 2020, from https://www.iied.org/dealing-covid-19-towns-cities-global-south

Mitlin, D., Beard, V. A., Satterthwaite, D., & Du, J. (2019). *Unaffordable and Undrinkable: Rethinking Urban Water Access in the Global South*. *World Resources Institute*. Retrieved from https://www.wri.org/wri-citiesforall/cities-all

Mitlin, D., & Satterthwaite, D. (2012). *Urban Poverty in the Global South: Scale and Nature*. *Routledge Library Editions*. Routledge. https://doi.org/10.4324/9780203104316

Municipalidad Provincial de Arequipa. (2016). *Plan de Desarrollo Local Concertado de Arequipa 2016 - 2021*. Retrieved from http://www.muniarequipa.gob.pe/descargas/transparencia/pdlc/PDLC.pdf

Muñoz, A. (2018). Movimiento de pobladores, desarrollo urbano y gobernabilidad local: situación y desafíos en el cono norte de Arequipa. In *Movimientos sociales, actores y representación política* (pp. 259–275). Retrieved from http://www.desco.org.pe/recursos/site/files/CONTENIDO/1248/13_PH_muñoz_dic18.pdf

Mutikanga, H. E., Sharma, S., & Vairavamoorthy, K. (2009). Water loss management in developing countries: Challenges and prospects. *American Water Works Association*, *101*(12), 57–68. https://doi.org/10.1002/j.1551-8833.2009.tb10010.x

Narayanan, S., Rajan, A. T., Jebaraj, P., & Elayaraja, M. S. (2017). Delivering basic infrastructure services to the urban poor: a meta-analysis of the effectiveness of bottom-up approaches. *Utilities Policy*, *44*, 50–62. https://doi.org/10.1016/J.JUP.2017.01.002

Nhamo, G., Nhemachena, C., & Nhamo, S. (2019). Is 2030 too soon for Africa to achieve the water and sanitation sustainable development goal? *Science of the Total Environment*, *669*, 129–139. https://doi.org/10.1016/j.scitotenv.2019.03.109

Njeru, J. (2006). The urban political ecology of plastic bag waste problem in Nairobi, Kenya. *Geoforum*, *37*(6), 1046–1058. https://doi.org/10.1016/J.GEOFORUM.2006.03.003

Olmstead, S. M., Stavins, R. N., & Kennedy, J. F. (2007). *Managing Water Demand*.

Ostrom, E. (1996). Crossing the great divide: Coproduction, synergy, and development. *World Development*, *24*(6), 1073–1087. https://doi.org/10.1016/0305-750X(96)00023-X

Paerregaard, K. (2013). Governing Water in the Andean Community of Cabanaconde, Peru. *Mountain Research and Development*, *33*(3), 207–214. https://doi.org/10.1659/mrd-journal-d-12-00107.1

Parikh, P., Diep, L., Gupte, J., & Lakhanpaul, M. (2020). COVID-19 challenges and WASH in informal settlements: Integrated action supported by the sustainable development goals. *Cities*, *107*(July), 102871. https://doi.org/10.1016/j.cities.2020.102871

Patrick, M., Steenland, M., Dismer, A., Pierre-Louis, J., Murphy, J. L., Kahler, A., … Handzel, T. (2017). Assessment of Drinking Water Sold from Private Sector Kiosks in Post-Earthquake Port-au-Prince, Haiti. *The American Journal of Tropical Medicine and Hygiene*, *97*(4 Suppl), 84. https://doi.org/10.4269/AJTMH.16-0692

Perreault, T. (2012). Dispossession by Accumulation? Mining, Water and the Nature of Enclosure on the Bolivian Altiplano. *Antipode*, *45*(5), no-no. https://doi.org/10.1111/anti.12005

Pierce, G. (2020). How collectively organised residents in marginalised urban settlements secure multiple basic service enhancements: Evidence from Hyderabad, India: *Urban Studies*, *57*(9), 1940–1956. https://doi.org/10.1177/0042098019863960

Pineda-Zumaran, J. (2016). Learning and Knowledge Generation in Local Decision Making in the South: The Case of Urban Infrastructure Provision in Arequipa, Peru. *Journal of Planning Education and Research*, *36*(1), 60–75. https://doi.org/10.1177/0739456X15601186

Price, H. D., Adams, E. A., Nkwanda, P. D., Mkandawire, T. W., & Quilliam, R. S. (2021). Daily changes in household water access and quality in urban slums undermine global safe water monitoring programmes. *International Journal of Hygiene and Environmental Health*, *231*, 113632. https://doi.org/10.1016/J.IJHEH.2020.113632

Prüss-Ustün, A., Bartram, J., Clasen, T., Colford, J. M., Cumming, O., Curtis, V., … Cairncross, S. (2014). Burden of disease from inadequate water, sanitation and hygiene in low- and middle-income settings: A retrospective analysis of data from 145 countries. *Tropical Medicine and International Health*, *19*(8), 894–905. https://doi.org/10.1111/tmi.12329

Renwick, M. E., & Archibald, S. O. (1998). Demand side management policies for residential water use: who bears the conservation burden? *Land Economics*, *74*(3), 343–359. https://doi.org/10.2307/3147117

Renwick, M. E., & Green, R. D. (2000). Do Residential Water Demand Side Management Policies Measure Up? An Analysis of Eight California Water Agencies. *Journal of Environmental Economics and Management*, *40*(1), 37–55. https://doi.org/10.1006/JEEM.1999.1102

Roca-Servat, D., Boter, M., & Correa, S. (2020). COMMUNITY-BASED WATER PROVISION IN COLOMBIA IN TIMES OF COVID-19. In *Public Water and Covid-19: Dark Clouds and Silver Linings*.

Rockström, J. (2003). Resilience building and water demand management for drought mitigation. *Physics and Chemistry of the Earth, Parts A/B/C*, *28*(20–27), 869–877. https://doi.org/10.1016/J.PCE.2003.08.009

RPP. (2017). Cisternas de agua potable no se abastecen para atender a 800 mil personas. Retrieved February 11, 2020, from https://rpp.pe/peru/arequipa/cisternas-de-agua-potable-no-se-abastecen-para-atender-a-800-mil-personas-noticia-1027781

Rusca, M., Boakye-Ansah, S. A., Loftus, A., Ferrero, G., & van der Zaag, P. (2017). An interdisciplinary political ecology of drinking water quality. Exploring socio-ecological inequalities in Lilongwe's water supply network. *Geoforum*, *84*, 138–146. https://doi.org/10.1016/j.geoforum.2017.06.013

Rusca, M., Schwartz, K., Hadzovic, L., & Ahlers, R. (2014). Adapting Generic Models through Bricolage: Elite Capture of Water Users Associations in Peri-urban Lilongwe. *The European Journal of Development Research 2014 27:5*, *27*(5), 777–792. https://doi.org/10.1057/EJDR.2014.58

Sanitation and Water for All. (2020). Country Experiences on COVID-19 and WASH. Retrieved October 1, 2020, from https://www.sanitationandwaterforall.org/news/country-experiences-covid-19-and-wash

Sauri, D. (2003). Lights and shadows of urban water demand management: The case of metropolitan region of Barcelona. *European Planning Studies*, *11*(3), 229–243. https://doi.org/10.1080/09654310303639

Sauri, D. (2013). Water Conservation: Theory and Evidence in Urban Areas of the Developed World. *Annual Review of Environment and Resources*, *38*(1), 227–248. https://doi.org/10.1146/annurev-environ-013113-142651

Sauri, D., & del Moral, L. (2001). Recent developments in Spanish water policy. Alternatives and conflicts at the end of the hydraulic age. *Geoforum*, *32*(3), 351–362. https://doi.org/10.1016/S0016-7185(00)00048-8

Savenije, H. H. G., & Van Der Zaag, P. (2009). Water as an Economic Good and Demand Management Paradigms with Pitfalls. *Water International*, *27*(1), 98–104. https://doi.org/10.1080/02508060208686982

Schriks, M., Heringa, M. B., van der Kooi, M. M. E., de Voogt, P., & van Wezel, A. P. (2010). Toxicological relevance of emerging contaminants for drinking water quality. *Water Research*, *44*(2), 461–476. https://doi.org/10.1016/J.WATRES.2009.08.023

Shields, K. F., Bain, R. E. S., Cronk, R., Wright, J. A., & Bartram, J. (2015). Association of supply type with fecal contamination of source water and household stored drinking water in developing countries: A bivariate meta-analysis. *Environmental Health Perspectives*, *123*(12), 1222–1231. https://doi.org/10.1289/EHP.1409002

Smiley, S. L. (2013). Complexities of water access in Dar es Salaam, Tanzania. *Applied Geography*, *41*, 132–138. https://doi.org/10.1016/j.apgeog.2013.03.019

Smiley, S. L. (2020). Heterogeneous water provision in Dar es Salaam: The role of networked infrastructures and alternative systems in informal areas. *EPE: Nature and Space*, *3*(4), 1215–1231. https://doi.org/10.1177/2514848620908194

Smiley, S. L., Agbemor, B. D., Adams, E. A., & Tutu, R. (2020). COVID-19 and water access in Sub-Saharan Africa: Ghana's free water directive may not benefit water insecure households. *African Geographical Review*. https://doi.org/10.1080/19376812.2020.1810083

Staddon, C., Everard, M., Mytton, J., Octavianti, T., Powell, W., Quinn, N., … Mizniak, J. (2020). Water insecurity compounds the global coronavirus crisis. *Water International*, *45*(5), 416–422. https://doi.org/10.1080/02508060.2020.1769345

Stern, N. (2007). *The Economics of Climate Change: The Stern Review*. Cambridge University Press. https://doi.org/https://doi.org/10.1017/CBO9780511817434

Stevenson, E. G. J., Ambelu, A., Caruso, B. A., Tesfaye, Y., & Freeman, M. C. (2016). Community Water Improvement, Household Water Insecurity, and Women's Psychological Distress: An Intervention and Control Study in Ethiopia. *PLOS ONE*, *11*(4), e0153432. https://doi.org/10.1371/JOURNAL.PONE.0153432

Sultana, F. (2011). Suffering for water, suffering from water: Emotional geographies of resource access, control and conflict. *Geoforum*, *42*(2), 163–172. https://doi.org/10.1016/J.GEOFORUM.2010.12.002

Sun, L., Chen, J., Li, Q., & Huang, D. (2020). Dramatic uneven urbanization of large cities throughout the world in recent decades. *Nature Communications*, *11*(1), 1–9. https://doi.org/10.1038/s41467-020-19158-1

Swyngedouw, E. (1995). The contradictions of urban water provision: a study of Guayaquil, Ecuador. *Third World Planning Review*, *17*(4), 387–405. https://doi.org/10.3828/twpr.17.4.c828066008888322

Swyngedouw, E. (1996). The city as a hybrid: On nature, society and cyborg urbanization. *Capitalism, Nature, Socialism*, *7*(2), 65–80. https://doi.org/10.1080/10455759609358679

Swyngedouw, E. (1997). *Power, nature, and the city. The conquest of water and the political ecology of urbanization in Guayaquil, Ecuador: 1880-1990*. *Environment and Planning A* (Vol. 29). Retrieved from https://journals.sagepub.com/doi/pdf/10.1068/a290311

Swyngedouw, E. (2006a). Circulations and metabolisms: (Hybrid) Natures and (Cyborg) cities. *Science as Culture*, *15*(2), 105–121. https://doi.org/10.1080/09505430600707970

Swyngedouw, E. (2006b). Dispossessing H 2 O: the contested terrain of water privatization. *Capitalism Nature Socialism ISSN:*, *16*(1). https://doi.org/10.1080/1045575052000335384

Swyngedouw, E., & Heynen, N. (2003). Urban Political Ecology, Justice and the Politics of Scale. *Antipode*, *35*(5), 343.

Swyngedouw, E., & Kaika, M. (2014). Urban Political Ecology. Great Promises, Deadlock… and New Beginnings? *Documents d'Analisi Geografica*, *60*(3), 459–481. https://doi.org/10.5565/rev/dag.155

The World Bank. (2018). Population living in slums (% of urban population). Retrieved October 17, 2021, from https://data.worldbank.org/indicator/EN.POP.SLUM.UR.ZS

The World Bank. (2020). Tackling COVID-19 (Coronavirus) with Water, Sanitation and Hygiene in DRC. Retrieved October 17, 2021, from https://www.worldbank.org/en/news/feature/2020/04/20/tackling-covid-19-coronavirus-with-water-sanitation-and-hygiene-in-drc

Tiwale, S. (2015). Understanding Lilongwe's thirst for water : linking infrastructure development to differentiated water supply. Retrieved May 9, 2021, from https://www.narcis.nl/publication/RecordID/oai:cdm21063.contentdm.oclc.org:masters2%2F93275

Truelove, Y. (2019a). Gray Zones: The Everyday Practices and Governance of Water beyond the Network. *Annals of the American Association of Geographers*, *109*(6), 1758–1774. https://doi.org/10.1080/24694452.2019.1581598

Truelove, Y. (2019b). Rethinking water insecurity, inequality and infrastructure through an embodied urban political ecology. *WIREs Water*, *6*(3), 1–7. https://doi.org/10.1002/wat2.1342

Tzaninis, Y., Mandler, T., Kaika, M., & Keil, R. (2020). Moving urban political ecology beyond the "urbanization of nature." *Progress in Human Geography*, *45*(2), 229–252. https://doi.org/10.1177/0309132520903350

UN-HABITAT. (2002). Leakage Reduction Projects Undertaken by Rand Water. Retrieved September 26, 2021, from https://unhabitat.org/leakage-reduction-projects-undertaken-by-rand-water

United Nations. (2010). *The human right to water and sanitation*. Retrieved from https://undocs.org/A/RES/64/292

Van Dijk, M. P., Etajak, S., Mwalwega, B., & Ssempebwa, J. (2014). Financing sanitation and cost recovery in the slums of Dar es Salaam and Kampala. *Habitat International*, *43*, 206–213. https://doi.org/10.1016/J.HABITATINT.2014.02.003

Veettil, B. K., & Kamp, U. (2019). Global Disappearance of Tropical Mountain Glaciers: Observations, Causes, and Challenges. *Geosciences*, *9*(5), 196. https://doi.org/10.3390/GEOSCIENCES9050196

Whittington, D., Nauges, C., Fuente, D., & Wu, X. (2015). A diagnostic tool for estimating the incidence of subsidies delivered by water utilities in low- and medium-income countries, with illustrative simulations. *Utilities Policy*, *34*, 70–81. https://doi.org/10.1016/J.JUP.2014.12.007

WHO/UNICEF. (2014). *Progress on Drinking Water and Sanitation*. (WHO/UNICEF, Ed.). Luxemburg: WHO/UNICEF. Retrieved from https://washdata.org/sites/default/files/documents/reports/2017-06/JMP-2014-Report.pdf

WHO/UNICEF. (2017). *Progress on Drinking Water, Sanitation and Hygiene Update and SDG Baselines 2017 Launch version July 12 Main report*. *WHO Library Cataloguing in Publication Data*. Retrieved from http://apps.who.int/bookorders.

Wilson, D., & Jonas, A. E. G. (2018). Planetary urbanization: new perspectives on the debate. *Urban Geography*, *39*(10), 1576–1580. https://doi.org/10.1080/02723638.2018.1481603

World Health Organization. (2020). WHO Director-General's opening remarks at the media briefing on COVID-19. Retrieved October 17, 2021, from https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---15-april-2020

Wright-Contreras, L., March, H., & Schramm, S. (2017). Fragmented landscapes of water supply in suburban Hanoi. *Habitat International*, *61*, 64–74. https://doi.org/10.1016/j.habitatint.2017.02.002

Zapana-Churata, L., March, H., & Sauri, D. (2021). Water demand management strategies in fast-growing cities. The case of Arequipa, Perú. *International Journal of Water Resources Development*, 1–25. https://doi.org/10.1080/07900627.2021.1903401

Zapana, L. (2018). Respuestas a la crisis hídrica en zonas agrícolas y urbanas: Caso de estudio "Proyecto de Irrigación Majes Siguas I" Arequipa – Perú. *Agua y Territorio*, (12), 145–156. https://doi.org/10.17561/at.12.3532

Zietlow, K. J., Michalscheck, M., & Weltin, M. (2016). Water conservation under scarcity conditions: testing the long-run effectiveness of a water conservation awareness campaign in Jordan. *International Journal of Water Resources Development*, *32*(6), 997–1009. https://doi.org/10.1080/07900627.2016.1159947

Zvobgo, L., & Do, P. (2020). COVID-19 and the call for 'Safe Hands': Challenges facing the under-resourced municipalities that lack potable water access - A case study of Chitungwiza municipality, Zimbabwe. *Water Research X*, *9*, 100074. https://doi.org/10.1016/j.wroa.2020.100074

Zyoud, S. H., Kaufmann, L. G., Shaheen, H., Samhan, S., & Fuchs-Hanusch, D. (2016). A framework for water loss management in developing countries under fuzzy environment: Integration of Fuzzy AHP with Fuzzy TOPSIS. *Expert Systems with Applications*, *61*, 86–105. https://doi.org/10.1016/J.ESWA.2016.05.016

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Chapter 2

Water access inequalities in rapidly growing cities of the Global South from the prism of Urban Political Ecology (UPE)

Abstract

This chapter analyzes inequalities in access to water in cities in the Global South through the prism of Urban Political Ecology (UPE). While urban water is provided by a variety of supply sources, there are inequalities of access in terms of affordability, quality, and service delivery. From the prism of UPE, inequalities of access are the result of social, political, cultural, and economic power relations. In urban areas with access to conventional networks, structural policies influence the circulation of water, a situation that gives rise to a series of access conditions. In peri-urban areas with access to alternative sources ("public" use basin, wells, tanker trucks, bottled water, among others.), neighborhood water distribution regulations shape water access practices and shape daily life. Therefore, more UPE studies are suggested to analyze the effects of water distribution regulations on daily water access practices.

2.1. Introduction

In 2018, 54 percent of the world's population lived in cities. By 2050 this figure is expected to reach 68 percent. Much of this growth will happen in the Global South, especially in Asia and Africa (Sun et al., 2020). Thus, the cities of these continents will grow faster, although with different expansion patterns (Zanganeh Shahraki et al., 2011). This rapid urbanization process poses significant challenges for the provision of basic services, especially the provision of drinking water and sanitation. Indeed, in many cities in the Global South, the expansion of drinking water networks fails to keep pace with urban expansion, despite the increase in distribution networks. Consequently, access to basic services such as water represents a challenge for some 1 billion people, especially in slums (Mitlin y Walnycki, 2020). Many slum households often rely on "informal" water sources, but these sources are not always safe, which could have adverse consequences for health and well-being. For example, the UNICEF report (2018) report notes that 1,000 children die daily from diarrheal diseases. Likewise, in the context of the Covid-19 pandemic, cases of infection have skyrocketed in urban areas with limited water and sanitation services (Corburn et al., 2020; Rafa et al., 2020).

Although water coverage figures in cities in the Global South have increased over the last two decades, these universal figures hide significant inequalities in access and ignore the new realities of water supply. For example, universal figures represent the number of people with access to the water source but say little about water quality and the availability of adequate quantities of water for domestic use. In other words, not all households connected to the drinking water network have the same quality and quantity of water supplied. Several studies have pointed out that the quality and availability of a city's drinking water can vary between and within neighborhoods in that city, even within urban settlements (Juran et al., 2017; Young et al., 2019). Likewise, many of these inequalities may be influenced, among other aspects, household socioeconomic status, socio-spatial characteristics, etc., so it will be important to promote new urban water policies that include low-income households (Adams, 2018a).

Similarly, universal access figures are usually interpreted as access to "safe" water sources (WHO/UNICEF, 2017). However, the reality of water supply is different, to give an example, the quantity of water is usually higher in some urban areas, but the quality is usually not homogeneous, making the water unsafe (Zapana-Churata et al, 2021). The causes of water insecurity are diverse and may vary according to the geographical context. In cities of the Global North, water insecurity may be related to high water costs (rather than infrastructure), which can increase water poverty (March y Sauri, 2017; Saurí, 2019). In contrast, in cities in the Global South, water insecurity may be associated, among other aspects, with an insufficient expansion of water networks, obsolete infrastructures, intermittent service, high water costs, etc. In this sense, some factors such as service intermittence may have implications for water availability, which could compromise quality (Kumpel y Nelson, 2016a; Lee y Schwab, 2005a), especially in informal urban settlements (Adams, 2018; Boakye-Ansah et al., 2016). On the other hand, intermittency can worsen the condition of distribution systems, in part due to water and air overpressure that can generate pipe breaks, with consequent network water losses (Kumpel y Nelson, 2016b; Lee y Schwab, 2005b; McKenzie, 2018). Water losses or "unaccounted for water" continues to be a problem faced by all utilities, although this reality is exacerbated in rapidly growing cities (Mutikanga et al, 2009). Although the world average of unaccounted for water is 35 (Farley et al, 2008), in cities of the Global South it can reach 60 percent of the water distributed, a fact that can contribute to skyrocketing urban water demand. In this sense, as March y Sauri (2017) points out, it is not surprising that the "functionalist" conceptions of water management based on water footprints, environmental footprints, and the like, which commonly underpin sustainable development policies (see, for example, Hoekstra y Chapagain, 2007; Newman, 2006; Sahely et al., 2003) consider cities as high resource-consuming environments. Therefore, it is important to mention, in addition, functionalist approaches ignore the wide variety of socio-spatial realities of cities, as well as the power relations that have implications in the development of water infrastructures and their circulation through the urban environment (Bakker, 2003; Domènech et al., 2013; Jeandron et al., 2019; March y

Sauri, 2017; Swyngedouw, 1995; Truelove, 2016).

In this sense, it should be noted that water supply systems and uses are closely related to the processes and forms of urbanization, as well as unequal relations of power and control over the resource (March, 2015; March y Sauri, 2010). In cities of the Global North, the use of water varies, among other aspects, with the compact or dispersed urban form. In cities of the Global South, water use may vary with the (un)planned (formal and informal) urban context, sources of water access and control, income, etc. (Marks et al., 2020; Sanchez et al., 2020). Thus, water consumption tends to be higher in "formalized" urban areas, commonly with higher economic incomes, where drinking water networks predominate, which is known as the ideal of "modern infrastructure" (Graham y Marvin, 2001). In contrast, water uses in informal urban areas tend to be low and highly heterogeneous, as households in these areas access a variety of water sources (including tanker trucks, wells, public use fountains, and rainwater, among others) (Meehan, 2014). Although water networks tend to gradually expand in informal urban areas, households are often forced to combine "formal and informal" sources of supply, in part due to system performance problems, a situation that prevents users from accessing sufficient water (Mitlin y Walnycki, 2020; Sanchez et al., 2020).

The present work aims to offer a state of the art from the prism of Urban Political Ecology on how inequalities in access to water in terms of accessibility, affordability, quality, and provision of services in cities of the Global South are produced and reproduced not only because of the lack of economic resources but also because of unequal power relations and because of structural policies, which are often exclusive.

2.2. The need for universal access to drinking water in cities of the Global South

Ensuring a universal water supply is a well-known need among the international community. The concern for universal drinking water supply stems, in part, from the establishment of the International Water and Sanitation Decade (1981-1990). More recent key milestones in this area were the Millennium Development Goals (MDGs); the explicit recognition of the Human Right to Drinking Water and Sanitation by the United Nations in 2010 (UN, 2010), and the establishment of the Sustainable Development Goals in 2015.

Millennium Development Goal 7 sought to halve the percentage of people without access to improved water sources by 2015. This goal would have been met by 2010 in almost all regions of the world, except for Sub-Saharan Africa (United Nations, 2015). In this regard, a UNICEF report (2014), noted that 89 percent of the world's population had access to improved water sources, a figure that shows significant progress in terms of access to drinking water. However, these universal figures have also been criticized. Several studies have pointed out that the term "access to improved source" had shortcomings in the definitional definition, similar to access metrics, which may have unrealistically inflated water coverage figures (Smiley, 2017). For example, MDG 7 measured access to an improved water source based on proximity. It was considered as "access to an improved water source" if it was within 100 meters, without taking into account some factors such as the reliability, quality, and quantity of the water (Clasen, 2010; Liddle et al., 2016; Stoler, 2012). Improved water sources have not always been safe (Parker et al., 2010; Smiley, 2013). Despite the proximity (within 100 meters), natural water sources can be altered with contaminants from industrial and agricultural activities, as well as the lack of sanitation. Ultimately, water from natural sources can be degraded during transportation or storage within homes (Sorenson et al., 2011).

In 2015, the UN established the Sustainable Development Goals (SDGs), whose targets are to be achieved between 2015-2030. Concerning water and sanitation, SDG number 6 seeks to "achieve universal and equitable access to safe and affordable drinking water for all". SDG 6 represents a new paradigm in access to safe and universal water. Unlike the MDGs that generally distinguished access to improved and unimproved water sources, SDG 6 goes beyond these two categorizations and classifies access to improved water sources under three conditions: safe, basic, and limited. Safely managed water includes drinking water from an improved water source that is on the premises, always available, and free of contaminants. Basic and limited-service include non-piped water in conventional network systems, although with important differences in terms of collection. It is considered a basic service if the water source for the collection is within 30 minutes of the place of residence (round trip), but if the collection time exceeds 30 minutes, then the service is defined as limited. Despite the relevance of these definitions of access to drinking water, other factors are of concern. For example, to consider a water source to be free of contaminants, SDG 6 includes only the analysis of Escherichia coli (WHO, 2016), without considering contamination by economic activities (industrial, agricultural, etc.) (Pal et al., 2014). Likewise, the supply of drinking water through network systems that represents a "safe water source" does not always guarantee water quality, in part due to intermittent service (Furlong y Kooy, 2017; Mitlin et al., 2019). Intermittent service forces households in many cities in the Global South to store water in containers. Storage of water in containers can be a relevant practice to mitigate water deficiencies, but it can also compromise water quality due to exposure to contaminants (Brick et al., 2004; Kumpel y Nelson, 2013). On the other hand, basic water sources that for collection in operational terms are within 30 minutes do not always guarantee accessibility, as these water sources are often controlled by social groups, which tend to provide water at limited times. This situation can increase the cost of water over time (the 30-minute limit can easily be exceeded).

On the other hand, SDG 6 by 2030 seeks to make access to water equitable, but its indicators do not consider the various realities of water supply. For example, reports from international organizations often differentiate access to water between urban and rural areas, but this action ignores internal inequalities in cities. These intra-urban inequalities include not only the different forms of supply in the form of "archipelagos", but also other relevant dimensions of water access such as water quality and service reliability. Thus, universal urban water coverage figures are often interpreted as access to the water safely (BID, 2015), but this approach obscures the meaning of water access in terms of affordability, reliability, and quality (Kooy y Walter, 2019; Stoler et al., 2012). Furthermore, network infrastructures that are discursively defined as "reliable" operate differently, for different user groups (Furlong y Kooy, 2017; Ioris, 2016). In other words, the frequency of service interruptions may be recorded much higher in low-income urban areas, so water quality could have much more deteriorated in these urban sectors (Boakye-Ansah et al., 2016).

On the other hand, residents of peri-urban areas of the Global South access a variety of "informal" water supply systems (tanker trucks, public use basin, bagged water, wells, etc.) (Stoler et al., 2012). They are considered "informal" because they are not recognized by formal policies, even though informal supply systems provide water to households without access to drinking water networks. However, despite the informal operation, alternative sources can achieve successes in terms of water supply, although with significant challenges to the quality of the resource. For example, in an urban context where residents rely on wells, access to or extraction of water (especially of higher quality) is often determined by economic income (Boakye-Ansah et al., 2016; Furlong y Kooy, 2017).

In any case, it is worth noting that unequal conditions of access to water (including inequalities in the functionality of supply systems, deteriorating water quality, and low service reliability) are related to socio-spatial differences, which, in turn, it is the result of political-ecological interactions. As Swyngedouw (2009) and Boelens et al. (2016), the interactions between power (social, political, economic, and cultural) and ecological processes (biological, chemical, and physical) produce a series of hydro-social conditions, often unequal. Swyngedouw's (1995) study in Guayaquil shows how power relations around water produce fragmented waterscapes, where higher-income social strata enjoy the highest quality drinking water, and the poor are increasingly vulnerable to poor water quality. In this sense, solutions to problems related to inequalities in access to water, including inequalities in the functionality, quality, and reliability of supply sources are, in part, political. With this in mind, we place Urban Political Ecology (UPR) as an analytical framework for understanding water inequalities in rapidly growing cities of the Global South.

2.3. Urban Political Ecology: a prism through which to delve into the understanding of inequalities in access to water

Urban Political Ecology (UPE) is a multidisciplinary analytical framework that is interested in socio-ecological relations in cities (Heynen et al., 2005; Keil, 2003; March, 2015; Swyngedouw y Heynen, 2003). EPU brings an innovative methodology that challenges the dominant technical-managerial approaches that separate the social context from biophysical systems. From the UPE point of view, economic, political, and cultural processes (manifested through the capitalist system) are largely responsible for the (re)production of urban natures and urban metabolism, often unevenly. Likewise, the (re)production of these urban natures, including the metabolic circulation of water through the city, is shaped by power relations, which favor urban elites, at the expense of poor social groups, thus producing large socio-environmental inequalities. In this sense, as mentioned in numerous studies, UPE aims to reconsider the urbanization process not only as simple social processes or natural resource flows (water, energy, waste, etc.), but as a "product" of metabolic processes of socio-natural transformation, which occur historically (Angelo y Wachsmuth, 2015; Swyngedouw, 1996, 2006).

Numerous academic contributions of the EPU have focused on the analysis of socio-ecological processes in urban settings (Heynen et al., 2006; Tzaninis et al., 2020), although in the contemporary context they also include other emerging discourses, related to gender studies, race, etc. (Heynen, 2014, 2016, 2018; Truelove, 2011; Tzaninis et al., 2020). An important part of the UPE has addressed the understanding of urban water (Bakker, 2003; Domene et al., 2005; Gandy, 2008; Kooy y Walter, 2019; Swyngedouw, 1995). For example, the study by Swyngedouw (1995) in Guayaquil is considered one of the relevant works in providing a broad analysis on how power relations (social, economic, political, and cultural) dominate water flows (p. g. water transfer between basins), with important advantages for economic capital and urban elites. The study also highlights how urban water policies based on drinking water production and distribution (which is usually financed by international development agencies) prioritize the requirements of urban elites and economic activities, which results in increased inequalities in access to the resource. Similarly, Kaika (2003) critically analyzes nature's production of water in Athens. The author points out that the "water scarcity" that Athens would have experienced between 1989 and 1991 was not the result of droughts understood as simply natural phenomena, but of the interrelation between social, economic, political, cultural factors and natural elements (e.g., the capture of water in reservoirs). Similarly, several UPE studies have also highlighted how power relations combined with natural processes have given rise to a series of socio-environmental conditions, with clear implications for social and environmental factors (Domènech et al., 2013; Sauri and del Moral, 2001). For example, large inter-basin water transfer projects supported by political, institutional, and economic practices produce urban environments with abundant water and others with permanent scarcity, but with important socio-environmental implications in rural areas (Hommes & Boelens, 2017; Ioris, 2012, 2016; Rodríguez-Labajos & Martínez-Alier, 2015).

A growing number of UPE studies focused on cities in the Global South have highlighted how socio-technological processes and power relations contribute to the production of inequalities in access to water (Alda-Vidal, Kooy, y Rusca, 2018; Gandy, 2004). For example, structural (top-down) urban water policies promote the development of drinking water network systems as a less costly option to guarantee water service in a "cheap" and "reliable" way. However, these systems are centralized in higher-income urban areas, in contrast, residents of peripheral areas are forced to access informal supply systems (tanker, public use pylon, bottled drinking water, etc.), often comparatively much more expensive than piped water. Although informal supply systems are not recognized by urban water policies, they complete the urban water landscape. For example, Meehan (2014) study shows how water in cities flows not only through conventional network systems, but through multiple pathways and forms, which together complete the hydrosocial cycle. Similarly, Furlong y Kooy (2017) have pointed out that water supply for most cities in the Global South is not just network infrastructure or its absence, but the range of practices and technologies that bring people and physical environment in a complex socio-ecological water policy. For example, in some cities in the Global South, "bottled" drinking water supply or "bottled" drinking water appear to be potentially viable (Kooy y Walter, 2019; Sharma y Bhaduri, 2013; Walter et al., 2017). However, despite these potentialities, it is also worth noting should also be noted that challenges remain, since it is not very clear whether the amount

of "pregnant" drinking water provided to households meets the needs of its users or whether the water quality is kept until its final consumption. In any case, addressing these challenges can be relevant to democratizing the water supply.

On the other hand, Urban Political Ecology has paid some attention to water quality, availability, and accessibility (Kooy y Walter, 2019; Smiley, 2020; Wright-Contreras, 2019). However, there are still few UPE studies that analyze these factors such as water quality, availability, accessibility, functionality, and reliability of the service in peri-urban areas of cities in the Global South. This is important because inequalities in access to water are often interpreted as the division between those who have connections within the household and those who do not (but who have access to other sources of supply). However, little attention has been paid to the inequality of access in terms of water quality, availability, accessibility, functionality, and reliability of the service present in centralized drinking water networks and informal water sources (Rusca et al, 2017). The study by Mitlin et al. (2019) in 15 cities in the Global South shows that "reliable" drinking water networks may not guarantee quality due to intermittency. On the other hand, water from informal systems is often more expensive, which would make water affordability more problematic. It is therefore urgent that the political ecology of urban water analyzes these factors in greater detail.

2.4. UPE in the analysis of inequalities in urban water quality, availability, and accessibility

One of the purposes of the UPE in the field of urban water is to facilitate the understanding of how power relations control and to redirect water flows, producing fragmented and highly unequal urban landscapes in social and environmental terms. Indeed, several UPE studies in fast-growing cities in the Global South have shown how unequal power relations legitimize and delegitimize water supply practices, resulting in large inequalities in access to water (see, Kooy y Walter, 2019; Smiley, 2020; Wright-Contreras, 2019). Although inequalities in access (which include different supply systems) are well documented, there are relatively few studies that analyze the implications of unequal power relations on the quality, availability, accessibility, and functionality of the water supply. As already mentioned, the urban water sector often classifies supply sources on scales in a safe, basic, and limited way. For example, drinking water supply networks are often considered as "homogeneous" systems that provide "reliable" and "safe" services in terms of quality, availability, accessibility, etc., and therefore must be extended in cities, where coverage is not universal. However, this notion obscures the inequalities of accessibility in terms of quality, availability, etc. (Wright-Contreras et al., 2017; Zapana-Churata et al., 2021). In fact, these water supply factors (quality, availability, and functionality) are often different within urban areas where the drinking water network predominates, as well as within peripheral urban areas where access to wells predominates, for example (Wright-Contreras et al., 2017). In any case, it is important to highlight that drinking water network expansions are not always developed to guarantee access to water, but may follow other logics such as, for example, the reproduction of power (from "top to bottom"), the commercialization of water and the enhancement of economic benefits for water company shareholders (Bakker, 2003; Empinotti et al., 2019; Meehan, 2014).

Inequalities in the quality, availability, functionality of the water supply, etc., are produced from the political decisions that define how and for whom the monitoring of water quality should be guaranteed, and how it should be developed, operated, maintain drinking water network systems and guarantee service (Alda-Vidal et al., 2018; Rusca et al., 2017). The study by Boakye-Ansah et al. (2016) points out that the distributive inequalities of water quality are associated with the power relations that define the forms of development of drinking water network infrastructures. Understanding the forms of infrastructure development is extremely important because as Tiwale (2015) points out, infrastructures determine where water should flow in cities and in what quantities. For example, the quality of installation materials such as pipes often varies depending on the planned and unplanned urban context. Likewise, drinking water networks are usually installed following technical regulations in planned and higher-income urban areas. In contrast, in low-income and unplanned urban areas, pipes are often of poor quality and are often exposed in streets, public spaces, etc., which makes them more prone to breakage, intermittent supply, and finally to water pollution (Tiwale, 2015).

Consequently, drinking water produced by utility companies is often distributed through different network infrastructures in terms of material quality. Therefore, since network infrastructures carry different amounts of water, protection against water contamination can vary significantly. Boakye et al. (2016) affirm that water quality tends to deteriorate from the point of treatment to the point of consumption, although not in all urban areas. For example, the quality of drinking water tends to have less deteriorated in higher-income neighborhoods and more deteriorated in lower-income neighborhoods. In this sense, the intermittency of the service is usually one of the explanatory factors for the deterioration of water quality, since it facilitates microbial contamination through the intrusion of water from outside the pipe. Likewise, intermittency tends to force households to store water in a variety of containers that do not always have sufficient hygienic guarantees (Bivins et al., 2017; Boakye-Ansah et al., 2016; Kumpel y Nelson, 2013).

Therefore, from a UPE approach, the objectives of ensuring urban water quality not only depend on technical issues such as infrastructure designs, treatment plants, or maintenance practices but also depend on the implications of power relations in water supply, which may vary depending on the urban context.

2.5. UPE in the analysis of water access inequalities at the peri-urban neighborhood level

While the UPE approach to urban water analysis has advanced in understanding how power relations control the distribution of resources, producing unequal urban environments, a UPE approach at the level of peri-urban areas can deepen and unravel other social power relations. For example, the UPE focus on the everyday water supply practices can broaden the understanding of the production and reproduction of inequalities of access in peri-urban neighborhoods.

While households in peri-urban areas of the Global South often rely on a range of alternative sources of water supply, access to these sources is often regulated by neighborhood or housing association "micronormatives" in peri-urban areas, which can facilitate or exclude from water supply and, consequently, produce dynamic and varied everyday supply realities (Llano-Arias, 2015; Truelove, 2019). Indeed, alternative sources may achieve some successes, but their functioning for supply depends, in part, on gender-related work, social class position, and networks of political patronage (Truelove, 2019).

For example, in peri-urban areas supplied by tanker trucks, the jobs of receiving and storing water often fall to women and girls (Sultana, 2009; Truelove, 2019). Consequently, as noted by Adams et al., (2018), Sultana (2009) and Truelove (2011) girls often leave schools to help at home to fetch water, so these daily practices may increase gender inequalities. On the other hand, water sources such as public pylons and wells are often controlled by small groups, which often determine the rules of access. Thus, access to water in peri-urban areas can be very different for different social groups. As Hofmann (2017), points out, water "managers" can restrict as well as facilitate day-to-day access to water, although these characteristics depend on agreements with individual users. Also, in terms of access, "stewards" who control water can access water at any time of the day, in contrast, users of these sources may be forced to invest a significant amount of time, in part due to multiple displacements (Adams, 2018b; Peloso y Morinville, 2014). Finally, regarding political patronage networks, Truelove (2019) notes that the flexibility and negotiability of fuzzy state governance allow state actors to selectively allocate some level of water improvement to groups. In this sense, the urban water UPE methodology with a focus on everyday practices of water access can deepen understandings of the production and reproduction of inequalities at the peri-urban neighborhood level.

2.6. Conclusions

This chapter has presented a state of the art of inequalities in access to water in cities of the Global South from the prism of Urban Political Ecology (UPE). As noted at the outset, in many cities in the Global South, water is supplied by a variety of supply sources, including conventional drinking water systems and "alternative sources" of supply (tankers, public standpipes, bottled water, among others). Generally, this division translates into large inequalities in access to quality water. Although structural urban water policies largely promote the development of conventional drinking water network systems, the fact is that their expansion does not keep up with rapid urbanization. Likewise, expanded or expanding water networks do not always guarantee other dimensions of water access such as quality, service, etc., especially, but not only, in low-income peri-urban areas. Therefore, many households experiencing accessibility problems (including households without access to potable water networks) must incorporate other alternative sources of water supply.

From the prism of Urban Political Ecology, it can be argued that inequalities in water supply and access that vary by urban context are, in part, the result of unequal power relations. Indeed, the power relations that revolve around urban water define the forms of water supply, including processes of inclusion and exclusion, and the conditions of access. Moreover, power relations influence the flows of water circulating in conventional network systems. This means that conventional systems based on "homogeneous" networks transport different quantities of water, making supply continuous in some urban sectors (commonly higher income) and intermittent in others (low income). These uneven processes have implications for water quality, especially in low-income urban areas. A better understanding of the influence of power relations on the deterioration of water quality in conventional systems can help to problematize not only quantity but also quality injustices of the resource and, consequently, elucidate strategies to reduce health risks for the most vulnerable users.

Similarly, UPE is relevant for analyzing inequalities of access in peri-urban areas where alternative sources (user pylons, tanker trucks, wells, etc.) are the main means of supply. While informal supply systems are potentially relevant to democratizing water supply, they do not always guarantee the equity of access to water. From the UPE perspective, distribution regulations and various daily practices to access water (which influence the circulation and make possible the social distribution of the resource), can produce inequalities of access in terms of quantity and quality. For example, due to the control of water by groups of leaders, accessibility to water can vary regularly. Commercialization of water (often at high prices) may force especially low-income households to seek alternative sources (such as water from rivers, neighbors, etc.). Water fetching work is often carried out by women, which can increase gender inequalities. In this sense, water distribution regulations at the peri-urban neighborhood level that attempt to democratize water may produce their own inequalities of access in terms of water quantity and quality. Further UPE studies that analyze the effects of water distribution policies and regulations on everyday water access practices in peri-urban areas would be required.

2.7. References

Adams, E. A. (2018a). Intra-urban inequalities in water access among households in Malawi's informal settlements: Toward pro-poor urban water policies in Africa. *Environment Development*, *26*, 34–42. https://doi.org/10.1016/j.envdev.2018.03.004

Adams, E. A. (2018b). Thirsty slums in African cities: household water insecurity in urban informal settlements of Lilongwe, Malawi. *International Journal of Water Resources Development*, *34*(6), 869–887. https://doi.org/10.1080/07900627.2017.1322941

Adams, E. A., Juran, L., & Ajibade, I. (2018). 'Spaces of Exclusion' in community water governance: A Feminist Political Ecology of gender and participation in Malawi's Urban Water User Associations. *Geoforum*, *95*, 133–142. https://doi.org/10.1016/j.geoforum.2018.06.016

Alda-Vidal, C., Kooy, M., & Rusca, M. (2018). Mapping operation and maintenance: an everyday urbanism analysis of inequalities within piped water supply in Lilongwe, Malawi. *Urban Geography*, *39*(1), 104–121. https://doi.org/10.1080/02723638.2017.1292664

Angelo, H., & Wachsmuth, D. (2015). Urbanizing urban political ecology: A critique of methodological cityism. *International Journal of Urban and Regional Research*, *39*(1), 16–27. https://doi.org/10.1111/1468-2427.12105

Bakker, K. (2003). Archipelagos and networks: urbanization and water privatization in the South. *The Geographical Journal*, *169*(4), 328–341. https://doi.org/10.1111/j.0016-7398.2003.00097.x

Banco Interamericano de Desarrollo. (2015). El futuro de los Servicios de Agua y Saneamiento en America Latina. In *BID*. Retrieved from https://publications.iadb.org/es/publicacion/15452/el-futuro-de-los-servicios-de-agua-y-saneamiento-en-america-latina-desafios-de

Bivins, A. W., Sumner, T., Kumpel, E., Howard, G., Cumming, O., Ross, I., … Brown, J. (2017). Estimating Infection Risks and the Global Burden of Diarrheal Disease Attributable to Intermittent Water Supply Using QMRA. *Environ. Sci. Technol*, *51*, 14. https://doi.

org/10.1021/acs.est.7b01014

Boakye-Ansah, A. S., Ferrero, G., Rusca, M., & Van Der Zaag, P. (2016). Inequalities in microbial contamination of drinking water supplies in urban areas: The case of Lilongwe, Malawi. *Journal of Water and Health*, *14*(5), 851–863. https://doi.org/10.2166/wh.2016.258

Boelens, R., Hoogesteger, J., Swyngedouw, E., Vos, J., & Wester, P. (2016). Hydrosocial territories: a political ecology perspective. *Water International*, *41*(1), 1–14. https://doi.org/10.1080/02508060.2016.1134898

Brick, T., Primrose, B., Chandrasekhar, R., Roy, S., Muliyil, J., & Kang, G. (2004). Water contamination in urban south India: Household storage practices and their implications for water safety and enteric infections. *International Journal of Hygiene and Environmental Health*, *207*(5), 473–480. https://doi.org/10.1078/1438-4639-00318

Clasen, T. (2010). Household Water Treatment and the Millennium Development Goals: Keeping the Focus on Health. *Environmental Science and Technology*, *44*, 7357–7360. https://doi.org/10.1021/es1018674

Corburn, J., Vlahov, D., Mberu, B., Riley, L., Caiaffa, W. T., Rashid, S. F., … Ayad, H. (2020). Slum Health: Arresting COVID-19 and Improving Well-Being in Urban Informal Settlements. *Journal of Urban Health*, *97*(3), 348–357. https://doi.org/10.1007/s11524-020-00438-6

Domene, E., Saurí, D., & Parés, M. (2005). Urbanization and sustainable resource use: The case of garden watering in the metropolitan region of Barcelona. *Urban Geography*, *26*(6), 520–535. https://doi.org/10.2747/0272-3638.26.6.520

Domènech, L., March, H., & Saurí, D. (2013). Contesting large-scale water supply projects at both ends of the pipe in Kathmandu and Melamchi Valleys, Nepal. *Geoforum*, *47*, 22–31. https://doi.org/10.1016/j.geoforum.2013.02.002

Empinotti, V. L., Budds, J., & Aversa, M. (2019). Governance and water security: The role of the water institutional framework in the 2013–15 water crisis in São Paulo, Brazil. *Geoforum*, *98*, 46–54. https://doi.org/10.1016/J.GEOFORUM.2018.09.022

Farley, M., Wyeth, G., Ghazali, Z. B., Istandar, A., & Singh, S. (2008). The Manager's Non-Revenue Water Handbook: A Guide to Understanding Water Losses. In *USAID*.

Furlong, K., & Kooy, M. (2017). Worlding Water Supply: Thinking Beyond the Network in Jakarta. *International Journal of Urban and Regional Research*, *41*(6), 888–903. https://doi.org/10.1111/1468-2427.12582

Gandy, M. (2004). Rethinking urban metabolism: water, space and the modern city. *City*, *8*(3), 363–379. https://doi.org/10.1080/1360481042000313509

Gandy, M. (2008). Landscapes of disaster: Water, modernity, and urban fragmentation in Mumbai. *Environment and Planning A*, *40*(1), 108–130. https://doi.org/10.1068/a3994

Graham, S., & Marvin, S. (2001). Splintering Urbanism: Networked Infrastructures, Technological Mobilities, and the Urban Condition. In *Technology and Culture* (1st ed., Vol. 43). https://doi.org/10.1353/tech.2002.0124

Heynen, N. (2014). Urban political ecology I: The urban century. *Progress in Human Geography*, *38(4) 598-*. https://doi.org/10.1177/0309132513500443

Heynen, N. (2016). Urban political ecology II: The abolitionist century. *Progress in Human Geography*, *40*(6), 839–845. https://doi.org/10.1177/0309132515617394

Heynen, N. (2018). Urban political ecology III: The feminist and queer century. *Progress in Human Geography*, *42*(3), 446–452. https://doi.org/10.1177/0309132517693336

Heynen, N., Kaika, M., & Swyngedouw, E. (2006). In the Nature of Cities: Urban Political Ecology and the Politics of Urban Metabolism. In *Routledge Library Editions*. https://doi.org/10.4324/9780203027523

Hoekstra, A. Y., & Chapagain, A. K. (2007). Water footprints of nations: Water use by people as a function of their consumption pattern. *Water Resources Management*, *21*(1), 35–48. https://doi.org/10.1007/s11269-006-9039-x

Hofmann, P. (2017). *Multi-layered Trajectories of Water and Sanitation Poverty in Dar es Salaam*. https://doi.org/10.1007/978-3-319-42686-0_7

Hommes, L., & Boelens, R. (2017). Urbanizing rural waters: Rural-urban water transfers and the reconfiguration of hydrosocial territories in Lima. *Political Geography*, *57*, 71–80. https://doi.org/10.1016/j.polgeo.2016.12.002

Ioris, A. A. R. (2012). Applying the strategic-relational approach to urban political ecology: The water management problems of the baixada fluminense, Rio de Janeiro, Brazil. *Antipode*, *44*(1), 122–150. https://doi.org/10.1111/j.1467-8330.2011.00848.x

Ioris, A. A. R. (2016). Water scarcity and the exclusionary city: the struggle for water justice in Lima, Peru. *Water International*. https://doi.org/10.1080/02508060.2016.1124515

Jeandron, A., Cumming, O., Kapepula, L., & Cousens, S. (2019). Predicting quality and quantity of water used by urban households based on tap water service. *Npj Clean Water*, *2*(1). https://doi.org/10.1038/s41545-019-0047-9

Juran, L., MacDonald, M. C., Basu, N. B., Hubbard, S., Rajagopal, R., Rajagopalan, P., & Philip, L. (2017). Development and application of a multi-scalar, participant-driven water poverty index in post-tsunami India. *International Journal of Water Resources Development*, *33*(6), 955–975. https://doi.org/10.1080/07900627.2016.1253543

Kaika, M. (2003). Constructing scarcity and sensationalising water politics: 170 Days that shook Athens. *Antipode*, *35*(5), 919–954. https://doi.org/10.1111/j.1467-8330.2003.00365.x

Keil, R. (2003). Urban Political Ecology. *Urban Geography*, *24*(8), 723–738. https://doi.org/10.2747/0272-3638.24.8.723

Kooy, M., & Walter, C. T. (2019). Towards a situated urban political ecology analysis of packaged drinking water supply. *Water (Switzerland)*, *11*(2), 225. https://doi.org/10.3390/w11020225

Kumpel, E., & Nelson, K. L. (2013). Comparing microbial water quality in an intermittent and continuous piped water supply. *Water Research*, *47*(14), 5176–5188. https://doi.org/10.1016/j.watres.2013.05.058

Kumpel, E., & Nelson, K. L. (2016a). Intermittent Water Supply: Prevalence, Practice, and Microbial Water Quality. *Environ. Sci. Technol*, *50*, 553. https://doi.org/10.1021/acs.est.5b03973

Kumpel, E., & Nelson, K. L. (2016b). Intermittent Water Supply: Prevalence, Practice, and Microbial Water Quality. *Environmental Science and Technology*, *50*(2), 542–553. https://doi.org/10.1021/acs.est.5b03973

Lee, E. J., & Schwab, K. J. (2005a, June 1). Deficiencies in drinking water distribution systems in developing countries. *Journal of Water and Health*, Vol. 3, pp. 109–127. https://doi.org/10.2166/wh.2005.0012

Lee, E. J., & Schwab, K. J. (2005b, June 1). Deficiencies in drinking water distribution systems in developing countries. *Journal of Water and Health*, Vol. 3, pp. 109–127. https://doi.org/10.2166/wh.2005.0012

Liddle, E. S., Mager, S. M., & Nel, E. L. (2016). The importance of community-based informal water supply systems in the developing world and the need for formal sector support. *Geographical Journal*, *182*(1), 85–96. https://doi.org/10.1111/geoj.12117

Llano-Arias, V. (2015). Community Knowledge Sharing and Co-Production of Water Services: Two Cases of Community Aqueduct Associations in Colombia. *Water Alternatives*, *8*(2), 77–98. Retrieved from www.water-alternatives.org

March, H. (2015). Taming, controlling and metabolizing flows: Water and the urbanization process of Barcelona and Madrid (1850–2012). *European Urban and Regional Studies*, *24*. https://doi.org/10.1177/0969776412474665

March, H., & Sauri, D. (2017). When sustainable may not mean just: a critical interpretation of urban water consumption decline in Barcelona. *Local Environment*, *22*(5), 523–535. https://doi.org/10.1080/13549839.2016.1233528

March, H., & Saurí, D. (2010). The Suburbanization of Water Scarcity in the Barcelona Metropolitan Region: Sociodemographic and Urban Changes Influencing Domestic Water Consumption. *The Professional Geographer*, *62*(1), 32–45. https://doi.org/10.1080/00330120903375860

Marks, S. J., Clair-Caliot, G., Taing, L., Bamwenda, J. T., Kanyesigye, C., Rwendeire, N. E., … Ferrero, G. (2020). Water supply and sanitation services in small towns in rural–urban transition zones: The case of Bushenyi-Ishaka Municipality, Uganda. *Npj Clean Water*, *3*(1), 1–9. https://doi.org/10.1038/s41545-020-0068-4

McKenzie, R. (2018). Why intermittent supplies are no answer to cities hit by drought. Retrieved April 24, 2020, from International Water Asociation website: https://www.thesourcemagazine.org/why-intermittent-supplies-are-no-answer-to-cities-hit-by-drought/

Meehan, K. M. (2014). Tool-power: Water infrastructure as wellsprings of state power. *Geoforum*, *57*, 215–224. https://doi.org/10.1016/J.GEOFORUM.2013.08.005

Mitlin, D., Beard, V. A., Satterthwaite, D., & Du, J. (2019). Unaffordable and Undrinkable: Rethinking Urban Water Access in the Global South. In *World Resources Institute*. Retrieved from https://www.wri.org/wri-citiesforall/cities-all

Mitlin, D., & Walnycki, A. (2020). Informality as Experimentation: Water Utilities' Strategies for Cost Recovery and their Consequences for Universal Access. *Journal of Development Studies*, *56*(2), 259–277. https://doi.org/10.1080/00220388.2019.1577383

Mutikanga, H. E., Sharma, S., & Vairavamoorthy, K. (2009). Water loss management in developing countries: Challenges and prospects. *American Water Works Association*, *101*(12), 57–68. https://doi.org/10.1002/j.1551-8833.2009.tb10010.x

Newman, P. (2006). The environmental impact of cities. *Environment and Urbanization*, *18*(2), 275–295. https://doi.org/10.1177/0956247806069599

ONU. Resolución 64/292. El derecho humano al agua y al saneamiento. , 660 Asamblea General de las Naciones Unidas § (2010).

Pal, A., He, Y., Jekel, M., Reinhard, M., & Gin, K. Y. H. (2014, October 1). Emerging contaminants of public health significance as water quality indicator compounds in the urban water cycle. *Environment International*, Vol. 71, pp. 46–62. https://doi.org/10.1016/j.envint.2014.05.025

Parker, A. H., Youlten, R., Dillon, M., Nussbaumer, T., Carter, R. C., Tyrrel, S. F., & Webster, J. (2010). An assessment of microbiological water quality of six water source categories in north-east Uganda. *Journal of Water and Health*, *8*(3), 550–560. https://doi.org/10.2166/wh.2010.128

Peloso, M., & Morinville, C. (2014). "Chasing for Water": Everyday Practices of Water Access in Peri-Urban Ashaiman, Ghana. *Water Alternatives*, *7*(1), 121–139. Retrieved from www.water-alternatives.org

Rafa, N., Uddin, S. M. N., & Staddon, C. (2020). Exploring challenges in safe water availability and accessibility in preventing COVID-19 in refugee settlements. *Water International*, *45*(7–8), 710–715. https://doi.org/10.1080/02508060.2020.1803018

Rodríguez-Labajos, B., & Martínez-Alier, J. (2015). Political ecology of water conflicts. *WIREs Water*, *2*(5), 537–558. https://doi.org/10.1002/wat2.1092

Rusca, M., Boakye-Ansah, S. A., Loftus, A., Ferrero, G., & van der Zaag, P. (2017). An interdisciplinary political ecology of drinking water quality. Exploring socio-ecological inequalities in Lilongwe's water supply network. *Geoforum*, *84*, 138–146. https://doi.org/10.1016/j.geoforum.2017.06.013

Sahely, H. R., Dudding, S., & Kennedy, C. A. (2003). Estimating the urban metabolism of Canadian cities: Greater Toronto Area case study. *Canadian Journal of Civil Engineering*, *30*(2), 468–483. https://doi.org/10.1139/l02-105

Sanchez, L. M. S. N., Kemerink-Seyoum, J. S., Batega, D. W., & Paul, R. (2020). Caught in the middle? Access to water in the rural to urban transformation of Bushenyi-Ishaka municipality, Uganda. *Water Policy*, *22*(4), 670–685. https://doi.org/10.2166/wp.2020.024

Sauri, D. (2019). The decline of water consumption in Spanish cities: structural and contingent factors. *International Journal of Water Resources Development*, *36*(6), 1–17. https://doi.org/10.1080/07900627.2019.1634999

Sauri, D., & del Moral, L. (2001). Recent developments in Spanish water policy. Alternatives and conflicts at the end of the hydraulic age. *Geoforum*, *32*(3), 351–362. https://doi.org/10.1016/S0016-7185(00)00048-8

Sharma, A., & Bhaduri, S. (2013). Consumption Conundrum of Bottled Water in India. *Bulletin of Science, Technology & Society*, *33*(5–6), 172–181. https://doi.org/10.1177/0270467614532441

Smiley, S. L. (2013). Complexities of water access in Dar es Salaam, Tanzania. *Applied Geography*, *41*, 132–138. https://doi.org/10.1016/j.apgeog.2013.03.019

Smiley, S. L. (2017). Defining and measuring water access: lessons from Tanzania for moving forward in the post-Millennium Development Goal era. *African Geographical Review*, *36*(2), 168–182. https://doi.org/10.1080/19376812.2016.1171154

Smiley, S. L. (2020). Heterogeneous water provision in Dar es Salaam: The role of networked infrastructures and alternative systems in informal areas. *EPE: Nature and Space*, *3*(4), 1215–1231. https://doi.org/10.1177/2514848620908194

Sorenson, S. B., Morssink, C., & Campos, P. A. (2011). Safe access to safe water in low income countries: Water fetching in current times. *Social Science and Medicine*, *72*(9), 1522–1526. https://doi.org/10.1016/j.socscimed.2011.03.010

Stoler, J. (2012). Improved but unsustainable: accounting for sachet water in post-2015 goals for global safe water. *Tropical Medicine & International Health*, *17*(12), 1506–1508. https://doi.org/10.1111/j.1365-3156.2012.03099.x

Stoler, J., Fink, G., Weeks, J. R., Otoo, R. A., Ampofo, J. A., & Hill, A. G. (2012). When urban taps run dry: Sachet water consumption and health effects in low income neighborhoods of Accra, Ghana. *Health and Place*, *18*(2), 250–262. https://doi.org/10.1016/j.healthplace.2011.09.020

Sultana, F. (2009). Fluid lives: Subjectivities, gender and water in rural Bangladesh. *Gender, Place and Culture*, *16*(4), 427–444. https://doi.org/10.1080/09663690903003942

Sun, L., Chen, J., Li, Q., & Huang, D. (2020). Dramatic uneven urbanization of large cities throughout the world in recent decades. *Nature Communications*, *11*(1), 1–9. https://doi.org/10.1038/s41467-020-19158-1

Swyngedouw, E. (1995). The contradictions of urban water provision: a study of Guayaquil, Ecuador. *Third World Planning Review*, *17*(4), 387–405. https://doi.org/10.3828/twpr.17.4.c828066008888322

Swyngedouw, E. (1996). The city as a hybrid: On nature, society and cyborg urbanization. *Capitalism, Nature, Socialism*, *7*(2), 65–80. https://doi.org/10.1080/10455759609358679

Swyngedouw, E. (2006). Metabolic urbanization: the making of cyborg cities. In *In the Nature of Cities Urban Political Ecology and the Politics of Urban Metabolism* (pp. 36–55). https://doi.org/10.4324/9780203027523-9

Swyngedouw, E. (2009). The Political Economy and Political Ecology of the Hydro-Social Cycle. *Journal of Contemporary Water Research & Education*, *142*(1), 56–60. https://doi.org/10.1111/j.1936-704X.2009.00054.x

Swyngedouw, E., & Heynen, N. (2003). Urban Political Ecology , Justice and the Politics of Scale. *Antipode*, *35*(5), 343.

Tiwale, S. (2015). Understanding Lilongwe's thirst for water : linking infrastructure development to differentiated water supply. Retrieved May 9, 2021, from IHE Delft Institute for Water Education website: https://www.narcis.nl/publication/RecordID/oai:cdm21063.contentdm.oclc.org:masters2%2F93275

Truelove, Y. (2011). (Re-)Conceptualizing water inequality in Delhi, India through a feminist political ecology framework. *Geoforum*, *42*(2), 143–152. https://doi.org/10.1016/j.geoforum.2011.01.004

Truelove, Y. (2016). Incongruent Waterworlds: Situating the Everyday Practices and Power of Water in Delhi. *South Asia Multidisciplinary Academic Journal*, (14), 0–25. https://doi.org/10.4000/samaj.4164

Truelove, Y. (2019). Gray Zones: The Everyday Practices and Governance of Water beyond the Network. *Annals of the American Association of Geographers*, *109*(6), 1758–1774. https://doi.org/10.1080/24694452.2019.1581598

Tzaninis, Y., Mandler, T., Kaika, M., & Keil, R. (2020). Moving urban political ecology beyond the "urbanization of nature." *Progress in Human Geography*, *45*(2), 229–252. https://doi.org/10.1177/0309132520903350

United Nations. (2015). The Millennium Development Goals Report. In *United Nations*. https://doi.org/978-92-1-101320-7

Walter, C. T., Kooy, M., & Prabaharyaka, I. (2017). The role of bottled drinking water in achieving sdg 6.1: An analysis of affordability and equity from Jakarta, Indonesia. *Journal of Water Sanitation and Hygiene for Development*, *7*(4), 642–650. https://doi.org/10.2166/washdev.2017.046

WHO/UNICEF. (2017). Progress on Drinking Water, Sanitation and Hygiene Update and SDG Baselines 2017 Launch version July 12 Main report. In *WHO Library Cataloguing in Publication Data*. Retrieved from http://apps.who.int/bookorders.

WHO. (2016). Report of the third global survey on eHealth Global Observatory for eHealth Global diffusion of eHealth: Making universal health coverage achievable. In *World Health Organization (WHO)*. Retrieved from http://apps.who.int/bookorders.

Wright-Contreras, L. (2019). A Transnational Urban Political Ecology of Water Infrastructures: Global Water Policies and Water Management in Hanoi. *Public Works Management & Policy*, *24*(2), 195–212. https://doi.org/10.1177/1087724X18780045

Wright-Contreras, L., March, H., & Schramm, S. (2017). Fragmented landscapes of water supply in suburban Hanoi. *Habitat International*, *61*, 64–74. https://doi.org/10.1016/j.habitatint.2017.02.002

Young, S. L., Boateng, G. O., Jamaluddine, Z., Miller, J. D., Frongillo, E. A., Neilands, T. B., … Stoler, J. (2019). The Household Water InSecurity Experiences (HWISE) Scale: Development and validation of a household water insecurity measure for low-income and middle-income countries. *BMJ Global Health*, *4*(5), 1750. https://doi.org/10.1136/bmjgh-2019-001750

Zanganeh Shahraki, S., Sauri, D., Serra, P., Modugno, S., Seifolddini, F., & Pourahmad, A. (2011). Urban sprawl pattern and land-use change detection in Yazd, Iran. *Habitat International*, *35*(4), 521–528. https://doi.org/10.1016/j.habitatint.2011.02.004

Zapana-Churata, L., March, H., & Sauri, D. (2021). Water demand management strategies in fast-growing cities. The case of Arequipa, Perú. *International Journal of Water Resources Development*, 1–25. https://doi.org/10.1080/07900627.2021.1903401

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Chapter 3

Spatial variation of access to water in rapidly growing cities: the case of Arequipa

Summary

Developing cities are experiencing unprecedented urbanization, which has important implications for water supply. Although in fast-growing cities of the Global South there have been important advances in the expansion of water networks, "informal" supply practices are also maintained (pipe trucks, public use pylons, wells, etc.). In this chapter, we address drinking water supply in two different urban realities in the city of Arequipa, Peru. Through surveys in the core and periphery of the city, and with the analysis of secondary data, we contrast service provision by characterizing accessibility, availability, quality of service, price, and preference of management model (public or private) in both environments. As a result, it can be affirmed that the expansion of network supply systems increases accessibility, especially in peripheral areas, but they also present deficiencies in terms of availability, service quality and affordability. Although to a lesser degree, these deficiencies also occur in the urban core, especially in relation to service interruptions and prices. Likewise, in districts of the urban periphery, informal supply systems remain precarious with possible unfavorable impacts in the long-term. Thus, difficulties are observed in accessing water in a safe, reliable and affordable manner are observed in both urban environments. However, the current public management model is preferred to the private model.

3.1. Introduction

Universal access to safe water sources continues to be a challenge for fast-growing cities in developing regions. This challenge is much more intense in times of rapid urbanization and population growth, such as the last decades of the 20th century and the first decades of the 21st century. UN (2018) and WB (2018) studies for Latin America have indicated that 81 percent of the population of this geographic group resides in cities and 25 percent of the urban population lives in informal settlements. Projections of these population dynamics indicate that by 2020, the population of peripheral areas will have increased to 160 million people (WB, 2018; UN, 2018). These population and territorial growth trends will continue for at least a few decades with the consequent pressure on basic resources such as water. Thus, the water demand will increase in the context of scarce resources in quantity and quality, in addition to being subjected to greater climatic variability. Some studies affirm that the growth of urban water supply infrastructure will be outpaced by population growth (Jouravlev, 2004; Mehta et al., 2014).

Most of the fast-growing cities in the Global South are experiencing increasing water needs, especially in informal urban settlements, where a large share of lower-income households is located (Azócar et al., 2008). Households in informal settlements present situations of vulnerability, not only because of their geographical location outside the planned framework but also because of their frequent dependence on unreliable water sources. Although in the periphery of some cities, the expansion of various traditional "informal" supply mechanisms (extraction of water from surface and underground sources) and its access through co-production between the State and citizens and local private actors, alleviate these problems (Allen et al., 2017; McMillan et al., 2014; Moretto et al., 2018; Rivera et al., 2017), in general, this informal sourcing also face problems, among other aspects, of legitimacy as they are not recognized by governments, they may even come to be considered as retrograde practices that should be eradicated (Liddle et al., 2016. However, whatever the way these supply systems operate, the fact remains that they seek to fill the gaps left by conventional supply. In practice, these informal systems do not represent a desirable alternative due to the low quality of service, high tariffs, and great complexity of the operation.

In the Latin American context, numerous proposals have been put forward to achieve a universal drinking water supply. For example, the International Decade for Drinking Water Supply and Environmental Sanitation (1981-90) has already focused on this problem (UN, 1983). Likewise, the UN report (1983) on access to water and sanitation in Latin America, quantified this access at 70 percent for urban areas and only 16 percent for rural areas. The report, at that time, highlighted the need for an economic investment of between 36 and 61 billion dollars until the end of the 20th century to close the inequality gaps between urban and rural contexts.

Decades later, the need to universalize access to water and sanitation was still in force and was taken up by the Millennium Development Goals (2000-2015). This occurred at the same time that access to water and sanitation was recognized as a human right in 2010 by the UN. Many countries adopted these measures and achieved improvements in water and sanitation coverage, although 40 countries, especially in the developing world, did not achieve these goals (WHO/UNICEF, 2014). In this sense, in 2015 new purposes of universal access to water and sanitation were established through the Sustainable Development Goals (SDGs) 2015-2030.

Universal access to basic services has also been pursued through numerous water policy reforms. In fact, the governments of Latin American countries adopted measures promoted by international organizations such as the World Bank, IMF, ECLAC, BIF, etc., in various international meetings such as the 1992 Dublin

Summit, the 2002 Johannesburg Summit or the Forum 2018 Water World Cup in Brazil, among others. The progressive application of neoliberal reforms, especially in the 1990s, significantly affected resource management, generating often pernicious social consequences. One of the effects on management has involved the strengthening of the hydraulic paradigm shift towards demand-based management (Saurí & del Moral, 2001). However, neoliberal reforms based on changes in management models (with a significant weight of corporatization of public companies) and the granting of full property rights (e.g., in Chile), have not achieved equitable objectives in water supply (Budds, 2012; Klien, 2014).

It should be recognized that progress has been made in water supply (UNICEF & WHO, 2019, which has to do both with reforms in resource management policies and with housing and urban planning policies. An example of this would be the housing policies in Chile implemented in the early 1970s (Pflieger & Matthieussent, 2008) and the urban social policies in Costa Rica and Uruguay, which have been key to improving the water supply. However, in other countries where water management policies were also reformed, but with little implementation of housing and planning policies and intense social differentiation, the extension of supply networks has not been achieved, especially in urban peripheries. Consequently, supply through centralized networks continues to coexist with informal water supply practices (distribution in tanker trucks, public use pylons, wells, etc.).

The complex form of water supply in fast-growing cities is mediated by institutional, political, economic, and cultural factors whose practice legitimizes certain modes of water supply, for example, the expansion of potable water networks (Mitlin et al., 2019). In fact, in a more inclusive context, water policies could propose forms of supply in terms of "co-production" between citizens and the State (McMillan, 2014). However, traditional sourcing practices are often delegitimized, even though these mechanisms fill in the space left by the formal sector. In any case, neither formal network supply systems nor informal systems supplied by other means seem to guarantee access to safe, reliable, and affordable access to water, especially in peripheral areas where low-income residents do not have water.

In this section we propose to examine the provision of water services in the city of Arequipa, Peru, by characterizing accessibility, availability, service quality, marketing price, and management model preference (public or private), analyzing the differences between the central and peripheral areas of the city. The case of Arequipa, Peru's second-largest city, can complement better-known cases, such as that of Peru's capital, Lima, or other Latin American cities. Like other fast-growing cities, Arequipa faces growing socio-environmental problems, including the challenge of providing safe water universally to its population. To characterize and compare the provision of services in central and peripheral areas of the city, 6 districts of the city Arequipa have been chosen, 3 of which are part of the core and 3 of the urban peripheries.

After this introduction, we present a section on general concepts on water distribution mechanisms and service provision, as well as some studies and experiences in more general contexts. We then address the dynamics of water distribution mechanisms and service provision in Arequipa and develop a methodological framework based largely on surveys and secondary data review, and the statistical analysis of the former. We then turn to the results and their discussion and finally present the conclusions of this chapter.

3.2. Water distribution systems and service provision

We use the term "informal supply systems" to refer to various water supply options that are different from the conventional supply system based on the public drinking water network (Dean Randall et al., 1997; Opryszko et al., 2009). Among these informal supply systems, we can mention the adaptation of traditional networks (own facilities), the transport of water in tanker trucks, access to options such as "public" use pylons and wells. The progressive presence of these supply mechanisms has originated within the framework of logic of water need in contexts of accelerated peripheral urbanization, although it is also partly the result of neoliberal reforms in water management and social differentiation practices. However, at the operational level, it should be noted that these water distribution practices are promoted through collaboration and negotiations with the local administration. Thus, small-scale supply mechanisms, in legal terms, can operate through formal or informal activities. Their operation within or outside the regulatory framework can generate important debates, but beyond criticism, informal supply mechanisms fulfill essential functions such as supplying water to urban dwellers who lack it. Thus, informal mechanisms fill the gap left by more formal models, whether public or private (Vilchis-Mata et al., 2018).

The trajectory of informal supply mechanisms and their experience have been essential in the urban dynamics of many cities in the Global South, for example in Sub-Saharan Africa (see Matsinhe, 2008 for Mozambique and Banana, 2015 for Tanzania). In Latin America, it would be worth highlighting cases such as the Pampeana region of Argentina, with various forms of supply grouped in cooperatives offering alternatives for the provision of water services (Bustos-Cara et al., 2013). In

Bolivia, it has been possible to offer an acceptable service, although with significant problems in administration and financing (Ampuero et al., 2005). In Colombia, joint initiatives have been developed between formal organizations and local initiatives that attempt to facilitate water distribution in urban peripheries (Bernal et al., 2014). In Mexico, small-scale mechanisms are widespread in irregular areas and provide improvements in the water supply service (Rivera et al., 2017). Similarly, in Venezuela, co-production practices (the supply of drinking water through traditional mechanisms) would have improved the supply of drinking water in peripheral urban areas (McMillan et al., 2014).

3.3. Provision of water services and rapid urbanization in Arequipa

The city of Arequipa is in the south of Peru, forming a metropolitan area of 20 districts. Arequipa, the second-largest city in the country in terms of population after the capital Lima, developed along the Chili and Socabaya rivers, which provide drinking water for the city, water for irrigation of approximately 10,000 agricultural hectares within the metropolitan area, water for electricity generation (225.63 MW) and water for industrial and mining development (Andersen, 2016). The hydrographic basin where the metropolitan area of Arequipa is located has an arid climate as it is located at the headwaters of the Atacama Desert. The contributions of rivers have historically been affected not only by climatic variations but also and fundamentally by the progressive development of economic activities and population growth. To the extent that water scarcity is influenced by socioeconomic factors, water flow is artificially regulated by transferring water between basins and dams. Thus, between 1950 and 2010, a total of seven dams were built in the upper Andes basin (Andersen, 2016; Zapana, 2018). Although these conventional strategies based on the increasing water supply compensate for the growing demand, they are also threatened by climate change that has affected the rainfall and snow-capped in the mountain range (EarthSky, 2019).

Arequipa's population growth experienced behaviors similar to the population dynamics of Peru's capital, Lima, as well as other cities in developing regions (Cohen, 2006). The urban population increased progressively from the middle of the 20th century to the present time (see Table Nº 1). Importantly, the industrial development of Arequipa, together with improvements in transport systems and the economic crisis in rural areas in the south of the country, led to regional immigration and, consequently, the urban population increased significantly (Bayer et al., 2009). In 1932, immigration created the first "informal settlements." However, the emergence of these settlements was also the result of various earthquakes in the 1950s, in which many people lost their homes (Garden, 1989). Several victims built temporary housing in "informal settlements". Although in 1960 these victims were relocated, informal settlements continued to grow rapidly. In fact, according to census data, in the period 1961-1972, the urban population grew by 170,000 people, with an annual rate of 4.8 percent, a figure lower than that of Lima (5.4 percent), but higher than the average of other fast-growing cities in the world (2.4 percent) (see Table Nº 1). Thus, in the 1980s, the urban population reached 584,000 inhabitants. The population increase at this time can be linked to the increase in economic activities such as infrastructure projects and the development of the Arequipa Industrial Park. These activities had the objective of promoting agro-industrial, energy, railway projects, etc., which together transformed the city into an attractive space for local immigration and from other areas of the south of the country.

Between 1980 and 1993, the population increased to 786,000 inhabitants, but with a lower growth rate (see Table Nº 1). This reduction was due to the serious economic crisis suffered by the country between 1975-1990 and the heavy deficit of the public sector during 1980-1990, with very important impacts on migratory flows (BCR, 1985). After the economic liberalization of the country (1990-2000), the population increased again rapidly to reach 1,103,000 inhabitants in 2017 with an annual growth rate of 1.8 percent, a figure higher than Lima and other fast-growing cities (see Table 3). Although the growth rate in Arequipa had declined, the 1990s and 2000s saw the largest expansion of informal settlements. This expansion has been due to the high demand for housing driven by immigration and the reduced interest of public policies in meeting the demand. Thus, the growth of "informal" settlements constituted the practical response of the new inhabitants. With this modality, houses are first built and later formalized in the local municipality to access basic services (water, sanitation, electricity, telecommunications, etc.).

Table 3. Population growth in Arequipa, Lima, and other cities with rapid urban growth

Year	Arequipa		Lima	City of fast-growing regions
	Population (miles)	T.C. (%)	T.C. (%)	T.C. (%)
1940	155	2,3	5,1	2,6
1941 - 1961	251	2,3	5,1	2,1
1961 - 1972	421	4,8	5,4	2,4
1972 - 1981	584	3,7	3,8	2,3
1981 - 1993	786	2,5	2,7	2,3
1993 - 2007	1 044	2,1	2,1	1,5
2007 - 2017	1 103	1,8	1,2	1,3

T.C.= Annual Average Growth Rate

Source: Own elaboration based on INEI,2009; BCR, 2016; ONU,2019[1]

Given the growing scarcity of water in Arequipa, in recent years there have been important debates about the needs and availability of the resource but generally focused on supply management. In fact, in 2019 the regional governor of Arequipa promoted his water policy to increase water supply through the construction of new dams. On the other hand, the public water company SEDAPAR S.A., has also increased the production of drinking water for the city: from 44 to 62 hm3 / year between 2007-2017. This has favored water network coverage, which went from 87.19 percent to 92.3 percent during 2007-2017. However, apart from the improvement in coverage, these general data, according to Bain (2014), conceal a general dissatisfaction in the provision of the service.

Despite improvements in the water supply, the 2017 Census showed still not very encouraging results. According to this census, only 79.24 percent of the population of the metropolitan area of Arequipa has access to drinking water networks inside their homes; 5.16 percent of the population has access to a public network outside their homes, but inside the building; and 15.59 percent of the population that does not have access to drinking water network infrastructures but has access to other distribution options.

The different supply mechanisms operate according to the legal framework for urbanization. For example, the service provider company supplies the resource through drinking water networks in the formal urban environment. On the other hand, the informal environment in the urban periphery is supplied by other supply mechanisms, which are strictly governed by commercial criteria. Thus, certain supply mechanisms operate informally, far from government control, which means that they are not supervised by the State or by the social groups that use these services. Despite this, they have a complex organizational structure that brings together individuals, groups from the urban periphery, and external actors. In this sense, informal supply systems assist water needs in areas ignored by urban planning regulations and formal water policies. This implies significant costs and risks for the lower-income population, due to high tariffs, dubious water quality, discontinuous flows, and payment difficulties.

3.4. Methodology

1 Available in: https://population.un.org/wpp/Download/Standard/Population/

Data collection

This work is based on surveys (N = 721) conducted in 2018 by a team (6 people) coordinated by the author of this thesis, as well as on the analysis of quantitative and qualitative data provided by the Instituto Nacional de Estadística e Informatica (INEI). The surveys were conducted in 6 districts of Arequipa (of the total of 20 that make up the metropolitan city (see Table 4): 3 representative districts of the urban environment with higher economic income (Arequipa DC, JL Bustamante, Yanahuara) and 3 districts of the area peripheral area with lower incomes (Characato, Sabandía, and Yura) (see Figure 8). Districts with higher incomes comprised urban areas with access to drinking water networks, while districts with lower incomes comprised urban environments with access to various off-grid water supply mechanisms. Subsequently, the sample size of the study population was determined, with a 95 percent confidence interval and a 5 percent margin of error.

Table 4. Surveys in the core and urban periphery of Arequipa

Districts		Surveys
Urban core	Arequipa D.C.	118
	J.L. Bustamante	184
	Yanahuara	52
Urban periphery	Characato	73
	Sabandía	40
	Yura	254
Total		721

The surveys included a body of structured questions with closed answers. Before carrying out the surveys, their content was evaluated in different pilot tests by inhabitants of Arequipa. Subsequently, surveys were conducted following the systematic sampling method. With the surveys, data were collected on various service provision factors that are detailed in Table No. 3. With data from each service provision factor, the expectations of the inhabitants of the core and the urban periphery were analyzed, as well as the perception about supply mechanisms in the peripheral area.

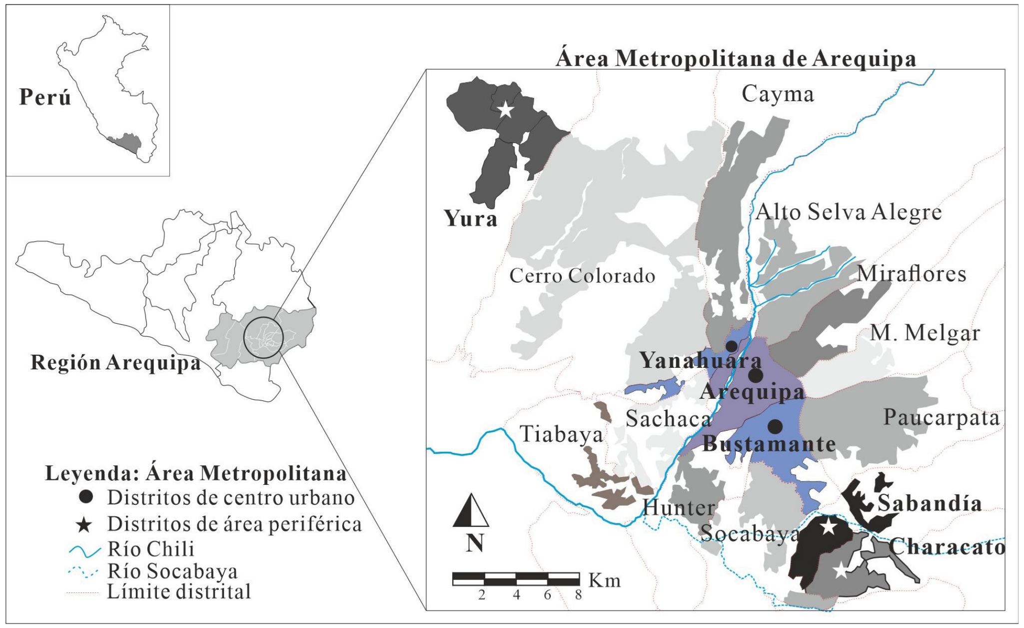
Finally, the results were complemented with quantitative and qualitative data from official sources such as SEDAPAR and the INEI.

Data analysis

The survey data were first subjected to descriptive statistical treatment. In Table

5, a general structure of the results of the service provision factors is presented. The data were then subjected to an analysis of variance (ANOVA) following the normality and homogeneity of values tests for the factors under study. The purpose of the ANOVA test was to compare the responses of the inhabitants of the central districts (Arequipa D.C., J.L. Bustamante, Yanahuara) with those of the urban periphery districts (Characato, Sabandía, and Yura).

Figure 8. Location of the study area: Arequipa and the 6 selected districts



Source: Own elaboration

In the following sections, we present the results of the study. First, the dynamics of accessibility to water in Arequipa during the last ten years is described (see Table 6). The analysis will highlight the variations in accessibility according to the districts of the center and the urban periphery. Subsequently, the results of the descriptive analysis of service provision factors concerning the geographic context of core and urban periphery are provided.

Table 5. Univariate descriptive analysis of service provision factors in 6 districts studied in the city of Arequipa.

Variable	Questions	Option	Obs.	%
Accessibility	What is the main source of access to water?	Drinking water	515	71,6
		Non-drinking water	150	20,9
		Bottled water	49	6,8
		Others	5	0,7
	Is there difficulty in accessing drinking water?	Yes	322	44,7
		No	398	55,3
Availability	Do you have drinking water in your house?	Yes	524	72,8
		No	196	27,2
	Do you have water 24 hours a day?	Yes	469	65,1
		No	251	34,9
Service quality	Have you had interruptions?	Yes	607	92,5
		No	48	7,5
	How long were you without water?	More than 10	394	63,7
		Less than 10	225	36,3
	Were you informed beforehand?	Yes	179	28,8
		No	443	71,3
	Do you know of any institution that monitors water quality?	Yes	225	31,3
		No	311	43,3
		Don´t Know	183	25,5
Affordability and pricing	Does the price of water cause you economic difficulties?	Yes	243	33,8
		No	317	44
		Sometime	160	22,2
	Would an eventual increase in the price of water affect you?	Yes	553	76,8
		No	113	113
		Probably	54	7,5
Management model	Do you think that privatization of water is a solution?	Yes	245	34
		No	419	58,2
		Don´t Know	56	7,8

The number of surveys for each variable was 721.
Observations. Obs=observations; % percentage (pooled data from 6 districts selected for this study).

Source: Own elaboration

3.5. Results

Before presenting the results of the survey, we address the dynamics of accessibility as a function of supply systems in Arequipa based on INEI census data. Following the proposed methodology, we first studied the variation inaccessibility in the districts of Arequipa D.C., J.L. Bustamante, and Yanahuara, and then in the districts of Characato, Sabandía, and Yura.

As we have commented previously, the unequal accessibility of water in Arequipa has numerous explanatory factors, but in general terms, it is related to the reduced scope of urban planning and the processes of social differentiation. Unequal access implies, on the one hand, urban environments with access to the drinking water network and, on the other hand, urban environments with access to various traditional off-grid mechanisms that complete, but do not guarantee accessibility (see Figure 9-10).

Figure 9. The urban core in Arequipa with access to the drinking water network

Source: Photo by Luís Zapana

Figure 10. Urban periphery in Arequipa with access to informal water supply systems.

Photo (A) and (B) are public pylons, photo (C) is water storage well
Source: Photo by Luís Zapana

Table 6 shows the evolution of access to "safe water" sources, especially access to the public drinking water network. Likewise, there are also improvements in access to informal water sources, especially to pylons public use and underground wells, although there are also decreases in access to informal sources such as tanker trucks and others. More disaggregated data indicate that, in the urban core, accessibility through the public network increased by 1.4 percent (Arequipa DC), 1.2 percent (JL Bustamante), and 1.3 percent (Yanahuara), while accessibility through other informal supply mechanisms has not shown significant variations due to the greater coverage of the drinking water network in the three districts with higher economic incomes. On the other hand, in the urban periphery districts, accessibility through drinking water networks has increased by 15.6 percent (Characato), 25.8 percent (Sabandía), and 44.5 percent (Yura). Likewise, access to other sources such as public pylons increased by 1.5 percent (Characato) and 36 percent (Yura), while access to wells increased by 3.3 percent (Characato). However, there have also been decreases in access to public use pylons in -0.7 percent (Sabandía) and access through tanker trucks in most of the urban periphery districts.

Table 6. Accessibility to water in 16 districts in the city of Arequipa

Districts	Water accessibility by source										N. Households	
	Drinking water network		Public pylons		Tanker truck		Well		Others			
	2007	2017	2007	2017	2007	2017	2007	2017	2007	2017	2007	2017
Arequipa D.C.	**98,1**	**99,5**	**0,7**	**0,4**	**0,1**	**0,0**	**0,1**	**0,1**	**0,0**	**0,0**	**17310**	**16 248**
A Selva Alegre	85,9	87,4	3,9	11,4	6,9	0,5	2,1	0,4	1,0	0,4	18671	24 754
Cayma	91,4	81,2	4,7	17,3	0,4	0,8	0,8	0,3	3,0	0,4	20308	27 865
Cerro Colorado	67,7	68,8	18,2	26,9	6,6	3,1	4,1	0,9	4,0	0,4	35859	63 674
Characato	**38,3**	**53,9**	**5,0**	**6,5**	**23,2**	**8,2**	**26,9**	**30,2**	**6,0**	**1,2**	**3286**	**4 127**
J. Hunter	94,7	92,5	3,0	6,1	0,1	0,4	0,1	0,8	2,0	0,4	10577	13 434
J.L. Bustamante	**97,8**	**99,0**	**1,0**	**0,7**	**0,1**	**0,1**	**0,0**	**0,1**	**1,0**	**0,1**	**18859**	**23 922**
M. Melgar	81,8	85,1	8,5	12,4	5,4	1,4	3,1	0,8	1,0	0,3	12877	18 491
Miraflores	89,2	94,4	7,4	4,2	0,6	0,8	1,2	0,4	1,0	0,1	13156	17 891
Paucarpata	87,6	91,5	2,4	4,9	3,2	1,8	4,3	1,4	2,0	0,4	29380	35 755
Sabandia	**65,0**	**90,8**	**4,1**	**3,4**	**9,4**	**0,6**	**3,1**	**4,5**	**18,0**	**0,6**	**1181**	**1 270**
Sachaca	72,2	80,7	20,7	12,6	0,3	0,3	2,5	6,0	4,0	0,4	4820	6 891
Socabaya	79,3	85,8	6,2	6,5	7,4	4,1	3,3	2,9	4,0	0,7	16106	20 863
Tiabaya	80,7	94,6	5,7	2,1	1,2	1,2	1,6	0,9	11,0	1,1	3764	4 343
Yanahuara	**97,7**	**98,9**	**0,3**	**0,5**	**0,2**	**0,1**	**0,8**	**0,4**	**0,0**	**0,1**	**6663**	**7 987**
Yura	**1,9**	**46,4**	**4,0**	**40,2**	**80,1**	**7,7**	**5,3**	**4,2**	**9,0**	**1,5**	**6191**	**13 179**

Note: Bold format highlights the 6 districts covered in the study's own survey (N=721); Other= includes spring, river and neighbor supply.

Source: Own elaboration based INEI 2017

After characterizing the water supply systems in Arequipa, through secondary data, we present the results of the survey (N = 721) conducted in 6 of the Arequipa districts (3 in the urban core with N=354 and 3 in peripheral areas with N=367) about the water service provision factors (see Table 4). The analysis of variance (ANOVA) has consisted of examining, for example, the perception of accessibility (in terms of physical access), availability (in terms of safe access), service quality, marketing price, and the preference of the management model (public or private), which may vary according to the urban core and periphery. The results of this analysis are presented in Table 7.

Regarding the *accessibility* of water service, we observed important differences between the urban core and the periphery: while 91.5 percent of the respondents in the urban center indicated access to safe drinking water sources, only 52.5 percent in the urban periphery had access to drinking water from the network, the rest having to resort to "informal" supply mechanisms.

Likewise, about the analysis of the difficulties of access to water, we observed that only 10 percent of the population in the urban core reported having these difficulties, while, in the urban periphery, 78.5 percent of the population indicated persistent difficulties.

In terms of water availability, the surveys data also show significant differences between the urban core and the periphery. For example, all respondents in the urban center indicated that they had potable water available in their homes, although 3.1 percent of this group stated that this water was not available 24 hours a day. In contrast, among respondents in the urban periphery, 46.6 percent said they had potable water in their homes, but only 34 percent said they had water available 24 hours a day.

Regarding the quality of water service, the analysis showed no significant differences since 92.4 percent of respondents from the urban center and 93 percent from the periphery affirmed having suffered service interruptions. In this sense, we asked about the interruption time. In that case, 44.9 percent of respondents from the urban core and 84.9 percent from the periphery stated that the interruptions lasted more than 10 hours. On the other hand, we observe significant differences regarding the information provided on service interruptions. While, in the urban center, 58.5 percent of those surveyed stated that they had not been informed about the reasons for the interruptions, this figure increased to 86.4 percent in the urban periphery. Likewise, surveys show that only 45.6 percent of the inhabitants of the urban core and 17.4 percent of inhabitants of the periphery recognize the institutions responsible for water management.

Regarding the marketing tariff, almost half of the respondents (48.8 percent) from the urban core indicated that the current tariffs could affect their household budgets, while the current tariff in the urban periphery could generate economic problems for 63.8 percent of those surveyed. However, a large part of those surveyed, both from the urban core (82.2 percent) and the periphery (86.1 percent) argued that a possible increase in current rates could affect their household budgets. Finally, regarding the preference for public or private water management, more than 50 percent of the respondents from both contexts indicated that public management is the best option for improved service provision.

Table 7. Comparative statistical analysis between the urban core and peripheral area

Variable	Questions	Option	N	Urban core		Urban Periphery		Comparison
				n	%	n	%	*p*-valor
Accessibility	What is the main source of access to water?	Drinking water	516	324	91,5	192	52,5	0,001
		Non-drinking water	150	7	2,0	143	39,1	
		Bottled water	49	21	5,9	28	7,7	
		Others	5	2	0,6	3	0,8	
	Is there difficulty in accessing drinking water?	Yes	323	35	9,9	288	78,5	0,001
		No	398	319	90,1	79	21,5	
Availability	Do you have drinking water in your house?	Yes	525	354	100	171	46,6	0,001
		No	196	0	0,0	196	53,4	
	Do you have water 24 hours a day?	Yes	470	343	96,9	127	34,6	0,001
		No	251	11	3,1	240	65,4	
Service quality	Have you had interruptions?	Yes	608	327	92,4	281	93	0,052
		No	48	27	7,6	21	7	
	How long were you without water?	More than 10	395	185	44,9	244	84,9	0,001
		Less than 10	225	151	55,1	40	14,1	
	Were you informed beforehand?	Yes	179	140	41,5	39	13,6	0,001
		No	444	197	58,5	247	86,4	
	Do you know of any institution that monitors water quality?	Yes	225	161	45,6	64	17,4	0,001
		No	312	78	22,1	234	63,8	
		Don´t Know	183	114	32,3	69	18,8	
Affordability and pricing	Does the price of water cause you economic difficulties?	Yes	244	61	17,2	183	49,9	0,001
		No	317	184	52	133	36,2	
		Sometime	160	109	30,8	51	13,9	
	Does the price of water cause you economic difficulties?	Yes	553	262	74	291	79,3	0,241
		No	114	63	17,8	51	13,9	
		Probably	54	29	8,2	25	6,8	
Management model	Do you think that privatization of water is a solution?	Yes	246	134	37,9	112	30,5	
		No	419	181	51,1	238	64,9	0,001
		Don´t Know	56	39	11	17	4,6	

N=number of variables (N=721); n=number of observations; %=percentaje; *p*-valor=significance level; urban core=Arequipa, Bustamante, Yanahuara; urban periphery=Characato, Sabandia, Yura. Source: Own elavoration

3.6. Discussion

The combination of the rapid urbanization in Arequipa, Peru's second city in terms of population, and a reduced water resources availability may intensify future water deficits in the city. Although a set of factors such as cultural practices, technical-managerial initiatives, and urbanization policies seem to reconfigure the availability and needs of water, at the same time, these factors are stressed by rapid urbanization.

In the last ten years, in Arequipa, access to drinking water services has increased considerably, especially in the urban core. In part, this has been driven by the 'modern infrastructure ideal', put into practice through legal, institutional and financial governance instruments. However, this impulse has resulted in significant differences in access to water between the urban core and the periphery despite the increase in drinking water network coverage in the periphery during 2007-2017. This is evident in the three districts studied (Characato, Sabandía, and Yura) (see Table 6). For example, in the extreme case is Yura, where it went from a low 1.9 percent to 46.5 percent. Similarly, in the Sabandía and Characato districts, it increased from 65 percent to 90.8 percent and from 38.3 percent to 53.9 percent respectively.

Undoubtedly, the progressive accessibility through drinking water networks in the urban core and periphery follows, among other aspects, the purposes of universal access promoted by the United Nations through the SDGs and urban integration processes (Rusk, 1993). From an urban planning perspective, the increase in accessibility is due, among other aspects, to the process of incorporation of informal settlements into the formal urban fabric. However, despite the challenges posed to urban integration processes, Arequipa's formal water sector considers the expansion of networks as the only water supply mechanism. In this sense, in the context of rapid urbanization in Arequipa, it is unlikely that the conventional system (potable water networks) will complete and guarantee universal access to water due to its limited operational framework in the formal urban environment, for cost recovery (Birkenholtz, 2010) and low interest in housing policies.

A set of often decentralized mechanisms fill the supply gaps in the informal peripheries, but due to their precarious operation and high-water costs, among other factors (Allen et al., 2006), they do not guarantee adequate service provision. However, regardless of the disadvantages, in the last ten years, access using public pylons and improved wells has increased by 37.7 percent and 4.7 percent respectively in the peripheral districts (Yura, Sabandía, and Characato).

The increase in these options is due, in part, to a process of reconfiguration or

"specialization" of the water supply and the integration of social groups into functional components (Graham & Marvin, 2001). Smaller-scale specialization cannot be seen as a failure of the formal water sector, but rather a place where the formal sector must participate and recognize capacities that need to be improved. In fact, in these sectors, the inhabitants organize, collaborate, negotiate and work with the local administration. Some results of this social dynamic are related to the strengthening of collective power that allows, among other aspects, to find solutions through the construction of storage tanks, the temporary installation of distribution networks, and the construction of pylons for public use. Likewise, in addition to improving their facilities, the inhabitants make agreements on the purchase of water and its distribution, set distribution schedules (usually from 6 to 8 p.m.), and expel from the service members who do not comply with the quotas agreed by them. On the other hand, the decrease in some mechanisms such as tanker trucks, for example, could be related to the high cost of transportation for individual households in the periphery (Allen et al., 2006). Its decrease, therefore, does not imply the withdrawal of this service, but rather the decrease of the service for individual households, so that its most significant activity lies in the provision of water to groups organized around public use pylons.

As regards the comparative analysis of the variable "source of access to water" (drinking, non-drinking, bottled water, and others), there are important differences between the urban core and the periphery. Although in the urban center, 91.5 percent of the inhabitants had access to drinking water sources and 5.9 percent had access to bottled water, in the urban periphery, only 52.5 percent had access to drinking water sources, followed by 39.1 percent with access to non-potable water, 7.7 percent to bottled water and 0.8 percent to other sources. These data reflect, on the one hand, an urban core integrated by drinking water networks and with higher accessibility rates and, on the other hand, an urban periphery segmented according to supply mechanisms.

It is important to note that, although the 2017 INEI census stated that 63.7 percent of the population of the Characato, Sabandía, and Yura districts had access to the drinking water network, our fieldwork shows only 52.5 percent of the population with this access. The difference could be related to dissatisfaction in the drinking water network service due to low quality and low pressure in the system, which are very common in fast-growing cities (Kooy & Bakker, 2008).

The results show that 39.1 percent of the inhabitants of the urban periphery have access to non-potable water. This is important because it not only reflects the exclusion of groups of inhabitants by legal and institutional norms but also highlights the persistence of conventional strategies that legitimize forms of supply, often with exclusionary practices (Coutard, 2008; Kooy & Bakker, 2008). In the urban periphery, although the various informal mechanisms produce favorable results, formal water policies delegitimize these strategies, resulting in increased difficulties in accessing water. Evidence from the urban periphery of Arequipa shows that small-scale mechanisms supply water needs, but, at the same time, are far from guaranteeing its quality. In this regard, cooperative strategies are required that go beyond the ideal of modern infrastructure and recognize traditional methods that could improve the provision of water services (Allen et al., 2017; Banana et al., 2015; Mitlin, 2008).

On the other hand, as we have indicated in the results, the difficulty of access (in terms of affordability) does not seem a relevant issue for the inhabitants of the urban center. Although the analysis shows 9.9 percent of the urban core population has with difficulties of affordable access to water, this is possibly due to the increase in water rates. The water rate has increased by 3.3 percent between 2015 and 2016 and by 3.56 percent as of September 2017. However, the difficulty of access to water in the periphery is a much more pressing issue, with 78 percent of the inhabitants reporting to problems largely related to a set of factors associated with water distribution, such as the high marketing tariff, the precariousness of temporary facilities, long waiting hours and the distribution of non-drinking water.

As far as household water availability (in terms of safe access) is concerned, the latter can vary between 100 percent in the urban core and 56.9 percent in the periphery. However, if we focus on availability for 24 hours a day, the numbers drop to 96.9 percent and 34.6 percent respectively. The decrease in the urban core could be related to some specific technical deficiency. In contrast, the drop in availability in the periphery (59.9 percent to 34.6 percent) would be linked, among other aspects, to low system pressure, leaks, poor quality installations, etc. These characteristics demonstrate that network coverage does not always guarantee safe and reliable accessibility.

Concerning the quality of the service, it was asked about the supply interruptions in the core and the urban periphery. According to the results, there are important interruptions in both contexts (see Table 7). These results are important because they not only call into question the concept of “safe water” that the conventional system in the drinking water network supposes, but they also bring to light the variable “interruptions or intermittence” whose importance is not considered in the management of the local water or the purposes of universalization of the Sustainable Development Goals.

Next, we ask about the duration of the interruptions, that is, the time without water in the households. In this regard, significant differences are observed between the core and the urban periphery. For example, 44.9 percent of respondents from the urban core stated that interruptions extended more than 10 hours, possibly due to the aging of the network system, a factor that normally requires the repair of water leaks or the replacement of pipes, etc. On the other hand, in the urban periphery, 84.9 percent of respondents affirmed that the interruptions were of more than 10 hours. This would be related, on the one hand, with the reduced pressure in the supply system, a characteristic factor in peripheral areas of the cities of the Global South (Kooy & Bakker, 2008) and, on the other hand, with the limited hours of water supply by supply mechanisms.

Turning to the commercialization tariff, we observe significant differences between the center and the urban periphery. However, beyond these differences, it is important to highlight the notable percentage of respondents from the urban core stating that current water tariffs harmed household budgets. We could assume that this would be related mainly to the increases in the tariff from 1.16 soles / m3 to 2.36 soles / m3 (equivalent to 0.34 US $ / m3 and 0.69 US $ / m3) between 2000 and 2017 (SEDAPAR, 2017). Vulnerability in the case of peripheral areas is even more pressing since the water tariff can vary from a minimum cost of 2.76 US $ / m3 to a maximum of 3.97 US $ / m3 between the different peripheral areas (personal communication, 2018). Of course, one of the many effects of high tariffs is related to reduced water consumption, for example, it was common for low-income families to buy 20 liters of water per day for 0.50 cents of the sun (0.14 US $). The survey shows that future increases in the price of water, regardless of the core or peripheral environment, can destabilize household economies.

Finally, and concerning the preference of the management model (public or private), we observed that 51.1 percent (urban center) and 64.9 percent (peripheral area) stated that the private model was not considered as an alternative to solve water service problems. The results, moreover, not only show an important social group (with accessibility and affordability problems) in disagreement with private models, but also a population that estimates that the challenges of universal supply can be solved with changes in public policies. In this sense, the objectives to achieve universal access must go beyond public or private debate. For example, Chile offers important evidence: the improvements in the coverage and service provision have not been due to water privatization but to the housing policies of 1970 that would have facilitated the development of supply systems for these housing (Pflieger & Matthieussent, 2008).

3.7. Conclusions

Rapid urbanization challenges modes of water supply, especially conventional network systems. In Arequipa (Peru), water supply and management policies have achieved important successes in terms of coverage and accessibility in the urban core. At the same time, however, peripheral urbanization has challenged the operational, economic, and political capacity of the system, so that water management policies in Arequipa continue to place drinking water network infrastructure as the only modern way to ensure supply. To achieve a more equitable supply, it is necessary that "formal" water management policies recognize the "informal" mechanisms and capacities of the peripheral area. In addition, housing and urban planning policies are essential.

The provision of services in the urban core and peripheral areas of a rapidly growing city like Arequipa does not show favorable results for all these services. There are improvements in accessibility and availability. However, these improvements, especially in accessibility, do not translate into increased affordability due to current commercialization tariffs, nor do they result in improved service quality. The progressive increase in tariffs may also generate a significant economic outlay for a large part of the population of the urban core, according to the results of our survey. The provision of services in peripheral areas is much more complex, with very high levels of access difficulties, interruptions, and concerns about future tariff increases, which have a significant impact on those households. In summary, this chapter attempted to demonstrate how the modern and formal supply system (drinking water networks) in Arequipa works differently for users in the core and the urban periphery. The latter combine formal and informal water supply systems. Thus, "informal" supply systems are essential for the inhabitants of the periphery without access to a drinking water network, but their importance in local water policy is far from being recognized and addressed. Faced with these realities of unequal supply, a joint effort with more inclusive policies can help improve the delivery of such an essential service as water.

3.8. References

Allen, A., Dávila, J. D., & Hofmann, P. (2006). The peri-urban water poor: citizens or consumers? *Environment & Urbanization*, *18*(2), 333–351. https://doi.org/10.1177/0956247806069608

Allen, A., Walnycki, A., & von Bertrab, É. (2017). The Co-production of Water Justice in Latin American Cities. In A. Allen, L. Griffin, & C. Johnson (Eds.), *Environmental Justice and Urban Resilience in the Global South* (pp. 175–193). Palgrave Macmillan. https://doi.org/10.1057/978-1-137-47354-7_10

Ampuero, R., Faysse, N., & Quiroz, F. (2005). *Metodología de apoyo a comités de agua potable en zonas periurbanas*. www.negowat.org

Andersen, A. O. (2016). Infrastructures of progress and dispossession: Collective responses to shrinking water access among farmers in Arequipa , Peru. *Focaal-Journal of Global and Historical Anthropology*, *3*(74), 28–41. https://doi.org/10.3167/fcl.2016.740103

Azócar, G., Henríquez, C., Valenzuela, C., & Romero, H. (2008). Tendencias sociodemográficas y segregación socioespacial en los ángeles chile. *Revista de Geografia Norte Grande*, *128*(41), 103–128. https://doi.org/10.4067/s0718-34022008000300006

Bain, R. E. S., Wright, J. A., Christenson, E., & Bartram, J. K. (2014). Rural: urban inequalities in post 2015 targets and indicators for drinking-water. *Science of the Total Environment*, *490*, 509–513. https://doi.org/10.1016/j.scitotenv.2014.05.007

Banana, E., Chitekwe-Biti, B., & Walnycki, A. (2015). Co-producing inclusive city-wide sanitation strategies: lessons from Chinhoyi, Zimbabwe. *IIED*, *27*(1), 35–54. https://doi.org/10.1177/0956247815569683

Bayer, A. M., Hunter, G. C., Gilman, R. H., Cornejo, J. G., Bern, C., & Levy, M. Z. (2009). Chagas Disease , Migration and Community Settlement Patterns in Arequipa , Peru. *PLoS Neglected Tropical Diseases*, *3*(12). https://doi.org/10.1371/journal.pntd.0000567

BCR. (1985). *Memoria 1985* (BCR (ed.); 1st ed.). Banco Central de Reserva del Perú. https://doi.org/bcrp.gob.pe/docs/Publicaciones/Memoria/Memoria-BCRP-1985.pdf

Bernal, A., Rivas, L., & Peña, P. (2014). Propuesta de un modelo de co-gestión para los Pequeños Abastos Comunitarios de Agua en Colombia. *Perfiles Latinoamericanos*, *22*(43), 159–184. http://www.scielo.org.mx/scielo.php?pid=S0188-76532014000100007&script=sci_arttext&tlng=pt

Birkenholtz, T. (2010). Full-cost recovery: Producing differentiated water collection practices and responses to centralized water networks in Jaipur, India. *Environment and Planning A*, *42*(9), 2238–2253. https://doi.org/10.1068/a4366

BM. (2018). *Crecimiento de la población*. Banco Mundial. https://datos.bancomundial.org/indicador/SP.POP.GROW

Budds, J. (2012). La demanda, evaluación y asignación del agua en el contexto de escasez: un análisis del ciclo hidrosocial del valle del río La Ligua, Chile. *Revista de Geografía Norte Grande*, *52*, 167–184. https://doi.org/10.4067/S0718-34022012000200010

Bustos-Cara, R., Sartor, A., & Cifuentes, O. (2013). Modelos de gestión del recurso agua potable: el caso de las cooperativas de servicios en pequeñas localidades de la Región Pampeana en Argentina. *Agua y Territorio*, *0*(1), 55. https://doi.org/10.17561/at.v1i1.1033

Cohen, B. (2006). Urbanization in developing countries: Current trends, future projections, and key challenges for sustainability. *Technology in Society*, *28*(1–2), 63–80. https://doi.org/10.1016/j.techsoc.2005.10.005

Coutard, O. (2008). Placing splintering urbanism: Introduction. *Geoforum*, *39*(6), 1815–1820. https://doi.org/10.1016/J.GEOFORUM.2008.10.008

Dean Randall, B., Cleland, L., Kuehne, C. S., & Sheer, D. P. (1997). Water supply planning simulation model using mixed-integer linear programming. *Journal of Water Resources Planning and Management*, *123*(2), 116–124. https://doi.org/10.1061/(ASCE)0733-9496(1997)123:2(116)

EarthSky. (2019). *Researchers investigate dramatic melt of glaciers in Peru*. EarthSky. https://earthsky.org/earth/disappearing-peruvian-glaciers

Garden, T. Van. (1989). Collective organization and action in squatter settlements in Arequipa, Perú. In F. Schuurman & T. Van Naerssen (Eds.), *Urban Social Movements in the Third*

World (First Edit, pp. 27–44). Routledge. https://books.google.es/books?hl=es&lr=&id=KFrRhIpzjzQC&oi=fnd&pg=PA27&dq=settlement+of+pueblo+joven+in+arequipa&ots=TSROaLMLcb&sig=U6hdg18ut6OG-SHGLCmnq-qsToA#v=onepage&q=settlement of pueblo joven in arequipa&f=false

Graham, S., & Marvin, S. (2001). Splintering Urbanism: Networked Infrastructures, Technological Mobilities, and the Urban Condition. In *Technology and Culture* (1st ed., Vol. 43, Issue 3). Taylor & Francis. https://doi.org/10.1353/tech.2002.0124

Jouravlev, A. (2004). Los servicios de agua potable y saneamiento en el umbral del siglo XXI. In *Ingeniare Revista chilena de ingenier* (Vol. 17, Issue 3). https://doi.org/10.3989/arbor.2000.i653.1000

Klien, M. (2014). Corporatization and the Behavior of Public Firms: How Shifting Control Rights Affects Political Interference in Water Prices. *Rev Ind Organ*, *44*, 393–422. https://doi.org/10.1007/s11151-013-9401-0

Kooy, M., & Bakker, K. (2008). Splintered networks: The colonial and contemporary waters of Jakarta. *Geoforum*, *39*(6), 1843–1858. https://doi.org/10.1016/J.GEOFORUM.2008.07.012

Matsinhe, N. P., Juízo, D., Macheve, B., & Santos, C. dos. (2008). Regulation of formal and informal water service providers in peri-urban areas of Maputo, Mozambique. *Physics and Chemistry of the Earth*, *33*(8–13), 841–849. https://doi.org/10.1016/J.PCE.2008.06.046

McMillan, R., Spronk, S., & Caswell, C. (2014). Popular participation, equity, and co-production of water and sanitation services in Caracas, Venezuela. *Water International*, *39*(2), 201–215. https://doi.org/10.1080/02508060.2014.886844

Mehta, V. K., Goswami, R., Kemp-Benedict, E., Muddu, S., & Malghan, D. (2014). Metabolic Urbanism and Environmental Justice: The Water Conundrum in Bangalore, India. *Enviromental Justice*, *7*. https://doi.org/10.1089/env.2014.0021

Mitlin, D. (2008). With and beyond the state-co-production as a route to political infl uence, power and transformation for grassroots organizations. *Environment & Urbanization*, *20*(2), 339–360. https://doi.org/10.1177/0956247808096117

Mitlin, D., Beard, V. A., Satterthwaite, D., & Du, J. (2019). Unaffordable and Undrinkable: Rethinking Urban Water Access in the Global South. In *World Resources Institute*. https://www.wri.org/wri-citiesforall/cities-all

Moretto, L., Faldi, G., Ranzato, M., Rosati, F. N., Ilito Boozi, J. P., & Teller, J. (2018). Challenges of water and sanitation service co-production in the global South. *Environment and Urbanization*, *30*(2), 425–443. https://doi.org/10.1177/0956247818790652

ONU. (1983). Agua Potable y Saneamiento Ambiental en América Latina, 1981-1990. In *ONU*. https://repositorio.cepal.org/bitstream/handle/11362/9981/S8100910_es.pdf?sequence=1&isAllowed=y

ONU. (2018). *Las ciudades seguirán creciendo, sobre todo en los países en desarrollo*. ONU. https://www.un.org/development/desa/es/news/population/2018-world-urbanization-prospects.html

Opryszko, M. C., Huang, H., Soderlund, K., & Schwab, K. J. (2009). Data gaps in evidence-based research on small water enterprises in developing countries. *Journal of Water and Health*, *7*(4), 609–622. https://doi.org/10.2166/wh.2009.213

Pflieger, G., & Matthieussent, S. (2008). Water and power in Santiago de Chile: Socio-spatial segregation through network integration. *Geoforum*, *39*(6), 1907–1921. https://doi.org/10.1016/j.geoforum.2008.09.001

Rivera, P., Navarro, K., & Chávez, R. (2017). Cobertura socio-espacial y consumo doméstico de agua en la ciudad de Tijuana: ¿es de utilidad la misma gestión para diferentes usuarios? *Agua y Territorio*, *0*(9), 34. https://doi.org/10.17561/at.v0i9.3475

Rusk, D. (1993). *Cities without suburbs*. Woodrow Wilson Center Press. https://scholar.google.es/scholar?hl=es&as_sdt=0%2C5&q=cities+without+suburbs+david+rusk&btnG=

Sauri, D., & del Moral, L. (2001). Recent developments in Spanish water policy. Alternatives and conflicts at the end of the hydraulic age. *Geoforum*, *32*(3), 351–362. https://doi.org/10.1016/S0016-7185(00)00048-8

SEDAPAR. (2017). Memoria Anual 2017. In *SEDAPAR*.

Vilchis-Mata, I., Garrocho-Rangel, C. F., & Díaz-Delgado, C. (2018). Modelo dinámico adaptativo para la toma de decisiones sostenibles en el ciclo hidrosocial urbano en México. *Revista de Geografia Norte Grande*, *2018*(71), 59–90. https://doi.org/10.4067/s0718-34022018000300059

WHO/UNICEF. (2014). *Progress on Drinking Water and Sanitation* (WHO/UNICEF (ed.)). WHO/UNICEF. https://washdata.org/sites/default/files/documents/reports/2017-06/JMP-2014-Report.pdf

Zapana, L. (2018). Respuestas a la crisis hídrica en zonas agrícolas y urbanas: Caso de estudio "Proyecto de Irrigación Majes Siguas I" Arequipa – Perú. *Agua y Territorio*, *12*, 145–156. https://doi.org/10.17561/at.12.3532

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Chapter 4

Urban water demand management strategies in the Global South: the case of Arequipa

Abstract

Using a socio-environmental perspective, the objective of this paper is to analyze strategies of Water Demand Management (WDM) in Arequipa, Perú, and their perception by residents through a survey for 6 city districts (3 in the core and 3 in the periphery) complemented with interviews with key stakeholders. Against the backdrop of uneven network water access between core and periphery, but also within the peripheral districts analyzed, results show significant differences in WDM. Strategies to reduce demand through pricing are dominant. Domestic water-saving technologies are uncommon, and awareness campaigns are limited to periods of water stress. Despite differences in water access, improvements in water networks (leak repair, adequate water pressure, and continuous supply) are the most demanded actions by residents.

4.1. Introduction

Access to reliable and safe water supplies represents one of the fundamental backbones of the urbanization process. Historically, this access has been made possible through the construction of infrastructures to bring and distribute clean water and eliminate polluted flows (Grigg, 2019). The demand for water supply and sanitation infrastructures continues today in many urban areas of the world fueled by population growth and economic development amidst growing concerns about future availability (Tortajada & Biswas, 2017; UNESCO, 2015).

However, many factors intervene to question the current infrastructural approach to water supply and sanitation. Increasing economic costs, including the much-needed renovation of urban water networks; social opposition to large water supply projects, and environmental impacts have raised the interest towards alternative sources (desalination and reclaimed water, for example) and towards water demand management (Butler & Memon, 2006). Water Demand Management (WDM) represents a fundamental pillar of sustainable water management (Brooks, 2006; Saurí, 2003). Broadly, WDM rests on three main types of instruments: economic (prices and taxes), technological (efficient water-saving devices), and awareness strategies (campaigns to limit water use).

WDM can be considered part of the Ecological Modernization (EM) approach originating within the affluent and relatively equitable societies of Central and Western Europe in the early 1980s (Spaargaren & Mol, 1992). Essentially EM argued for the application of technological and market instruments to environmental problems without compromising the operation of the market economy (Jänicke, 2008). Proponents of EM developed instruments such as the "polluter pays" principle, the precautionary approach, or the obligation of conducting environmental impact assessments of policies, plans, and programs. In the water field, the influence of EM through WDM measures such as the application of the principle of "full cost recovery", can be noticed in legislation such as the European Water Framework Directive of 2000 (Kaika, 2003). Interest in WDM, especially its economic dimensions, also coincided with the Dublin declaration of 1992, emphasizing the consideration of water as an economic good (ICWE 1992), and with changes in urban water governance towards a greater role for private companies (Araral, 2009). WDM has made headway in Europe, Australia, or North America, but it has attracted also the attention of water managers in Africa (Crow-Miller, Webber, & Molle, 2017; Gumbo, 2004; Mwakalila, 2007); Asia (Araral & Wang, 2013; Tortajada, 2006), and, perhaps to a lesser extent, Latin America (Adler, 2011).

Given this interest, one important question is whether WDM has any role to play in improving water services in fast-growing cities with uneven water supply (Horne, Tortajada, & Harrington, 2018). Prices, changing tariff structures, the promotion of water-saving technologies, or the increase in water awareness among consumers implicitly assume a socially and spatially homogeneous city. However, the contemporary socio-spatial diversity of many urban areas indicates otherwise, and the reality of "splintering urbanism", with some neighborhoods having access to networked water and others lacking this access, remains common despite the important advances made in extending water supply networks (Graham & Marvin, 2001; Kooy & Bakker, 2008; Mitlin, Beard, Satterthwaite, & Du, 2019).

Hence, WDM strategies in consolidated urban areas with universal water access might differ from those strategies applied to fast-growing cities with uneven water access. More significantly, WDM strategies may differ considerably between formally planned urban areas and informal, unplanned settlements (Sharma & Vairavamoorthy, 2009) but studies considering the full range of WDM initiatives in fast-growing cities with uneven water access are still scarce.

The objective of this paper is to shed light on WDM strategies and their perception by citizens of central and peripheral areas of fast-growing cities in Latin America, through the case of the city of Arequipa, Peru. Arequipa is the second-largest city in Peru, and one of the fastest-growing cities in South America in population and economic terms (The Business Year, 2015). Arequipa represents also an example of polarized urban growth between planned, core areas having access to water networks, and unplanned, peripheral areas where networked water supply is insufficient or absent and must be complemented with more uncertain and comparatively more expensive sources. It is important to note that in this paper we use the binary core/planned and peripheral/unplanned areas as a heuristic device to shed light on the different realities of water supply in Arequipa. However, we acknowledge that these categories, and especially the notion of peripheral/unplanned areas are not monolithic and may encompass different socio-economic conditions and different materialities of everyday life, influencing in turn how WDM intersects with those uneven conditions.

The paper is organized as follows. After this introduction, we review recent academic contributions to WDM strategies in their triple dimension of economic, technological, and awareness instruments and explore their possible effectiveness for fast-growing cities characterized by uneven access to water. This is followed by a presentation of Arequipa focusing on recent population and urban development and the characteristics of water supply and consumption in the city. Section four describes the methodology of the study, which is primarily based on the analysis of several surveys to citizens (N=721), complemented by interviews with key stakeholders in the city water sector to characterize water supply practices and their perception by residents in three districts located in the formal urban core and three districts located in the informal settlements of the periphery. Section five presents and discusses results and is divided into two subsections. The first includes an overview of WDM measures in Arequipa while in the second, survey results are presented and discussed in the light of socio-spatial differences in the city. Finally, in the conclusions, findings for Arequipa are discussed in terms of lessons learned of possible interest for other fast-growing cities lacking homogenous universal levels of water provision.

4.2. Strategies of Water Demand Management in urban areas

WDM aims at providing efficient resource use and conservation through technology and market principles (Huber, 2000; Rogers, De Silva, & Bhatia, 2002; Savenije & Van Der Zaag, 2002). Prices can stimulate users to be more prudent in consuming water, and, at the same time, fulfill cost recovery requirements. Likewise, technology-driven water conservation and campaigns to educate the population on proper water behaviors help in the efforts to reduce water consumption (Tortajada, González-Gómez, Biswas, & Buurman, 2019). The combination of these strategies is seen as one important reason behind the observed decline of water consumption in certain cities of North America, Europe, or Australia (Sauri, 2019).

WDM assumes homogeneous areas with universal levels of service provision. While this may be the case in most cities of North America, Australia, or Europe, the situation in fast-growing cities of Latin America, Asia, or Africa is rather different. In

the latter, there is significant polarization between, in general terms, the formal, legal, and planned city, and the informal, alegal, and unplanned city, (Kooy & Bakker, 2008; Pflieger & Matthieussent, 2008).

According to the United Nations (2018), 20 percent of the urban population in developing countries lives in informal settlements. The achievement of sustainability objectives such as universal water supply and sanitation in these areas remains a daunting task (Dovey, 2015; Montoya et al., 2020; Soyinka et al., 2018), and access to water and energy is usually problematic. It is estimated that by 2050, the demand for water in cities will increase by up to 33 percent (UNESCO, 2015), possibly aggravating and widening unequal access between formal and informal urban settlements. Moreover, the sprawled nature of many informal settlements does not facilitate the enlargement of water supply networks due to costs, the uncertain nature of legal titles to land ownership, or, simply, little political will. Faced with this reality, households tend to rely on a set of supply systems with different characteristics and levels of provision and that are selected according to price, type of source, distance from the source or quality of service (Ahlers et al., 2014). All these alternatives fail to ensure a steady supply of water, resulting in water consumption in informal settlements that tend to be lower than in the formal city (Adams, 2018; Kooy & Bakker, 2008). Moreover, water quality from these may be worse than water from the public networks (Rusca et al., 2017).

Economic strategies for WDM have gained significant leverage over technological or awareness strategies on two assumptions. The first is that price increases would lead to lower consumption. The second is that higher prices may act as a stimulus for water companies to invest in the enlargement of water networks in growing urban areas (Rogers et al., 2002). However, these assumptions often do not materialize because higher water prices may have unfavorable effects on low-income households. The limited capacity to pay of households located especially in the informal city discourages investment by water companies and may lead even to the termination of concessions (Bakker, 2003, 2007).

According to some authors Fernández (2015) and Molinos-Senante & Donoso (2016), water prices in Latin America are relatively low but have registered high increases in recent years (Brichetti, 2019). In most cities, water prices follow the principle of increasing block tariffs whereas unitary pricing, regardless of consumption, is rapidly declining. 88.6 percent of water companies have adopted the increasing block structure, while only 11.6 percent use uniform rates (Brichetti, 2019). Block pricing is seen by its proponents as an appropriate alternative to control demand, improve affordability and equity in access, and contribute to expanding supply networks (Baerenklau et al., 2014; Mayer et al., 2008). Other views, however, are highly critical (Boland & Whittington, 2000). One of the most controversial issues concerns distributional impacts. In Latin America, block pricing only appears to work reasonable well for middle-income groups while it may affect disproportionately low-income groups, especially large households, and may not induce behavioral change in high-income groups (see Barde & Lehmann, 2014, for the case of Lima).

In general terms, the use of water-saving fixtures (for instance, low flush toilets, low flow showers, faucet aerators, among others) can reduce the demand for water between 30 and 50 percent for indoor uses and between 5 and 10 percent for outdoor uses (Sauri, 2013). However, the reduced purchase capacity of many low-income households may explain the difficulties in accessing efficient technologies in fast-growing urban areas.

More efficient technologies may not only bring substantial savings to final users but also to water operators as well. Although probably impossible to know in exact terms, some authors estimate that water losses from distribution networks, or "non-revenue water", amount to 126 billion cubic meters per year worldwide (Liemberger & Wyatt, 2019). In developing countries, this figure may represent between 30 and 60 percent of distributed volumes (Mutikanga, Sharma, & Vairavamoorthy, 2009). Part of this water is lost through leaks owing to aging and deteriorating system components, while other losses may be due to inadequate operational management (McKenzie, 2018). Additionally, unregistered connections may represent between 10 and 15 percent of the water distributed in the networks (Kingdom, Liemberger, & Marin, 2006).

Awareness campaigns are addressed to change behaviors by encouraging or making mandatory water conservation practices among the public. Awareness campaigns usually involve the transmission of messages to conserve water through popular media, especially during periods of water stress. In fast-growing cities with social and spatial uneven access to water, awareness campaigns might not be effective for households lacking reliable access or consuming little water. For example, in Jordan, while awareness campaigns could have increased people's attitudes toward conservation, this change did not occur because water available was already very limited (Kingdom et al., 2006). In Salta (Argentina), awareness campaigns have included, among other items, advertisements, educational programs, or information for the installation of water meters. However, total consumption has not diminished due to the significant losses of water in the public network (Iribarnegaray et al., 2014). Also, during the drought in Sao Paulo (Brazil) in 2014-2015, awareness campaigns were part of measures implemented to reduce water consumption. According to Braga & Kelman (2020), these campaigns reduced consumption by 25 percent. However, other authors point at the severe restrictions on water availability as the most likely cause of the decline (McKenzie, 2018). Awareness campaigns tend to be designed in very general terms and usually ignore differential consumption patterns within urban areas and may fail to address the specific needs of some citizens. In times of drought, the message is to save water with most messages targeting indoor uses and especially habits of personal hygiene.

In Latin America, some decreases in consumption have been documented between 2000 and 2014-15. For example, water consumption in Chilean cities fell from 22.7 to 18.6 m^3/household/month between 2000 and 2014 (Donoso, 2015). In Buenos Aires, consumption decreased from 383 to 327.5 liters/per capita/day (lpcd) between 2005 and 2014. Likewise, in Brasilia, consumption declined from 166 lpcd to 152 lpcd between 2006 and 2015. Finally, in Lima, consumption decreased slightly from 155 to 152 lpcd between 2005 and 2014. According to some studies, declines can be attributed to the application of WDM instruments, especially pricing (Donoso, 2015). However, other factors, including the incidence of drought episodes, which may reduce the availability of water, maybe present as well (March & Sauri, 2017). In addition, frequent interruptions in supply and loss of pressure in the network affect consumption (Lee & Schwab, 2005). Hence, precarious and often unreliable water distribution systems may also become a manifestation of uneven access to the resource (Mitlin et al., 2019; Ojeda de la Cruz et al., 2017).

4.3. The case of Arequipa

Arequipa (1.3 million people) is the second-largest city of Peru after Lima (CAF, 2018). It is located in the southern region, bordering the Atacama Desert at some 2,300 meters above sea level. The city has an arid climate with annual precipitation of only 19 mm, and water availability depends on river flows originating in the Andes.

The recent historical trajectory of Arequipa follows the pattern of many cities in the developing world in terms of fast urbanization fueled by immigration processes (Cohen, 2006). Until 1940, the city experienced moderated growth, but since 1940 it began to gain population in increasing numbers. From 155,000 inhabitants in 1940, Arequipa grew to 421,000 in 1960, with an annual growth rate of 4.8 percent (Garden, 1989). In the early 2000s, the city passed the 1 million mark and in 2017 it reached 1.3 million people (INEI, 2017). Population growth in Arequipa has followed a typical spatial pattern of cities in the developing world. While core districts, historically concentrating most of the population, have experienced moderate increases, the urban peripheries have progressed faster, especially in the 1990s. Local migration (rural-urban) and migration from other Peruvian regions, above all from Andean areas of Cuzco and Puno, attracted by agro-industrial, energy, and transportation activities (Bayer et al., 2009), have contributed significantly to the growth of Arequipa. Unable to absorb immigration within the limits of the planned city, Arequipa has witnessed the increase of urbanization in the non-planned peripheries known locally as *Barrios Urbanos Marginales* (BUM) (Calderon-Cockburn, 2017; Muñoz, 2018). BUMs, have developed out of the planning system and under the driving force of the market (legal and illegal, including land trafficking as in the *Cono Norte* part of the city). Thus, vast spaces located in the outskirts of the urban area are occupied and built, usually in the form of single-family houses, according to the occupants' economic possibilities. Essential services (water, sanitation, and electricity) may be provided eventually depending on two factors: collective action under organized community groups demanding the legalization of the new urban land or initiatives of "land formalization" adopted by the local government (Azuela & Tomas, 1996). According to Sin Fronteras (2018), in the urban periphery of Arequipa, there are more than 200 informal housing associations. The informal status means denial of access to basic services such as water, sanitation, or electricity, resulting in harsh living conditions. Inhabitants of these urban sectors organize and mobilize in front of state agencies to demand recognition of their establishment, usually through a "certificate of possession". This certificate of recognition (which is a prerequisite before formalization) is requested by utility companies (Castro & Riofrio, 1996). However, despite social mobilizations, public entities do not always provide these certificates, in part because informal housing may be located in areas considered to be at risk (IMPLA, 2016). Formalized housing associations have access to basic services (water and sanitation), although affordability and reliability issues may remain, while "uncertified" housing associations end up excluded from all the basic services and must recur to other alternative sources of water not only more expensive but are also more costly to store.

It is important to acknowledge that peripheral areas in Arequipa show important internal differences due to their historical trajectories. Table 8 provides information on the origin of the population, average income, and population in poverty conditions for the six districts included in the study. From the table, important differences in terms of income and poverty can be observed between the core and the periphery (for example, average income in the core districts of Arequipa and Yanahuara almost doubles that of the periphery districts) but internal differences within the periphery can be also noticed. For example, almost 50 percent of the population of the Yura district in the periphery was not born in the city and comes especially from the Andean highlands which on the other hand provides most of the immigrants to the city. Yura also observes the highest percentage of the population in poverty (more

than 20 percent of the total).

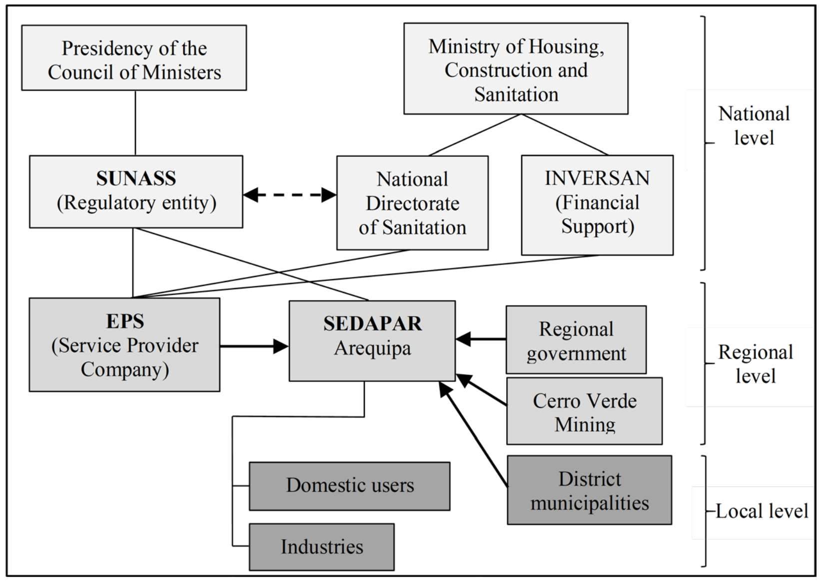
Table 8. Social composition by origin in the surveyed districts

Districts		Social composition by origin						Average per capita income per year (US$)	Poverty (%)
		Local population (%)	Regional migration		National migration				
			Coast (%)	Highlands (%)	Coast (%)	Highlands (%)	Rainforest (%)		
High income	Arequipa	67,01	3,51	3,39	10,33	14,82	0,62	More than 6790,72	1,2
	Yanahuara	69,92	3,73	3,31	11,61	10,38	0,47	More than 6790,72	1,5
	J.L. Bustamante	67,83	3,51	3,41	8,76	15,19	0,41	Average 5854,3	3,5
Low income	Characato	64,5	1,61	3,95	8,12	21,15	0,52	Less than 3036,64	15,6
	Tiabaya	76,24	1,29	1,55	3,33	17,1	0,31	Average 3401,91	13,2
	Yura	51,04	0,9	13,4	2,19	32,12	0,27	Less than 3401,91	21,6

Source: O Own elaboration from National Population and Housing Census (INEI, 2017) and Income-stratified plans concerning major city blocks (INEI, 2020)

Urban water services in Peru are provided by public service entities called EPS, which are supervised by SUNASS (*Superintendencia de Servicios de Saneamiento*) (see Figure 11). In the Arequipa region, the municipal service EPS SEDAPAR (*Servicio de Agua Potable y Alcantarillado de Arequipa*) treats and supplies the water. Although SEDAPAR together with the regional government and municipalities have invested significantly in infrastructure, especially for the expansion of the public drinking water network, rapid urbanization is outpacing infrastructure development.

Figure 11. Organization of the urban water sector in Peru



Source: Own elaboration

The Chili and Socabaya rivers provide water for Arequipa as well as for the irrigation of some 10,000 agricultural hectares in the nearby areas, and for the generation of electricity (Andersen, 2016; CAF, 2018). Surface water flows are seasonal and depend on rainfall and snow in the Andes. Given the increase in water demand due to rapid population growth and economic activities (SEDAPAR, 2018), river flows have experienced an unprecedented decrease in recent decades exacerbated by variations in rainfall and the reduction of snowpacks in the Andes (Vuille et al., 2008). The response to ensure future water availability has been the planning and construction since 1961 of several dams to regulate flows (AQUASTAT - FAO, 2015). While the hydraulic system has enhanced water supply for the city, it has also affected ecological and social uses and redistributed water volumes and rights (Zapana et al. in press).

The hydraulic complex known as "Regulated Chili" can store, on average, some 177 cubic hectometers of water per year (Autoridad Nacional del Agua, 2019), increasing the water flow in the Chili River from the original 5 cubic meters/second to 13 cubic meters per second. Hydraulic regulation has made it possible to improve the supply of water by 18.5 cubic hectometers between 2006 and 2017 but it has not solved water scarcity in the urban periphery. A small proportion of water supply, especially in the informal settlements of the periphery, comes from groundwater sources (see Table 9).

Table 9. Water supplied and water billed in Arequipa (2006-2017)

Years	Water supplied (Hm3)		Water billed (Hm3)				
	Surface	Underground	Social	Domestic	Public	Commercial	Industrial
2006	35,7	8,5	·	·	·	·	·
2007	39,2	8,9	·	·	·	·	·
2008	38,9	8,7	·	·	·	·	·
2009	41,5	7,8	·	·	·	·	·
2010	42,2	7,8	·	·	·	·	·
2011	41,3	7,4	0,1	26,1	2,8	4,0	1,5
2012	42,2	8,2	0,1	27,2	2,9	4,4	1,6
2013	49,8	8,3	0,2	29,5	2,1	5,6	1,6
2014	52,8	8,6	0,3	31,7	2,2	5,7	1,5
2015	55,3	8,1	0,3	33,6	2,1	5,8	1,1
2016	57,8	8,2	0,6	34,5	2,2	5,4	0,9
2017	54,2	8,2	0,9	34,0	2,1	5,2	0,8

Source: Own elaboration from Servicio de agua potable y Alcantarillado de Arequipa (SEDAPAR).

Nevertheless, the increase in supply has been unable to compensate for the increase in demand partly because some 23.2 Hm3 per year, or about a third of the water supplied, is lost in the distribution network (INEI, 2019; Superintendencia Nacional de Servicios de Saneamiento, 2018). Imbalances between supply and consumption reached a critical moment in 2016 when a strong decrease in rainfall possibly related to climate change (see, Vuille et al., 2008) affected the upper Chili River basin. For SEDAPAR, this episode showed the need for increasing water use licensing. SEDAPAR had a permit of 1960 liters/second for drinking water production, but managers noted that demand was over 2315 liters/second. Hence and after a water emergency was declared in the city (RPP, 2016), water managers and city community groups asked the Peruvian government to increase the hydraulic capacity of the Chili river system by building new reservoirs. At the same time, they also called for a more significant role for water conservation to reduce consumption.

Like other rapidly growing cities in the developing world, Arequipa is characterized by its internal disparity in access to essential services. Water supply in the city combines conventional (public water networks) and alternative supply systems (pipe trucks, public fountains, wells). The latter facilitate the distribution of water in sectors without access to the public network (Bakker, 2003).

In Arequipa, the conventional supply system operated by SEDAPAR is widely present in the urban core. In contrast, informal systems usually managed by private actors are more common in the periphery, with different degrees of intensity depending on specific areas. Here the purchase of non-network water is usually done in groupings to negotiate better prices and reduce waiting times in transportation.

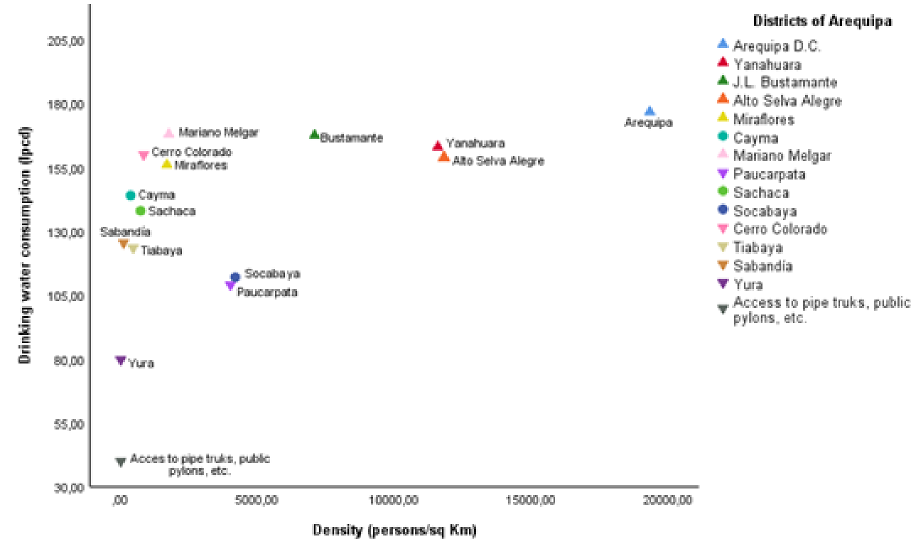
According to the most recent annual report of (SEDAPAR, 2018), the supply of water through public networks in the city of Arequipa increased from 89.7 to 92 percent of the urban area between 2008 and 2018, reflecting an effort to make water coverage universal. However, household water coverage also includes supply from public water tankers and pylons (especially in the urban periphery recently “formalized”). In addition, access to water through networks is ridden with problems related to water losses, supply interruptions, or low pressure of the system (La República, 2019). Water losses may be smaller than in other Latin American cities (Ojeda de la Cruz et al., 2017; Superintendencia Nacional de Servicios de Saneamiento, 2018), but remain significant for Arequipa, which suffers from recurring droughts. In the urban peripheries, the presence of non-conventional supply systems may involve access to one or more water sources in highly variable proportions (Constantine et al., 2017; Misra, 2014), including public pylons or fountains, private wells (of dubious quality), or water transported by privately operated water trucks, more expensive to obtain than the former and also of uncertain quality in some cases.

In 2019, the average water consumption in Arequipa attained 140 liters per capita per day (lpcd) (SEDAPAR, 2019a). This average obscures important differences of consumption between the core and the peripheral areas, but also within the same informal areas, as some have higher degrees of connection to the network than others. Accordingly, differences in water consumption between the core and the periphery of Arequipa are primarily related to access to the public water network (see Figure 12).

The average consumption per capita in the three districts of the urban core included in the study (Arequipa DC, Yanahuara, and JL Bustamante) was 169 lpcd. In comparison, the water consumption in three districts of the peripheral area included in our study (Yura, Sabandía, and Tiabaya) was 109 lpcd for the 48 percent of the population with access to the public water network (see Figure 13). Large disparities in income and situations of poverty, which modulate the capacity to pay for the resources, might be a central element in understanding uneven patterns of water consumption (see Figure 12). According to the income threshold for poverty established

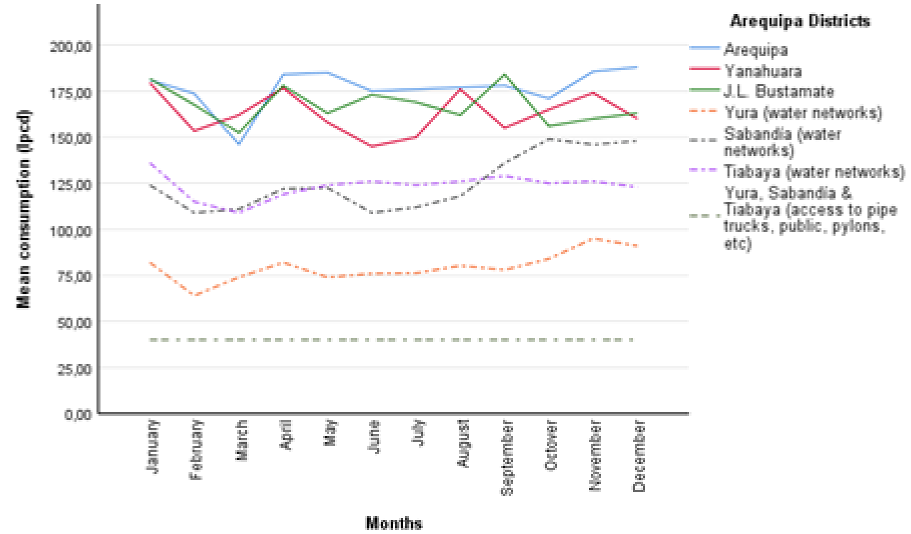
in the country (less than half the minimum wage), in the urban core of Arequipa, only 2 percent of the population is considered poor, while in the peripheral area, poverty reaches 16 percent of the total (BCR, 2016; see also Table 8).

Figure 12. Arequipa. Monthly average water consumption by district 2019



Source: Own elaboration from Servicio de agua potable y Alcantarillado de Arequipa (SEDAPAR).

Figure 13. Mean monthly water consumption (lpcd) in six Arequipa Districts

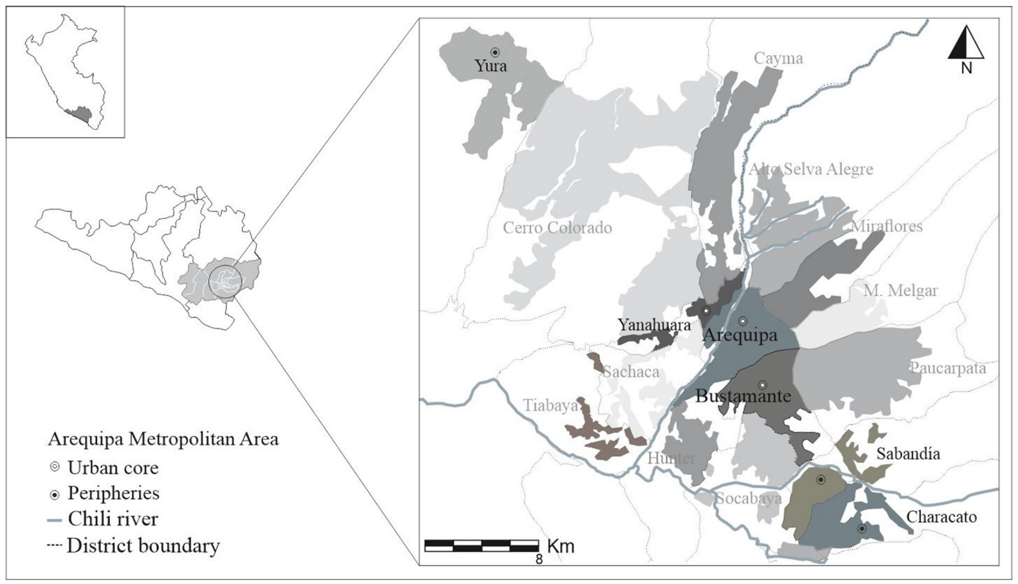


Source: Own elaboration from Servicio de agua potable y Alcantarillado de Arequipa (SEDAPAR).

4.4. Methodology

To assess whether WDM strategies differ between the urban core and the urban periphery of Arequipa, as well as to investigate the perception by citizens of WDM measures, we used WDM-related variables from a database built from household surveys (N=721) conducted between September and November 2018 by a trained team of six people led and coordinated by the first author. Following statistical sampling methods, surveys were carried out in 6 of the 20 districts of Arequipa as mentioned before: three districts from the urban core (n=354), and three districts from the urban periphery (n=367 (see Figure 14). The districts of the urban core had higher incomes and almost all households were supplied by the city public water network, while the districts of the urban periphery had lower economic incomes and households were supplied partly by the city water network, but also from other sources (see also Table 8 for sociodemographic data of the six districts).

Figure 14. location of surveyed districts.



Source: own elaboration

The household survey included a set of 29 closed questions on the perception of users on water availability, accessibility, and quality; satisfaction with the service; prices; domestic water-saving technologies, and water awareness. Following the objectives of this paper, we focused on the set of variables from the database related to the three components of WDM (economic instruments, efficient technologies, and water awareness measures) as well as data on the perception of water provision (accessibility, availability, and quality of water service).

The selected variables from our database were the first subject to a descriptive analysis for each district (see Table 10). Second, a non-parametric Chi-square analysis (x^2), after the tests of normality and homogeneity of values, was performed in order to examine comparatively how the adoption of WDM measures, their perception, and water service delivery factors (accessibility, availability, and quality of water service) varied between households in the core and periphery districts (see Table 10).

In addition to the analysis of the database developed from the survey, interviews were conducted with representatives of SEDAPAR (Water and Sewer Services of Arequipa); SUNASS (National Supervising Agency for Water and Sanitation), and AUTODEMA (Autonomous Authority of the Majes-Siguas water supply project), and with representatives and members of two housing associations in the urban periphery. Interviews took place between September and November 2018 and were face-to-face with the exception of one made by telephone. Topics covered in the interviews with water managers included, among other aspects, the challenges for the water sector in Arequipa, water pricing systems, distribution technologies, and water awareness strategies. On the other hand, the interviews with the representatives and members of the housing associations referred mainly to the provision of water services, water access tariffs, and domestic water-saving technology. Ancillary sources included annual urban water management reports and drinking water production data, provided by SEDAPAR as well as miscellaneous economic and sociodemographic statistical information (Instituto Nacional de Estadistica e Informática, 2017; SEDAPAR, 2017b, 2018, 2019b).

4.5. Results and discussion

4.5.1. Documenting WDM measures in Arequipa

Water administrators, regulators, and providers in Arequipa show certain disagreements as to effective approaches to water management (Filippi et al., 2014). While the Arequipa Regional Government and the Peruvian ANA (National Water Authority), among others, prefer strategies focused on increasing the water supply (construction of dams and micro-dams at the headwaters of the Andean river basins), the public water and sanitation company SEDAPAR appears to be more committed to water demand management. SEDAPAR has two main concerns. First, supply drinking water in "efficient" ways, and second, solve what they consider a "lack of education" among the public regarding the use of basic services (Filippi et al., 2014). However, the water network suffers from technical problems, resulting in many inefficiencies (leaks, insufficient water pressure in the pipes, etc.). Moreover, other actors intervening in the Arequipa water cycle have their own agendas. The Cerro Verde mining company, a private actor and member of the Multisectoral Committee of the Chili River Basin, has funded infrastructures such as dams, canals, and water and wastewater treatment plants in the city. However, these actions also favor extractive activities by the company. For example, the mining company has pursued several expansion projects based on copper extraction, requiring additional water rights, but, in turn, generating massive citizen protests as well.

Given the increasing difficulties in financing new water supply infrastructures for Arequipa, SEDAPAR has implemented a series of measures focused on managing water demand. Economic and awareness measures are the most used. In contrast, the installation of water-efficient technologies, although favored by water managers, is limited mostly due to the lack of government subsidies.

Economic measures

In Arequipa, the use of economic instruments differs according to the water source. In the urban core and the peripheral areas where water is served from the public network, increasing block rates are the most widely used strategy for managing water demand. A fixed-rate per liter is common in peripheral areas with limited or no access to the public network as citizens need to resort to alternative water providers.

In the urban areas serviced by the public network, the water bill is composed of a fixed charge (equivalent to 0.84 US$/month), and three consumption blocks (with volumetric ranges of 0-10; 11-30, and 31 and more m^3/month), with different rates for each block. The water rate is 0.14 US$/$m^3$ higher between the first and second blocks and 0.45 US$/$m^3$ higher between the second and third blocks. The tariff for these blocks increases annually after the application of the "principle of tariff regulation" addressed to provide for the recovery of investment costs, the costs of exploring new water sources, the efficiency of water consumption, and the criteria of equitable distribution (Superintendencia Nacional de Servicios de Saneamiento, 2014a, 2014b). In total, SEDAPAR clients can expect to pay between 8.30 and 9.69 US$/month equivalent to 3.7 percent of the minimum wage.

The domestic water tariff has increased continuously since 2000. Between 2001 and 2018, the average water rate went from 0.34 US$/$m^3$ to 0.69 US$/$m^3$ (SEDAPAR, 2018). Local water administrators argued that the increasing block rate structure improved equity and provided benefits to poor households who consumed less than 10 m^3/household/month (Superintendencia Nacional de Servicios de Saneamiento, 2014b). However, in Arequipa, this consumption level only occurred in the Yura district, the poorest of all. In contrast, in other low-income districts with larger households, such as Tiabaya, average consumption could rise to 16 m^3/household/month.

In areas where basic water needs are not principally (or solely) served by the public water supplier but by private operators, a fixed rate per liter is widely used. This fixed-rate does not aim at water conservation or to distributive equity, but simply responds to a process of cost recovery (e.g., water transport) plus fees for private operators (Water and Sanitation Program, 2008). These tariffs are established outside the legal framework of tariff determination characteristic of the formal sector, and tend to stress the economic capacity of customers, limiting the purchase of water to essential uses only. Rates oscillate between 2.76 US$/$m^3$ and 3.97 US$/$m^3$ (Interviews with presidents of Salud Del Sur and Villa Tambo housing associations, November 2018). As peripheral areas may be supplied with different water sources, different pricing schemes according to the water source are common.

Technological measures

Public programs for the use of water-efficient technologies are rare in Arequipa. Water fixtures are not always replaced by more efficient devices and conventional devices (WCs, etc.) are still widely found in Arequipa households, especially in peripheral areas. Households there may not modernize their facilities because water consumption is already low, and the costs of water-saving devices could absorb an important part of the family income.

A good technical condition of the public water network system (stable supply and adequate pressure) is essential to implement WDM strategies. In Arequipa, it has been estimated that about a third of the system's pipes have not been renovated in more than 40 years (El Buho, 2019a; SEDAPAR, 2017a). Much of this aged system is in the urban core, where water supply is less problematic. Although important investment programs for the maintenance and renovation of aging pipes (usually in some districts of the urban core) have been carried out in 2017 and 2018, investment figures are often smaller in contrast to the cost of the expansion of water supply systems in the growing urban periphery (SEDAPAR, 2017b, 2018). Massive investments in expanding networks also have political motivations and are avidly sought by representatives seeking to increase the number of votes.

Awareness campaigns

In Arequipa, SUNASS and SEDAPAR have issued educational and public programs to promote water conservation. Educational programs at the local level include talks at schools while public information includes public lectures, advertisements in the local media, and leaflets distributed with the bills. After the water emergency was declared in 2016, water managers intensified awareness campaigns. For example, SUNASS started the education program "Good practices for saving drinking water" aimed at students from schools both in the core and in the peripheries of the city (SUNASS, 2018a). Similarly, the local water utility SEDAPAR has launched numerous educational and public information programs, for example, the programs "Every drop counts" or "the Culture of water", targeted schools in the different districts with different consumptions of water. Educational programs are oriented towards promoting more "responsible" behaviors. Through presentations and advertisements in the most popular newspapers, SEDAPAR encourages users to conserve and reduce water consumption, to repair leaks, and replace faulty faucets and other fixtures. In interviews given to local media, the SUNASS coordinator states that the water consumption in Arequipa should be around 100 lpcd (referring to the recommendations by the WHO) (El Buho, 2019b; Prensa Regional, 2019). In sum, awareness campaigns can increase positive attitudes toward water conservation. However, these attitudes may not translate into conservation practices because many households, especially in the peripheral area, already consume relatively little water. Additionally, and related to the above, awareness campaigns appear to be oblivious to the sociodemographic conditions of certain districts populated by poor immigrants from other regions of the country. For example, the *Cono Norte* of Arequipa (Cerro Colorado and Yura districts) is home to both local inhabitants and Andean migrants from Puno and Cuzco. Public water from network systems in *Cono Norte* is partially distributed in the formal urban environment, where the per capita water consumption of its inhabitants is the lowest in contrast to the water consumption of the urban core of Arequipa. However, households in the informal urban area, generally made up of migrants, are excluded from public water services, so they tend to resort to other sources of water supply.

4.5.2. Differences in WDM strategies between core and periphery districts

In table 2 we present the overall survey results on the perception of WDM strategies disaggregated by area (urban core and periphery) and districts. Before discussing responses related to WDM, it is worth noting that, near 50 percent of respondents declared having difficulties in accessing water, although most (72 percent) had water available at their homes. Moreover, nine out of ten respondents reported interruptions in the service.

Table 10. Perception of water demand management (WDM) strategies in Arequipa: Urban Core and periphery districts

Variables	Questions	Answers	Urban Core Districts					Peripheries Districts				Comparison
			N	1 (%)	2 (%)	3 (%)	%	4 (%)	5 (%)	6 (%)	%	*p*-value
Accessibility	Do you have difficulty accessing drinking water?	Yes	**323**	10,8	9,4	9,3	**9,9**	75,7	40	85,4	**74,5**	**0,001**
		No	**398**	89,2	90,6	90,7	**90,1**	24,3	60	14,6	**25,5**	
Availability	Do you have drinking water at home?	Yes	**525**	100,0	100,0	100,0	**100**	44,6	85	41,1	**55,3**	**0,001**
		No	**196**	0,0	0,0	0,0	**0**	55,4	15	58,9	**44,7**	
	Do you have drinking water available 24 hours a day?	Yes	**470**	95,4	97,8	97,7	**96,9**	40,5	82,5	25,3	**40,7**	**0,001**
		No	**251**	4,6	2,2	2,3	**3,1**	59,5	17,5	74,7	**59,3**	
Quality of the Water Service	Have you had any interruptions in the water service?	Yes	**608**	88,5	95,0	93,0	**92,4**	78,4	84,2	96,9	**93,0**	**0,052**
		No	**48**	15,0	9,0	3,0	**7,6**	21,6	15,8	3,1	**7,0**	
Economic Measures: Affordability and Price	Does the price represent a problem for you?	Yes	**244**	23,8	14,9	7,0	**17,2**	36,5	17,5	58,9	**49,9**	**0,001**
		No	**317**	59,2	48,6	44,2	**52,0**	62,2	62,5	24,5	**36,2**	
		Likely	**160**	16,9	36,5	48,8	**30,8**	1,4	20	16,6	**13,9**	
	Would you be affected by an eventual price increase?	Yes	**553**	70,0	76,8	74,4	**74,0**	75,7	62,5	83	**80,8**	**0,241**
		No	**114**	22,3	13,8	20,9	**17,8**	21,6	30	9,1	**12,9**	
		Likely	**54**	7,7	9,4	4,7	**8,2**	2,7	7,5	7,9	**6,3**	
Technological Instruments	Do you have and use water saving devices at home?	Yes	**121**	21,5	23,8	27,9	**23,4**	6,8	22,5	9,5	**10,9**	**0,001**
		No	**328**	38,5	42,5	37,2	**40,4**	58,1	47,5	48,6	**48,3**	
		Don't know	**272**	40,0	33,7	34,9	**36,2**	35,1	30,0	41,9	**40,7**	
Measures Related to Water Awareness	Do you think that the consumption of water should decrease?	Yes	**279**	63,1	53,6	55,8	**57,3**	35,1	37,5	13,8	**20,5**	**0,001**
		No	**321**	27,7	12,7	11,6	**18,1**	62,2	37,5	77,5	**69,2**	
		Sometimes	**121**	9,2	33,7	32,6	**24,6**	2,7	25,0	8,7	**10,3**	
	Do you reuse water at home?	Yes	**495**	66,9	73,5	65,1	**70,1**	74,3	65,0	65,6	**63,9**	**0,207**
		No	**211**	30,0	24,3	30,2	**27,1**	24,3	35,0	32,8	**34,4**	
		Sometimes	**15**	3,1	2,2	4,7	**2,8**	1,4		1,6	**1,7**	
	Who should be responsible for water conservation?	State	**569**	68,5	65,7	69,8	**67,2**	89,2	62,5	94,9	**90,1**	**0,001**
		Private company	**74**	13,8	17,7	7	**15,0**	6,8	27,5	2	**5,3**	
		Citizen	**14**	7,7	0	0	**2,8**	4,1	0	0,3	**1,0**	
		NGO	**64**	10	16,6	23,3	**15,0**	0	10	2,8	**3,6**	

N=number of surveys (N=721); 1=Arequipa D.C.; 2=J.L. Bustamante; 3=Yanahuara; 4=Characato; 5=Sabandía; 6=Yura; (%)=percentage; %=average percentage; *p*-value from Chi-Square=significance level of the comparison between urban core and periphery. Source: Own elaboration from surveys, 2018.

A more detailed analysis by urban area and district reveals statistically significant differences in accessibility, availability, and quality of service. As to accessibility, only 10 percent of respondents in the urban core manifested to have difficulties in accessing water while in the informal districts of the periphery, this figure rose to almost 75 percent. All respondents in the core but only 55 percent in the periphery declared to have water available at their homes (in two of the three informal districts, the proportion was less than 50 percent). Continuous supply was almost universal in the core but much more reduced in the periphery where only 40 percent of respondents enjoyed water 24 hours day (25.3 percent in the poor Yura district). Interruptions in the service were widespread in both areas, although in two of the three districts of the periphery, the percentage of households declaring these interruptions was smaller (78.4 percent in Characato and 84.2 percent in Sabandia) than in the three districts of the urban core (see Table 10).

As to WDM measures, current prices did not represent a problem for 43.1 percent of the respondents, but more than 75 percent declared that price increases would affect the economy of their households. Only 16 percent of all respondents declared to use water-saving devices at home. Regarding water awareness, most respondents argued that water consumption should not decrease, and that water conservation should be a responsibility of the State and not of individual users. Finally, over 70 percent of all respondents manifested to reuse water. Results from Chi-square tests showed significant differences between the urban core and periphery. For example, the current water rate represented a problem for 48 percent of respondents in the urban core and for almost 64 percent of respondents from the peripheral areas. On the other hand, regarding an eventual increase in the rate, there was no significant difference (core and urban periphery), since an eventual increase in the tariff could affect negatively the family income of 74 percent of respondents in the core and of 81 percent in the periphery. Results showed that the option of increasing the water rates to control consumption might cause substantial difficulties in family economies, especially but not only those of the peripheral areas.

The water administrators of Arequipa indicated that, contrary to that perception, the increase in tariffs through increasing block rates (IBR) was fair, since IBR sets a relatively moderate price for the first consumption block and higher prices for the second and third blocks (Interview with representatives of SEDAPAR and SUNASS, and with the executive manager of AUTODEMA, 2018). Water managers claimed that poor inhabitants consuming less water paid less than wealthy inhabitants consuming larger volumes. In this sense, a representative of SUNASS argued that: "the population must understand that behind tap water there is a very big cost. In this sense,

the block tariff structure makes possible for the water utility to recover investments" (interview with a representative of SUNASS, November 2018). Along the same lines, it was also mentioned that:

> *The block tariff structure makes it easy for users to pay a different price, for example, the first consumer block has a special rate and is aimed at low-income citizens. Likewise, the rate structure will also allow the incorporation of payment for ecosystem services* (Interview with a representative of SEDAPAR, October 2018).

Authors such as Griffin & Mjelde (2011) and Liu et al., (2003) point out that the use of the IBR without considering the size of the household may deepen inequities. In Arequipa, the size of households in the urban core (districts of Arequipa DC, Yanahuara, and Bustamante) is relatively small for water consumption of 22 m^3/household/month. In contrast, the size of households in the peripheral area (Yura, Characato, and Sabandia) is relatively large for water consumptions that can attain an average of 13 m^3/household/month (SEDAPAR, 2019b). According to these data, water consumption in both areas falls in the second block (10-30 m^3), but the economic impact is much higher for poorer households of the peripheral areas. This would explain the dissatisfaction of the poorer inhabitants of the periphery neighborhoods with the current tariff structure. From Griffin & Mjelde (2011) and Liu et al., (2003), as well as from previous research on the distributional effects of WDM measures (Duke, Ehemann, & Mackenzie, 2002; Renwick & Archibald, 1998), it could be argued that the recovering of investment costs, and the objectives of efficiency and financial security in Arequipa through higher prices sought by the water utility may be met at least in part at the expense of poor households. On the other hand, block pricing does not apply to households in peripheral areas not connected to the network who pay more for their water consumption, up to, on average, 3.36 US$/$m^3$ (Interview with presidents of Salud del Sur and Villa Tambo Housing Associations, 5 November 2018). Moreover, there were also complaints about the quality of non-network water:

> *We are abandoned by public institutions that manage water… this water is not only more expensive than the water supplied in the urban core but is of poor quality. The water we buy is sometimes dirty, but we are told that it can be drunk* (Interviews with members of Salud del Sur and Villa Tambo Housing Associations, 5 November 2018).

"We are abandoned by public institutions that manage water… this water is not only more expensive than the water supplied in the urban core but is of poor quality. The water we buy is sometimes dirty, but we are told that it can be drunk" (Interviews with members of Salud del Sur and Villa Tambo Housing Associations, 5 November

2018).

Regarding technology, the survey asked whether households used improved technological devices to save water. Results reported significant differences between the urban core and the periphery (see Table 10). 23 percent of respondents in the core district used these devices. In comparison, in the peripheral areas, this figure was only 10.9 percent. In sum, an overwhelming proportion of households in both areas did not pursue this strategy. Reasons for the limited use of water-efficient domestic technology may be related to the lack of subsidies or interest-free loans for the purchase of water-saving devices. For example, 40.4 percent (urban core) and 48.3 percent of respondents stated that they did not use these devices due to their high cost. Likewise, users in the periphery were skeptical about water-saving technology because their main concern was the improvement of the quantity and quality of water supplied to them (Interviews with members of Salud del Sur and Villa Tambo Housing Associations, November 2018).

These answers may reflect the numerous limitations that water supply suffers both in the core and in the urban periphery. This means that the need for technological improvements in the public water network was perceived as far more critical than the need for technological improvements at the household scale. In the urban core, 9.9 percent of households had experienced occasional difficulties accessing network water, and 92.4 percent indicated that the water service suffered interruptions (see Table 10). Meanwhile, in the peripheral area, 74.5 percent of households stated that they had difficulties in accessing water, 44.7 percent that they did not have potable water in their homes, 59.3 percent that they did not have water service 24 hours a day, and 93 percent that the service was affected by interruptions (see Table 10). These interruptions were frequent due to physical causes such as broken pipes (El Comercio, 2019). In this sense, a representative from SUNASS noted that:

> *The difficulties of access to water have to do with rapid urbanization. There is an urban population that has settled above the level of the origin of the drinking water plant. This situation not only increases supply costs but also makes it difficult to supply water. However, the population continues to grow in these sectors* (Interview with a representative of SUNASS, November 2018).

According to the results, the implementation of water-saving measures may be hampered by the costs of technological devices that can exceed family income and the interruptions in the water supply that can difficult the performance of these devices. Likewise, results show that technological measures to reduce water consumption were seen as a responsibility of the water utility and not of individual households because of the deficient operation of the public network. In general, although water managers encourage users to install water-saving devices, it is likely that these efforts, although probably increasing the motivation of users, fail to materialize due to the various constraints discussed above. In this respect, Iribarnegaray et al. (2014) in Salta (Argentina) and Araral & Wang (2013), and Lavee et al. (2013) in other fast-growing cities show how technological measures alone cannot achieve the objectives of reducing water consumption. More attention to service interruptions starting with the renovation of aging pipes and subsidies for purchasing water-saving equipment may be attractive for the inhabitants of the urban core. For the urban periphery, promoting access to water-saving equipment for the poor was less relevant than reducing interruptions in water supply, recognizing informal supply practices, or encouraging the improvement of existing traditional water-saving and reuse practices. As a matter of fact, the reuse of water in homes was a common practice with no significant differences between the urban core and the periphery (see Table 10). In Arequipa, 70.1 percent (urban core) and 63.9 percent (peripheral areas) of respondents stated that they reused water in their homes. The final purpose of reused water varied between the urban core and the peripheries. In the urban core, the cleaning of floors and the entrance to buildings was the most frequent use followed by garden irrigation. In the peripheries, general house cleaning and, above all, toilet flushing was the most mentioned.

Regarding awareness measures, the survey asked whether residents should reduce their water consumption since this was the main objective of awareness campaigns promoted by water managers in Arequipa (SEDAPAR, SUNASS, and AUTODEMA), especially after the drought episode of 2016 (RPP, 2016). As the executive manager of AUTODEMA argued:

> *Although the water consumption figure in Arequipa is lower than the average of 250 lpcd in Tacna, with the awareness campaigns it is desired to reduce consumption from 136 lpcd (average population use) to 110 lpcd in Arequipa. This figure would be optimal for population use* (Interview with, executive manager of AUTODEMA, 5 October 2018).

In this respect, the responses showed significant differences between the urban core and periphery (Table 2). For example, 57.3 percent of those surveyed in the urban core felt that water consumption by citizens of Arequipa should decrease, but only 20.5 percent of those surveyed in the peripheral area believed the same. However, although awareness campaigns seem to increase the interest of the inhabitants, especially of the urban core towards reducing water consumption, these initiatives could also face significant degrees of public resistance , partly because awareness campaigns ignore the different socio-demographic characteristics of the Arequipa districts, as observed in other locations ranging from Salta, Argentina (Iribarnegaray et al., 2014) to Blagoevgrad, Bulgaria, (Clark & Finley, 2007) among other examples (Kingdom et al., 2006).

67.2 percent of the inhabitants of the core and 90.1 percent of the inhabitants of peripheral areas believed that water conservation should be the responsibility of the State. In comparison, only 2.8 percent of the inhabitants of the urban core and 1 percent of peripheral areas believed that water conservation should be the responsibility of the citizens. Again, this appears to imply the general state of dissatisfaction with the public network and the need to improve city water infrastructures and practices in conserving water before asking for similar efforts from the citizens.

Although a large proportion of inhabitants (63.1 percent) of the Arequipa district (urban core) seemed enthusiastic about reducing water consumption, there are doubts as to whether the inhabitants of these sectors can effectively curb their consumption (see Table 10). This action requires significant efforts at the household level, for example, replacing conventional water-saving devices with more efficient ones when 78.5 percent (of Arequipa DC) do not use these devices. Likewise, awareness campaigns do not seem to have significantly affected the districts of the peripheral areas where only 20 percent of respondents believed that they should use less water. Although respondents from Characato (35.1 percent) and Sabandía (37.5 percent) were optimistic about reducing water consumption, these districts faced significant challenges in accessing water (CAF, 2018).

Awareness campaigns usually assume that water consumption is homogeneous, without considering the significant differences in consumption within cities (March & Sauri, 2017; Sauri, 2019) and the fact that especially in the informal, low-income settlements, that rely on non-networked sources, water consumption is already low (Kooy & Bakker, 2008). Awareness campaigns may be more effective in urban cores, since according to Martínez-Espiñeira & García-Valiñas (2012), households with higher incomes may incorporate water conservation practices, while low-income households tend to have already stronger water conservation habits. In any case, to achieve their objectives, it will be necessary for the water utility to guarantee quality service without interruptions in the service.

Finally, in the survey, responders from both core and periphery neighborhoods call for greater efforts by the water company to solve the numerous deficiencies associated with the networked water service while the company insists on mandatory (pricing) and voluntary (awareness campaigns) to stimulate water savings. Neighbors hold the company responsible for not attending efficiently to demands by consumers about improvements in the provision of water. On its part, the company tends to transfer to citizens the bulk of the responsibility to reduce water consumption given the continuous problems in ensuring sufficient, reliable, and secure supplies of network water.

4.6. Conclusions

Water demand management (WDM) has been praised as a tool to curb excessive water consumption. WDM uses economic, technological, and awareness instruments to achieve reductions in consumption, increase efficiency and, according to its proponents, promote intra and intergenerational equity. However, when WDM strategies are to be applied in cities with strong urban disparities between planned and formal areas and unplanned and informal areas they should consider the socio-economic conditions of the populations targeted, and especially, the uneven urban socio-spatial configurations.

One important question is to discern whether and to what extent patterns of water consumption per capita vary according to the urban layout (planned and unplanned) of the city mostly because access to water from the public network will be determined by the location of households either in the planned, legal, formal city or in the unplanned, alegal and informal city. A critical difference between the core and the peripheral areas is that in the planned and high-density urban core water supply is safe and universal. Contrarily, in the unplanned, low-density peripheries, access to public networks is not universal, and the sources of water supply are more heterogeneous, more limited, less reliable, and comparatively more expensive. As mentioned in the introduction, we have used in the paper the binary core/planned and peripheral/unplanned areas as a heuristic device to highlight the dramatic different realities of water supply in cities of the Global South. But this should not be interpreted as understanding informal areas as undifferentiated and monolithic realities. Rather we must acknowledge that informal areas may involve different socio-economic structures and different materialities of everyday life, including different degrees of dependence towards the non-networked water source. Hence WDM strategies should be aware of such differences to work towards reducing the uneven patterns of water access in informal areas.

In Arequipa, WDM strategies (economic, technological, and awareness strategies) have important limitations. For example, although not always, the economic measures that are preferred by local water managers are based on the increasing block rates with differentiated prices for each block. This is supposed to foster efficiency, reduce consumption and improve equity, assuming that more affluent households would pay more because they consume more water than poorer households. However, in the case of the six districts of Arequipa included in the survey, households of the more prosperous urban core and households of the more impoverished peripheries connected to the public network; fall in the same consumption blocks because the latter have more members. Hence, and paradoxically, the objectives of efficiency and financial security sought by the water utility may be met at least in part at the expense of the poorer households.

Likewise, in the six districts of Arequipa studied, technological measures that promote water consumption efficiency are used only by a small group of urban core households. Leaving aside the lack of public subsidies to install water-saving devices at home, most households in the core and the periphery believe that, prior to domestic water-saving technology, an effort must be made by SEDAPAR to repair leaks, limit the frequent interruptions of the service and provide sufficient water pressure, especially in the periphery areas.

Last, awareness campaigns such as that launched on the occasion of the water crisis of 2016 in the city seem to have a more considerable influence in the urban core where the water supply is more universal. In the peripheral area where the water supply is more heterogeneous (network, pylons for public use, water trucks, wells), awareness campaigns lose relevance, since water consumption per capita is already low. Moreover, messages may be insensitive to the reality of water use by poor, immigrant populations.

In sum, results for the case of Arequipa appear to indicate that Water Demand Management (WDM) shows limitations as a feasible policy option given the difficulties in having access to safe and reliable water from public networks. As in other cities fast-growing cities with a strong duality of formal and informal areas, it is fair to acknowledge the progress made in the universalization of water supply and sanitation, but, as the case of Arequipa shows, the universalization of water services may be plagued with difficulties requiring substantial investments while certain districts must rely on other, more problematic sources. Finally, water reuse is not generally included in WDM strategies at least explicitly. The fact that water conservation is practiced may imply that the most important objective of WDM is already met without a need to increase prices to make people more water responsible.

4.7. References

Adams, E. A. (2018). Thirsty slums in African cities: household water insecurity in urban informal settlements of Lilongwe, Malawi. *International Journal of Water Resources Development*, *34*(6), 869–887. https://doi.org/10.1080/07900627.2017.1322941

Adler, I. (2011). Domestic water demand management: Implications for Mexico city. *International Journal of Urban Sustainable Development*, *3*(1), 93–105. https://doi.org/10.1080/19463138.2011.567085

Ahlers, R., Cleaver, F., Rusca, M., & Schwartz, K. (2014). Informal space in the urban waterscape: Disaggregation and co-production of water services. *Water Alternatives*, *7*(1), 1–14. Retrieved from https://www.water-alternatives.org/index.php/alldoc/articles/vol7/v7issue1/230-a7-1-1

Andersen, A. O. (2016). Infrastructures of progress and dispossession: Collective responses to shrinking water access among farmers in Arequipa, Peru. *Focaal-Journal of Global and Historical Anthropology*, *3*(74), 28–41. https://doi.org/10.3167/fcl.2016.740103

AQUASTAT - FAO. (2015). AQUASTAT - FAO's Global Information System on Water and Agriculture. Retrieved March 24, 2020, from FAO website: http://www.fao.org/aquastat/es/databases/dams

Araral, E. (2009). The failure of water utilities privatization: Synthesis of evidence, analysis and implications. *Policy and Society*, *27*(3), 221–228. https://doi.org/10.1016/j.polsoc.2008.10.006

Araral, E., & Wang, Y. (2013). Water demand management: review of literature and comparison in South-East Asia. *International Journal of Water Resources Development*, *29*(3), 434–450. https://doi.org/10.1080/07900627.2013.826413

Autoridad Nacional del Agua. (2019). Demanda de Uso. Retrieved March 24, 2020, from Ministerio de Agricultura y Riego website: https://www.ana.gob.pe/2019/consejo-de-cuenca/quilca-chili/DU

Baerenklau, K. A., Schwabe, K. A., & Dinar, A. (2014). Do Increasing Block Rate Water Budgets Reduce Residential Water Demand ? A Case Study in Southern California. *Agricultural & Applied Economics Association's 2014 AAEA Annual Meeting, Minneapolis, MN, July 27-29, 2014*, 1–22. Retrieved from https://escholarship.org/uc/item/3kf28290#main

Bakker, K. (2003). Archipelagos and networks: urbanization and water privatization in the South. *The Geographical Journal*, *169*(4), 328–341. https://doi.org/10.1111/j.0016-7398.2003.00097.x

Bakker, K. (2007). Trickle Down? Private sector participation and the pro-poor water supply debate in Jakarta, Indonesia. *Geoforum*, *38*(5), 855–868. https://doi.org/10.1016/J.GEOFORUM.2005.11.011

Barde, J. A., & Lehmann, P. (2014). Distributional effects of water tariff reforms - An empirical study for Lima, Peru. *Water Resources and Economics*, *6*(5–8), 30–57. https://doi.org/10.1016/j.wre.2014.05.003

Bayer, A. M., Hunter, G. C., Gilman, R. H., Cornejo, J. G., Bern, C., & Levy, M. Z. (2009). Chagas Disease , Migration and Community Settlement Patterns in Arequipa , Peru. *PLoS Neglected Tropical Diseases*, *3*(12). https://doi.org/10.1371/journal.pntd.0000567

BCR. (2016). Informe Económico y Social Región Arequipa. In *BCR*. Retrieved from https://www.bcrp.gob.pe/docs/Proyeccion-Institucional/Encuentros-Regionales/2016/arequipa/ies-arequipa-2016.pdf

Boland, J. J., & Whittington, D. (2000). The political economy of water tariff design in developing countries: IBTs versus uniform price with rebate. In A. Dinar (Ed.), *The Political Economy of Water Pricing Reforms* (pp. 215–235). Retrieved from http://documents1.worldbank.org/curated/en/199301468771050868/pdf/multi-page.pdf

Braga, B., & Kelman, J. (2020). Facing the challenge of extreme climate: the case of Metropolitan Sao Paulo. *International Journal of Water Resources Development*, *36*(2–3), 278–291. https://doi.org/10.1080/07900627.2019.1698412

Brichetti, J.-P. (2019). *Panorama de las tarifas de agua en los países de Latinoamérica y el Caribe*. Retrieved from https://publications.iadb.org/publications/spanish/document/Panorama_de_las_tarifas_de_agua_en_los_países_de_Latinoamérica_y_el_Caribe_es_es.pdf

Brooks, D. B. (2006). An operational definition of water demand management. *International Journal of Water Resources Development*, *22*(4), 521–528. https://doi.org/10.1080/07900620600779699

Butler, D., & Memon, F. (2006). Water demand management. In *IWA Publishing*. Retrieved from https://cataleg.uab.cat/iii/encore/record/C__Rb1656099__SWater Demand Management__Orightresult__U__X7?lang=cat

CAF. (2018). Vulnerabilidad y adaptación al cambio climático en Arequipa Metropolitana. In CAF (Ed.), *CAF* (1st ed.). https://doi.org/scioteca.caf.com/handle/123456789/1181

Calderon-Cockburn, J. (2017). La insoportable levedad de la planificación urbana y lo legal informal en el Perú. In *La informalidad en Perú* (pp. 221–235). Retrieved from http://www.desco.org.pe/recursos/site/files/CONTENIDO/1118/12_Calderon_PHj17.pdf

Castro, M., & Riofrio, G. (1996). La regularización de las barriadas: el caso de Villa El Salvador (Perú). In A. Azuela & F. Tomas (Eds.), *Centro de estudios mexicanos y centroamericanos* (pp. 45–88). https://doi.org/10.4000/books.cemca.923

Clark, W. A., & Finley, J. C. (2007). Determinants of Water Conservation Intention in Blagoevgrad, Bulgaria. *Society & Natural Resources*, *20*(7), 613–627. https://doi.org/10.1080/08941920701216552

Cohen, B. (2006). Urbanization in developing countries: Current trends, future projections, and key challenges for sustainability. *Technology in Society*, *28*(1–2), 63–80. https://doi.org/10.1016/j.techsoc.2005.10.005

Constantine, K., Massoud, M., Alameddine, I., & El-Fadel, M. (2017). The role of the water tankers market in water stressed semi-arid urban areas:Implications on water quality and economic burden. *Journal of Environmental Management*, *188*, 85–94. https://doi.org/10.1016/j.jenvman.2016.11.065

Crow-Miller, B., Webber, M., & Molle, F. (2017). The (Re)turn to Infrastructure for Water Management? *Water Alternatives*, *10*(2), 195–207. Retrieved from www.water-alternatives.org

Donoso, G. (2015). Water Pricing in Chile: Decentralization and Market Reforms. In A. Dinar, V. Pochat, & J. Albiac-Murillo (Eds.), *Water Pricing Experiences and Innovations* (Vol. 9, pp. 83–96). https://doi.org/10.1007/978-3-319-16465-6_5

Dovey, K. (2015). Sustainable Informal Settlements? *Procedia Social and Behavioral Sciences*, *179*, 5–13. https://doi.org/10.1016/j.sbspro.2015.02.406

Duke, J. M., Ehemann, R. W., & Mackenzie, J. (2002). The distributional effects of water quantity management strategies: A spatial analysis. *Review of Regional Studies*, *32*(1), 19–35. Retrieved from https://ideas.repec.org/a/rre/publsh/v32y2002i1p19-35.html

El Buho. (2019a). Arequipa: El 40% de tuberías necesitan ser cambiadas por antigüedad. Retrieved May 4, 2020, from El Buho website: https://elbuho.pe/2019/12/arequipa-el-40-de-tuberias-necesitan-ser-cambiadas-por-antiguedad/

El Buho. (2019b). Sedapar: las tarifas de agua potable subirán en Arequipa a inicios del año 2020. Retrieved September 9, 2020, from El Buho website: https://elbuho.pe/2019/03/sedapar-tarifas-de-agua-subiran-arequipa/

El Comercio. (2019). Arequipa: 200 mil personas se quedan sin agua por rotura de tubería Arequipa. *El Comercio*, p. 1. Retrieved from https://elcomercio.pe/peru/arequipa/arequipa-200-000-pobladores-quedan-servicio-agua-rotura-tuberia-noticia-nndc-598579-noticia/?ref=ecr

Fernández, D. (2015). Water Pricing in Colombia: From Bankruptcy to Full Cost Recovery. In A. Dinar, V. Pochat, & J. Albiac-Murillo (Eds.), *Water Pricing Experiences and Innovations* (Vol. 9, pp. 117–138). https://doi.org/10.1007/978-3-319-16465-6_7

Filippi, M. E., Hordijk, M., Alegría, J., & Rojas, J. D. (2014). Knowledge integration: A step forward? Continuities and changes in Arequipa's water governance system. *Environment and Urbanization*, *26*(2), 525–546. https://doi.org/10.1177/0956247814539233

Garden, T. Van. (1989). Collective organization and action in squatter settlements in Arequipa, Perú. In F. Schuurman & T. Van Naerssen (Eds.), *Urban Social Movements in the Third World* (First Edit, pp. 27–44). Retrieved from https://books.google.es/books?hl=es&lr=&id=KFrRhIpzjzQC&oi=fnd&pg=PA27&dq=settlement+of+pueblo+joven+in+arequipa&ots=TSROaLMLcb&sig=U6hdg18ut6OG-SHGLCmnq-qsToA#v=onepage&q=settlement of pueblo joven in arequipa&f=false

Graham, S., & Marvin, S. (2001). Splintering Urbanism: Networked Infrastructures, Technological Mobilities, and the Urban Condition. In *Technology and Culture* (1st ed., Vol. 43). https://doi.org/10.1353/tech.2002.0124

Griffin, R. C., & Mjelde, J. W. (2011). Distributing water's bounty. *Ecological Economics*, *72*, 116–128. https://doi.org/10.1016/j.ecolecon.2011.09.013

Grigg, N. S. (2019). Global water infrastructure: state of the art review. *International Journal of Water Resources Development*, *35*(2), 181–205. https://doi.org/10.1080/07900627.2017.1401919

Gumbo, B. (2004). The status of water demand management in selected cities of southern Africa. *Physics and Chemistry of the Earth*, *29*, 1225–1231. https://doi.org/10.1016/j.pce.2004.09.029

Horne, J., Tortajada, C., & Harrington, L. (2018). Achieving the Sustainable Development Goals: improving water services in cities affected by extreme weather events. *International Journal of Water Resources Development*, *34*(4), 475–489. https://doi.org/10.1080/07900627.2018.1464902

Huber, J. (2000). Towards industrial ecology: sustainable development as a concept of ecological modernization. *Journal of Environmental Policy and Planning*, *2*(4), 269–285. https://doi.org/10.1080/714038561

IMPLA. (2016). Plan de Desarrollo Metropolitano 2016-2025. Retrieved April 1, 2020, from Instituto Municipal de Planeamiento website: http://impla.gob.pe/publicaciones/pdm-2016-2025/

INEI. (2017). Arequipa: nota de prensa. Retrieved March 24, 2020, from INEI website: https://www.inei.gob.pe/prensa/noticias/arequipa-alberga-a-1-millon-316-mil-habitantes-9903/

INEI. (2019). *Anuario de Estadisticas Ambientales* (INEI, Ed.). Retrieved from https://www.inei.gob.pe/media/MenuRecursivo/publicaciones_digitales/Est/Lib1704/libro.pdf

Instituto Nacional de Estadistica e Informática. (2017). Censos Nacionales 2017: XII de Población, VII de Vivienda y III de Comunidades Indígenas. *Instituto Nacional de Estadistica e Informática (INEI)*. Arequipa.

Iribarnegaray, M. A., De La Zerda, M. F. E., Hutton, C. M., Brannstrom, C., Liberal, V. I., Tejerina, W., & Seghezzo, L. (2014). Water-conservation policies in perspective: Insights from a Q-method study in Salta, Argentina. *Water Policy*, *16*(5), 897–916. https://doi.org/10.2166/wp.2014.159

Jänicke, M. (2008). Ecological modernisation: new perspectives. *Journal of Cleaner Production*, *16*(5), 557–565. https://doi.org/10.1016/j.jclepro.2007.02.011

Kaika, M. (2003). Constructing scarcity and sensationalising water politics: 170 Days that shook Athens. *Antipode*, *35*(5), 919–954. https://doi.org/10.1111/j.1467-8330.2003.00365.x

Kingdom, B., Liemberger, R., & Marin, P. (2006). The Challenge of Reducing Non-Revenue Water (NRW) in Developing Countries How the Private Sector Can Help: A Look at Performance-Based Service Contracting. In *World Bank*. Washington: World Bank.

Kooy, M., & Bakker, K. (2008). Splintered networks: The colonial and contemporary waters of Jakarta. *Geoforum*, *39*(6), 1843–1858. https://doi.org/10.1016/J.GEOFORUM.2008.07.012

La Repúbica. (2019). Arequipa: Servicio de agua potable se restringe en el 60% de Arequipa por lluvias. *La República*, p. 1. Retrieved from https://larepublica.pe/sociedad/1408671-arequipa-servicio-agua-potable-restringe-60-arequipa-lluvias/

Lavee, D., Danieli, Y., Beniad, G., Shvartzman, T., & Ash, T. (2013). Examining the effectiveness of residential water demand-side management policies in Israel. *Water Policy*, *15*(4), 585–597. https://doi.org/10.2166/wp.2013.146

Lee, E. J., & Schwab, K. J. (2005, June 1). Deficiencies in drinking water distribution systems in developing countries. *Journal of Water and Health*, Vol. 3, pp. 109–127. https://doi.org/10.2166/wh.2005.0012

Liemberger, R., & Wyatt, A. (2019). Quantifying the global non-revenue water problem. *Water Science and Technology: Water Supply*, *19*(3), 831–837. https://doi.org/10.2166/ws.2018.129

Liu, J., Savenije, H. H. G., & Xu, J. (2003). Water as an economic good and water tariff design Comparison between IBT-con and IRT-cap. *Physics and Chemistry of the Earth*, *28*(4–5), 209–217. https://doi.org/10.1016/S1474-7065(03)00027-5

March, H., & Sauri, D. (2017). When sustainable may not mean just: a critical interpretation of urban water consumption decline in Barcelona. *Local Environment*, *22*(5), 523–535. https://doi.org/10.1080/13549839.2016.1233528

Martínez-Espiñeira, R., & García-Valiñas, M. Á. (2012). Adopting versus adapting: adoption of water-saving technology versus water conservation habits in Spain. *International Journal of Water Resources Development*, *29*(3), 400–414. https://doi.org/10.1080/07900627.2012.721695

Mayer, P., DeOreo, W., Chesnutt, T., & Summers, L. (2008). Water budgets and rate structures: Innovative management tools. *Journal / American Water Works Association*, *100*(5). https://doi.org/10.1002/j.1551-8833.2008.tb09636.x

McKenzie, R. (2018). Why intermittent supplies are no answer to cities hit by drought. Retrieved April 24, 2020, from International Water Asociation website: https://www.thesourcemagazine.org/why-intermittent-supplies-are-no-answer-to-cities-hit-by-drought/

Misra, K. (2014). From formal-informal to emergent formalisation: Fluidities in the production of urban waterscapes. *Water Alternatives*, *7*(1), 15–34. Retrieved from http://www.water-alternatives.org/index.php/volume7/v7issue1/231-a7-1-2/file

Mitlin, D., Beard, V. A., Satterthwaite, D., & Du, J. (2019). Unaffordable and Undrinkable: Rethinking Urban Water Access in the Global South. In *World Resources Institute*. Retrieved from https://www.wri.org/wri-citiesforall/cities-all

Molinos-Senante, M., & Donoso, G. (2016). Water scarcity and affordability in urban water pricing: A case study of Chile. *Utilities Policy*, *43*, 107–116. https://doi.org/10.1016/j.jup.2016.04.014

Montoya, J., Cartes, I., & Zumelzu, A. (2020). Indicators for evaluating sustainability in Bogota's informal settlements: Definition and validation. *Sustainable Cities and Society*, *53*, 1–7. https://doi.org/10.1016/j.scs.2019.101896

Muñoz, A. (2018). Movimiento de pobladores , desarrollo urbano y gobernabilidad local: situación y desafíos en el cono norte de Arequipa. In *Movimientos sociales, actores y representación política* (pp. 259–275). Retrieved from http://www.desco.org.pe/recursos/site/files/CONTENIDO/1248/13_PH_muñoz_dic18.pdf

Mutikanga, H. E., Sharma, S., & Vairavamoorthy, K. (2009). Water loss management in developing countries: Challenges and prospects. *American Water Works Association*, *101*(12), 57–68. https://doi.org/10.1002/j.1551-8833.2009.tb10010.x

Mwakalila, S. (2007). Residents' perceptions of institutional performance in water supply in Dar es Salaam. *Physics and Chemistry of the Earth*, *32*(15–18), 1285–1290. https://doi.org/10.1016/j.pce.2007.07.037

Ojeda de la Cruz, A., Alvarez-Chavez, C. R., Ramos-Corella, M. A., & Soto-Hernandez, F. (2017). Determinants of domestic water consumption in Hermosillo, Sonora, Mexico. *Journal of Cleaner Production*, *142*(4), 1901–1910. https://doi.org/10.1016/j.jclepro.2016.11.094

Pflieger, G., & Matthieussent, S. (2008). Water and power in Santiago de Chile: Socio-spatial segregation through network integration. *Geoforum*, *39*(6), 1907–1921. https://doi.org/10.1016/j.geoforum.2008.09.001

Prensa Regional. (2019). Arequipa: prevén incremento de las tarifas de agua potable para el 2020. Retrieved September 9, 2020, from Prensa Regional website: https://www.prensaregional.pe/arequipa-preven-incremento-de-las-tarifas-de-agua-potable-para-el-2020/

Renwick, M. E., & Archibald, S. O. (1998). Demand side management policies for residential water use: who bears the conservation burden? *Land Economics*, *74*(3), 343–359. https://doi.org/10.2307/3147117

Rogers, P., De Silva, R., & Bhatia, R. (2002). Water is an economic good: How to use prices to promote equity, efficiency, and sustainability. In *Water Policy* (Vol. 4).

RPP. (2016). Declaran en emergencia uso de agua poblacional en Arequipa. Retrieved May 28, 2020, from RPP website: https://rpp.pe/peru/arequipa/declaran-en-emergencia-uso-de-agua-poblacional-en-arequipa-noticia-998432?ref=rpp

Rusca, M., Boakye-Ansah, S. A., Loftus, A., Ferrero, G., & van der Zaag, P. (2017). An interdisciplinary political ecology of drinking water quality. Exploring socio-ecological inequalities in Lilongwe's water supply network. *Geoforum*, *84*, 138–146. https://doi.org/10.1016/j.geoforum.2017.06.013

Sauri, D. (2013). Water Conservation: Theory and Evidence in Urban Areas of the Developed World. *Annual Review of Environment and Resources*, *38*(1), 227–248. https://doi.org/10.1146/annurev-environ-013113-142651

Sauri, D. (2019). The decline of water consumption in Spanish cities: structural and contingent factors. *International Journal of Water Resources Development*, *36*(6), 1–17. https://doi.org/10.1080/07900627.2019.1634999

Saurí, D. (2003). Lights and shadows of urban water demand management: The case of metropolitan region of Barcelona. *European Planning Studies*, *11*(3), 229–243. https://doi.org/10.1080/09654310303639

Savenije, H., & Van Der Zaag, P. (2002). International Water Resources Association Water as an Economic Good and Demand Management Paradigms with Pitfalls. In *Water International* (Vol. 27).

SEDAPAR. (2017a). Expediente tecnico: renovación de redes de agua potable y alcantarillado de la calle José Antonio Taboada, Distritos Sachaca y Yanahuara, Provincia y Departamento de Arequipa. *Water and Sewer Services of Arequipa (SEDAPAR)*. Arequipa.

SEDAPAR. (2017b). Memoria Anual 2017. In *SEDAPAR*. Arequipa.

SEDAPAR. (2018). MEMORIA ANUAL 2018. In *SEDAPAR*. Arequipa.

SEDAPAR. (2019a). Facturación histórica de pensiones de agua potable y alcantarillado-Arequipa Metropolitana. *Water and Sewer Services of Arequipa (SEDAPAR)*. Retrieved from www.sedapar.com

SEDAPAR. (2019b). Memoria Anual 2019. In *Sedapar*.

Sharma, S. K., & Vairavamoorthy, K. (2009). Urban water demand management: Prospects and challenges for the developing countries. *Water and Environment Journal*, *23*(3), 210–218. https://doi.org/10.1111/j.1747-6593.2008.00134.x

Soyinka, O., Wai, K., & Siu, M. (2018). Urban informality, housing insecurity, and social exclusion; concept and case study assessment for sustainable urban development. *City, Culture and Society*, *15*, 23–36. https://doi.org/10.1016/j.ccs.2018.03.005

Spaargaren, G., & Mol, A. P. J. (1992). Sociology, environment, and modernity: Ecological modernization as a theory of social change. *Society and Natural Resources*, *5*(4), 323–344. https://doi.org/10.1080/08941929209380797

Superintendencia Nacional de Servicios de Saneamiento. (2014a). Determinación de la fórmula tarifaria, estructura tarifaria y metas de gestión aplicables a SEDAPAR S.A. para el quinquenio 2015-2020. Retrieved from SUNASS website: http://repositorio.sunass.gob.pe/handle/uss/45

Superintendencia Nacional de Servicios de Saneamiento. (2014b). Metas de gestión, fórmula tarifaria y estructura tarifaria correspondiente al quinquenio 2015- 2020, para los servicios de agua potable y alcantarillado que brinda SEDAPAR S.A. *El Peruano*. Retrieved from https://www.sunass.gob.pe/doc/normas legales/2014/re36_2014cd.pdf

Superintendencia Nacional de Servicios de Saneamiento. (2018). Situación del agua no facturada en operadores de América Latina. *SUNASS*, p. 6. Retrieved from https://www.sunass.gob.pe/tallerBench2018/Publicaciones/4aderasa.pdf

The Business Year. (2015). Eruption of Activity: Perú 2015. Retrieved August 20, 2020, from Economy website: https://www.thebusinessyear.com/peru-2015/eruption-of-activity/focus

Tortajada, C. (2006). Water Management in Singapore. *International Journal of Water Resources Development*, *22*(2), 227–240. https://doi.org/10.1080/07900620600691944

Tortajada, C., & Biswas, A. K. (2017). The rapidly changing global water management landscape. *International Journal of Water Resources Development*, *33*(6), 849–851. https://doi.org/10.1080/07900627.2017.1376834

Tortajada, C., González-Gómez, F., Biswas, A. K., & Buurman, J. (2019). Water demand management strategies for water-scarce cities: The case of Spain. *Sustainable Cities and Society*, *45*, 649–656. https://doi.org/10.1016/j.scs.2018.11.044

UNESCO. (2015). *The United Nations World Water Development Report 2015: Water for a Sustainable World* (UNESCO, Ed.). Retrieved from http://www.unwater.org

United Nations. (2018). Las ciudades seguirán creciendo, sobre todo en los países en desarrollo. Retrieved June 14, 2019, from UN website: https://www.un.org/development/desa/es/news/population/2018-world-urbanization-prospects.html

Vuille, M., Francou, B., Wagnon, P., Juen, I., Kaser, G., Mark, B. G., & Bradley, R. S. (2008). Climate change and tropical Andean glaciers: Past, present and future. *Earth-Science Reviews*, *89*(3–4), 79–96. https://doi.org/10.1016/j.earscirev.2008.04.002

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Chapter 5

Water supply in times of Covid-19: The role of "formal and informal" water providers and collective action in Arequipa

Abstract

The arrival of Covid-19 in Peru implied strict confinement. Yet, essential public services, such as water supply, continued to operate. We explore the responses of (in)formal water providers to guarantee supply during the first wave of the pandemic and the differences between the urban core and periphery in Arequipa. While the public company implemented installment payment , suspension of water shutoffs, and the distribution of free water for unpiped homes; these efforts were limited by frequent interruptions. By contrasting our findings with other cities of the Global South we shed light on the challenges and innovative responses implemented during the pandemic.

5.1. Introduction

Water and sanitation services constitute a fundamental element for societal development and well-being. In emergencies situations (natural disasters, pandemics, etc.) their relevance is much more evident. In December 2019, a new infectious respiratory disease (Covid-19), caused by the Severe Acute Respiratory Syndrome coronavirus 2 (SARS-CoV-2), was first discovered in Wuhan (China). Covid-19 spread rapidly around the globe. On January 30, 2020, the World Health Organization (WHO) declared a public health emergency of international concern and on March 11, the disease caused by Covid-19 was declared a global pandemic. To curb the spread of Covid-19, various regions and countries advocated for social distancing measures, including quarantine measures. Many companies and public services temporarily shut down their activities to reduce the rate of transmission of the virus. Although the focus of attention was centered on public health (World Health Organization, 2020), it was also critical to ensure the operations of essential services, such as water supply and sanitation, especially in cities of the Global South where the urban water landscape is usually fragmented (Truelove, 2019). In these cities, water utilities only serve approximately 70 percent of the urban dwellers (Ahlers et al., 2014). Moreover, in many countries, the proportion of urban households receiving piped water appears to have declined (Satterthwaite, 2016). Thus, formal water networks (public and private) coexist, complement, and overlap with "informal" supply systems such as tanker trucks, public pylons, or wells.

The objective of this paper is to analyze how different actors involved in water supply, including water utilities, local organizations, and informal water providers in cities from the Global South respond to the health emergency caused by the Covid-19 pandemic. After reviewing the still-nascent literature on responses to the pandemic, we examine the case of Arequipa, the second-largest city in Peru, where, as in many cities of the Global South, water is provided by both the formal sector (a public company) and the informal sector (small-scale operators). Specifically, we are interested in the strategies pursued by water utilities to guarantee water supply in times of pandemic especially during the first wave of Covid-19 from March to October 2020; how these utilities are collaborating to implement these strategies; and how neighborhood associations and informal water providers (tanker truck operators) in peripheral areas are responding to the challenges posed by the pandemic in terms of water services and multi-actor collaboration.

The methodological approach is based on interviews with representatives of the public water company SEDAPAR of Arequipa; officials of other public organizations with responsibilities in the city water management; representatives of regional and local governments, representatives of neighborhood community groups in the urban peripheries of the city, and tanker truck operators. In addition, the article uses secondary sources of information such as official reports and media news.

5.2. Water services and Covid-19: main challenges in the Global South

Water and sanitation services are essential to maintain environmental health, the economy of communities, and human life itself, as stated in Objective 6 of the United Nations 2030 Agenda for Sustainable Development (UN, 2015). In a pandemic context, water supply is vital for the continuity of the urban fabric. Failure to guarantee water services can increase the risk of contagion to Covid-19, especially in informal settlements and refugee camps, where access to water services continues to be a problem for more than a billion people worldwide (Mitlin, 2020).

Following the outbreak of the Covid-19 pandemic and the ensuing lockdowns, water utilities incorporated several measures to guarantee water supply, including the reconnection of water pipes, the temporary suspension of payments for water even for users with scheduled water shutoffs (AquaRating, 2020; Cooper, 2020), moratoria on water shutoffs, discounts up to 100 percent of the water bill, the free delivery of drinking water through pipe trucks, and the expansion of various water supply points, especially in informal settlements (Amankwaa & Ampratwum, 2020; Cooper, 2020; Mcdonald, et al., 2020; Smiley et al., 2020). Measures to improve access to safe water could help mitigate the spread of Covid-19 by reinforcing hygiene habits (Gwenzi, 2021). Still, it is also likely that these measures may have failed to reach the poorest city dwellers, especially households in slums and other marginalized groups living in precarious housing, such as migrants, undocumented refugees, and homeless people which already experienced difficulties accessing water and sanitation services before the pandemic (Ezbakhe et al., 2019; Staddon et al., 2020). At the other extreme, some measures to address the Covid-19 crisis such as the deferral of payments, water subsidies, or the delivery of free water, may have ultimately benefitted wealthier households enjoying in-home water connections to the piped network (Amankwaa & Ampratwum, 2020). In addition, poorer households usually share their water facilities and therefore may easily exceed established limits of water consumption increases the risk to be excluded from certain policies and subsidies (Mosello, 2017). Moreover, these households might be served by informal water providers, that, although not recognized by formal water governance structures, remain very active in the urban areas of the Global South (Adams et al., 2020; Bakker, 2003; Misra, 2014; Smiley, 2013; Swyngedouw, 1995).

Although measures implemented by water utilities have begun to be scrutinized in academic and non-academic publications (Mcdonald et al., 2020; Sanitation and Water for All, 2020; UN-HABITAT, 2020), there is still a lack of detailed studies on how water operators have secured water access during the pandemic in urban environments affected by important socio-spatial segregation processes. Not much is known as to what new governance mechanisms have appeared following the Covid-19 crisis. On the other hand, there is insufficient evidence on how informal water providers are facing the challenge of providing water during the spread of Covid-19 (for some exceptions, see the case of Nigeria in Agada (2020) or the Latin America community initiatives reported by Duque Franco et al., (2020)). Small scale, informal providers supply water to those in need with reasonable success (Liddle et al., 2016). Nevertheless, they face recurrent conflicts with water companies (Smiley et al., 2020). Thus, it is likely that during the crisis caused by Covid-19, informal providers are encountering numerous limitations regarding either the continuity of their operations or the enforcement of stringent measures to guarantee water supply.

Before Covid-19, water utilities faced already numerous challenges such as water losses in networks, the partial recovery of their investment costs, or the slow and limited expansion of the service in peripheral settlements (Bakker, 2010; UNESCO, 2019). However, Covid-19 may pose new challenges in terms of health risks, shortages in supply chains, continuity of operations, and anticipated financial impacts (The World Bank, 2020) not only for formal but also for informal water operators (Corburn et al., 2020; Spearing et al., 2020).

In the case of low-income countries, uncertainties regarding the reimbursement of the additional costs assumed by water utilities during the pandemic threaten their financial sustainability in the long term (Amankwaa & Ampratwum, 2020). Due to declining revenues, informal providers, in particular, may require additional resources, since they depend on the direct contribution of households in peripheral urban settlements, where incomes may also have dropped significantly (Duque et al., 2020). There is little understanding of how informal providers have reacted to the Covid-19 crisis and what have been their relations with formal operators and local actors (such as neighborhood associations) in securing access to water in informal urban areas.

5.3. Covid-19 and water in Peru

On March 15, 2020, the Peruvian government declared a state of national emergency and ordered one of the first and strictest confinements in Latin America. Data on Covid-19 infections was shared, the National Health System of Peru was reinforced; economic aid packages for citizens to stay at home were distributed, and action was taken to guarantee the continuity of urban services, especially, the provision of water and sanitation (Supreme Decree No. 044-2020-PCM, 2020). To confront the crisis produced by Covid-19 numerous emergency decrees were published.

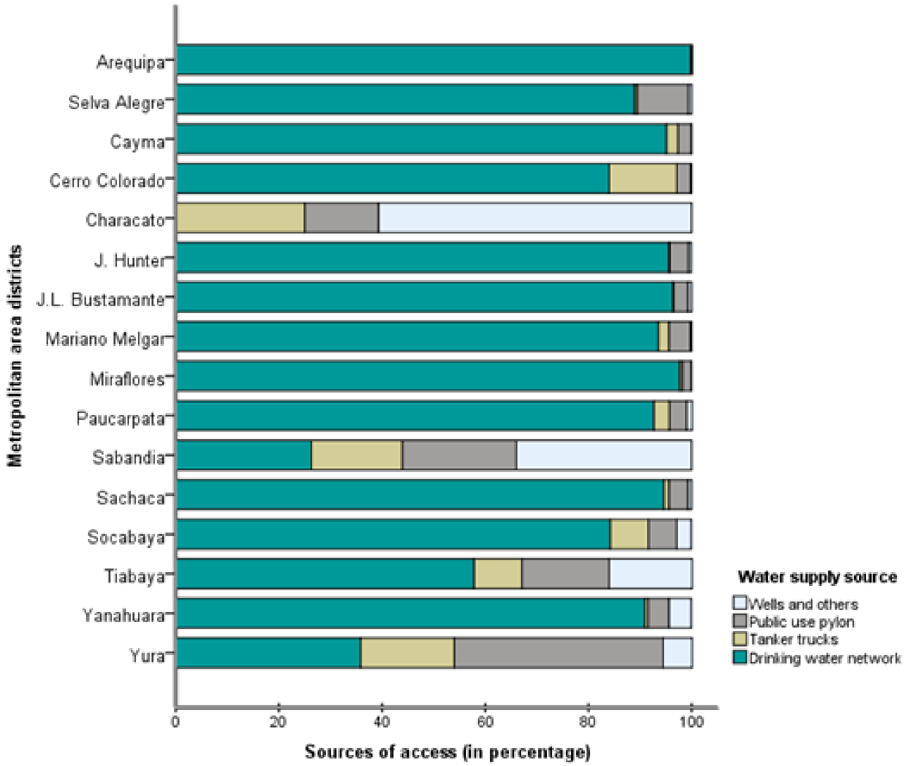
The Emergency Decree No. 036-2020 (2020) was issued on April 10, including three relevant measures to guarantee the continuity of basic water and sanitation services. First, the payment of water bills in installments for a period of up to 24 months, without interest charges or arrears. This measure was only addressed to residential users included in two categories of water consumption: Social (i.e., social programs) and Domestic (i.e., houses and apartments consuming less than 50 m^3/month). Second, the suspension of scheduled water shutoffs, either for maintenance of the supply system or for accumulated debt. Third, and perhaps most important, water was to be distributed free of charge. Hence, water companies had to supply free water to low-income residents, especially in urban areas where the coverage rate of the drinking water network was low or non-existing. To achieve this purpose, the incorporation of small-scale suppliers such as water tanker trucks were suggested. For instance, in the city of Lima, the public water company and the Ministry of Housing, Construction and Sanitation, mobilized some 360 tanker trucks to distribute free water in more than 200 settlements in the city (El Peruano, 2020). In total, the National Association of Sanitation Service Providers of Peru pointed out that the distribution of water through tanker trucks benefited more than 1.5 million people.

5.4. Case study and Methodology

Case study: Formal and informal water supply in Arequipa

Arequipa is the second-largest city in Peru and is home to approximately 1.3 million inhabitants (INEI, 2017). In Arequipa, water is treated and supplied by the company *Servicio de Agua Potable y Alcantarillado de Arequipa* (SEDAPAR). However, the company has not been able to provide drinking water to the entire population of the city (see Figure 15). Despite numerous reforms and large investments in supply infrastructure (Pineda-Zumaran, 2016; SEDAPAR, 2018a), not all inhabitants of the informal urban peripheries are connected to the public network (Muñoz, 2018). Even for households in the consolidated urban periphery, the struggle for secure and reliable water remains a permanent challenge.

Figure 15. Drinking water coverage in the Arequipa metropolitan area



Source: own elaboration, with data from SEDAPAR Annual Report, 2018.

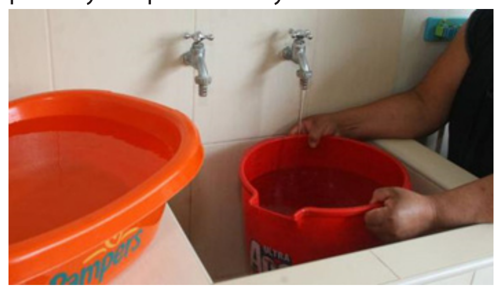
Water networks tend to concentrate in high-income districts. These districts have more connections per inhabitant, while the number of connections is lower in the districts of the urban periphery. Many inhabitants of poorer urban sectors must buy water from other sources, often at higher prices (see Table 11). Despite comparatively higher prices, informal water sources remain the main option for more than 15 percent of the urban population. However, informal providers are not recognized by local urban water policies, so they must operate outside government control resulting in high costs and health risks for users.

Table 11. Main actors in the supply of drinking water in Arequipa

Water supply actors	Organizations	Descriptions
Urban core	SEDAPAR	The public company provides drinking water and wastewater services to the population of the Arequipa region.
	SUNASS	It is the regulatory body that contributes to the access and quality of drinking water and sewage services in Peru.
	Municipalities	Public entities that are in charge, among other aspects, of extending drinking water networks.
	Arequipa Regional Government	Public entity that is in charge, among other aspects, of managing the major water infrastructure, although it can also invest in the expansion of drinking water networks in the city.
Urban periphery	Tank truck operators	Suppliers of drinking water in urban sectors without access to drinking water networks.
	Housing Associations	Groups of inhabitants of the urban periphery of Arequipa without access to public services

Source: Own elaboration

Figure 16. Water supplied by the public utility in the urban core.



Source: Photo by El Comenrcio (2015).

Figure 17. Informal supply systems in the urban periphery

Source: Photo by Correo (2021)

Source: Photo by Luis Zapana

Methodology

Thirteen semi-structured telephone interviews were conducted by the first author between July and September 2020 with public representatives from the Arequipa Water and Sewerage Service (SEDAPAR); the National Water and Sanitation Supervisory Agency (SUNASS); the Arequipa Regional Government; the Municipality of Arequipa, and the District of Characato; as well as with representatives from the Housing Associations of Jardines del Colca, La Victoria, Villa Tambo, and Juventud de Characato, and four tanker truck operators (see Table 12). The interview had 12 questions and was organized by major themes such as the measures taken to ensure access to drinking water during the declaration of the Covid-19 pandemic: the collaborations among public institutions, and the actions from water tanker truck operators and housing associations in the urban periphery of Arequipa. Interviews with representatives of public institutions also addressed how measures to guarantee water supply could encounter significant challenges depending on the reach and state of the public water network. Ancillary sources included annual reports on water management in urban areas, reports on water tariff studies provided by SUNASS, disaggregated data on the production and consumption of drinking water provided by SEDAPAR, as well as miscellaneous economic and socio-demographic statistical information.

Table 12. Actors interviewed from the Arequipa metropolitan area

Entity/association	Position	Interview date	Interview code
SEDAPAR	Planning and Business Development Manager	16/6/2020	Interview #1
SUNASS	Decentralized coordinator in Arequipa	17/6/2020	Interview #2
Regional Government of Arequipa	Advisor to the Regional Government of Arequipa	22/6/2020	Interview #3
Provincial Municipality of Arequipa	Urban Development Manager	18/6/2020	Interview #4
District Municipality of Characato	Manager of Citizen Services	16/6/2020	Interview #5
Jardines del Colca Housing Associations	Association Representative	31/7/2020	Interview #6
La Victoria Housing Association	President of the Association	31/7/2020	Interview #7
Villa Tambo Housing Association	President of the Association	29/7/2020	Interview #8
Juventud de Characato Housing Association	President of the Association	21/9/2020	Interview #9
Water Supply in Tanker Trucks	Tank Truck Operator	1/9/2020	Interview #10
Water Supply in Tanker Trucks	Tank Truck Operator	28/9/2020	Interview #11
Water Supply in Tanker Trucks	Tank Truck Operator	28/9/2020	Interview #12
Water Supply in Tanker Trucks	Tank Truck Operator	28/9/2020	Interview #13

Source: Own elaboration

5.5. Results

The response by public organizations in Arequipa to guarantee water supply amid the COVID-19 pandemic

Government regulations indicated that the measures adopted had to be enforced after the declaration of the state of emergency of March 16, 2020. In Arequipa SEDAPAR suspended the collection of the March bill and made an offer to clients, especially low-income households, to divide the amount of this bill into a period of up to 24 months. However, due to the extension of the state of emergency until the end of November 2020, SEDAPAR extended the payment of bill installments until one month after the end of the state of emergency. Installment payments had to be processed through the SEDAPAR digital platform which raised concerns about who had the means to follow this option. As reported in the interview with the SUNASS representative, of the 270,000 SEDAPAR household connections, only 1,000 clients had used the digital platform of the public service company to request payment of bills in installments (Interview #2). For this reason, SUNASS issued a complementary regulation of automatic installment payments for the most vulnerable persons which were critical since many of them had lost their jobs and had no income (Interview #4). Although this measure was primarily designed for the most vulnerable, some informants pointed at some unintended effects. For example, the representative of the Regional Government of Arequipa warned that the payment in installments could lead to the accumulation of debt, while the inability of poor families to pay in the established period would probably force the water utility to extend the payment period beyond 24 months (Interview #3). Likewise, residents interviewed in the urban periphery (i.e., Yura, Characato, and Sabandia neighborhoods) stated that the payment of monthly bills in installments reproduced inequalities and did not benefit their associates. In addition to their limited access to the public water network, these residents had to face the fact that small-scale providers such as tanker truckers did not include payment installments as a measure to ensure the continuity of water supply (Interviews #6, 7, 8, and 9).

The second measure enforced was the suspension of scheduled water shutoffs, either due to non-payment of bills (accumulated debts) or to maintenance works of water networks. Although shutting off the water supply due to non-payment of bills tends to be somehow ignored, in 2015 there were 27,876 water supply shutoffs due to payment defaults rising to 37,496 cases in 2016 (SEDAPAR, 2016). In fact, Peruvian legal provisions for the regulation of basic water and sanitation services indicate that the country's public utilities can shut off the water supply whenever the user fails to pay two consecutive bills or when loans are overdue. Even though dwellers of the urban periphery with access to public networks consume less water than dwellers of the urban core, the former are more prone to experience water supply shutoffs due to their inability to afford the water bills. Therefore, when the utility company shuts off the water, users become dependent on informal sources or, ultimately, reconnect to the public network without the permission of water managers, an action known locally as "clandestine connections". For example, in 2015, 2,036 "clandestine connections" were identified and shut down by SEDAPAR. A third of these clandestine connections occurred in one district of the urban periphery (Yura) (SEDAPAR, 2016). Faced with this situation, during the health crisis produced by Covid-19, the water utility suspended all water shutoffs, even for users with debts for more than three months. In fact, the SEDAPAR representative stated that as a measure to reduce the spread of Covid-19, the company had suspended water supply shutoffs for all users for the entire period of the state's declaration of emergency (Interview #1). In addition, and according to information provided by the Arequipa public water company, during the first wave of Covid-19, the company restored service for 6,498 residential users (this figure has probably increased during the second wave of the pandemic) who had been previously disconnected due to lack of payment.

The company also suspended water shutoffs related to maintenance works of the water supply systems and the cleaning of reservoirs (Interview #1). In Arequipa, shutting off water to carry out maintenance tasks of water supply infrastructures is a common practice (Zapana-Churata et al., 2021). A large part of these tasks concern pipe breakdowns, since around a third of the network pipes, have not been renewed for more than 40 years (SEDAPAR, 2017). Failures in the water network system motivate users to install water storage tanks at home. In Arequipa, water storage tanks have gained importance, especially for households in the urban periphery. Although these tanks may offer numerous benefits, they are also far from guaranteeing secure availability of household water, especially, but not only, when long periods of interruptions in service due to systems maintenance are reported (El Comercio, 2019). For example, during the state of emergency corresponding to the first wave of Covid-19, the public drinking water network experienced at least two significant episodes of pipe breakdowns. The first occurred in July 2020, after the main pipe broke and left 35 percent of the Arequipa population without water for six consecutive days (El Buho, 2020a). After the incident, the utility in collaboration with the municipalities and water truck operators had to supply water using 37 water tanker trucks. The second was registered in September 2020 when a pipe break in the distribution system of a reservoir left three districts of the city without water. In this case, the emergency was responded with a fleet of 20 tankers (El Buho, 2020b).

Although the suspension of programmed water shutoffs due to either payment defaults (accumulated debts) or maintenance tasks of water supply systems alleviated the lack of water in the most vulnerable households, the representatives of housing associations in the urban periphery of Arequipa argued that this measure lacked effectiveness for households that relied on other sources of water (Interviews #6,7,8 and 9). For example, tanker truck operators did not provide water continuously; instead, they only could supply water twice a week at most. Thus, the suspension of programmed shutoffs appears to have made little impact in households relying on small-scale water providers. In any case, during the first wave of the pandemic, the housing associations of the urban periphery had to maintain a routine of buying and distributing rationed water (normally from 6:00 p.m. to 8:00 p.m.) and even had to procure a minimum amount of free water to families who could not afford the cost.

Regarding the distribution of water free of charge to domestic users to ensure that hygiene routines were not compromised during the pandemic (Emergency Decree No. 036-2020), the SEDAPAR representative stated that free water was distributed utilizing the 37 tanker trucks owned by the utility company:

> *The distribution of water in SEDAPAR and municipal water trucks was carried out in two-day periods. These efforts, will be maintained throughout the period of the state of emergency* (Interview #1).

While this response exemplifies an intervention aimed at alleviating the burden of urban periphery households, its scope was also limited due to many factors, including transportation availability, storage, and distribution of water to homes. However, this practice was also a relief for households suffering numerous interruptions of the water service, especially in the urban core. In any case, the possibility of free water supply in the urban periphery was limited and several representatives of housing associations in these areas expressly stated that, despite requests for water supply to SEDAPAR, between the irruption of Covid-19 in March and July 2020, the company had supplied free water to these districts just once or twice.

> *After having insisted several times to SEDAPAR, the company has just supported us with two tanker trucks during the crisis of the Covid-19* (Interview #6).
>
> *Our association has requested support from public institutions with water supply, but we have not obtained answers; the municipality has provided us with water by tanker truck, although it was only once during the state of emergency* (Interview #8)

Strengthening institutional collaborations to ensure water access amid the Covid-19 pandemic in Arequipa

The representatives of various government institutions interviewed recognized the importance of collaboration to guarantee water supply in pandemic times. For instance, the representative of the Provincial Municipality of Arequipa affirmed that his institution had already signed collaboration agreements with SEDAPAR before the pandemic, especially, but not only, in projects to expand the drinking water and sanitation network (Interview #4). This representative also reported that after the declaration of the state of sanitary emergency in Peru due to Covid-19, the municipality and SEDAPAR signed a temporary collaboration agreement, by which the former committed to providing resources (tanker trucks and fuel) and operational personnel, and the latter to provide drinking water in the tanker trucks to be distributed in the urban periphery. Similarly, although there were no temporary agreements, the provincial representative of Arequipa also mentioned that the institution had supplied tanker trucks to the district municipality of Characato, thus improving provincial-to-district collaborations. The rapid organization of responses to Covid-19 may have benefitted from numerous collaborative experiences around other emergencies caused by natural disasters, already contemplated in SEDAPAR's Emergency Plan (SEDAPAR, 2018b). In this regard, the representative of the Regional Government of Arequipa pointed that:

> *Collaborations to respond to emergencies, for example with SEDAPAR, are not recent. We always act in a cooperative manner. Yet, we must strengthen these collaborations because the population of the urban periphery not only lacks access to water, but also it does not have a regular economic activity and therefore they lack enough income to buy water* (Interview #3).

While there is an extensive collaborative experience in responding to natural emergencies in Arequipa, institutional alliances are usually temporary. For instance, after an incident at two main drinking water production plants, more than 800,000 inhabitants of Arequipa were left without water from the network in February 2017 (RPP, 2017). Therefore, water was partially supplied by tankers during days. The emergency caused by Covid-19 poses new challenges to existing inter-institutional collaborations in ensuring the continuity of water supply for large periods of time under continuous external stress.

Figure 18. Free water distribution in the urban core of Arequipa

Source: IIII

The importance of the exchange of information and experiences during Covid-19 must also be emphasized. As Crowther (2014) points out, the exchange of information is key to the success of emergency response collaborations, especially in new emergencies such as the Covid-19 pandemic. The representative of SUNASS argued that in addition to monitoring water supply operations, the health emergency brought together representatives from SEDAPAR and the district municipality of Characato (which lacks access to the public drinking network, see Fig. 1), to provide training on water supply policy changes, share reliable information, and exchange experiences on measures taken to guarantee water supply, including mutual support agreements (Interview #2). The representative of SEDAPAR reported that after the first meeting convened by SUNASS (days before the state of emergency began) SEDAPAR and the municipal operator of Characato had agreed to collaborate on activities such as operation and maintenance of water networks (Interview #1). He also suggested that SEDAPAR had to send trained staff to lead the activities of cleaning water storage reservoirs and maintaining water distribution equipment. Similarly, the representative of the Characato district recognized that the collaborations have facilitated the continuity of operations for the supply of water not only to the population with access to the public drinking water network but also to the urban dwellers supplied through tanker trucks and pylons for public use (Interview #5).

The role of housing associations and informal water providers in peripheral Arequipa in times of Covid-19

The third objective of the paper is to examine how local actors in the urban periphery of Arequipa dealt with the challenge of accessing water in cases where the public utility was unable to accomplish this task. In Arequipa, informal providers are the main source of water supply for around 15 percent of the population who does not have access to the public water network and for the population connected to the network but affected by intermittent service (see Fig. 1). Although there are a variety of water supply sources, pylons for public use are preferred to other supply options such as wells or tanker trucks. In fact, the network of "public" pylons managed by leaders of housing associations includes, among other artisanal facilities, storage tanks (locally known as "reservoirs") connected to water distribution pipes. However, these artisanal facilities may not operate or guarantee the service if they are not supplied with water from private tanker trucks. Thus, housing associations or even smaller social groups with public pylons must purchase water from tanker trucks (usually with a capacity of 15,000 liters), with a price ranging from 35 to 38 US$ per tanker.

In the urban periphery of Arequipa, tanker trucks commonly transport and discharge water into the storage facilities of the housing associations, although they can also discharge into the households' reservoirs (Interview #11). In terms of frequency of discharge at the reservoirs, tanker trucks usually perform this operation between two to three times per week in normal times. The number of water discharges may increase or decrease with the consumption levels of households forming part of housing associations (Interview #13). Ultimately, service can be completely interrupted, if the demand for water from tanker trucks in the urban core is higher than tanker capacity (and this demand tends to increase with breakdowns in the drinking water networks). While tanker truck providers have maintained water supply with some regularity in the urban periphery, during episodes of pipe breakdowns, water supply in the periphery diminished since the public utility requested the service of tanker trucks to supply residents in the urban core.

In any case, after the declaration of the state of emergency in Peru, water truck suppliers continued their operations. Tanker trucks did not incorporate government-mandated measures, but they lowered their tariffs. As reported in our interviews, tanker operators stated that the water price equivalent to a tanker truck decreased from 35 to 27 US$, although this decrease depended on the distance of the neighborhoods from the urban core and was temporary (Interview #10, 11, 12 and 13). It should be noted that the decrease in the water tariff did not imply a reduction in the cost of water itself, but, rather, that the cost of water transportation was assumed by the tanker operators. Concerning the cost of water, the public service company SEDAPAR had traditionally granted water "bonds" for the inhabitants of the urban periphery which remained unaltered during the first wave of the pandemic. For example, a bond of 13 m^3 of water had a cost of 4 US$, an amount that did not change during the state of emergency. One truck operator recognized that:

> *At the beginning of the state of emergency we charged the normal water tariff, which was 35 US$, but after one month we were forced to lower the cost of water transportation, because we saw that people could not pay this amount* (Interview #12).

One of the main preoccupations of tanker truck operators was the risk of contagion of Covid-19. Therefore, to prevent contagion they funded and implemented their own measures for both personal protection and disinfection of water supply equipment, although with significant limitations in terms of information and implementation. As one of the operators explained:

Water suppliers have taken many precautions when distributing water to avoid contagion. For this, we decided to use gloves, masks, boots and we also used chlorine-based disinfection supplies. For example, we had to disinfect the hoses before

discharging the water into the reservoirs of the housing associations (Interview #10).

Housing associations play a fundamental role in the provision of water in peripheral Arequipa and this role has become even more critical during the pandemic. Although these associations - more than 250 - remain outside the scope of the "Metropolitan Development Plan" and households are therefore excluded from access to basic services (water, drainage, etc.), their residents organize, work, and negotiate services with the local administration. For example, residents of housing associations work collectively to develop their own water supply infrastructures such as storage reservoirs connected to several public pylons (Muñoz, 2018; Water and Sanitation Program, 2008). Although the reservoirs facilitate the storage of water that is purchased from tanker trucks, they may not guarantee the quality of these flows. Moreover, although the water reservoirs are connected to public pylons, water from pylons is not available 24 hours a day. The housing associations have an alternate day schedule for water distribution, commonly between 6 and 8 p.m., which according to interviewees, has not changed during the state of emergency.

As the representative of the *Jardines del Colca* housing association pointed out, all housing associations have a person elected by the leaders, who are responsible, among other tasks, of monitoring the water stored in the reservoirs and of buying and distributing water from tanker trucks (i.e., manage the water in each pylon for public use) (Interview #6). In the public pylons, water is provided to the members according to their purchasing power although with some important exceptions. Members usually buy between 2 and 4 buckets of water per day. The cost per bucket (commonly 20 liters) can reach 0.14 US$, that is, five times more than the cost of water from the public network. However, during the state of emergency, households with higher family incomes increased their purchases from 6 to 10 buckets, a figure that could leave lower-income households without water. As reported by the housing associations, to curtail disparities in water appropriation, the number of buckets sold per household was limited:

> *The association has decided not to sell more than 8 buckets of water per family, it has decided to set a limit to rationalize the water. Water is indispensable for life, and everyone must have access to this resource* (Interview #7).

> *Some families have increased the purchase of water, but in our association, you cannot buy more than 8 buckets of water per day* (Interview #8).

While water is marketed through housing associations, a minimum amount of free water is also provided to the most vulnerable households. For instance, the representative of the La Victoria housing association stated that many families in his association had lost their jobs due to the socio-economic crisis caused by Covid-19.

Hence, the housing association decided to support these families with a bucket (20 liters) of free water per day (Interview #7).

5.6. Discussion

Recent research in cities of the Global South has started to critically examine the Covid-19 relief responses offered by public authorities and water services operators, highlighting particularly the impacts on vulnerable groups (De Groot & Lemanski, 2020; Gupte & Mitlin, 2020). In Arequipa, a Peruvian city with an important socio-spatial segregation pattern, despite the implementation of measures by the State and the public utility to guarantee water supply to vulnerable populations (especially low-income households in the urban periphery), inequalities around water access during the pandemic are likely to be reinforced in practice if public authorities continue to disregard other sources of water supply than the public network. According to our results, measures to guarantee access to urban water such as payment of bills in installments and the suspension of water shutoffs have benefited households connected to the water network, which are mainly located in high-income districts with 24-hour water availability and water consumption over 20 m^3/household/month. However, these measures have not sufficiently addressed the needs of low-income districts, where water consumption is less than 10 m^3/household/month, the water supply is disrupted more often, and households rely more on informal sources.

Our findings illustrate that, even during the Covid-19 pandemic, urban water policies in cities of the Global South such as Arequipa consider network infrastructures as the only means of supply water and tend to underestimate the role of informal supply systems and community-based initiatives (Adams et al. 2020). In fact, our case study mirrors recent debates on the hybridity, (in)formality, and diversity of water supply systems in the Global South, arguing that these reductionist views should be replaced by actions acknowledging that water provision is in practice co-produced through a range of formal to informal interdependent actors, practices, and infrastructures (Truelove, 2019; Schwartz et al. 2015).

In Arequipa measures to support water security amidst the pandemic may paradoxically increase pre-existing inequalities, especially between the planned urban core and the unplanned urban periphery. More comparative studies, however, would be needed to substantiate these findings but our results for Arequipa highlight the unexpected outcomes of some initiatives identified in other geographies such as the Free Water initiative promoted in Ghana, which may not benefit the most insecure water households because unconventional forms of accessing water were not fully considered (Amankwaa & Ampratwum, 2020; Smiley et al., 2020). As argued by previous research, recognizing everyday practices to access water beyond the dualistic framing of urban water governance as either legal or illegal would help to design locally-grounded measures covering the multiple suppliers and users involved in water provision (Truelove, 2019).

The distribution of free water has been one of the most relevant measures implemented during the pandemic in Latin American (Serrano & Gutierrez-Torres, 2020), African (UN-HABITAT, 2020), and Asian cities (Sanitation and Water for All, 2020) (see also McDonald et al. 2020). In the case of Arequipa, this measure involved the supply of water in tanker trucks to households of the city not connected to the public network (approximately 15 percent of the total). However, the measure suffers from significant limitations in terms of scope, as shown by concerns expressed by the housing associations of the periphery regarding the limited-service received during the first months of the emergency. The number of water tanker trucks mobilized by public authorities has been key to determining the success of this measure in countries such as Venezuela, albeit with important implications for the public health and financial resources of users (Mcmillan, 2020). Insufficient water supplied by water tanks as well as conflicts overuse has also been reported in African and Latin American cities during the pandemic (Gupte & Mitlin, 2020; Ortega & Orsini, 2020; Parik et al., 2020).

Cumulative failures in the water network, such as recurrent pipe ruptures, not only increase the amount of water lost (which may have important implications for cost recovery or other water demand management objectives) (AL-Washali et al., 2016; Mutikanga et al., 2009; Superintendencia Nacional de Servicios de Saneamiento, 2018) or put into risk the quality of network water but also increase the demand for water in tanker trucks especially in the urban core. This jeopardizes the implementation of measures such as the distribution of free water in tanker trucks in the non-networked urban peripheries. Therefore, the urban water provision systems in the Global South should pay special attention to the structural and long-term improvement of the drinking water network systems but also recognize the existing supply alternatives in the urban peripheries in face of threats ranging from Covid-19 to climate change (Keulertz et al., 2020).

Institutional collaborations in Arequipa on common issues such as personnel management or hygienic protocols have been fruitful, especially when institutions with legal status have been involved. However, a collaboration between formal and informal organizations and providers has been exceptional. Despite little collaborative exchanges, informal water providers and collective action in the urban periphery have engaged in many collaborative initiatives (such as information exchanges for the implementation of personal protective equipment, purchase of disinfection supplies for tanker trucks, decrease in the water tariff of tanker trucks, distribution of a minimum of free water, etc.), although with important challenges when accessing reliable information to manage the pandemic. In any case, the pandemic also challenged these exchanges due to the social distancing requirements and the limited time available for water officials to share their experiences with other actors from the urban periphery (Roca-Servat et al,. 2020; Satorras et al,. 2020). On the other hand, the representatives of (in)formal water providers in Arequipa stated that collaborations to address Covid-19 challenges could continue once the pandemic is over, although some informants were skeptical about their fate arguing that they might depend on the economic resources of public institutions. Nevertheless, it is important to recognize the intensity of the collaborations (whether in the formal or informal sphere) as a strength to face not only future emergencies but also to overcome day to day challenges of urban water supply (Duque Franco et al., 2020).

Informal water providers did not receive government support but continued their operations during the first wave of Covid-19. Private water truck operators, for example, had no formal responsibilities for water supply, but were actively adapting since the first cases of Covid-19 were detected in the city. Similarly, Nigeria's informal water providers such as individuals or small enterprises that treat and distribute water to households and businesses helped to alleviate the deficits caused by poor public water infrastructures during the pandemic (Agada, 2020). In the case of Arequipa, tanker truck operators had to self-fund measures to adapt to Covid-19. According to our interviews, operators experienced additional expenses during the health crisis (e.g., purchase of personal protective equipment and disinfectants, transportation registration, health certificates) which added to the usual operating costs. Due to rising costs and lack of government support, some operators applied for loans from private financial institutions. Tanker operators also faced economic challenges, which might have implications for their long-term business plans.

Despite the numerous challenges faced by water tanker operators and housing associations, in the case of Arequipa, their efforts to ensure water supply offered a timely intervention to limit the spread of Covid-19 and secure safe water in urban settlements where basic services are limited (see similar cases in Mitlin, 2020; Rafa et al., 2020). However, while many efforts have been made by informal providers in Arequipa, including efforts to maintain or even reduce the price of water during the pandemic, daunting challenges remain. For example, lowering the price of water by a few figures is not enough for households that have experienced a significant reduction in family income or have ultimately lost their jobs altogether due to confinement. Likewise, the reduction in the price of water was a temporary measure,

meaning that this price might return to its original state at any time or even increase in future waves of the pandemic. These effects have implications on water consumption and the health of poor households, as well as affecting the viability of water operators, especially informal ones. In any case, public water managers especially in the urban Global South, should not ignore the heterogeneity of basic service provision in cities and recognize instead the multiple capacities and experiences accumulated in these urban areas.

5.7. Conclusions

With the arrival of Covid-19 to the cities of the Global South, governments of different countries closed their borders and ordered strict population confinements. Although many activities came to a standstill, essential public services, such as water supply, continued their operations. In cities of the Global South the service is provided by formal (public and private water companies) and informal (small water providers), or ultimately by a hybrid combination of both. Little is known about how informal water providers have responded, what measures they have implemented to guarantee water supply, and whether the measures taken have been sufficient to address the challenges posed by the pandemic. Therefore, by examining the case of Arequipa, Peru's second-largest city (where urban dwellers are supplied by both formal and informal providers), we have explored the strategies followed by the public water utility to secure water supply, the collaborations with stakeholders in urban water management, and the responses of informal providers, including collective action, to address the challenges of the first wave of Covid-19. The paper adds empirical insights into the literature criticizing reductionist views by formal water supply systems arguing instead that water provision in many cities of the Global South is in practice co-produced through a range of formal to informal actors, practices, and infrastructures. In particular, the case of Arequipa illustrates how formal and informal water services configuring the city's waterscape have organized themselves to ensure water supply amidst the sanitary crisis originated by Covid-19, especially during the first wave.

The public water sector of Arequipa implemented important measures to guarantee urban water supply such as payment in installments, suspension of water shutoffs, and distribution of free water (in tanker trucks), the latter designed for households in the urban periphery without access to the water network. According to these measures, it can be stated that the public utility proposed to expand its services beyond its usual scope, as it included households not connected to the public water network. However, in practice, the implementation of these ambitious measures (including free water) has mainly benefited households in the planned districts of the urban core, which are connected to the public network and enjoy a relatively stable service. However, the success of these measures has been relatively smaller in the urban periphery, where service is intermittent, and water is often not available 24 hours a day. Although free water, for example, was designed for poor households in the urban periphery lacking access to the public network, it has mostly failed to reach households in these sectors for two reasons. First, the number of tanker trucks from SEDAPAR and the municipalities is small, and they have not been able to cope with the high water demand. Second, the tanker trucks of these public institutions first supplied free water to households in the districts of the urban core, which had no water due to frequent breakdowns in the public network.

Moreover, in Arequipa, the sanitary crisis stimulated collaborations between public servants involved in formal urban water management. Public officials exchanged information constantly and helped each other in making numerous decisions, which benefited mostly the residents of the urban core. However, these collaborations did not extend in general to the urban periphery, and informal water providers and representatives of housing associations. It should be noted, however, that during the episodes of ruptures in the water mains that affected several districts of Arequipa, the formal water supplier contracted the service of informal water trucks, which, in turn, affected the availability of water in the housing associations of the urban periphery. In the urban periphery, there have also been collaborations between informal providers and housing associations, although not without significant difficulties. Therefore, this paper suggests the need to implement more collaborative procedures on urban water, especially between formal and informal water actors.

We can also conclude that collective action in the informal water sector has been intense to secure water for peripheral districts. For example, informal providers decided to continue their operations, lower the price of water, and distribute a minimum of free water. However, these measures also presented several limitations. While the decrease in the price of water is a relevant gesture (considering that the price of tanker water is five times more expensive compared to network water), it has not been sufficient for households that have lost their jobs and income. Although some households and representatives of housing associations decided to help their members with free water, these supports are temporary and there are doubts as to whether these measures will persist during the new waves of the pandemic.

Finally, the pandemic in Arequipa as well as in other cities of the Global South has exposed in clear ways the significance of informal actors, institutions, and alternative water governance mechanisms, ranging from infrastructural components (household water reservoirs; neighborhood distribution systems) to political actors (the neighborhood associations) and the introduction of elements of the moral economy in the distribution of water such as the prohibition of water grabbing by better-off households.

In sum, responses of formal and informal water providers in the context of the Covid-19 pandemic contribute significantly to alleviating deficiencies in water access in the city of Arequipa. Nonetheless, it is also important to highlight some limitations that informal water services may suffer, such as the high cost of water for inhabitants of the urban periphery compared to public network tariffs. Moreover, water distribution without planning and in the absence of involvement of public institutions may motivate users to violate social distancing measures and thus favor the spread of Covid-19 as reported in other cities from the Global South. In this sense, water access challenges can be better addressed with greater involvement of the formal water sector but also and essentially by the recognition of the role of informal water systems. We consider that a better understanding of the challenges and adaptive responses implemented by water utilities and local communities to address the health and socio-economic crisis of Covid-19 in the Global South can contribute to advance towards the human right to water both in exceptional but more importantly in normal times.

5.8. References

Adams, E., Zulu, L., & Ouellette-Kray, Q. (2020). Community water governance for urban water security in the Global South: Status, lessons, and prospects. *Wiley Interdisciplinary Reviews: Water*, *7*(5), 1–21. https://doi.org/10.1002/wat2.1466

Agada, S. (2020). Nigeria's Informal Water Providers: Filling in the Public Gaps. In *Public Water and Covid-19: Dark Clouds and Silver Linings*. Retrieved from https://www.municipalservicesproject.org/sites/municipalservicesproject.org/files/publications/17-Nigeria.pdf

Ahlers, R., Cleaver, F., Rusca, M., & Schwartz, K. (2014). Informal space in the urban waterscape: Disaggregation and co-production of water services. *Water Alternatives*, *7*(1), 1–14. Retrieved from https://www.water-alternatives.org/index.php/alldoc/articles/vol7/v7issue1/230-a7-1-1

AL-Washali, T., Sharma, S., & Kennedy, M. (2016). Methods of Assessment of Water Losses in Water Supply Systems: a Review. *Water Resources Management*, *30*(14), 4985–5001. https://doi.org/10.1007/s11269-016-1503-7

Amankwaa, G., & Ampratwum, E. F. (2020). COVID-19 'free water' initiatives in the Global South: what does the Ghanaian case mean for equitable and sustainable water services? *Water International*, *45*(7–8), 722–729. https://doi.org/10.1080/02508060.2020.1845076

AquaRating. (2020). TARIFAS: Algunas acciones sobre tarifas que han implementado algunos países - AquaRating. Retrieved September 1, 2020, from https://aquarating.org/resiliencia-adaptacion-y-esperanza-como-las-empresas-de-agua-estan-implementando-la-continuidad-del-negocio-durante-covid-19-2-2/

Bakker, K. (2003). Archipelagos and networks: urbanization and water privatization in the

South. *The Geographical Journal*, *169*(4), 328–341. https://doi.org/10.1111/j.0016-7398.2003.00097.x

Bakker, K. (2010). The limits of "neoliberal natures": Debating green neoliberalism. *Progress in Human Geography*. https://doi.org/10.1177/0309132510376849

Cooper, R. (2020). Water for the urban poor and Covid-19. In *Department for International Development*. Retrieved from https://theconversation.com/day-zero-is-meant-to-cut-cape-towns-water-

Corburn, J., Vlahov, D., Mberu, B., Riley, L., Caiaffa, W. T., Rashid, S. F., … Ayad, H. (2020). Slum Health: Arresting COVID-19 and Improving Well-Being in Urban Informal Settlements. *Journal of Urban Health*, *97*(3), 348–357. https://doi.org/10.1007/s11524-020-00438-6

Crowther, K. G. (2014). Understanding and overcoming information sharing failures. *Journal of Homeland Security and Emergency Management*, *11*(1), 131–154. https://doi.org/10.1515/jhsem-2013-0055

De Groot, J., & Lemanski, C. (2020). COVID-19 responses: infrastructure inequality and privileged capacity to transform everyday life in South Africa. *Environment and Urbanization*, 095624782097009. https://doi.org/10.1177/0956247820970094

Duque Franco, I., Ortiz, C., Samper, J., & Millan, G. (2020). Mapping repertoires of collective action facing the COVID-19 pandemic in informal settlements in Latin American cities. *Environment and Urbanization*, *32*(2), 523–546. https://doi.org/10.1177/0956247820944823

El Buho. (2020a). Arequipa: 7 distritos siguen sin agua potable. Retrieved January 8, 2021, from El Buho website: https://elbuho.pe/2020/07/arequipa-aqui-zonas-de-cisternas-para-7-distritos-tras-5-dias-sin-agua/

El Buho. (2020b). SEDAPAR: Rotura de tubería reservorio dejó sin agua a tres distritos. Retrieved January 8, 2021, from El Buho website: https://elbuho.pe/2020/09/sedapar-rotura-de-tuberia-de-reservorio-dejo-sin-agua-a-tres-distritos-de-arequipa/

El Comercio. (2019). Arequipa: 200 mil personas se quedan sin agua por rotura de tubería Arequipa. *El Comercio*, p. 1. Retrieved from https://elcomercio.pe/peru/arequipa/arequipa-200-000-pobladores-quedan-servicio-agua-rotura-tuberia-noticia-nndc-598579-noticia/?ref=ecr

El Peruano. (2020). MVCS distribuye agua potable en zonas de Lima que no cuentan con el servicio. Retrieved January 8, 2021, from El Peruano website: https://elperuano.pe/noticia/93327-mvcs-distribuye-agua-potable-en-zonas-de-lima-que-no-cuentan-con-el-servicio

Emergency Decree No. 036-2020. (2020). Decreto de urgencia. *El Peruano*. Retrieved from https://cdn.www.gob.pe/uploads/document/file/581842/DU036_2020.pdf

Ezbakhe, F., Giné-Garriga, R., & Pérez-Foguet, A. (2019). Leaving no one behind: Evaluating access to water, sanitation and hygiene for vulnerable and marginalized groups. *Science of The Total Environment*, *683*, 537–546. https://doi.org/10.1016/J.SCITOTENV.2019.05.207

Gupte, J., & Mitlin, D. (2020). COVID-19: what is not being addressed. *Environment and Urbanization*, 095624782096396. https://doi.org/10.1177/0956247820963961

Gwenzi, W. (2021). Leaving no stone unturned in light of the COVID-19 faecal-oral hypothesis? A water, sanitation and hygiene (WASH) perspective targeting low-income countries. *Science of the Total Environment*, *753*, 141751. https://doi.org/10.1016/j.scitotenv.2020.141751

INEI. (2017). Arequipa alberga a 1 millón 316 mil habitantes. Retrieved October 13, 2019, from INEI website: http://m.inei.gob.pe/media/MenuRecursivo/noticias/nota-de-prensa-n181-2017-inei_1.pdf

Keulertz, M., Mulligan, M., & Allan, J. A. (2020). The impact of COVID-19 on water and food systems: flattening the much bigger curve ahead. *Water International*, 1–5. https://doi.org/10.1080/02508060.2020.1779515

Liddle, E. S., Mager, S. M., & Nel, E. L. (2016). The importance of community-based informal water supply systems in the developing world and the need for formal sector support. *Geographical Journal*, *182*(1), 85–96. https://doi.org/10.1111/geoj.12117

Mcdonald, D. A., Spronk, S., & Chavez, D. (2020). Public Water Dark Clouds and Silver Linings. In *Municipal Service Project*. Retrieved from www.tni.org

Mcmillan, R. (2020). DEFENDING PUBLIC WATER IN TIMES OF CRISIS: "POPULAR WATER GOVERNMENT" IN CARACAS, VENEZUELA. In *Municipal Service Project* (pp. 197–220). London.

Misra, K. (2014). From formal-informal to emergent formalisation: Fluidities in the production of urban waterscapes. *Water Alternatives*, *7*(1), 15–34. Retrieved from http://www.water-alternatives.org/index.php/volume7/v7issue1/231-a7-1-2/file

Mitlin, D. (2020). Dealing with COVID-19 in the towns and cities of the global South | International Institute for Environment and Development. Retrieved August 23, 2020, from International Institute for Environment and Development website: https://www.iied.org/dealing-covid-19-towns-cities-global-south

Mosello, B. (2017). How to reduce inequalities in access to WASH Urban water in Ghana. In *WaterAid*. Retrieved from www.odi.org/twitter

Muñoz, A. (2018). Movimiento de pobladores , desarrollo urbano y gobernabilidad local: situación y desafíos en el cono norte de Arequipa. In *Movimientos sociales, actores y representación política* (pp. 259–275). Retrieved from http://www.desco.org.pe/recursos/site/files/CONTENIDO/1248/13_PH_muñoz_dic18.pdf

Mutikanga, H. E., Sharma, S., & Vairavamoorthy, K. (2009). Water loss management in developing countries: Challenges and prospects. *Journal / American Water Works Association*, *101*(12), 57–68. https://doi.org/10.1002/j.1551-8833.2009.tb10010.x

Ortega, F., & Orsini, M. (2020). Governing COVID-19 without government in Brazil: Ignorance, neoliberal authoritarianism, and the collapse of public health leadership. *Global Public Health*, 1–21. https://doi.org/10.1080/17441692.2020.1795223

Parikh, P., Diep, L., Gupte, J., & Lakhanpaul, M. (2020). COVID-19 challenges and WASH in informal settlements: Integrated action supported by the sustainable development goals. *Cities*, *107*(July), 102871. https://doi.org/10.1016/j.cities.2020.102871

Pineda-Zumaran, J. (2016). Learning and Knowledge Generation in Local Decision Making in the South: The Case of Urban Infrastructure Provision in Arequipa, Peru. *Journal of Planning Education and Research*, *36*(1), 60–75. https://doi.org/10.1177/0739456X15601186

Rafa, N., Uddin, S. M. N., & Staddon, C. (2020). Exploring challenges in safe water availability and accessibility in preventing COVID-19 in refugee settlements. *Water International*, *45*(7–8), 710–715. https://doi.org/10.1080/02508060.2020.1803018

Roca-Servat, D., Boter, M., & Correa, S. (2020). COMMUNITY-BASED WATER PROVISION IN COLOMBIA IN TIMES OF COVID-19. In *Public Water and Covid-19: Dark Clouds and Silver Linings*.

RPP. (2017). Cisternas de agua potable no se abastecen para atender a 800 mil personas.

Retrieved February 11, 2020, from Radio Programas del Perú website: https://rpp.pe/peru/arequipa/cisternas-de-agua-potable-no-se-abastecen-para-atender-a-800-mil-personas-noticia-1027781

Sanitation and Water for All. (2020). Country Experiences on COVID-19 and WASH. Retrieved October 1, 2020, from Sanitation and Water for All website: https://www.sanitationandwaterforall.org/news/country-experiences-covid-19-and-wash

Satorras, M., Saurí, D., & March, H. (2020). Reinventing public water amid covid-19 in terrassa. In *Municipal Service Project* (pp. 61–84). Retrieved from https://www.municipalservicesproject.org/sites/municipalservicesproject.org/files/publications/4-Terrassa.pdf

Satterthwaite, D. (2016). Missing the Millennium Development Goal targets for water and sanitation in urban areas. *Environment & Urbanization*, *28*(1), 99–118. https://doi.org/10.1177/0956247816628435

SEDAPAR. (2016). Memoria Anual 2016. In *SEDAPAR*.

SEDAPAR. (2017). Memoria Anual 2017. In *SEDAPAR*. Arequipa.

SEDAPAR. (2018a). MEMORIA ANUAL 2018. In *SEDAPAR*. Arequipa.

SEDAPAR. (2018b). Plan de emergencia 2018 SEDAPAR. In *SEDAPAR*. Retrieved from https://www.sedapar.com.pe/wp-content/uploads/2016/11/Plan-Emergencia-AREQUIPA.pdf

Serrano, A., & Gutierrez-Torres, D. (2020). Latin America moving fast to ensure water services during COVID-19. Retrieved February 1, 2021, from World Bank website: https://blogs.worldbank.org/water/latin-america-moving-fast-ensure-water-services-during-covid-19

Smiley, S. L. (2013). Complexities of water access in Dar es Salaam, Tanzania. *Applied Geography*, *41*, 132–138. https://doi.org/10.1016/j.apgeog.2013.03.019

Smiley, S. L., Agbemor, B. D., Adams, E. A., & Tutu, R. (2020). COVID-19 and water access in Sub-Saharan Africa: Ghana's free water directive may not benefit water insecure households. *African Geographical Review*. https://doi.org/10.1080/19376812.2020.1810083

Spearing, L. A., Thelemaque, N., Kaminsky, J. A., Katz, L. E., Kinney, K. A., Kirisits, M. J., … Faust, K. M. (2020). Implications of Social Distancing Policies on Drinking Water Infrastructure: An Overview of the Challenges to and Responses of U.S. Utilities during the COVID-19 Pandemic. *ACS ES&T Water*. https://doi.org/10.1021/acsestwater.0c00229

Staddon, C., Everard, M., Mytton, J., Octavianti, T., Powell, W., Quinn, N., … Mizniak, J. (2020). Water insecurity compounds the global coronavirus crisis. *Water International*, *45*(5), 416–422. https://doi.org/10.1080/02508060.2020.1769345

Superintendencia Nacional de Servicios de Saneamiento. (2018). Situación del agua no facturada en operadores de América Latina. *SUNASS*, p. 6. Retrieved from https://www.sunass.gob.pe/tallerBench2018/Publicaciones/4aderasa.pdf

Supreme Decree No. 044-2020-PCM. (2020). Decreto Supremo N°044-2020-pcm. *Diario Oficial El Peruano*, (90), 545318–545321.

Swyngedouw, E. (1995). The contradictions of urban water provision: a study of Guayaquil, Ecuador. *Third World Planning Review*, *17*(4), 387–405. https://doi.org/10.3828/twpr.17.4.c828066008888322

The World Bank. (2020). Considerations for Financial Facilities to Support Water Utilities in the COVID-19 Crisis. In *The World Bank*. Retrieved from www.worldbank.org/gwsp

Truelove, Y. (2019). Gray Zones: The Everyday Practices and Governance of Water beyond the Network. *Annals of the American Association of Geographers*, *109*(6), 1758–1774. https://doi.org/10.1080/24694452.2019.1581598

UN-HABITAT. (2020). Aqua Publica and UN-GWOPA co-host webinar on water operators' response to COVID-19 emergency. Retrieved February 1, 2021, from Aqua Publica Europea website: https://www.aquapublica.eu/article/news/aqua-publica-and-un-gwopa-co-host-webinar-water-operators-response-covid-19-emergency

UN. (2015). Transforming our World: The 2030 Agenda for Sustainable Development. Retrieved October 7, 2020, from United Nations website: https://sustainabledevelopment.un.org/post2015/transformingourworld/publication

UNESCO. (2019). The United Nations World Water Development Report 2019: Leaving no one behind. In *UNESCO*.

UNICEF, & WHO. (2019). Progress on household drinking water, sanitation and hygiene 2000-2017. In *UNICEF/WHO*. Retrieved from https://washdata.org/sites/default/files/documents/reports/2019-07/jmp-2019-wash-households.pdf

Water and Sanitation Program. (2008). Agua y saneamiento para las zonas marginales urbanas de América Latina. In *Water and Sanitation Program (WSP)*. Retrieved from http://www.wsp.org/sites/wsp.org/files/publications/Medellin.pdf

World Health Organization. (2020). COVID-19: Operational guidance for maintaining essential health services during an outbreak. *WHO*, 1–14. Retrieved from https://apps.who.int/iris/bitstream/handle/10665/331561/WHO-2019-nCoV-essential_health_services-2020.1-eng.pdf?sequence=1&isAllowed=y

Zapana-Churata, L., March, H., & Sauri, D. (2021). Water demand management strategies in fast-growing cities. The case of Arequipa, Perú. *International Journal of Water Resources Development*, 1–25. https://doi.org/10.1080/07900627.2021.1903401

Chapter 6

General discussion and conclusions

6. General discussions and conclusions

This thesis has explored how access to drinking water supply, including affordability, quality, and service delivery varies within fast-growing cities in the Global South. To this end, the city of Arequipa, Peru, has been chosen as a case study in an attempt to answer the main research questions, which are related to the chapters of this thesis. This final chapter of the thesis is structured around the four research questions of the thesis: a) How does access to water supply vary spatially in rapidly growing cities such as Arequipa? (Section 6.1); b) To what extent do strategies by the water company contribute to improving access to water supply in Arequipa? (Section 6.2); c) What role do informal supply systems and collective action play in access to water in Arequipa? To what extent the formal urban water sector in Arequipa cooperates with informal water source providers? (Section 6.3); d) In the context of the Covid-19 health emergency, how are formal and informal water providers, responding in Arequipa? (Section 6.3)

Each of those sections summarizes the main results reported in the previous chapters, including some policy implications. The chapter ends up with a reflection around the limitations of the thesis and suggestions for future research work.

6.1 Socio-spatial inequalities in water supply, quality, affordability, and access in the rapidly growing city of Arequipa

Cities of the Global South are experiencing rapid urbanization through planned areas and much more importantly through unplanned settlements which reconfigure the urban water landscape. In general, it can be stated that the supply and access to drinking water vary according to the context of planned and unplanned urbanization (Bakker, 2003). In the planned urban context, the conventional drinking water network is often the main source of supply, whereas unplanned urban areas are often served by a variety of traditional and new water sources (Liddle, Mager, & Nel, 2016; Smiley, 2013). Given these differences in access, urban water managers and administrators harness economic, technical, and administrative efforts to extend drinking water networks (which is very relevant to reduce accessibility gaps) or ultimately introduce liberal mechanisms (privatization or corporatization of the water supply service) that to promote its expansion (Auriol & Picard, 2009; González-Gómez & García-Rubio, 2018; K'Akumu, 2004). In most cities of the Global South, urban water managers advocate for water network expansion because it "represents" the safest, fastest, and most modern way to distribute the resource among the population. However, it should be noted that this conventional method is also used to extend State power and control (Meehan, 2014). In contrast, water managers are not attracted to traditional sources because they do not "fit" the policies of the ideal of modern infrastructure, so they are not officially recognized in public portfolios, even though these informal sources are critical in the provision of water to populations without access to the network. In any case, given the preference for water networks, their expansion may reduce inequalities of access to some extent, although inequality of access in rapidly growing cities is by no means the only problem. Other dimensions such as affordability, quality, and service delivery are also very relevant.

In Chapter 3, the objective was to examine the provision of water services in Arequipa through the characterization of accessibility, availability, quality of service, and marketing price, analyzing the differences between the urban core and the periphery concerning these items. To meet this objective, information was collected in three districts of the planned urban core and with higher economic income and in three other districts of the partially planned urban periphery and with low economic income through surveys and semi-structured interviews, in addition to consultations of secondary sources. In general, it can be stated that the public agencies that administer water in Arequipa have managed to extend drinking water networks universally in districts of the urban core which translates into almost universal water accessibility. This means that all residents of the urban core districts have drinking water connections within the household. However, in the periphery, accessibility is very different between and within districts. For example, in the district of Sabandía access to piped water reaches 90 percent of the population, while in the other two districts of the study (Yura and Characato) access reaches less than 50 percent of residents so that more than half of the latter are forced to access informal water supply systems. Access to water through informal supply systems varies between districts of the urban periphery. For example, this study shows that in the Yura district, residents mostly access water through public pylons, while in Characato and Sabandia they mostly use wells. The preference for one informal system or another could be related, among other aspects, to the spatial characteristics of the districts and economic income. The Yura district is remarkably arid, which makes groundwater extraction unfeasible, whereas the Characato district has natural sources of groundwater-fed by snowmelt from the Andes, so access to water through wells is easier and the most preferred option. Moreover, higher-income residents (although a smaller percentage) of the peripheral districts have their own water storage facilities in their homes, so these residents buy water directly from tanker truck providers. In summary, the case of Arequipa shows that inequalities in access to informal water supply systems also exist in the urban periphery and are determined, among other aspects, by socio-spatial characteristics, income, and proximity to natural water sources. Therefore, these findings relate to results of other studies in fast-growing cities of the Global

South indicating that access varies with proximity to water sources, income, urban settlement characteristics, and a variety of social and cultural factors (Adams et al., 2016; Adams et al., 2019).

While the case of Arequipa reflects important inequalities in access to water, i.e., districts of the urban core with almost universal and homogeneous accessibility and districts of the periphery with large disparities in access, this study also sheds light on the inequalities of access in terms of affordability, quality, and service provision that affect both districts in the urban core and the periphery. The success in terms of coverage and accessibility in the urban core districts (achieved by Arequipa's public water agency) does not translate into increases in affordability, quality, and service delivery. In other words, households in the urban core districts can be said to have physical access within the household (which in political terms is understood as a home with safe water), but the water supply is not always constant, in part due to broken pipes. Also, water may not be affordable due to rising tariffs, affecting not only low-income households. Surveys conducted in districts of the urban core reveal that more than half of the residents in this sector have experienced service interruptions. These results are especially relevant in a context where the public agency that manages water in Arequipa considers the physical access of households in the urban core as areas covered with constant water flows when in practice the water service is intermittent. Water managers in Arequipa ignore service interruptions, even though interruptions can cause contamination of the resource and an increase in water unaccounted for. Even international reports that examine the progress of access to water generally consider physical connections but ignore factors affecting physical facilities (WHO/UNICEF, 2017). In any case, this study shows us that universal accessibility in urban core districts only translates into the number of people physically connected to the network and does not reflect distributional equity of water, quality issues, and service provision. In other words, this thesis reveals that in urban areas with "universal access", inequalities of access in terms of affordability, quality, and service provision are also common.

Accessibility in terms of affordability, quality, and service delivery in peripheral districts is much more complex. Surveys conducted in urban periphery districts show that more than half of residents with household drinking water connections have experienced service interruptions. In contrast to urban core districts, drinking water service interruptions in urban periphery districts are more frequent and last longer. Interruptions in the urban periphery are due, in part, to a lack of system pressure or repeated pipe breaks, which are common in these urban sectors (El Comercio, 2019). These system failures are, in part, the result of installation flaws, as compliance with the technical procedures for expansion and installation of drinking water networks is lacking or, simply, the water networks are not maintained (Correo, 2016), which is a recurrent phenomenon in many cities of the Global South (Boakye-Ansah et al., 2016; Tiwale, 2015). In any case, service interruptions in urban periphery districts (often prolonged) not only leave households without water but also have profound implications for the residents' daily lives, as they force these residents to seek other methods of supply. While informal supply systems contribute to water accessibility (although with significant challenges), they do not guarantee accessibility in terms of affordability, quality, and service delivery. According to our surveys in districts of the urban periphery of Arequipa, water in public use pylons and wells, is not available 24 hours a day, because these small-scale water sources are controlled by housing association managers and individual groups who often set specific water supply schedules and prices (water from these sources is often five times more expensive than water in the urban core). Residents of the urban periphery must adapt to water distribution and commercialization schedules, whereby the water tariff varies according to the source. In Arequipa periphery districts not only inequalities in access to supply systems are found. Inequalities in affordability and service provision, determined by income and social and cultural processes, are also widespread as these factors define how and in what quantities water should be provided to households. These results can be of great assistance to Arequipa's water planners and managers, as well as water managers in other fast-growing cities of the Global South who must face multiple challenges to ensure water supply, as they may help in implementing broader urban water policies that address existing challenges in affordability, water quality, and service delivery.

Chapter 3 suggests that the expansion of drinking water networks in cities of the Global South is important, but it is also extremely important to pay attention to the operation of these networks, as well as to land management, like the latter, for example, not only challenges the expansion of drinking water networks but also their operational capacity. Likewise, this study shows that in the urban context where drinking water networks face challenges, informal supply systems appear as complementary alternatives, so the contribution of informal supply systems is acknowledged, instead of stigmatized as unreliable at most temporary suppliers of water.

6.2 Water management strategies influence on access to water in Arequipa

Chapter 4 addresses the issue of the most commonly used urban water management strategies in Arequipa. The public agency that manages water in the city of Arequipa promotes top-down urban water management strategies, especially after numerous droughts and episodes of water scarcity that the city has suffered, to reduce “exaggerated” water uses. The top-down water management strategy sponsored by the public agency in Arequipa is related, among other aspects, to Water Demand Management (WDM), which includes economic, technological strategies and awareness campaigns to save water. The discourse promoting demand management revolves around very “high” water uses. In other words, the public water agency in Arequipa argues that household water consumption patterns are very high or ultimately that household’s wastewater. Thus, Arequipa’s public agency advocates WDM strategies to drastically reduce water consumption patterns, although these discourses do not recognize, among other aspects, the different socio-spatial realities, which represent the forms of access to water in cities in the Global South (Bakker, 2003; Kooy & Bakker, 2008; Wright-Contreras et al., 2017). In this sense, this chapter analyzes to what extent top-down strategies (economic and technological strategies, and awareness campaigns) influence access to water in Arequipa.

Chapter 4 is based on surveys, interviews, and analysis of per capita water consumption data in three districts of the urban core (with higher economic incomes), where access to drinking water is almost universal, and three districts of the urban periphery (with lower economic income), where access to water is much more unequal and uncertain.

The public water agency in Arequipa has promoted the implementation of economic instruments with the aim of reducing water consumption and distributing the resource more equitably. The Increasing Block Rate (IBR) is the economic method used in Arequipa, as in most fast-growing cities of the Global South (Brichetti, 2019; Donoso, 2015; Nauges & Whittington, 2009). The IBR has gained relevance in Arequipa, as well as in other cities in the Global South because it has three attractive characteristics. First, prices are set according to the consumption block, with the first block usually having a lower price and the last block having a higher price, so the first is usually designed for low-income households. Second, it is understood that high-income households consume more water, so there is a possibility that high-income households provide subsidies to poor households. Third, higher block prices require households to reduce their water consumption.

Chapter 4 of this thesis shows that the implementation of economic strategies to reduce water consumption in Arequipa develops with unfavorable effects on the economy of households in districts both of the urban core and the urban periphery. Surveys reveal that current water rates in Arequipa affect negatively 17 and 50 percent of the population in the urban core and the periphery respectively. Likewise, an eventual increase in water tariffs might affect an average of 75 percent of the population in both urban settings. These results are relevant since the public water agency in Arequipa has introduced three blocks of water consumption, where the first block of 10m^3/month is designed for poor households in the urban periphery districts. However, in Chapter 4 it was seen that households in poor districts consume between 12 and 14 m^3/month (the figure in the second consumption block), partly due to the higher number of people per household, which is common in low-income households in the Global South (Du, King, & Chanchani, 2020; Staddon et al., 2020). More people tend to naturally increase water consumption figures per household. Consequently, according to these results, it can be stated that poor households do not benefit from the cross-subsidies implied by the IBT, since their water consumptions fall in the second, more expensive block. The method used in Arequipa (where the water tariff increases annually) to reduce water consumption patterns affects the wellbeing of low-income households. With higher numbers of people either in the urban core or in the periphery (the latter showing more unfavorable impacts), this price system can widen existing inequalities of accessibility and affordability in both urban environments. In other words, demand management based on tariff increases will not achieve its main purpose of reducing the water use patterns of at least 75 percent of Arequipa’s urban population, because the water consumption per capita/day is already low, especially in the periphery districts. Another reason why tariffs may not reduce water consumption or may reduce it at a cost in health and wellbeing is due to the inelasticity of water demand for essential uses (Boland & Whittington, 2000; Whittington et al., 2015). This would explain households’ unfavorable perception of rising prices.

Chapter 4 argues against the abstractions that justify economic methods to reduce water consumption patterns (Fernández, 2015; Molinos-Senante & Donoso, 2016) but do not consider socio-spatial differences in cities of the Global South (Mitlin & Satterthwaite, 2012; Wright-Contreras et al., 2017). For example, price increases in Arequipa could improve the financial sustainability of the public water agency SEDAPAR but contribute little to social and environmental sustainability. These results support the hypothesis of other studies in cities of developed and developing countries that claim that improved water sustainability and “water security” purposes are carried out to the detriment of the poorest social segments (Empinotti et al., 2019; March & Sauri, 2017; Saurí, 2013, 2019).

Chapter 4 also shows that the public water agency in Arequipa has promoted the implementation of technological strategies and awareness campaigns. Regarding technological strategies, the public agency often encourages all its water users to upgrade their domestic water fixtures (low-flow toilets, showers, faucets, washing machines, etc.) to reduce water consumption. The upgrading of domestic water devices is relevant because it can help reduce consumption by up to 50 percent, at least in cities of the developed world (Inman & Jeffrey, 2006). However, the results of Chapter 4 reveal that, regardless of the public agency efforts, only 23.4 percent of the population in Arequipa's urban core districts have used water-saving devices (even though water coverage in the urban core is almost universal), while in districts in the urban periphery this percentage declines by half to 10.9 percent of the population. Numbers for the population using water-saving devices are relatively low for a variety of reasons including the high price of certain fixtures; water consumption already low, and service interruptions and need to access to different water supply systems, especially in districts in the urban periphery, which may make difficult the operation of efficient systems. The price of water-saving devices in Arequipa may represent a significant amount of household income. These problems could be addressed with subsidies for the purchase of water-saving devices, since, according to WDM's experience, subsidies have been relevant in the modernization of household water installations in the developed world. However, in the context of Arequipa, subsidies for the purchase of water-saving devices, other than costly for public organizations, could have significant limitations if service interruptions and water shortages in peri-urban districts are not addressed first. In summary, chapter 4 shows that the technological strategies preferred by modernization programs (who assume water consumption in absolute terms) present important limitations. More significantly, the concern of households in the urban core of Arequipa is how to ensure a supply of water threatened by service interruptions, while the concern of households in the urban periphery is simply how to obtain more water.

Regarding awareness campaigns to reduce water consumption, Chapter 4 shows that the public water agency in Arequipa has promoted various awareness programs, including advertisements in local media, conferences, and educational talks. One of the objectives of the awareness campaigns in Arequipa is to stimulate behavior towards more "sustainable" consumption. Awareness campaigns target the entire urban population of Arequipa, including residents of the urban periphery with access to informal water supply systems. It should be noted that the background of the awareness campaigns is that the consumption should be reduced in "all households". However, Chapter 4 of this thesis shows different perceptions of users concerning reducing water consumption. For example, while 57.3 percent of the residents of the urban core agreed that water consumption should decrease, only 20.5 percent of the urban periphery agreed. It could be concluded that awareness campaigns seem to motivate more the residents of the urban core compared to the urban periphery. However, the result for the urban core is not surprising, because all households have

access to drinking water, and water consumption varies between 150 to 170 liters per capita per day. The study also argues that the different perceptions of urban residents regarding the decline in water consumption could be related, among other aspects, to environmental concerns and not necessarily to the awareness campaigns carried out by the public water agency. On the other hand, although 57.3 and 20.5 percent of the residents of the urban core and periphery respectively show positive attitudes to reduce water consumption, this study highlights that in practice, these positive attitudes, will likely not translate into smaller consumptions, especially in the periphery where water consumption is already quite low. Also, the positive attitudes of urban residents may be mitigated by constant water service interruptions. In this sense, Chapter 4 reflects that awareness campaigns are relevant, but their effectiveness in a rapidly growing city with great socio-spatial differences such as Arequipa is limited. In any case, the effectiveness of awareness campaigns will depend on the recognition of strong socio-spatial differences in consumption. It is therefore probably meaningless to ask for further reductions to households that consume comparatively little water (March et al., 2015; March et al., 2013; Saurí, 2013). The results of Chapter 4 contrast with other research in cities of the Global South that identify important limitations of awareness campaigns (Iribarnegaray et al., 2014; Zietlow et al., 2016).

Finally, Chapter 4 highlights the theoretical relevance of water demand management and some limitations of its implementation in rapidly growing urban contexts. WDM strategies such as pricing, the implementation of water-saving devices, and awareness campaigns are promising for reducing water consumption, but their implementation in cities in the Global South (where social inequalities are higher) may have important implications on the wellbeing of the most disadvantaged. Still, targeted deployment can help improve WDM results. In any case, urgent attention to service interruptions, improvement of service delivery, expansion of quality service in suburban districts, etc., will be key to the implementation and social success of WDM.

6.3 The role of informal supply systems and collective action and the formal sector in coping with the Covid pandemic

Many countries of the Global South face rapid urbanization coupled with informal peri-urban growth, where water and sanitation infrastructures are often inadequate or in some cases non-existent. A large proportion of the population in peri-urban areas of the Global South do not have access to safe drinking water provided by public utilities (Andreasen & Møller-Jensen, 2016; Smiley, 2020; Swyngedouw, 1995). Faced with this situation, "informal" water providers of different sizes and scale levels have become prevalent and seek to fill the water supply gap left by public agencies

(Akbar, Minnery, van Horen, & Smith, 2007; Liddle et al., 2016). However, despite these contributions, informal systems are not recognized by urban water policies, because public agencies consider informal providers to be traditional, unreliable, and temporary that will disappear at some point, or ultimately assume that they are not compatible with "modern" urban water policies (Bakker, 2010; Cross & Morel, 2005; Misra, 2014). Chapter 5 argues against conventional views that advocate certain water supply practices and delegitimize others and highlights the role of formal and informal supply systems in access to water supply in the fast-growing city of Arequipa, especially in the context of the first wave of the Covid-19 pandemic.

Chapter 5 shows that, in Arequipa, water is provided by a variety of supply systems, which are commonly classified as formal and informal, because the latter is not recognized in water policy agendas. The formal providers are constituted by the public agency SEDAPAR which supplies water through the public network in all districts of the urban core and a part of the districts of the urban periphery. Informal providers rely on pylons for public use, tanker trucks, wells, etc., which fill the empty water supply space left by the public agency, especially in districts of the urban periphery (Muñoz, 2018). Informal providers serve approximately 15 percent of Arequipa's urban population and have achieved significant improvements in water service. For example, in the Yura district, they have been able to gradually expand the facilities of public-use pylons to increase accessibility. They have also built water storage tanks to increase water availability. Likewise, residents of the urban periphery have been involved in various ways in improving these facilities. However, given the informal context in which small-scale water providers operate, some challenges persist such as, for example, the high price of water that can cost five times more than in the urban core, little control of water quality, the limited availability of water during the day, among other challenges that have also been identified in numerous cities in the Global South (Agbemor & Smiley, 2020; Liddle et al., 2016; Mapunda et al., 2018; Opryszko et al., 2009). With these structural conditions in the background, Chapter 5 highlights the role of formal and informal water providers in ensuring water supply in the context of the first wave of the Covid-19 pandemic. Chapter 5 is based on interviews with representatives of the water agency in Arequipa, officials of other institutions with responsibilities for urban water management, representatives of the local and regional government of Arequipa, representatives of housing associations, and truck water providers. It also uses data provided by the public agency SEDAPAR.

Chapter 5 shows that, in the context of the rapid spread of Covid-19, the public water agency of Arequipa (SEDAPAR) implemented a series of measures to guarantee access to water for its users including the poor and most vulnerable households

in the urban periphery. The most relevant measures refer to the fractioning of water bills for up to 24 months; the suspension of scheduled water cuts, and the distribution of free water in tanker trucks, the latter designed for the population without access to drinking water networks. Although the measures implemented are especially important to keep under control the possible negative impacts of Covid-19, especially in districts of the urban periphery, Chapter 5 shows that the implemented measures have been limited in scope. In other words, the measures have largely benefited the residents with the highest economic incomes of the urban core and not the vulnerable households as had been intended. Chapter 5 argues that there are at least two reasons to explain this outcome. First, regulations facilitating access to the measures (e.g., the fractioning of water bills for up to 24 months and the suspension of scheduled water cuts) indicated that users had to request these benefits through the platform provided by the public service company, but only 25 percent of Arequipa's urban population enjoys internet access (Instituto Nacional de Estadística e Informática, 2017). Second, the failure of the drinking water network system (due to pipe breaks) left several districts of Arequipa without water, so the free water measure was addressed to the population affected by the pipe breaks (generally higher-income segments). In summary, the measures implemented by the public agency in Arequipa have been undermined by digital divides and water supply complexities. Significant digital divides exist in cities in the Global South (Mariscal, 2005). Still, digital platforms were the most widely used medium during the Covid-19 pandemic in Arequipa. On the other hand, water service interruptions in Arequipa, as in numerous cities in the Global South (Mitlin et al., 2019), have limited the scope of the measures implemented by the public agency SEDAPAR. Water service interruptions are much more frequent in districts on the urban periphery so that the measure " suspension of water cut-offs " in peripheral areas may not be relevant. Even though the measures implemented may have a limited scope, not only in Arequipa, but in other cities of the Global South as well (Amankwaa & Ampratwum, 2020; Stoler, Wendy, & Wutich, 2020), Chapter 5 is not intended to discourage future measures dictated by the public agencies such as SEDAPAR to guarantee water supply, but conversely suggests that in implementing these measures attention should be paid to the complexities of water supply (interruptions, low pressure, diversity of sources of water access) and to the city's socio-spatial differences. For example, targeting better the measures implemented by the public water agency could have benefited poor households. Also, collaboration with tanker operators considered "informal" could have increased the reach of free water. Chapter 5 argues for the need to implement innovative responses that really work in very complex urban contexts, such as those of the Global South.

Given that the measures implemented by the public agency SEDAPAR to guarantee the supply of water have been concentrated in districts of the urban core, informal water providers have played a relevant role in the supply of water to districts in the urban periphery. Despite the travel restrictions imposed by the Peruvian government and the high degree of contagion posed by Covid-19, informal providers continued their operations because they need to continue in business and also because they have a commitment to their users. Likewise, informal providers also implemented a set of measures to protect personnel from possible contagion.

Concerning measures to guarantee water supply, Chapter 5 notes that informal suppliers decided to maintain the price of water during the first wave of Covid-19. In some exceptional cases, informal providers lowered the water tariff, especially for the most vulnerable populations. Likewise, within the Housing Associations, those in charge of water provision through public use pylons allocated a minimum amount of free water for vulnerable households. The minimum amount of water was one bucket per day, that is, 20 liters of water per household per day. About personal protection, all informal providers allocated a minimum of their income to purchase personal protective equipment and disinfectants. However, although they bought their equipment, they did not receive training on how to use equipment and disinfectants, as they were not summoned by the public water agency. In any case, informal providers followed general recommendations that have been addressed in the local media to avoid contagion of their personal, which was key to the continuity of their operations. In this regard, Chapter 5 reflects how the measures implemented by informal providers have facilitated access to water in districts on the urban periphery. Likewise, a collaboration between residents of the urban periphery has been key to the "equitable" allocation of water. For example, agreements regarding maximum water purchase limits have been critical to securing the resource at the household level. Similarly, the distribution of free water has been a key gesture for households that have lost income due to mobility restrictions. However, although these measures are very relevant to guaranteeing water supply, Chapter 5 also exposes some limitations. For example, fixing the water supply at 8 buckets may not be meaningful for households with reduced incomes or limited storage capacities. On the other hand, the decrease in water costs and the distribution of free water may not be sustained in the long term, because the operability of informal providers is highly dependent on the commercialization of water. The distribution of free water may not be equitable, because this measure was implemented based on income and not based on the number of persons per household. Also, the limited water distribution points have led to overcrowding, which could increase Covid-19 infections.

In any case, Chapter 5 does not intend to question the future initiatives of informal providers, but rather the objective was to emphasize the community efforts around the supply of water that helped to mitigate the unfavorable effects of Covid-19 in Arequipa. It can even be said that informal providers have supported the public agency SEDAPAR in the tragic scenario of COVID related impacts, which has been anticipated by numerous experts for cities in the Global South (Corburn et al., 2020; von Seidlein, Alabaster, Deen, & Knudsen, 2021; Wilkinson et al., 2020). Likewise, the chapter is aware of the limitations of informal providers not as an unfavorable condition, but as a factor that must be improved with the support of the public water agency and government institutions in the city. In other words, a collaboration between the public water agency and informal providers could improve service delivery in peripheral urban areas. With this in mind, Chapter 5 attempts to contribute to the growing literature that addresses the potential role of informal providers in water supply in cities in the Global South (Allen, Dávila, & Hofmann, 2006; Chakava, Franceys, & Parker, 2014; Chitonge, 2014), or even to increase water accessibility in cities in the Global South (Adams & Zulu, 2015; Kooy, 2014a; Narayanan, Rajan, Jebaraj, & Elayaraja, 2017).

6.4. Limitations and future research

After summarizing and discussing the main results of the thesis, it is important to be aware of the limitations faced throughout the development of the research. One first limitation of this research is related to data availability. Although for the case of Arequipa there are universal water supply data based on averages, it is a challenge to find disaggregated data, e.g., water consumption per capita/day by districts or neighborhoods in the urban core and periphery. The Arequipa water agency provided us with water consumption data, but these data are generally from urban areas connected to potable water networks. Residents of the urban peripheries manage certain data (which may differ according to access to the water source such as public pylon, wells, tanker trucks, etc.) that help provide water consumption data, but these data are not always collected by public institutions, so they are often not always available. For example, Chapter 5 would have benefited from disaggregated water consumption data for districts in the urban periphery, especially during the Covid-19 pandemic. Lack of data or limited data availability (including outdated data) can hinder the objective of urban water policies (FAO, 2021; IBNet, 2019). In any case, the lack of data, especially of per capita/day water consumption in urban periphery districts could be considered as a constraint for Chapter 5.

Another limitation is related to the number of housing association representatives interviewed since in Arequipa there are more than 200 housing associations with different regulations and diverse ways of accessing water. Housing associations are widely scattered in the urban periphery of Arequipa and access one or multiple sources of water supply, which varies according to the local urban context. Considering the multitude of housing associations, we only interviewed the representatives who answered our calls or had a telephone number. The opinion of a larger number of housing association representatives could have helped to broaden the discussion in Chapters 3 and 5.

Also, another limitation could be related to the number of respondents from informal urban water providers. While a variety of supply systems exist in Arequipa (with various representatives), we have only interviewed a "few" representatives of informal water providers, we say "a few" rather than a number because there is no exact number of representatives of informal water providers. On the other hand, although the representatives of informal water providers are usually predisposed to agree to interviews, not all of those we have tried to contact have agreed to the interview because they have some distrust due to their operating in informality, as they fear being fined by the public water agency. In any case, a larger number of interviewees from this collection could have benefited chapters 3, 4, and 5.

Given that the present research work highlights inequalities in access to water, including affordability, quality, and service provision in fast-growing cities in the Global South, further empirical work based on case studies analyzing intra-urban access inequalities is desirable. As discussed in this thesis, comparisons of water access are usually made between urban and rural contexts, but not within cities, so this research work may be a relevant starting point to analyze, for example, how access to drinking water varies (including affordability, water quality, availability and service provision) within the context of planned (commonly called "formal") urban areas and within unplanned (informal) urban areas, in the latter, how accessibility varies within neighborhoods and households, whether "formal or informal". This is important because typically international organizations and local water managers often rely on water "universal access" figures, but these figures do not always guarantee water affordability, drinking water quality, and the number of service hours available, due to public network operation problems (Mitlin, 2019). In addition, reports by international organizations based on water "universal access" figures may overstate the success of water supply, but these averages also do not take into account, among other aspects, the number of drinking water supply cut-offs due to non-payment of the bill (Burt & Ray, 2014; Mcdonald et al., 2020). High tariffs or poorly targeted water cross-subsidies can affect low-income residents and households with higher numbers, which can increase the number of water-poor urban residents (March & Sauri, 2017; Saurí, 2003).

Moreover, this thesis shows significant inequalities in water access in urban fringe districts, but we believe that case studies at the neighborhood level can reflect better how inequalities occur daily (e.g., with water transport that can compromise water quality) and how these everyday inequalities may shape residents' urban lives. Although Chapter 5 highlights the potential of informal sources of supply, it would be advisable to analyze, for example, to what extent informal sources of supply (recognized by the public water sector) may or may not ensure the equal involvement of women and men. As recognized in numerous studies, as well as in Chapter 2 of this study, in most urban settlements in the Global South, lack of water is a problem that mainly affects women (Adams et al., 2018; Cole, 2017; Truelove, 2011). Indeed, women often bear a disproportionate burden of water management in their households (including, among other things, water collection and storage). Empirical work showing possibilities for women to lift the daily burdens of water provision and use can have important implications for women's lives and their overall well-being. As noted by Adams (2018), gender equity in urban water management has multiple benefits, including strengthening community water management.

Also, given that water supply is intermittent in the urban core and periphery, it would be interesting to study how households cope and adapt to it, and what implications their adaptation involves. If the answer is water storage, then it would be interesting to study repercussions on water quality and more generally, the impacts on the health of consistent poor-quality water.

6.5 References

Adams, E. A., Boateng, G. O., & Amoyaw, J. A. (2016). Socioeconomic and Demographic Predictors of Potable Water and Sanitation Access in Ghana. *Social Indicators Research*, *126*(2), 673–687. https://doi.org/10.1007/s11205-015-0912-y

Adams, E. A., Juran, L., & Ajibade, I. (2018). 'Spaces of Exclusion' in community water governance: A Feminist Political Ecology of gender and participation in Malawi's Urban Water User Associations. *Geoforum*, *95*, 133–142. https://doi.org/10.1016/j.geoforum.2018.06.016

Adams, E. A., Sambu, D., & Smiley, S. L. (2019). Urban water supply in Sub-Saharan Africa: historical and emerging policies and institutional arrangements. *International Journal of Water Resources Development*, *35*(2), 240–263. https://doi.org/10.1080/07900627.2017.1423282

Adams, E. A., & Zulu, L. C. (2015). Participants or customers in water governance? Community-public partnerships for peri-urban water supply. *Geoforum*, *65*, 112–124. https://doi.org/10.1016/J.GEOFORUM.2015.07.017

Agbemor, B. D., & Smiley, S. L. (2020). Tensions between Formal and Informal Water Providers: Receptivity toward Mechanised Boreholes in the Sunyani West District, Ghana. *Journal of Development Studies*, *57*(3), 1–17. https://doi.org/10.1080/00220388.2020.1786059

Ahlers, R., Cleaver, F., Rusca, M., & Schwartz, K. (2014). Informal space in the urban waterscape: Disaggregation and co-production of water services. *Water Alternatives*, *7*(1), 1–14. Retrieved from https://www.water-alternatives.org/index.php/alldoc/articles/vol7/v7issue1/230-a7-1-1

Akbar, H. M. D., Minnery, J. R., van Horen, B., & Smith, P. (2007). Community water supply for the urban poor in developing countries: The case of Dhaka, Bangladesh. *Habitat International*, *31*(1), 24–35. https://doi.org/10.1016/J.HABITATINT.2006.03.001

Allen, A., Dávila, J. D., & Hofmann, P. (2006). The peri-urban water poor: citizens or consumers? *Environment & Urbanization*, *18*(2), 333–351. https://doi.org/10.1177/0956247806069608

Amankwaa, G., & Ampratwum, E. F. (2020). COVID-19 'free water' initiatives in the Global South: what does the Ghanaian case mean for equitable and sustainable water services? *Water International*, *45*(7–8), 722–729. https://doi.org/10.1080/02508060.2020.1845076

Andreasen, M. H., & Møller-Jensen, L. (2016). Beyond the networks: Self-help services and post-settlement network extensions in the periphery of Dar es Salaam. *Habitat International*, *53*, 39–47. https://doi.org/10.1016/J.HABITATINT.2015.11.003

Auriol, E., & Picard, P. M. (2009). Infrastructure and public utilities privatization in developing countries. *World Bank Economic Review*, *23*(1), 77–100. https://doi.org/10.1093/wber/lhn014

Bakker, K. (2003). Archipelagos and networks: urbanization and water privatization in the South. *The Geographical Journal*, *169*(4), 328–341. https://doi.org/10.1111/j.0016-7398.2003.00097.x

Bakker, K. (2010). *Provatizing Water: Gobernance Failure and the World's Urban Water Crisis*. New York: Cornell University Press. Retrieved from https://books.google.es/books?hl=en&lr=&id=qIMG3Ik6NXwC&oi=fnd&pg=PR6&ots=WISkAhqS2W&sig=VShLzGTl6xxVBN4r_7k4eN0A2us&redir_esc=y#v=onepage&q&f=false

Bayliss, K., & Waeyenberge, E. Van. (2017). Unpacking the Public Private Partnership Revival. *The Journal of Developing Studies*, *54*(4), 577–593. https://doi.org/10.1080/00220388.2017.1303671

Bender, K. (2017). Introducing Commercial Finance into the Water Sector in Developing Countries. *World Bank Group*. https://doi.org/10.1596/26187

Boakye-Ansah, A. S., Ferrero, G., Rusca, M., & Van Der Zaag, P. (2016). Inequalities in microbial contamination of drinking water supplies in urban areas: The case of Lilongwe, Malawi. *Journal of Water and Health*, *14*(5), 851–863. https://doi.org/10.2166/wh.2016.258

Boland, J. J., & Whittington, D. (2000). The political economy of water tariff design in developing countries: IBTs versus uniform price with rebate. In A. Dinar (Ed.), *The Political Economy of Water Pricing Reforms* (pp. 215–235). Oxford University Press. Retrieved from http://documents1.worldbank.org/curated/en/199301468771050868/pdf/multi-page.pdf

Brichetti, J.-P. (2019). *Panorama de las tarifas de agua en los países de Latinoamérica y el Caribe*. Retrieved from https://publications.iadb.org/publications/spanish/document/Panorama_de_las_tarifas_de_agua_en_los_países_de_Latinoamérica_y_el_Caribe_es_es.pdf

Burt, Z., & Ray, I. (2014). Storage and non-payment: Persistent informalities within the formal water supply of hubli-dharwad, India. *Water Alternatives*, *7*(1), 106–120. Retrieved from https://www.water-alternatives.org/index.php/volume7/v7issue1/236-a7-1-7/file

Chakava, Y., Franceys, R., & Parker, A. (2014). Private boreholes for Nairobi's urban poor: The stop-gap or the solution? *Habitat International*, *43*, 108–116. https://doi.org/10.1016/j.habitatint.2014.01.012

Chitonge, H. (2014). Cities Beyond Networks: The Status of Water Services for the Urban Poor in African Cities. *African Studies*, *73*(1), 58–83. https://doi.org/10.1080/00020184.2014.887743

Cole, S. (2017). Water worries: An intersectional feminist political ecology of tourism and water in Labuan Bajo, Indonesia. *Annals of Tourism Research*, *67*, 14–24. https://doi.org/10.1016/J.ANNALS.2017.07.018

Corburn, J., Vlahov, D., Mberu, B., Riley, L., Caiaffa, W. T., Rashid, S. F., … Ayad, H. (2020). Slum Health: Arresting COVID-19 and Improving Well-Being in Urban Informal Settlements. *Journal of Urban Health*, *97*(3), 348–357. https://doi.org/10.1007/s11524-020-00438-6

Correo. (2016). Arequipa: vecinos de Tiabaya sufren la falta de agua debido a tuberías con sarro. Retrieved September 29, 2021, from https://diariocorreo.pe/edicion/arequipa/arequipa-vecinos-de-tiabaya-sufren-la-falta-de-agua-debido-a-tuberias-con-sarro-698262/

Cross, P., & Morel, A. (2005). Pro-poor strategies for urban water supply and sanitation services delivery in Africa. *Water Science and Technology*, *51*(8), 51–57. https://doi.org/10.2166/wst.2005.0223

Donoso, G. (2015). Water Pricing in Chile: Decentralization and Market Reforms. In A. Dinar, V. Pochat, & J. Albiac-Murillo (Eds.), *Water Pricing Experiences and Innovations* (Vol. 9, pp. 83–96). Springer. https://doi.org/10.1007/978-3-319-16465-6_5

Du, J., King, R., & Chanchani, R. (2020). Tackling Inequality in Cities is Essential for Fighting COVID-19. Retrieved October 8, 2021, from https://www.wri.org/insights/tackling-inequality-cities-essential-fighting-covid-19

El Comercio. (2019). Arequipa: 200 mil personas se quedan sin agua por rotura de tubería Arequipa. *El Comercio*, p. 1. Retrieved from https://elcomercio.pe/peru/arequipa/arequipa-200-000-pobladores-quedan-servicio-agua-rotura-tuberia-noticia-nndc-598579-noticia/?ref=ecr

Empinotti, V. L., Budds, J., & Aversa, M. (2019). Governance and water security: The role of the water institutional framework in the 2013–15 water crisis in São Paulo, Brazil. *Geoforum*, *98*, 46–54. https://doi.org/10.1016/J.GEOFORUM.2018.09.022

FAO. (2021). Base de datos AQUASTAT. Retrieved August 23, 2021, from http://www.fao.org/aquastat/statistics/query/index.html?lang=es

Fernández, D. (2015). Water Pricing in Colombia: From Bankruptcy to Full Cost Recovery. In A. Dinar, V. Pochat, & J. Albiac-Murillo (Eds.), *Water Pricing Experiences and Innovations* (Vol. 9, pp. 117–138). Springer. https://doi.org/10.1007/978-3-319-16465-6_7

González-Gómez, F., & García-Rubio, M. A. (2018). Prices and ownership in the water urban supply: a critical review. *Urban Water Journal*, *15*(3), 259–268. https://doi.org/10.1080/1573062X.2018.1436187

IBNet. (2019). Countries - IBNet Tariffs Database. Retrieved September 4, 2019, from https://tariffs.ib-net.org/sites/IBNET/Wizard/Countries?regionId=4

Inman, D., & Jeffrey, P. (2006). A review of residential water conservation tool performance and influences on implementation effectiveness. *Urban Water Journal*, *3*(3), 127–143. https://doi.org/10.1080/15730620600961288

Iribarnegaray, M. A., De La Zerda, M. F. E., Hutton, C. M., Brannstrom, C., Liberal, V. I., Tejerina, W., & Seghezzo, L. (2014). Water-conservation policies in perspective: Insights from a Q-method study in Salta, Argentina. *Water Policy*, *16*(5), 897–916. https://doi.org/10.2166/wp.2014.159

K'Akumu, O. A. (2004). Privatization of the urban water supply in Kenya: Policy options for the poor. *Environment and Urbanization*, *16*(2), 213–222. https://doi.org/10.1630/0956247042310025

Kooy, M. (2014a). Developing Informality: The Production of Jakarta's Urban Waterscape. *Water Alternatives*, *7*(1), 35–53. Retrieved from http://www.water-alternatives.org/index.php/allabs/232-a7-1-3/file

Kooy, M. (2014b). *Developing Informality: The Production of Jakarta's Urban Waterscape*. Retrieved from www.water-alternatives.org

Kooy, M., & Bakker, K. (2008). Splintered networks: The colonial and contemporary waters of Jakarta. *Geoforum*, *39*(6), 1843–1858. https://doi.org/10.1016/J.GEOFORUM.2008.07.012

Liddle, E. S., Mager, S. M., & Nel, E. L. (2016). The importance of community-based informal water supply systems in the developing world and the need for formal sector support. *Geographical Journal*, *182*(1), 85–96. https://doi.org/10.1111/geoj.12117

Mapunda, D. W., Chen, S. S., & Yu, C. (2018). The role of informal small-scale water supply system in resolving drinking water shortages in peri-urban Dar Es Salaam, Tanzania. *Applied Geography*, *92*(January), 112–122. https://doi.org/10.1016/j.apgeog.2018.02.001

March, H., Hernández, M., & Saurí, D. (2015). Assessing domestic water use habits for more effective water awareness campaigns during drought periods: A case study in Alicante, eastern Spain. *Natural Hazards and Earth System Sciences*, *15*(5), 963–972. https://doi.org/10.5194/NHESS-15-963-2015

March, Hug, Domènech, L., & Saurí, D. (2013). Water conservation campaigns and citizen perceptions: The drought of 2007-2008 in the Metropolitan Area of Barcelona. *Natural Hazards*, *65*(3), 1951–1966. https://doi.org/10.1007/s11069-012-0456-2

March, Hug, & Sauri, D. (2017). When sustainable may not mean just: a critical interpretation of urban water consumption decline in Barcelona. *Local Environment*, *22*(5), 523–535. https://doi.org/10.1080/13549839.2016.1233528

Mariscal, J. (2005). Digital divide in a developing country. *Telecommunications Policy*, *29*(5–6), 409–428. https://doi.org/10.1016/j.telpol.2005.03.004

Mcdonald, D. A., Spronk, S., & Chavez, D. (2020). *Public Water Dark Clouds and Silver Linings*. *Municipal Service Project*. Kingston. Retrieved from www.tni.org

Meehan, K. M. (2014). Tool-power: Water infrastructure as wellsprings of state power. *Geoforum*, *57*, 215–224. https://doi.org/10.1016/J.GEOFORUM.2013.08.005

Misra, K. (2014). From formal-informal to emergent formalisation: Fluidities in the production of urban waterscapes. *Water Alternatives*, *7*(1), 15–34. Retrieved from http://www.water-alternatives.org/index.php/volume7/v7issue1/231-a7-1-2/file

Mitlin, D., Beard, V. A., Satterthwaite, D., & Du, J. (2019). *Unaffordable and Undrinkable: Rethinking Urban Water Access in the Global South*. *World Resources Institute*. Retrieved from https://www.wri.org/wri-citiesforall/cities-all

Mitlin, D., & Satterthwaite, D. (2012). *Urban Poverty in the Global South: Scale and Nature*. *Routledge Library Editions*. Routledge. https://doi.org/10.4324/9780203104316

Molinos-Senante, M., & Donoso, G. (2016). Water scarcity and affordability in urban water pricing: A case study of Chile. *Utilities Policy*, *43*, 107–116. https://doi.org/10.1016/j.jup.2016.04.014

Muñoz, A. (2018). Movimiento de pobladores , desarrollo urbano y gobernabilidad local: situación y desafíos en el cono norte de Arequipa. In *Movimientos sociales, actores y representación política* (pp. 259–275). Retrieved from http://www.desco.org.pe/recursos/site/files/CONTENIDO/1248/13_PH_muñoz_dic18.pdf

Narayanan, S., Rajan, A. T., Jebaraj, P., & Elayaraja, M. S. (2017). Delivering basic infrastructure services to the urban poor: a meta-analysis of the effectiveness of bottom-up approaches. *Utilities Policy*, *44*, 50–62. https://doi.org/10.1016/J.JUP.2017.01.002

Nauges, C., & Whittington, D. (2009). Estimation of Water Demand in Developing Countries: An Overview. *World Bank Research Observer*, (25), 263–294. https://doi.org/10.1093/wbro/lkp016

Opryszko, M. C., Huang, H., Soderlund, K., & Schwab, K. J. (2009). Data gaps in evidence-based research on small water enterprises in developing countries. *Journal of Water and Health*, *7*(4), 609–622. https://doi.org/10.2166/wh.2009.213

Sauri, D. (2003). Lights and shadows of urban water demand management: The case of metropolitan region of Barcelona. *European Planning Studies*, *11*(3), 229–243. https://doi.org/10.1080/09654310303639

Sauri, D. (2013). Water Conservation: Theory and Evidence in Urban Areas of the Developed World. *Annual Review of Environment and Resources*, *38*(1), 227–248. https://doi.org/10.1146/annurev-environ-013113-142651

Sauri, D. (2019). The decline of water consumption in Spanish cities: structural and contingent factors. *International Journal of Water Resources Development*, *36*(6), 1–17. https://doi.org/10.1080/07900627.2019.1634999

Smiley, S. L. (2013). Complexities of water access in Dar es Salaam, Tanzania. *Applied Geography*, *41*, 132–138. https://doi.org/10.1016/j.apgeog.2013.03.019

Smiley, S. L. (2020). Heterogeneous water provision in Dar es Salaam: The role of networked infrastructures and alternative systems in informal areas. *EPE: Nature and Space*, *3*(4), 1215–1231. https://doi.org/10.1177/2514848620908194

Staddon, C., Everard, M., Mytton, J., Octavianti, T., Powell, W., Quinn, N., … Mizniak, J. (2020). Water insecurity compounds the global coronavirus crisis. *Water International*, *45*(5), 416–422. https://doi.org/10.1080/02508060.2020.1769345

Stoler, J., Wendy, J., & Wutich, A. (2020). Beyond handwashing: Water insecurity undermines COVID-19 response in developing areas. *Journal of Global Health*, *10*(1), 19–22. https://doi.org/10.7189/jogh.10.010355

Swyngedouw, E. (1995). The contradictions of urban water provision: a study of Guayaquil, Ecuador. *Third World Planning Review*, *17*(4), 387–405. https://doi.org/10.3828/twpr.17.4.c828066008888322

Tiwale, S. (2015). Understanding Lilongwe's thirst for water : linking infrastructure development to differentiated water supply. Retrieved May 9, 2021, from https://www.narcis.nl/publication/RecordID/oai:cdm21063.contentdm.oclc.org:masters2%2F93275

Truelove, Y. (2011). (Re-)Conceptualizing water inequality in Delhi, India through a feminist political ecology framework. *Geoforum*, *42*(2), 143–152. https://doi.org/10.1016/j.geoforum.2011.01.004

von Seidlein, L., Alabaster, G., Deen, J., & Knudsen, J. (2021). Crowding has consequences: Prevention and management of COVID-19 in informal urban settlements. *Building and Environment*, *188*(August 2020), 107472. https://doi.org/10.1016/j.buildenv.2020.107472

Walnycki, A. (2017). Contesting and Co-Producing the Right to Water in Peri-Urban Cochabamba. In *Future City* (Vol. 6, pp. 133–147). Urban Water Trajectories. https://doi.org/10.1007/978-3-319-42686-0_9

Whittington, D., Nauges, C., Fuente, D., & Wu, X. (2015). A diagnostic tool for estimating the incidence of subsidies delivered by water utilities in low- and medium-income countries, with illustrative simulations. *Utilities Policy*, *34*, 70–81. https://doi.org/10.1016/J.JUP.2014.12.007

WHO/UNICEF. (2017). *Progress on Drinking Water, Sanitation and Hygiene Update and SDG Baselines 2017 Launch version July 12 Main report*. *WHO Library Cataloguing in Publication Data*. Retrieved from http://apps.who.int/bookorders.

Wilkinson, A., Ali, H., Bedford, J., Boonyabancha, S., Connolly, C., Conteh, A., … Whittaker, L. (2020). Local response in health emergencies: key considerations for addressing the COVID-19 pandemic in informal urban settlements. *Environment and Urbanization*, *32*(2), 503–522. https://doi.org/10.1177/0956247820922843

Wright-Contreras, L., March, H., & Schramm, S. (2017). Fragmented landscapes of water supply in suburban Hanoi. *Habitat International*, *61*, 64–74. https://doi.org/10.1016/j.habitatint.2017.02.002

Zietlow, K. J., Michalscheck, M., & Weltin, M. (2016). Water conservation under scarcity conditions: testing the long-run effectiveness of a water conservation awareness campaign in Jordan. *International Journal of Water Resources Development*, *32*(6), 997–1009. https://doi.org/10.1080/07900627.2016.1159947

About the autor

Luis Zapana Churata is an Agricultural Engineer, graduated from the Faculty of Agronomy, at the National University of San Agustin de Arequipa-Peru. After completing his undergraduate studies, he has worked in agricultural projects in public and private institutions in the Arequipa region and subsequently, in 2015/2016 he studied a master's degree in Interdisciplinary Studies in Environmental, Economic and Social Sustainability (specializing in Science and Management of Global Change) at the Institute of Environmental Science and Technology, at the Autonomous University of Barcelona, Spain.

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List of publications

Zapana-Churata, L., March, H., & Sauri, D. (2021). Water demand management strategies in fast-growing cities. The case of Arequipa, Perú. *International Journal of Water Resources Development*, 1–25. https://doi.org/10.1080/07900627.2021.1903401.

Zapana, L. (2018). Respuestas a la crisis hídrica en zonas agrícolas y urbanas: Caso de estudio "Proyecto de Irrigación Majes Siguas I" Arequipa – Perú. *Agua y Territorio*, (12), 145–156. https://doi.org/10.17561/at.12.3532.

Zapana, L., March, H., & Saurí, D. (2020). Las desigualdades en el acceso al agua en ciudades latinoamericanas de rápido crecimiento: el caso de Arequipa, Perú. *Revista de Geografia Norte Grande*, *80, publication on december 1, 2021*.

Zapana-Churata, L. Las desigualdades de acceso al agua en ciudades del Sur Global desde el prisma de la Ecología Política Urbana. Submitted to the journal *Documents d'Anàlisi Geogràfica* in October 2021.

Zapana-Churata, L., Satorras, M., March, H., Sauri, D. Water supply in COVID-19 times: The role of public operators, housing associations and informal providers in Arequipa (Peru). Submitted to the journal *Water International*. Paper status under review.

Conferences

Zapana-Churata, L., Satorras, M., March, H., Sauri, D. (2021). COVID-19 and responses of water services in the cities of the global south: The case of Arequipa, Peru. *II International Conference on Water and Sustainability*, Terrassa, Spain.

Zapana-Churata, L. (2021). El agua y desafíos post Covid-19 en la ciudad de Arequipa, Perú. *Foro Internacional Hacia la Nueva Cultura del Agua y la Paz*, Valle del Cauca, Colombia.

Zapana, L., March, H., & Saurí, D. (2019). Las desigualdades en el acceso al agua y su relación con el desarrollo urbano: el caso de estudio en Arequipa-Perú. *X International Meeting WATERLAT GOBACIT*, Concepción, Chile.

Zapana, L., March, H., & Saurí, D. (2019). Las desigualdades en el acceso al agua y su relación con el desarrollo urbano: un análisis a través del ciclo hidrosocial en Arequipa, Perú.

XXVI CONGRESO DE LA ASOCIACIÓN ESPAÑOLA DE GEOGRAFIA, Valencia, Spain.
Zapana, L., March, H., & Saurí, D. (2018). Las desigualdades en el acceso al agua: un análisis a través del ciclo hidrosocial en áreas urbanas. *IX International Meeting WATERLAT GOBACIT*, Joao Pessoa, Brasil.
Zapana, L., March, H., & Saurí, D. (2018). Respuestas a la crisis hídrica en zonas agrícolas y urbanas: caso de estudio Proyecto de Irrigación Majes Siguas I, Arequipa, Perú. *IX International Meeting WATERLAT GOBACIT*, Joao Pessoa, Brasil.

Research stays

Research stays at the Department of Environmental Science (Research Group: Water Resources Management) at Wageningen University & Research, Wageningen, The Netherlands, from January 6 to April 06, 2020.
Objective of the stay:
To share experiences and previous results of the present study with the working team and specialists.
To concretize and reinforce the research content and attend seminars.
To develop the second objective of the thesis which was the elaboration of a research article.
The research stay was supervised by Drs. Rutgerd Boelens, Jeroen Vos and Lena Hommes.

Cover photo taken by Sandra Benavides. The image shows the city of Arequipa in the middle of an agricultural area (known locally as La Campiña) that is becoming less and less extensive due to rapid urbanization.

The photo on the back cover was provided by Alejandra Huanca. This image shows a natural water source from which "clean" groundwater springs in the Characato district of Arequipa City.