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Urban waterscapes and water service provision in informal settlements
Lessons for sustainable water access in Lima, Peru

A Thesis submitted in the Partial Fulfillment for the Requirement of the Degree of Master of Science in Integrated Urbanism and Sustainable Design

by

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Abstract

Located in an arid coast, Lima's urban areas face difficulties to sustain water security. The urban informal settlements of the periphery are particularly vulnerable due to the lack of official infrastructure networks of the water utility Sedapal and the expensive supply of alternative private providers (water trucks). The document builds upon the understanding of the scholarship in urban waterscapes, water delivery configurations and informal urbanization. Moreover, it reflects in two theoretical frameworks about the co-production of water services (Faldi et al 2019) and the sustainable water supply (Dakyaga et al 2018) accordingly.

The purpose of this research is to explore the realities of water supply practices of the urban poor located in the outskirts of Lima city. It follows an explorative and descriptive study through a case-based approach. To achieve that aim, the research gathers evidence from fieldwork in three barrios of the peri-urban settlement Jose Carlos Mariategui located in the district of San Juan de Lurigancho. The investigation illustrates how the urban waterscape shapes and is being shaped by the socio-spatial organization of the settlement, the everyday practices for basic water access and the current policy discourses of the water utility.

Findings from the case study reveal the opportunities and challenges of progressive self-provision and community-led schemes. It demonstrates that heterogeneous systems for water access in hillsides draw generally from the interlinkages between formal-informal provisions such as public water standpipes with unofficial arrangements. Thus, hybrid service provision modalities emerge to secure daily needs. It is constructed by adaptation strategies, social behavior such as modes of contestation and trust, and institutional-organizational arrangements for operation and maintenance.

The research seeks to contribute to the academic debates on water supply configurations in the global south and to deepen the understanding for sustained water provision in informal areas.

Keywords: urban waterscapes, informal settlements, water access, everyday practices,

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Acronyms and abbreviations

APT	'*Agua para Todos'* Water for all
CENCA	Urban Development Institute NGO
CEPLAN	'*Centro Nacional de Planeamiento Estratégico*' National Strategic Planning Center
COFOPRI	'Comisión de Formalización de la Propiedad Informal' Formalization Agency of Informal Property
COP	'*Certificado de posesión*' Certificate of possession
EPS	*'Empresa Prestadora de Servicios'* Water Supply and Sanitation Service Company
INEI	National Institute for Statistics
JCM	Jose Carlos Mariategui Settlement
LMA	Lima Metropolitan Area
MINSA	Ministry for Health
MINAM	Ministry of Environment
MML	Metropolitan Municipality of Lima
MVCS	Ministry for Housing, Construction, and Sanitation
NGO	Non-Governmental Organization
PPP	Public-Private Partnership
SEDAPAL	'*Servicio de Agua Potable y Alcantarillado de Lima*' Water Utility Company
SJL	District of San Juan de Lurigancho
SUNASS	Regulatory Entity for Water Suppliers
WSS	Water and Sanitation Services

Introduction

The rapid expansion of cities and the climate shocks have affected the availability of natural resources particularly water, influencing both the provision to basic urban services for all and the incremental scarcity stress for societies; while disproportionally affecting areas more vulnerable than others. According to the United Nations, half of the population is already living in urban areas, and by 2050 the global water demand is "projected to increase by 55%, mainly due to growing demands from manufacturing, thermal electricity generation, and domestic use" (UN Water, 2015, p.2). Hence, experts and governments enquire how to balance the growing population demands and build efforts for poverty alleviation and sustainable development in contexts of uncertainty.

In Lima Metropolitan Area, overpopulation and urban sprawl have increased the challenges of sustaining access to clean water and sanitation for the human settlements, especially those in the periphery that locate beyond the end of supply networks. Urban expansion is also followed by environmental impacts. For instance, the rise of extractive economies alongside the water basins from Rimac, Chillon, Lurin Rivers (the main source of drinking water) affects the quality of the water sources with high ecological cost implications and influences the deficit of water supply for the metropolis.
Likewise, the absence of instruments of territorial planning, and land use regulation encouraged the lack of protection/ conservation of natural resources in water basins, coastal Lomas, and riversides. The impacts of water scarcity on health, security, environment, and socio-economic development of settlements (UN Water, 2015) become more evident in this context.
Lima is also the second biggest city located in a desert, after Cairo, with reduced

water reserves. Although, the water problems in Lima seem to mainly emerge from its geographical conditions (Fernandez-Maldonado, 2008); water scarcity is not just about the physical shortage, but also the socio-economic-political spheres of scarcity such as lack of adequate management and unequal distribution (Ioris, 2011). As a result, the water issues affect increasingly the informal settlements due to their insecurity of tenure, the context of invisibility and absence of recognition, and the uneven development between the metropolitan city and the peripheries (Mesclier et al., 2015).

According to a study from GRADE (2018), informal urbanization has taken part in almost 93% of Peruvian cities. It has influenced an enlarged lack of provision to drinking water and sanitation facilities in peri-urban informal sites (Fernandez-Maldonado, 2008), accompanied by the bottom-up driven mechanisms for adapting to the critical water insecurity (Ioris, 2011). On the other hand, solutions from the government to satisfy the water demand prioritize infrastructure, discriminating socio-economic implications, and qualitative provision for low-income settlements. The case of the program for extension of networks "Agua para Todos" has improved the water coverage, but there are still 3 million people within the Lima Metropolitan Area (LMA) with no access to safe water and sanitation (Comercio, 2020).

This research explores the realities of water supply practices in informal settlements of hillside areas, where infrastructure for water and sanitation services (WSS) is not present. For this, it comprises the understanding of the community operations for water access and their implications in management, technology decisions and contextual factors to self-secure access to water daily. The findings also highlight the approach of the water utility, Sedapal, in the co-production of water services that catches up with spontaneous urbanization under neoliberal principles. Lastly, it questions the sustainability of bottom-up mechanisms. The research argues the interdependencies of formal-informal strategies, to aim for improved development of informal areas in a future allocation of services, and contributing to a more coordinated approach towards water security planning.

The research is organized into the following eight chapters:
Chapter 1. Conceptual framework: this chapter explores the theories on urban waterscapes and the current debates on systems of water provision. It highlights the implications of spontaneous urbanization in delivery configurations. Lastly,

it details the framework used in the analysis of the arrangements of supply practices and discussion of sustainable water access.
Chapter 2. Spatial context: It describes the contextual aspects of Lima Metropolitan Area (LMA), and the status of the delivery system, to present the general aspect of urban waterscapes in the periphery.
Chapter 3. Research questions and research methodology: This chapter explains the problem statement, the research questions and objectives. It emphasizes the methodological approach for the selection, data collection and analysis of the case study of Jose Carlos Mariategui (JCM) settlement in the district of San Juan de Lurigancho (SJL).
Chapter 4. Case study overview: It gives an overview of the urbanization process of SJL, among the socio-spatial dynamics and its water supply profile. It also highlights the success and limitations attributed to the State programs in facilitating access to WSSs to informal areas.
Chapter 5. Findings and discussion: First, it presents the realities of water provision in informal urban spaces of the settlement of JCM with the description of the current social program of 'Agua es Vida'. Second, it displays the variety of water supply practices, focusing particularly on the water system of barrio Biohuerto as the representative mechanism facing scarcity of drinking water uphill. Finally, it reveals the heterogeneity of everyday practices at the household level are presented to understand the conditions of individual and/or collective struggles.
Chapter 6. Framework for discussion: The discussions argue the hybridization of water practices in the case of JCM and the contestation of urban waterscapes in hillside areas. It discusses the implications for sustainable access in spontaneous settlements, and the role of the community in the local water management, alongside the effects on the operation of an unofficial water system.
Chapter 7. Lessons and recommendations: Based on the research, the lessons follow the understanding of the theories on urban waterscapes, supply practices, and informal urbanization.
Chapter 8. Conclusions: It frames the implications for practices and the suggested considerations for further research.
Finally, the document shows the references used in the research and the annexes of specific documents and interviews developed in the field research work.

1 Theorethical Framework

This chapter clarifies the concepts and theories fundamental to this thesis. A framework is developed for arguing the discussions and reflections on access to water services in the context of Lima's informal settlements.
The conceptual framework examines primarily the debates on urban waterscapes and water supply systems. It also presents the challenges of informality in service provision.
The present document aims to contribute to the academic gap of exploring urban waterscapes in informal settlements, to reveal the realities of the water utility discourses for universal coverage and the everyday strategies among unserved low-income households. The research argues on the sustainability of water practices that are generally bypassed in the extension of infrastructure networks.

1.1. Urban waterscapes

The theory of urban waterscapes has been discussed widely across the discourses on urban political ecology (UPE). Its major representative, Eric Swyngedouw, refers to «the tensions, the conflicts and the forces that flow with the water through the body, the city, the region and the world [that] show the cracks in the lines, the meshes in the network [and] the spaces of resistance and power» (Swyngedouw 2004, p.26). UPE scholars argue the reproduction of inequalities from the realities of formal and informal water provision as the aftermath of flows of water influencing capital accumulation through the urban waterscape. This approach supports the analytical attention on neo-liberalization shaping the circulation of water through networked systems (Gandy, Kaïka, Swyngedouw cited in Lopez 2014, p.26). Hence, this waterscape becomes the landscape whereby water flows correlate with political and economic power relations.

Furthermore, the urban waterscape enquires on the interdependencies between society and the transformations of water in both physical and social processes (Ahlers et al 2014). Thus, it describes constructed landscapes in constant transformation affected by "the interplay of institutional frameworks, discursive practices, technical choices and struggles over meanings of water" (Budds and Hinojosa, Loftus, Perreault et, Swyngedouw cited in Lopez 2014, p.23). These constructed landscapes also rely on the heterogeneity of everyday experiences producing the 'lived' space and reproducing 'capital' (Lefebvre cited in Ahlers et al, 2014).

In this sense, the research employs an urban and socio-ecological lens. Studying urban waterscapes emphasizes the ways at which water flows drive power operations under certain modes of governance, in both the urban and natural system, and influence as well as daily practices of low-income households, their capacities and social assets in constructing their habitat, their communities, and thus the cities.
The literature on case-study based research about urban waterscapes highlights the shaping processes of contestation (Lopez 2014) or the fluid tapestry of formality-informality (Misra 2014). The concept thus becomes a useful tool to approach all the formats of water service provision in developing areas especially into the realities of unequal access, use, and distribution.

1.1.1. The urbanization of water

Urban water states the approach of nature into the urbanization process. Nature in the city is exposed by research from Heynen, Kaïka and Swyngedouw 2006 (cited in Lopez, 2014) as a metabolic process, where nature or resources flow into the city as a commodity, e.g. water natural resources transformed in potable or drinking water. Lopez argues that urbanization inserts nature into "structures of capital" (2014, p.3) such as the commodification of resources into regulated quantities of a provision that can mobilize resources for certain environments while neglecting others.

Additionally, scholars on nature's materiality (Bakker and Bridge, Castree, Sultana cited in Lopez 2014) refer to different types of water that flow through the urban waterscape as an important factor that influences the material, discursive and institutional strategies to secure access to water. For Lopez, the relationship between nature, society, and urban infrastructure describes the biophysical and

spatial characteristics of water, such as its material features, e.g. “raw/potable, abundant/scarce, safe/unsafe, legal/illegal, physical/commercial loss” (2014, p.146). This heterogeneity of waters justifies how various practices are constructed, mobilized, and consolidated in water supply provision by the disconnected population (Lopez 2014).

1.1.2. Contested urban waterscapes

It refers to the landscapes where urban water becomes a much-disputed resource, due to changes in legal frameworks and institutional reforms. For instance, research on contested urban waterscapes (Lopez 2014) argues the emergence of informal landscapes from disconnected households because of the prevalence of market-oriented processes for provision impacting self-service provision or needs-driven formats.

Moreover, Jaglin (2012) explains that the performance and characteristics of networked services differ according to the forms of state intervention, economic and political determinants. In this sense, ‘governance failure’ helps to understand the impacts of disconnection, e.g. how institutional principles of public utilities were unsuccessful at integrating local socio-political processes and created room for other supply systems beyond conventional service (Jaglin 2012, p.58). In contested urban waterscapes, the differences between disconnected and connected areas raise questions of equity, governance intervention, and social construction of discourses of water.

1.1.3. Fluidities in the urban waterscapes

It refers to the landscapes where urban water is key in the interplay between formal and informal organized systems for water supply.
The literature on exploring water service provision stresses the academic discussion of formal-informal dichotomy to explain the realities of water supply practices (Ahlers et al 2014). However, there is little research about the everyday strategies of low-income households that are excluded from the formal infrastructure networks or those who deal with erratic daily supply. On the other hand, contemporary studies argue the definition of formal and informal practices for access to water, while discussing the classification of those as practices of ‘emergent formalizations’ (Misra 2014).

For the scope of this research, the concept of ‘informal practices’ follows the ar-

gument of Lopez (2014). These practices are the "result of the articulation and interaction between diverse social, political, ecological and economic processes" rather than the antithesis of formal as "something undesirable, unsustainable, inefficient, to be eliminated or in need to be formalized and regulated" (Lopez 2014, p. 162).

1.2. Water service provision and urban infrastructure networks

The metabolism of water in cities is possible through urban infrastructure networks. Infrastructure is conceptualized as physical artifacts that organize the flows of water through the city (Jaglin 2014). The water service provision in southern urbanization requires reflecting in its urban diversity such as "the implications of this diversity of conditions for the co-evolution of technology and social practice" (Jaglin 2014, p.437). In this sense, Jaglin emphasizes the term "delivery configurations" to describe all the service delivery channels that combine actors, institutions, and resources that reflect the diversity of service needs encouraging innovation to aim for the delivery of a good (Ibid, pp. 436-438).

These configurations include conventional and non-conventional 'dispositifs' (Ibid, p.437). Whereby, they reflect the dynamic processes including the heterogeneity of actors organizing the water access structure or being affected by the technology and network of tools, knowledge, and value within (Jaglin, 2012).

1.2.1. Water supply configurations

Conventional network models

It refers to the centralized supply network that is usually associated in terms of universal coverage as the most efficient and economical means (Courtard cited in Jaglin 2012). Models of networked urban services exist within the formal water supply and sanitation system. Jaglin (2012) argues the focus on the universality of conventional systems given to the expansion of services and within the dominated settings of urbanization in the South.

These systems appear to address ineffectively the needs of the peri-urban poor and the understanding of the "rationale and rules that govern informal practices" (Allen et al 2006, p.15). Although the standardized networked services seem to support efficient delivery, private companies and governments have failed to understand the "multiple coexisting systems complementary to the centralized network" (Faldi et al 2019, p.3), especially of those peri-urban communities.

Alternative socio-technical model

The socio-technical subsystems are one example of delivery configurations. It represents a "pragmatic response to the dislocation between supply and demand" (Jaglin 2012, p.59). For Agustin Maria 2007 (cited in Jaglin 2012, p. 56), the alternative socio-technical devices are "factors of change in the current [conventional] system". They can be decentralized subsystems and/or hybrid arrangements such as extensions of centralized piped water systems (Faldi et al 2019).

Moreover, Pilo (2017) argues that the development of the socio-technical perspective encourages the right to urban services. Whereby the human right to water is usually contradicted by policies of disconnection for illegal land tenure status or no-payment, and discourses driven by commercialization principles (Lopez 2014; Ahlers et al 2014). For instance, scholars argue that market principles influence institutional arrangements into "the transformation of notions of citizenship (e.g. from citizen to customer), discursive representations of nature (e.g. from a public good to scarce commodity) as well as material practices (e.g. from modern networked city to the splintering of infrastructures)" (Lopez 2014, p.9). This right to exercise water services concerns the most to the informal settlements because of their meaning of 'recognition' by the provision.

Everyday practices and human infrastructure

The concept of everyday practices describes the ways for negotiating access to drinking water, whereby daily negotiations build social relationships to governance the delivery and consequently the reconfiguration of urban spaces. The implications of understanding the everyday strategies highlight the role of the users and the heterogeneity in water (Peloso and Morinville 2014). Jaglin et al (2006) points out the implementation of other 'unconventional or not traditional methods' as an advantageous strategy against the absence of connections or sporadic service of official supply networks, to meet daily needs despite higher purchases of water.

Moreover, the literature on everyday practice refers to the 'multiple' and 'repetitive' actions made to manage and ensure water access (Peloso and Morinville 2014). These actions also constitute the social connections that mediate people to water flows. Simone 2004 (cited in Peloso and Morinville 2014) refers in this case to the framework of 'people as infrastructure'. This approach relates to the concept of agency that distinguishes the capabilities over various water sources through having control within differences of power (Swyngedouw 2004).

The understanding of practices of everyday life highlight how people "improvise, strategize and make decisions in the face of water insecurity and structural imbalances of power" (Peloso and Morinville 2014, p. 125)

Demand-driven practices

The literature on the WSS for the peri-urban poor (Allen et al 2006) refers to the ample range of informal water-supply practices, which exist outside the formal strategies and mechanisms ad usually remain 'invisible' to the policymaker.
The literature presents both the policy-driven and needs-driven mechanisms involved in WSS services. Three different actors, e.g. the public sector, the private sector, and the community, provide self-help mechanisms for water provision (Table 1.1). Allen et al (2006) point out that those 'policy-driven' mechanisms have been incapable to address the needs of the peri-urban poor, while the 'needs-driven' strategies seem to be effective ways of improvement.

Table 1.1 — Configuration of water supply practices according to the provider
Source: Allen A., Dávila, J. D. & Hofmann, P. (2006)

Table 1.1: Configuration of water supply practices according to the provider		
Provider	**Policy-driven practices**	**Needs-driven practices**
Public (state provider)	The offer from the public management	The offer of the end-user supported by the State
Private operator	The emergence of a supply market with private actors	A supply market emerging from the needs of the end-user
Community	-	The arrangements operated by the community for self-provision • Rainwater harvesting • Water theft • Paid provision from neighbors • Clandestine connections • Own individual wells and boreholes • Piped network kiosks with NGO support • Boreholes and kiosks run by a community • Horizontal condominiums

Moreover, scholars exploring water service modalities disagrees on the romanticized use of informal labels to characterize resourceful economies and arrangements of collective action distinctive of the poor; if underestimating informality within the broader spaces where also the rich operate illegal practices (Jaglin 2014, pp. 437-438). In this regard, the notion of service delivery configurations explains that the shift from illegal to legal water provision is not a linear process, but a mediating operation including the participation of various actors.

1.2.2. The dimensions of co-production of water service provision

The concept of service co-production states as a promising option to discuss service delivery in the Global South (Faldi et al 2019). The literature background in co-production was mostly discussed within public administration and management scholarships. The framework of Faldi et al (2019) though stresses on the investigations that started their discussions within the South (Ostrom cited in Faldi et al 2019) and internationally (United Nations in Faldi et al 2019) to argue the active role of citizens in contribution for service provision and the participation of local governments to co-produce the improvement of informal settlements.

This research builds upon the comprehensive framework of the co-production of water and sanitation services proposed by Faldi et al (2019). It is worth mentioning that this framework constitutes part of the conceptual framework for analysis (Figure 1.4). Thus, it does not focus exclusively in aspects of co-production. Its importance lies in the scope of the concept whereby co-produced arrangements discuss the deficiencies of centralized systems, the importance of spatial and socio-technical differentiations for better categorization and implications of alternative service delivery (Faldi et al 2019) and incorporate the understanding of informal practices and management conflicts within access to services (Ahlers et al 2014).

The interactions of three dimensions compose the chosen framework: the managerial, the techno-environmental, and the spatial. The following stresses the factors of each dimension, which will guide the analysis of this thesis.

Managerial dimension

It refers to the users, intermediaries and providers.

The engagement of users is through multiple roles, such as citizen, client, and customer (Nabatchi et al 2017). For the author, a citizen is a community member acting collectively or individually for a social goal; the client is a legitimate recipient of services; and the customer is the recipient of the public service (Ibid, 2017). The framework exemplifies cases of community-based provisions when larger groups of users can lead to shortcoming factors for decision-making because of the variety of interests but also advantages for low-cost organizations (Faldi et al, 2019).

The case of the Global South deploys a heterogeneity of intermediaries with different types of cooperation among the phases of the delivery cycle (Allen et al 2006). For instance, the framework presents the private sector, the community

sector, and the semi-professional civil society organizations differentiating their degree of institutionalization e.g. the formally structured or the informal scheme (Faldi et al 2019, p.20).

Furthermore, the service providers encompass the centralized state authorities or decentralized agencies with roles of service operation and maintenance (Allen et al. 2006). Likewise, the most representative case refer to the regular provision directly supplied by the public sector or public-private organizational arrangements at the city level.

Techno - environmental dimension

It refers to the socio-technical infrastructure of the water supply systems, to examine altogether the "physical and social capitals…: engineered works and governing/managing rules" (Faldi et al 2019, p.24). This dimension reflects on the capacities of technology for urban services affecting or being affected by ecological factors e.g. the natural resources. It further considers the interrelations between the resource systems and the infrastructure configurations (Faldi et al 2019).

The authors state how the resource availability influence the governance arrangements between actors and the local solutions proposed, realizing the impact on ecological systems. Other features refer to their quality, quantity, the multi-scalar nature of water resources, and user-knowledge of the resource (Ibid).

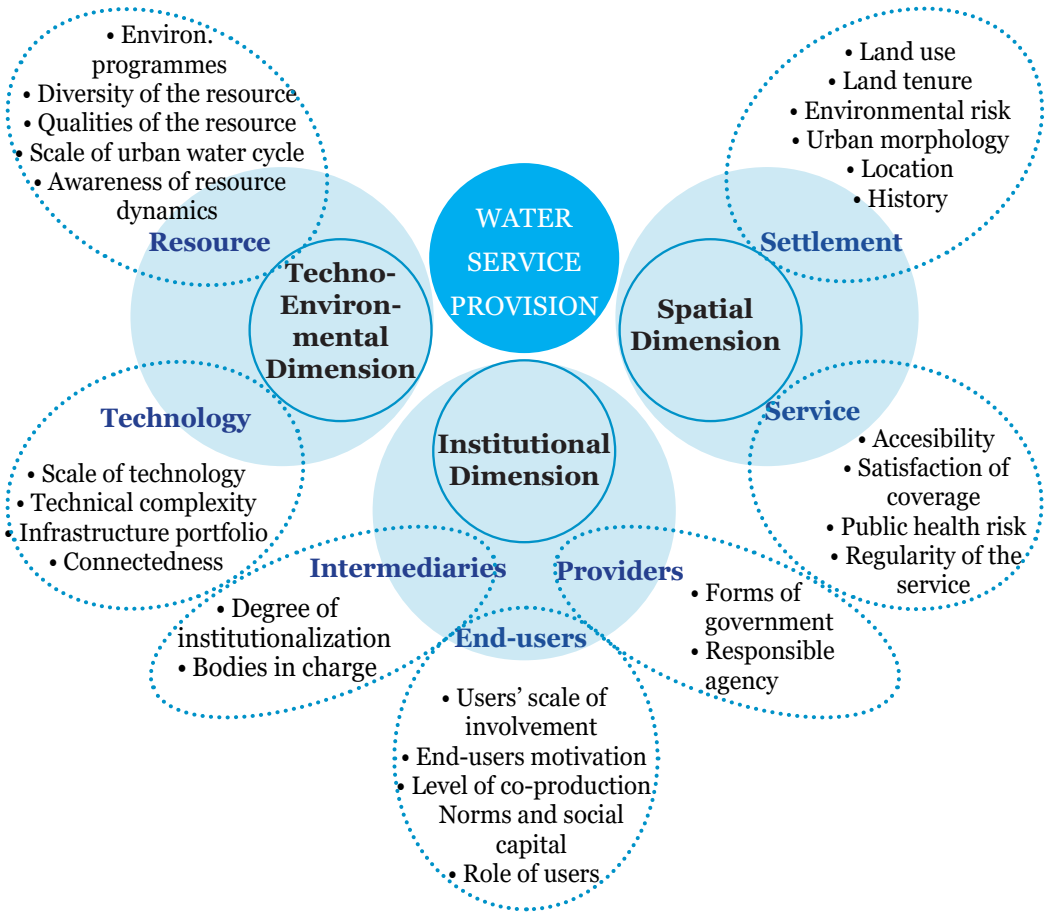
Moreover, the infrastructure configuration conceptualizes the role of the technology as "a mediator between different institutional configurations of users/providers and different resources mobilized in the service" (Faldi et al 2019, p.30). The authors reflect on the scale, the complexity and connectedness of the technology. For instance, when examining water services, the extent of the technological system depends on the primary levels - household scales – up to collective levels- settlement scales- that it serves (Moretto and Ranzato cited in Faldi et al 2019). The complexity refers to the type of technology alongside the management required for its operation. Thus, it correlates with the organizational support and level of expertise involved (Yu et al cited in Faldi et al 2019). Lastly, connectedness refers to the structure of the technology. The literature relates that the infrastructure portfolio is a key factor influencing certain structures and devices within the service provision. Its examination reveals tools of hybridization or reconfiguration of conventional systems (Faldi et al 2019, p.32).

Spatial dimension

It refers to the contextual factors of the service and the settlement, involved in the phases of service delivery. The framework states the importance of place-based conditions to understand how choices adopted in the past influence practices of the present and technology decisions (Faldi et al 2019).

The relationship with the socio-spatial configuration of accessibility to the service shapes and is shaped by space and territory. For instance, according to Allen et al (2006), the distance to water sources and density of users defines spatial accessibility. While the cost of operation, maintenance, and use of co-produced arrangements are influenced by economic accessibility. Faldi et al (2019) also highlight that these factors highly correlate to location conditions, socio-economic profile, and status of urban, rural, or peri-urban.

Figure 1.1 — Dimensions in the co-production of water service provision
Elaborated by author, 2020. Based on Faldi, G. et.al. (2019)



The framework emphasizes the implications of land and settlement rights as the regulatory frameworks that influence urban services provision in marginal areas or mechanisms of co-production with their resources (Ibid, 2019). Moreover, the available technology depends on the urban morphology of the settlement because physical conditions can influence the quality of resources and feasibility for constructing services (Ibid, 2019).

1.2.3. Sustainability for water access

Securing access to improved water has been one of the focus of the Millennium Development Goals (MDGs) and the Sustainable Development Goals (SDGs), where SDG 6 (UN 2016) claims for universal and equitable access to safe and affordable water for everyone by 2030.

For Faldi et al (2019) there is the need of guaranteeing a sustainable management of the system, maintaining service equity and efficiency, and ensuring water and environmental standards. For Adams (2017) the complexities of drinking water availability in informal settlements are not just about access to improved sources to entail reliability and regularity of the resource for household use. Then, the concept of water insecurity "is used as a more nuanced and multidimensional expression of poor water access to uncover more broadly the underlying causes, everyday challenges, and struggles for drinking water often hidden from traditional metrics and large-scale national and international surveys." (Adams 2017, p.2). Therefore, to achieve water security in unserved populations, the capacities of both, the public and informal supply actors should be acknowledged between water practices of provision and consumer requirements.

This research builds upon the criteria of domestic water sustainability from Dakyaga et al (2018) to evaluate the multiple water systems. The chosen framework was used for the analysis of informal water supply markets in Dar es Salaam, Tanzania. It enabled the identification of suppliers-consumers perspectives and their capacities for access to improved water. The discussions also reflect the water security conceptualization of access to enough safe water at an affordable price for every person to lead a clean, healthy, and productive life while ensuring the natural environment is protected and enhanced (Global Water Partnership [GWP] 2000).

The framework of Dakyaga et al (2018) identifies five layers to examine how domestic water supply is sustained. These relate the economic, socio-technical, or-

Table 1.2: Indicators of sustainable water supply	
Layers	**Indicators**
Economic	• Financial management • Financing & cost recovery abilities • Operations and maintenance of facilities • Strong knowledge of the local economy served
Socio-technical	• Human resources • Sustain coordination • Treatment of water for safe consumption • Appropriate technologies • Design and construction of facilities • Operation and maintenance
Organizational and institutional	• Acceptance of local institutions • Strong partnership with other actors • Unionized operation • Collective interest and mutuality • Legal and regulatory framework
Socio-cultural	• Knowledge of local culture • Knowledge of local water supply needs • Sensitivity of water services to gender, race, income groups and health • Willingness to sustain operations
Environmental & health management	• Hydro-Technical knowledge (water quality regulations) • Physically accessible • Safe water production • Safe water distribution • Water supply sensitive to health

Table 1.2 — Indicators of sustainable water supply
Source: Dakyaga & et al., 2018

ganizational and institutional, socio-cultural, and environmental & health layers (Table 1.2). The authors state that "domestic water access sustainability depends on sustainable water supply, local economic conditions, water availability, spatial distance, [and] the capacity of the water supply actors for quality water supply" (Dakyaga et al 2018, p. 123). Hence, the layers discuss both, the operations of the systems and the abilities of the actors involved.

1.3. Informal urbanization and access to water

By 2050 on a global scale, approximately 2.5 billion more inhabitants are projected to add into urban areas reaching 68% of the world's population with increased growth pressure in the developing world (United Nations 2019).
Although population growth varies from country to country, Africa and South Asia are urbanizing rapidly than other regions of the world, while Latin-American is expected to increase in its 13% (United Nations 2019) with their 24% of

the regions' population residing in informal settlements by 2050 (UN-Habitat 2015). The case of water and sanitation services (WSS) in Latin America is relevant to this research because company utility face (will continue facing) complex demands of growth pressure, are not able to meet efficiently a secure provision with well-resourced institutions, and are strongly affected by corruption and political clientelism.

Furthermore, the rapid expansion of the urban fabric in metropolises of developing countries occurs mostly in spaces with economic opportunities that are not completely urban but no longer rural referred to as "third places" (Mesclier et al 2015, p.3) e.g. the case of peri-urban areas. Peri-urban territories lie outside the coverage of formal networked water and sanitation systems, because of their affected formal right to basic services and rapid expansion. For Allen (2003) the inhabitants of these territories seem to involve a mix of newcomers and well-established dwellers who promote collective action. From which, there is a competition for limited water resources, but also the extensive use of decentralized approaches involving user involvement for solutions with less capital (Allen 2003).

Second, institutional fragmentation challenges coordinated action and impacts conflicts between stakeholders' resources and their areas of influence. Poor urban governance within a populist approach of exchanging votes for favors endangers rational planning processes (Fernandez-Maldonado 2008) and manifests spatially in service delivery for certain neighborhoods while others do not receive extra services because of lack of involvement in the political power contestations. On one hand, the public and private sector have been unable or unwilling, to deal with water and sewage networks provision adequately (Jaglin and Zerah 2010). These situations refer to the issues of conventional supply-driven, centralized network systems for water supply and sanitation services aiming for universal coverage.

1.3.1. Informality footprint in WSS services

The literature on informal water service arrangements refers to the 'informal' actors influencing the modes of operation and service delivery. While 'informal' services are described as "inefficient, creative, complicated, traditional, unsustainable, or illegal" influenced by spatial policies and non-spatial policies (Ahlers et al 2014, p.2). On the other hand, Allen et al (2006) consider the informal schemes as self-provision activities developed by communities, without formal

agreements with official authorities.
The informal space in the urban waterscape is attributed to Ahlers et al (2014), whose article studies the manifestations and interpretations of informality in water supply practices. For instance, the informal provision refers to the "survival strategy of the poor [whereby] such provision includes stable enterprises and dynamic businesses able to accumulate capital and economic development in many areas and sectors" (Ibid, p.2).
It results in the legitimization of certain practices with social and political implications and the contestation of water supply. For Jaglin, informal offers, "adapt better to urban growth, poverty, changes in land use, and the nomadism of small economic activities" (2012, p.61).

1.3.2. Spontaneous urbanization and the water-poor

Studies examining the reasons for low access to urban infrastructure and sanitation services in low-income areas reflect upon the sector governance arrangements and the perspectives for the operationalization of utility companies (Luthi 2012 p.62). For Roth 1987 (cited in Luthi 2012) political interests are prioritized over commercial principles in the operationalization, resulting in financial losses with inadequate levels of service.

The water-poor concept deploys its conceptualization from the urban poor. The latter is usually characterized as a homogenous group that encompasses a diversity of ethnicity and religious affection, thus influencing 'socio-cultural complexities' and conflicts of interests amid the group (Allen et al 2006).

Spontaneous urbanization, also referred to as informal urbanization, conceptualizes the unplanned and un-served settlements constructed as a response to the lack of adequate and affordable urban land for housing (Luthi 2012, p.59). The lack of formality of spontaneous settlements affects greatly the opportunities of access to municipal infrastructure and urban services. Their lack of recognition also influences the scale and depth of urban poverty due to outdated projections. Another reason for households without access to water corresponds to the disconnection measures of the company utility for cases of non-payment (Lopez 2014). These cases illustrate an emerging informal urban waterscape due to the continuous differentiation with the formal infrastructure networks.
Diverse scholars present the lack of tenure security as a crosscutting key theme that echoes in the manifestation of inequalities, political interests, especially the

lack of basic urban service provision (Luthi 2012; Lopez 2014; Misra 2014). For instance, Lopez (2014) explains three main reasons for not justifying the investment of infrastructure networks in illegal households. First, supporting connections contributes to disorganized urban growth. Second, there are technical difficulties for constructions e.g., settlers in high-risk zones. Third, the struggles to be connected depending on political clientelism, which differentiates citizenship rights from one another.

1.4. Framework for analysis

The research employ the crosscutting variables based on the following:

Figure 1.2 — Factors and components of water delivery arrangements
Elaborated by author, 2020. Based on Misra, K. (2014); Ahlers, R.; Cleaver, F.; Rusca, M. & Schwartz, K. (2014); Jaglin, S. (2014)
i: Refers to boreholes, river, neighbour, springs, canals, gorundwater, wells

Organizational forms	modes of production	modes of provision	modes of distribution	modes of access
Institutional forms	Rules	Policies	Legal and regulatory structures	
Actors	Service providers	Users	Agency	State
Type of source	Public water	Water fountain	Water cistern	Others [i]
Method of access	Water pipelines	Public taps	Tank trucks	Drawing water
Degree of connection	Parcel connected	Disconnected	Directly to household	
Degree of modality	Formal	Informal	Hybrid	
Levels of access	Regularity	Sufficiency	Affordability	
Arrangement for provision	Small-scale Self provision	Traditional Group provision	Non-statutory Community prov	Retailers Resellers

Components

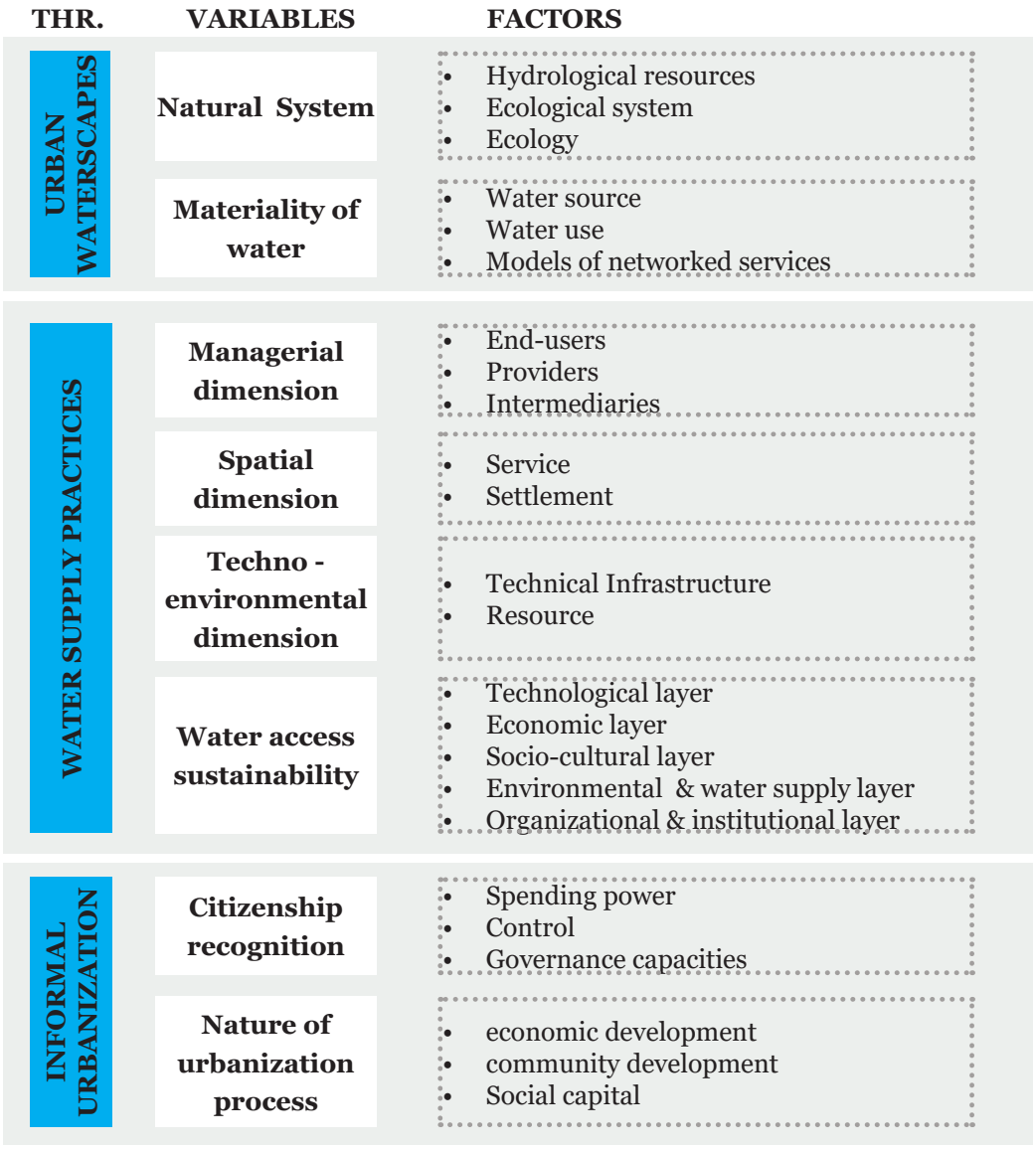


Figure 1.3 — Theorethical framework for analysis
Source: Author, 2020.

2 Spatial Context

The first part of this document presents the spatial context of the Lima Metropolitan Area (LMA), where the case study is located. The case study is presented in depth in chapter 4. The overview of the waterscape of LMA reveals both the natural system and the socio-urban system at which water flows through networks and urban landscapes. The understanding of the urban environment sheds light on the particularities of the periphery and the hydrological characteristics of the resources that seem to challenge how water and sanitation services (WSS) develop in the metropolis. Analysis of the current situation of the water infrastructure sector deploys the modes of organization of the Lima Water company SEDAPAL and the issues within the delivery systems in the periphery.

2.1. Urban environment

Lima city is the largest city and the capital of Peru. The seaport of El Callao and the city of Lima are the two parts of the LMA. According to INEI (2018), the population of Lima is 9'485,405, which represents the third part of the population of Peru. These almost 10 million people live in the 43 districts of Lima city and the 6 districts of El Callao seaport.

Each district has its administrative unit for the specific territory. In addition to the existence of a specific district municipality, there exists the municipality of Lima with its mayor administering all the districts. The 43 districts have also been divided into 4 macro-regions (map 2.1). The institutional fragmentation between these administrative units and the national and local levels challenges the construction of a unified vision of the city (Metzger et. al. 2015). For instance, socio-economic transformations are adopted per territory, revealing the benefits of particular places over the development of the peripheral areas.

Map 2.1 — Lima Metropolitan Area administrative units and location of the case study
Source: MML, 2014

The thesis focuses on the district of San Juan de Lurigancho located in the eastern area. The selection seeks to contribute to the diversity of urban waterscapes of low-income settlements in the periphery.

Table. 2.1 — Overview of the Lima metropolitan area under study
Source: INEI, 2018; LIMACOMOVAMOS, 2018; UN World Urbanization prospects, 2020

Table 2.1: Overview of the metropolitan area under study

Population 2018 (inhab.)	Area (km²)	Annual population growth rate (%)	Metropolitan administrative structure	WSS metropolitan formal system
10 million	2,673	1.78	Lima Metropolitan Area: Lima capital city, 2 provinces, 49 districts	Decentralized company SEDAPAL / metropolitan level

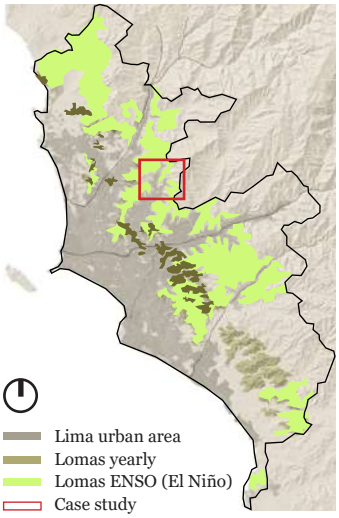
2.1.1. Ecological system in the periphery

The coastal Lomas or 'Lomas costeras' are protected ecosystem areas, recognized as part of the ecological structures of the LMA (MML 2014c). It is constituted by the group of Lomas of 19 districts from the periphery of Lima.

The Lomas ecosystem is known for its seasonality between winter and summer. The massive fog appearance during winter (July to October) supports seasonal plant formations and unique biodiversity (Kato 2018). This specific micro-climatic condition of higher humidity, lower temperature, and constant rainfall differentiate hillsides from the rest of the coastal areas. Subsequently, the dry and stony hills of the periphery are transformed into a green belt that surrounds the Lima city (map 2.2).

Numerous research refers to the irregular occupation in the Lomas areas that is degrading the ecosystem; such as land trafficking, changes in land use for cemeteries and illegal mining, and the continuous expansion of spontaneous settlements (PNUD 2018).

The occupation in the hillsides as the last urban growth zone benefited the low-income population who found empty land as housing, despite the topographical hazards and risks. These areas thus become precarious conditions for the dwellers, for instance through areas without basic services and accessibility limitations (MML 2014a), and places where the excess of humidity (almost 100%) influences respiratory diseases (PNUD, 2018). On the other hand, the microclimatic conditions of the Lomas ecosystem influence high fog's condensation as a water resource. Studies examining the water quality collected by fog catchers have demonstrated that its domestic use is no possible, thus it is used for irrigation of the typical flora during the arid season (Ricaldi, interview 2020).



Map 2.2 — The Lomas ecosystem in the Metropolitan Area and the location of the case study
Source: Eba Lomas project, 2017

Furthermore, the aim for the conservation of the Lomas ecosystem has influenced the creation of local social enterprises of organized civil society denouncing its degradation and finding overall ways for decision-making improvement (Kato 2018). To rehabilitate the Lomas ecosystem, the local social initiatives promote awareness campaigns for cleaning and reforestation and capacity building for eco-tourism.
The existence and appropriation of the Lomas have reached a singular impact in Villa Maria del Triunfo and Carabayllo district, where the partnerships with institutional and private entities have made possible projects for irrigation, fog catchers' implementation, and Eco touristic routes (Ricaldi, interview 2020). On the contrary, most of the Lomas in San Juan de Lurigancho district reveals a degraded ecosystem because of the extensive informal occupation.

2.1.2. Risks and geomorphological aspects

The major proportion of urbanized land of the metropolis lies in the alluvial fans of the three river ba-

sins, which is considered as appropriate soil for the construction of buildings (MML 2014a, p.803). However, the trend of Lima city's growth has expanded in three other critical zones, such as slopes, wetlands, and sandbanks.

The PLAM 2035 reports some consolidated areas of the southern districts and the northern districts are examples of the city expansion onto sandbanks, despite the low consistency soils and loose terrain (MML 2014a). Likewise, for the urbanization of wetland terrain, settlements have developed despite swampy soils and high water levels. Both critical zones have disadvantageous features when constructing buildings and the infrastructure for urban services provision, because of both: its high exposure to seismic events of regular intensity and the implications of significant investment in the foundation works to secure the stability of the terrain (Ibid pp.803-805).

On the other hand, progressive and unplanned urban settlements have occupied the edges of the valleys and the ravines of the periphery. These high-risk terrains have greatly pronounced slopes (over 49%), which demand stability interventions within e.g. retaining walls and access roads become necessary before the housing and urban services' implementation (Ibid p.804). However, the low financial capital of the population living informally in these hillsides has forced them to prioritize their investments in housing self-construction.

The conditions of physical vulnerability in the peripheral areas, illustrate the difficulties in securing housing in good quality and for provisioning conventional water networks. The particularities of the territory in hillsides demand a contextualized understanding of comprehensive universal coverage.

2.2. Hydrological system

The urbanization of LMA extends into a desert ecosystem while occupying the river valleys of Rimac, Chillon and Lurin (map 2.3). The surface water of these rivers constitutes the main resource for drinking water supply in Lima. It represents 80% of the supply, while the groundwater contributes to the other 20%, and 72% capacity of the surface water relies on precipitation (9 mm per year) to fill the water reservoirs (Aquafondo 2015).

However, the freshwater water availability that is finally treated for provision is affected by two main reasons. First, the challenges of lack of precipitation and

fast deglaciation of the Andes mountains influence the uncertainty of the water flows of coastal rivers (Alcazar et al cited in Aquafondo, 2015). Second, the continuous city growth produced a shift in urbanization from occupying agricultural land to lands that never had natural water (MML 2014a). It influenced the occupation in marginal strips of watercourses, and the development of peripheral districts while increasing the demand for resources.

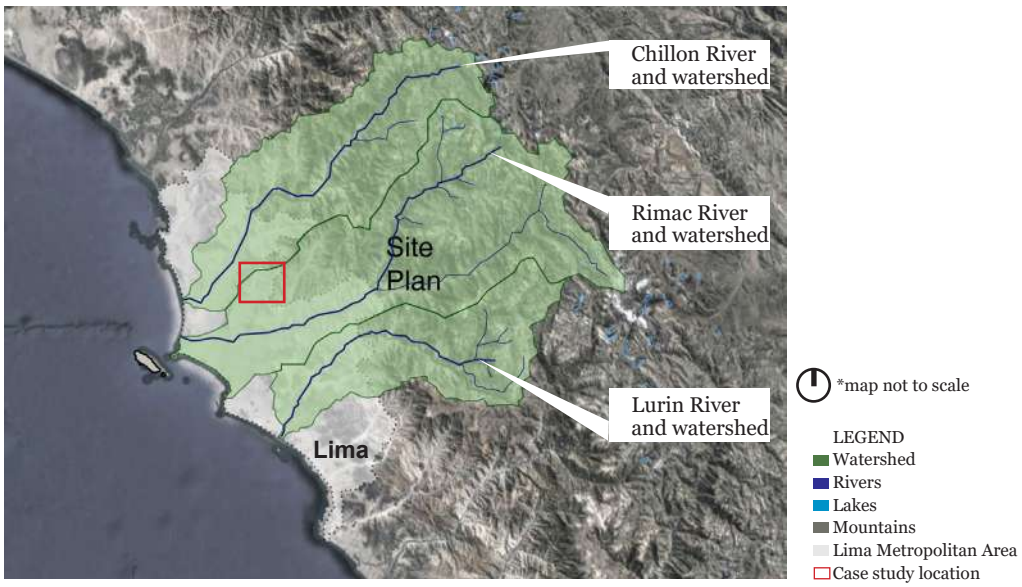
2.2.1. Rimac water basin

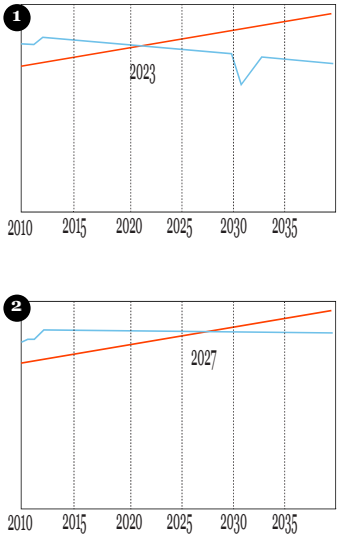
The case of the Rimac water basin is relevant because it constitutes 69% of the water supply for the metropolis (Aquafondo 2016). The water basins also compose the resources of the two aquifers of Lima, whereby 90% of the supply comes from the Chillon - Rimac aquifer and 10% from the Lurin aquifer. Overall, the resources of surface water and groundwater are used within the supply networks for population use, while the resources from irrigation channels and fog catchers are not considered within the infrastructure networks.

2.2.2. Water availability

Although Cairo and Lima are both cities with water stress (UN Water 2015), the water availability per capita differs from 1000-1700 m3/hab/year in Cairo and 125 m3/hab/year in Lima (AQUAFONDO 2016, p.14). This illustrates the alarming situation of water scarcity in the metropolis.

Map 2.3 — The Chillón, Rímac and Lurín river basins in Lima Metropolitan Area
Source: AQUAFONDO, 2015





1 Climate change *Dry* (in two consecutive years without precipitation 2031-2032)
2 Climate change *Humid*
Supply rate
Demand rate

Figure 2.1 — Scenarios of supply and demand for water availability in Lima. Source: AQUAFONDO, 2016

The LIWA project (2013) describes in-depth the hydrological risks and the future scenarios of water stress in Lima. It argues that climate change effects are influencing critical scenarios of water deficit in 2040 corresponding to the growing water demand for domestic and productive use, the irregular supply from the basins, and no awareness of use and reuse of the resource.

As noted, the water demand surpasses the drinking water availability in both dry and humid periods (figure 2.1). For this reason, projects of the water utility have focused on implementing engineering megaprojects e.g. water treatment plants, osmosis plants, or the desalinization plants to treat seawater (AQUAFONDO 2016) as efforts on bridging the service gap for districts that have no coverage.

2.3. The water sector of Lima Metropolitan Area

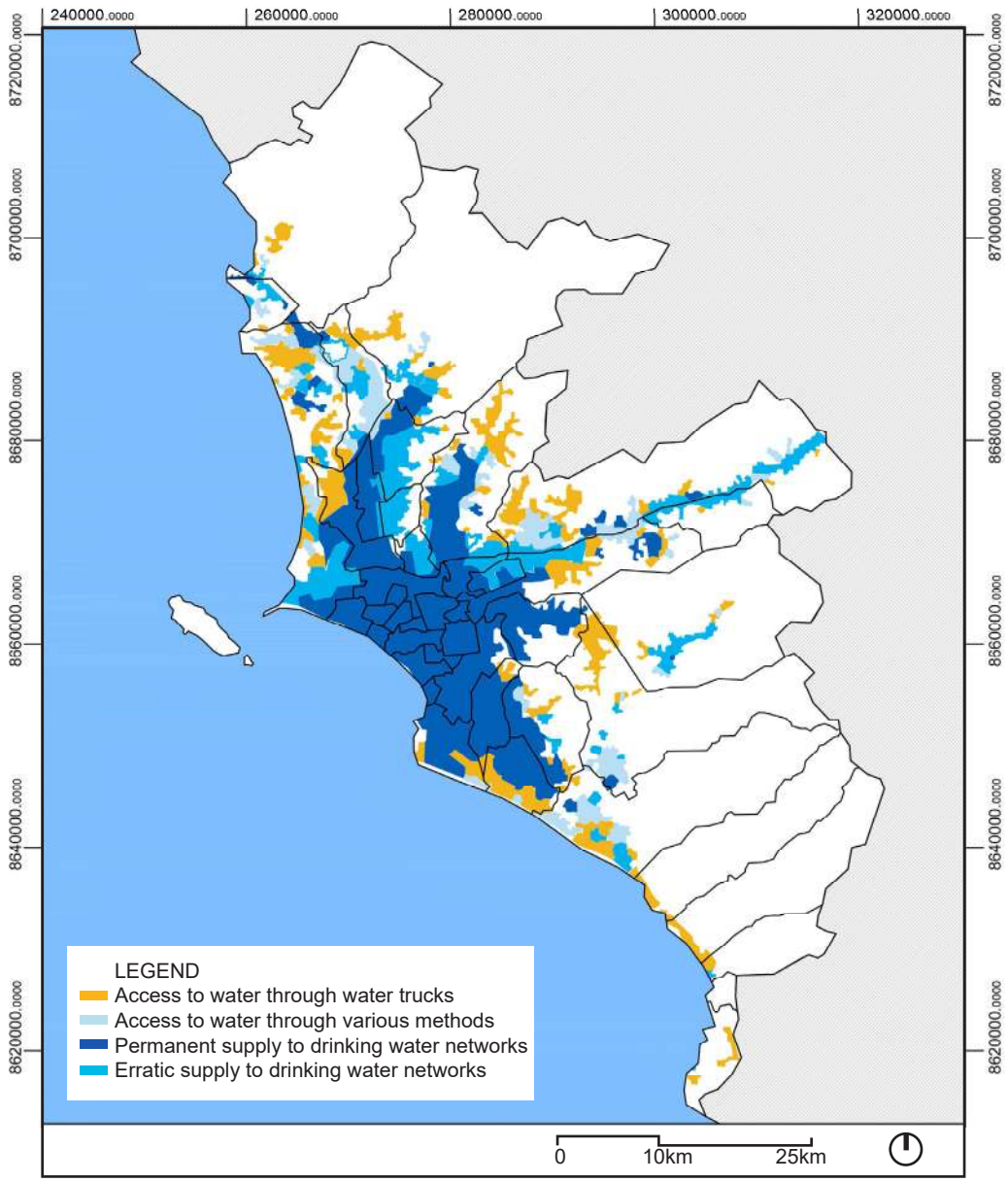
The following refers to the analysis of the water delivery system in LMA and the corresponding organization of the water utility to understand the water access situation of peri-urban hillside areas. Luthi (2012) states that contexts of continuous population growth challenge the ability of service companies, and resources of local authorities for providing acceptable water sufficiency for all. This is the case of LMA and the different methods for provision among different areas of the metropolis.

According to Metsclier et al (2015), this differentiation reflects a link with the socio-spatial exclusion within the territory. For instance, the central areas, where middle and upper-income groups live, include the complete provision of services comparing to the rest of the urban areas. In contrast, the poorest of the

urban population lives mostly in unplanned settlements of the peri-urban fringes where provision obeys debates on illegality and challenges of difficult topography (Fernandez-Maldonado 2008).

The following map illustrates the location of those deprived areas where water infrastructure is not present, and the major water sources are water trucks (2.6%) and water standpoints (2%) (INEI 2017).

Map 2.4 — Lima urban area according to (in)existent water and sewage services.
Source: Meztger & et.al., 2015



The areas that lack affordable quality housing are mainly exposed to water insecurity. For instance, San Juan de Lurigancho (SJL) has the highest housing deficit (GESTION 2014). Further, it represents one of the districts with a higher supply gap, about 300,000 households without water services (MML 2014a).

2.3.1. Urban water supply in Lima city

According to the last national census (INEI 2017), the percentage of the population connected to the public network has increased on average from almost 67% to 90% from 1993 to 2017, while 9.1% still lacks direct access to drinking water (Table 2.2).

The progressive reduction of households without direct connection (from 8% to 3%) seems to reveal the success of policies and programs focused on networks' extension (see chapter 4). These reforms based on supply augmentation "have improved the situation at the aggregate level, but there is still no sustainable solution for the crucial dilemma of cities with high poverty restrictions: self-financed network expansions versus service affordability" (Fernandez-Maldonado 2008, p.1884).

According to WHO (World Health Organization), the recommended water consumption is 150 liters/day/inhabitant to cover the necessities of hygiene and use (UN Water 2015). Contrarily, the water consumption in Lima reveals an inefficient use and distribution.
Although the water utility SEDAPAL provides approximately a total of 270 liters/day/inhabitant (SEDAPAL, 2018), there are major differences among districts consumption.

Table 2.2 — Evolution of water supply in the Lima Metropolitan Area and Callao
Source: INEI, 1993; INEI, 2007; INEI, 2017

Table 2.2: Evolution of water supply in the Lima Metropolitan Area and Callao			
Types of water provision	**1993**	**2007**	**2017**
Connection to public network within the home	66.65 %	75.5 %	90.9%
Connection to public network outside the house but inside the premises	8.01 %	7.5 %	3.0 %
Public standpipes	7.12 %	3.8 %	2.0 %
Water truck or similar	12.93 %	9.0 %	2.6 %
Water wells (groundwater sources)	3.34 %	1.8 %	0.5 %
Superficial water sources (springs, river, ditch, lake, lagoon)	0.64 %	0.4 %	n.a.
Others	1.3 %	2.2 %	1.0%

A report has revealed that these differences correlate with the socioeconomic level of the district (Comercio 2015).

For instance, San Isidro district consumes up to 346 liters/day/inhabitant, and Miraflores district, 316 liters/day, while the consumption in Villa El Salvador, San Juan de Lurigancho, and Villa Maria del Triunfo districts is below 100 liters/day (figure 2.2). The first two are high-income districts with total coverage of water and sanitation services (WSS), who pay monthly prices below 20 soles (McGrath 2014).

McGrath emphasizes the monthly payment of medium/low-income districts with informal areas, representing up to 120 Nuevos soles (40 dollars) when accessing water from the delivery truck or 80 soles (27 dollars) for public water points plugged to hoses. These clearly illustrate the misuse of scarce resources, abundance in wealthier neighborhoods, and higher cost rates in low-income settlements, especially the ones located in the peri-urban areas that lack services.

2.3.2. Institutional Framework

The administrative body of the WSS in Peru is the Ministry of Housing, Construction and Sanitation (MVCS), which also sets up the design standards of the supply infrastructure system.

The supervision bodies are the Ministry of Health (MINSA) who evaluates the sanitary conditions of the facilities and the drinking water; and the Ministry of Agriculture (MINAGRI) regulates the extraction and contamination of water resources respectively.

Furthermore, the National Superintendence of Sanitation Services (SUNASS) is the private institution that regulates and supervises the tariffs' affordability, and efficiency of the Service Providers (EPS).

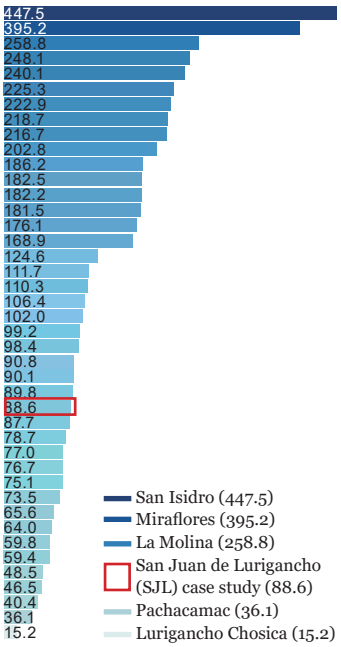


Figure 2.2 — Statistics on water consumption between districts (litters/inhab./day)
Source: El Comercio, 2015

Among these, SEDAPAL is the utility responsible for the provision of WSS at the metropolis level. Even though the debates on the privatization of services, SEDAPAL continued as a "state-own company [but] governed by private law and established as a private company" (Mesclier et al 2015, p. 3). Other EPSs are the municipalities, private sector at municipal or regional level, Water and Sanitation Committees, and private small-scale local operators at the neighborhood level, which emerge in the areas that are not covered by the water utility (WSP 2007, p.15).

Mendoza (2016) argues the overlapping responsibilities within the actors involved in the WSS framework (table 2.3), which combined with poorly managed decentralization have contributed to inefficient allocation of services. In this regard, Ioris (2011) emphasizes the interconnections of the sociopolitical deficiencies in the context of growing demand and less natural resources challenging water governance in Lima. While Aquafondo (2015) reinforces the debate on integrated water management to support financially sustainable decision-making of scarce water resources, integration, cooperation, and active participation between actors and users.

Table 2.3 — Institutional framework of water and sanitation services (WSS) in LMA
Source: SEDAPAL, 2018. Plan Nacional de Saneamiento 2017-2021

Table 2.3: Institutional framework of water and sanitation services (WSS)		
Functions	Responsible Entity Urban	Responsible Entity Rural
Presidency • Sector policy • Regulations • Development programs • Investment plans • Technical assistance	MVCS and related departments	
Regulation	SUNASS	
Supervision	MINSA (DIGESA), MINAGRI (ANA)	
Funding and investments	MEF and related departments	
Management and Implementation of policies	OTASS	-
Service Providers	EPS SEDAPAL	JASS Community organizations
Formulation and Execution	PNSU: Programa Agua Segura para Lima y Callao	PNSR
	Regional and Local governments	

2.3.3. Delivery system and water flows

The SEDAPAL water infrastructure is separated into specific production and distribution systems (figure 2.3). The PLAM 2035 Report (MML 2014a) describes the stages of the production system into extraction, storage with the delivery of raw water, treatment, and delivery of treated water.

The distribution system includes the storage of treated water, the distribution networks (primary and secondary pipelines), and access to water. It also encompasses both, the networks of SEDAPAL and supply by water trucks or water standpoints. The delivery devices for access are household connections including metering, public pool, sanitary unit, or others (MML 2014a).

Since the unit of analysis of this document is the low-income settlements in peripheral areas, the research focusses on the phase of access to water and the social category of the domestic typology (residential and social water use).

2.3.4. System of water networks

It refers to the SEDAPAL infrastructure of conventional water networks for direct household connections.

The components of this distribution system involve three water treatment plants (Atarjea, Chillon and Huachipa) to treat the raw water from basins and produce drinking water on average of 20m3/s, at the city scale (SEDAPAL 2018). The water treatment plants complement with (9) big storage reservoirs that store 326,790 m3, to deliver the drinking water among the primary and secondary distribution system. Further, (849) medium storage reservoirs are used to regulate the water pressure and volumes supplied in other ar-

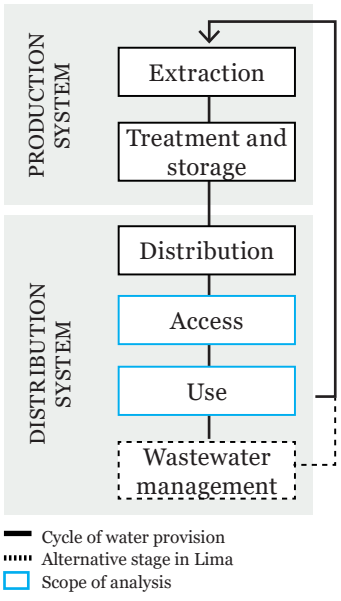


Figure 2.3 — Water Delivery system in Lima city
Elaborated by Author, 2020. Adapted from the water and sanitation cycle, Allen et al., 2014

eas by secondary networks (MML 2014a). These refer to the elevated reservoirs and those located in the hillsides, becoming also a relevant aspect of the waterscape and part of the technology for provision in peri-urban areas of Lima.

On the other hand, the deficiencies in the distribution network report high levels of water loss and low levels of micro metering (WSP 2007, p.24). These affect the operationalization of services. For instance, there are roughly 180 million liters of water loss due to pipelines leakages between the production and distribution system, lack of maintenance of the water infrastructure, and illegal connections and water theft (LIMA COMO VAMOS 2018).

2.3.5. System of water trucks

The absence of water infrastructure through household connections forces residents to approach non-conventional water supply systems. WSP (2007) refers to the failure of service providers within their administrative zone as the key factor facilitating a supply market for other operators. The water trucks are "private operators with municipal authority that are supplied from wells of SEDAPAL to deliver drinking water" (MML 2015, p.33). This system has an autonomy of functions and provides water services without legal or official contracts with end-users, only supplying after payment on-site.

The municipality regulates the maintenance, sanitary conditions, and quality of services of this private operator. However, the investigation of FOVIDA (2004) argued that 28% of municipal authorities do not control the quality of water employed by water trucks. Even though SEDAPAL provides water with good quality to the water trucks, 60% of these operators use other sources with residual chlorine no recommendable for drinking consumption (FOVIDA 2004). Thus, the considerable health impacts using contaminated water, and the struggles of time spent on its everyday purchase appear to influence higher associated costs for the end-users.

Overall, the water trucks are the most predominant type for access to water in peripheral areas with a low-income population living on hillsides. For their consumption, it is stored in plastic containers outside the households, but this method makes it easily polluted and affected by mosquitoes, worsening the vulnerability of the community (McGrath 2014). The service of water trucks is also expensive compared to the water supplied by public networks (Metzger et al

2015). It becomes evident the issues of low-income dwellers of the periphery facing both unaffordable and poor quality water.

2.3.6. Strategy and Objectives SEDAPAL (2017-2021)

According to Sedapal, reducing the gap in WSS infrastructure and maintaining a regular service provision of the districts already connected is possible through projects that renovate old facilities and increase the capacity of new networks (2018, p.6).

The goal to achieve universal coverage 100% with 24 hours continuity by 2021 has been supported by the Ministry of Housing, Construction and Sanitation (MVCS) through the program Safe Water for Lima and Callao (PASLC). This program also articulates important subprograms throughout the territory, each with specific objectives for the universal coverage. These refer to (1)'Dialogo por el Agua' strategy deeply discussed in Leveque thesis (2017), (2)'Program 148', (3) 'Agua es Vida', and (4) Sembrando agua.

2.4. Conclusions spatial context

The unit of analysis refers to the settlements located in the hillsides of the periphery of Lima, occupying areas at risk and part of the fragile seasonal ecosystem of Lomas.

This chapter focused on the physical conditions of WSS in the metropolis. It emphasizes that water is inefficiently allocated, regressively priced, and is of limited access in the periphery. The PLAM 2035 states that "factors of topography, accessibility and/or lack of primary networks" influence the existence of areas without services (MML 2014a, p. 711).

These geographical conditions make the expansion of networks through conventional systems highly costly (Fernandez-Maldonado 2008). Moreover, failing to understand the extent of the population lacking access to WSS, livable dwellings, and safe land tenure is a recurrent issue from governmental authorities (Luthi 2012).

3 Research questions and methodology

3.1. Problem statement

Rapid expansion and unreliable state services have increased the difficulties to sustain water security in informal settlements of the periphery. The habitability conditions of these settlements are, in general, precarious, with limited access to basic urban services, health, and education. Hence, the lack of direct access to tap water has contributed to particular water supply practices influencing the livelihood of the settlement.

The Ministry of Health emphasizes the "insufficient coverage of water, sanitation, and wastewater treatment services,... poor sustainability of the systems built, rates that do not allow coverage the costs of intervention, operation, and maintenance of the services,... institutional and financial weakness, and inadequate management of water resources in terms of quantity and quality which generates greater health risks for population consumption" (MINSA p.48). Therefore, there is a strong need for understanding the implications in water supply and the growth of informal areas, especially in the context of climatic variability and uncertain future water availability in Lima city.

3.2. Objectives of the study

3.2.1. Research aim

Exploring an integrated approach to service delivery in urban low-income settlements that capitalize on the local practices/knowledge and improved management of water access. Highlighting the realities of under-theorized practices in

informal settlements will contribute to a comprehensive water policy goals and sustained interventions of the water utilities that guarantee human rights to water, sanitation, and a healthy environment.

Objective

Exploring the implications of diverse water provision arrangements in the urban waterscapes of the periphery and the effects of water access sustainability.

Secondary objectives

- Understand the urban waterscapes and their relationships with water supply practices.
- Define the local strategies to deal with shortage, discontinuity or absence of water and the implications on habitability conditions
- Draw and understanding of institutional and organizational frameworks for water (self) provision in informal areas.

3.2.2. Research questions

How water supply practices influence the production of urban waterscapes for sustainable access in informal areas of Lima?

Secondary questions:

- How are the urban waterscapes being shaped by the socio-spatial organization of the settlement?
- How does the settlement access to water daily, under circumstances of illegality and precarious contextual factors?
- What are the co-production arrangements that organize access to water service provision?
- What can be learned from the operationalization of systems for the extension of networks?
- How can water access sustainability be enhanced in a context under hybrid provision arrangements?

3.2.3. Research focus

Unpacking the complexity of the diverse types of water services, focusing on which negotiations, appropriations and social behaviors are inherent to the community. Explaining the dynamics from the practices for water access and identifying the aspects lacking to accomplish sustainable alternatives for informal settlements from the hillsides of the periphery.

The knowledge and data developed can contribute to new research directions to further the critical study of pro-poor alternatives in the water sector and over-

shadowed experiences of informal water access.
It expects to identify, describe, and understand the following:

- Outcomes reveal how the water disruption systems affected the socio-spatial productions of space in informal settlements influencing local cultural norms and solutions of adaptation.
- The allocation of shared spaces for water provision challenges the modes of contestation and solidarity. Its understanding helps to complement principles for integrated management of shared water risks.
- The conclusions on the modalities of water service provision display a correlation between the spatial context, the actors in control, and the technological mechanisms for ensuring access to water.

3.3. Methodology

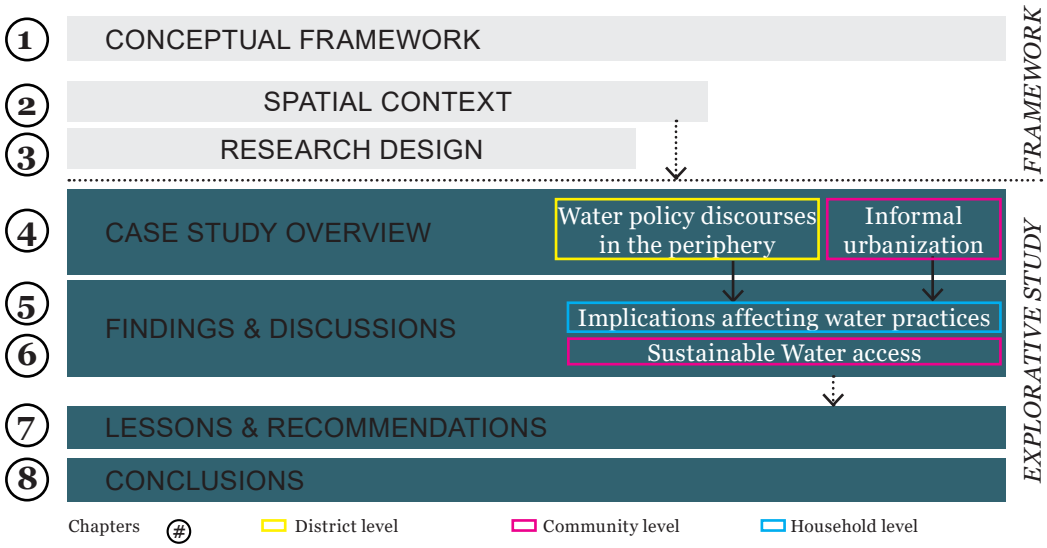
The research Strategy

The research draws lessons from the field visit and the theoretical frameworks of coproduction of water services of Faldi G., Rosati F., Moretto L. & Teller J.(2019) and the water supply sustainability assessment of Dakyaga F., Kyessi A. & Msami J. (2018).
It has three main pillars of investigation according to the following key themes and scales of analysis. First, the description of urban waterscapes of the periphery that include the natural and socio-urban features at the district level. Second, acknowledging informal urbanization processes and water policy discourses in the periphery as influencing factors in the social organization and decisions for alternative strategy-making at the community level. Third, the discussion and implications of everyday practices at the household level, followed by an analysis of domestic sustainability focused on the assemblage of informal-formal water networks (figure 3.1)

Methodological Approach

This thesis uses an exploratory-descriptive approach and case study analysis. The explorative study is developed in chapters 4, 5, and 6. It determines in-depth explanations of the water supply practices in a relevant research setting that challenges safe and clean water access. It compiles on-site observations and maps to probe and localize the progressive experiences of water services in the community. It collects information from interviews and questionnaires to enquire about specific insights and qualities of community-managed networks.

Figure 3.1 — Chapters and research strategy
Source: Authors, 2020



3.3.1. Selection of the case Study

For the scope of the research, the investigation focuses on one representative case study, whose selection follows three criteria.

- Socio-spatial criteria: The case study is a low-income hillside settlement from the periphery whose water access is partially covered in some barrios or completely uncovered in recently occupied areas.
- Ecological criteria: The case study is located in the fragile ecosystem of coastal Lomas in the hills. Its presence signifies particular geography within the territory, and its recognition as a protected area aims to limit the extension of continuous informal occupation.
- Technological criteria: The case study organizes in-situ distinctive technological approaches for water provision. Future public investment of extension of water networks is expected to be implemented in the area.

3.3.2. Methods of data collection

This thesis applies qualitative research to analyze the dimensions of water services in the informal peri-urban settlements. The qualitative fieldwork includes mixed methods such as semi-structured questionnaires (SSQs), interviews, field observations, and documentation through photos. The data collection also included an examination of secondary sources of relevant theoretical information and grey literature for the case study.

The data collection aims to gather in-depth information about the water delivery

configurations; the roles and responsibilities within water access, construction and maintenance; the actions of CBO leaders and members and (informal) governance structures within the settlement.

The investigation focusses on three barrios from the settlement of Jose Carlos Mariategui (JCM) as the case study of analysis. It is located in San Juan de Lurigancho district. It was purposely selected because of the rapid expansion in the outskirts and the highest percentage of housing deficit with absence of tap water connections. JCM is a representable sample of largest settlements located in coastal Lomas ecosystems, with different land tenures, statuses of consolidation and existence of continuous occupation.

The strong presence of NGOs working on-site facilitates coordination with community leaders to collaborate with research. Past international workshops and initiatives, who have investigated the case study, make their findings and publications available online, broadening the understanding of the research setting. Furthermore, one barrio demonstrated further interest to participate in academic projects and aspire technical support for transformative changes.

Field research work

The fieldwork is organized in three levels during the field visit to Lima, Peru from March until June 2020 (Table 3.1).

Firstly, (1) the preliminary stage refers to the coordination of appointments with representatives of SEDAPAL (Lima water utility), experts and NGOs. It includes the preparation of questionnaires and materials needed for the data collection.
Secondly, (2) an initial screening visit in JCM helps to identify the relevant communities for qualitative fieldwork. The decision follows the criterion presented and willingness to participate. This stage includes work in parallel about institutional level interviews targeting NGOs and representatives of the water utility, following the participant observation on-site. In the representative communities, the semi-structured questionnaires (SSQs) were carried out with the inhabitants and community level interviews. Due to limitations for the continuation of fieldwork under lockdown, there is a following process of expert interviews carried out online.
Third, (3) the transcription and interpretation of the samples to process the relevant evidence, goes in parallel with phase 2.

	1. Preliminary Tasks	2. Data Collection	3. Data Processing
CONTENT	Preparation of documents Coordination appointments with representatives SEDAPAL NGO CENCA	**Primary Data collection** Interviews Experts  Observations on site Spatial mapping Household questionnarie **Secondary data collection** Case study: Literature on evolution of state programs for extension of networks	Documentation, transcription, evaluation of evidence of interviews and observation.
TOOLS & METHODS	Stakeholder Mapping	Questionnarie Semi-struct. Interview Observations	Literature Review
OUT-PUT	Basis for database	Data generation from NGOs, civil society organizations/ Private Sector, Water utility.	Reflect back on variables.

Table 3.1 — Phases of Field research work
Source: Author, 2020

Primary data collection

Primary data is obtained by semi-structured questionnaires on-site, semi-structured and remote interviews and literature review on the water utility policies and their types of water provision for peri-urban areas in Lima. The chapter of Annexes presents a list of interviewed actors and the transcription of a questionnaire model, though original documents are in Spanish to facilitate interaction. Based on the case study, the 18 questionnaires included participants with diverse demographic information and the location of their household within the settlement. Additional interviews were conducted with a representative of SEDAPAL, and with the community leaders and water caretakers of the settlement to enquire about their perspectives on 'appropriate' modes for water security management. Primary data aim to reveal the local coping strategies for water supply, both at community and household level. Data refer to the current drinking water sources and conditions of access; the average quantity of water collected; the water user profile, its storage behavior; perceptions about water access; and glimpses of hygiene and sanitation practices. This information is complemented with observations on-site to identify general patterns in informal areas.

Secondary data collection:

Secondary data refers to the findings of previous investigations and workshops delivered in JCM. For instance, the project of 'Transformative planning for en-

Table 3.2: Matrix categories of questions and methods of collection				
Research Questions	**Fieldwork Phase**	**Aims**	**Methods**	**Results presented**
How are the urban waterscapes being shaped by the socio-spatial organization of the settlement?	Phase 1 Findings at district level (SJL) and community level (JCM)	To gather information about the urbanization processes and evolution of water supply in the case study.	Literature review of policy documents and secondary sources + Interview with experts	Chapter 4: urban waterscapes in the periphery. The case of San Juan de Lurigancho (SJL)
How does the settlement access to water daily, under circumstances of illegality and precarious contextual factors?	Phase 1 Households from Jose Carlos Mariategui.	To get an understanding of the mechanisms for water access, challenges, and arrangements within the community.	Household questionnaire administered on-site + Participant observation	Chapter 5: Findings of water delivery configurations. Discussions on regulatory practices, social organization and decision-making spheres.
What are the co-production arrangements that organize access to water service provision?	Phase 2 Representatives from Community Based Organizations	To understand the organization of community and local management practices.	Semi-structured interview with community leaders and water caretaker	Chapter 6: Discussions on spatial, managerial and techno-environmental dimensions of the service
What can be learned from the operationalization of systems for the extension of networks?	Phase 3 Water Utility	To gather information on projects for the extension of networks developed in informal settlements.	In-depth interview with a representative from SEDAPAL	Chapter 4: Discussions on water policy discourses and implications
How can water access sustainability be enhanced in a context under hybrid provision arrangements?	Phase 1,2,3 Validation Research	To identify capacities of the operations of the community-led system + Effects of disincentives for end-users.	Household questionnaire	Chapter 6: Discussions about sustainable layers of water access.

Table 3.2 — Matrix catergories of research questions and methods for data collection
Source: Author, 2020

vironmental justice in Lima' had a focus on risks and water findings in two different settlements of JCM. The findings helped to frame an overall status of the water supply gap in this settlement.

3.4. Limitations of the thesis

The realization of the research methodology was affected by the corona measures of lockdown and curfew implemented from March until June 2020 in Lima city. Taking into account that fieldwork was originally planned in six weeks, between

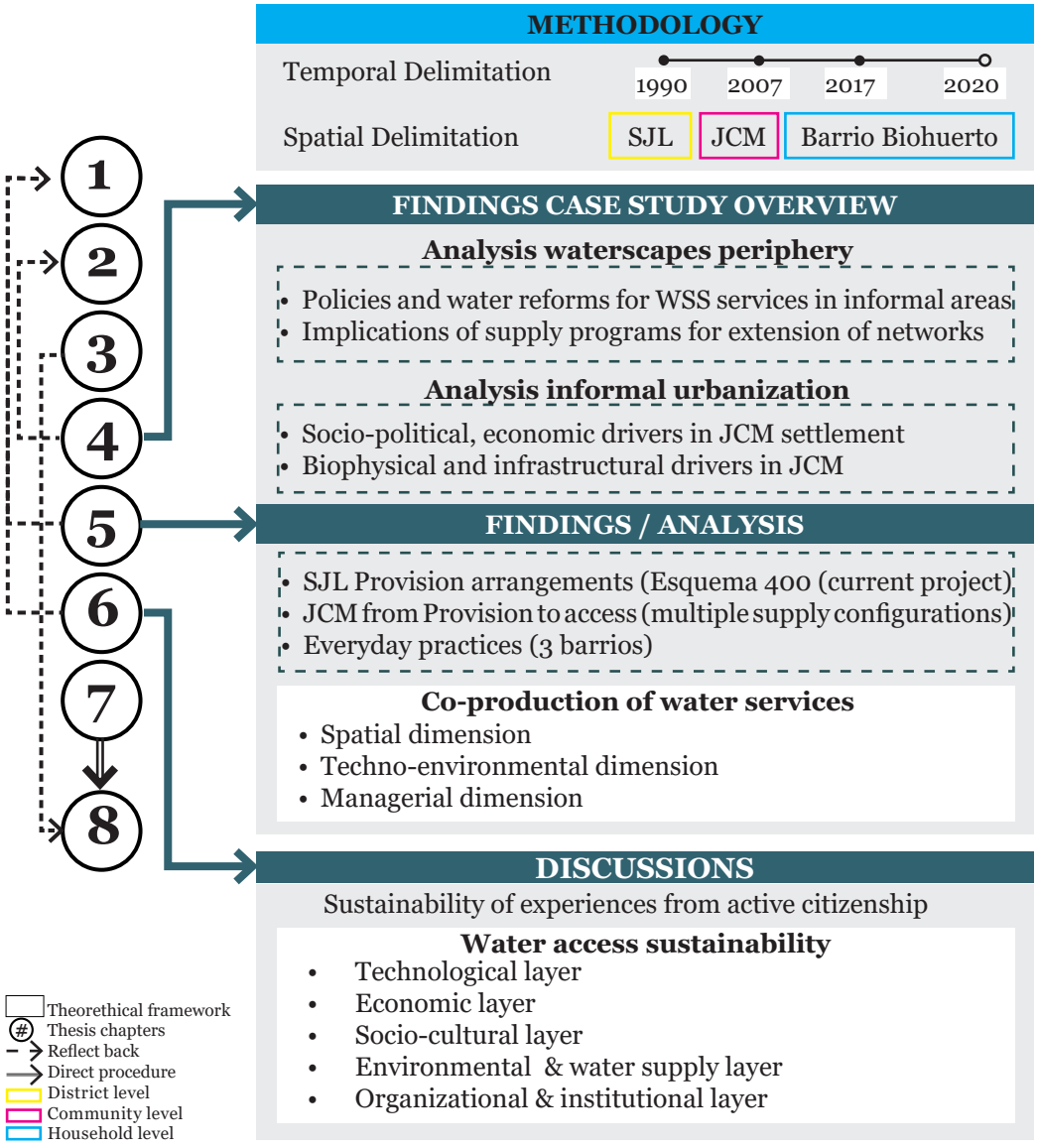
March 2020 and April 2020.
These limitations concerned greatly the collection of qualitative data and they influenced the restructuring of the research. However, long-term stay abroad encouraged deeper insight knowledge.
Despite the limitations of reaching the community leaders during the first days of fieldwork, the screening stage allowed the faster identification of main actors from the community through the coordination with NGOs and citizen initiatives working on-site. The first two weeks of fieldwork were very fruitful. Since lockdown measures started (third week of fieldwork), the household questionnaires were no longer suitable to collect primary data.
For the scope of the research, the online questionnaires lack direct insight between researcher and interviewed participant that strength the understanding and mapping of household water practices. Online interviews are also difficult to perform with poor communities who lack basic services especially internet connection.
Furthermore, the lockdown measures affected the continuation of interviews with experts from NGOs and the water utility, but online communication facilitated the data collection. In the cases where it was still difficult to reach any communication, it was required to analyze secondary sources through up-to-date investigations, news publications or presentations about the data required. However, specific basic information on demography, socioeconomic, housing was limited in recent informal areas.
Overall, the thesis does not aim to present all the strategies for water access neither conclude on advantageous informal practices but attempts to layout common patterns of water access that seem to replicate in hillside areas and have been invisibilized in water planning that pace with informal urbanization.

3.5. Proposed Framework of Analysis

The thesis argues a critical view of the impacts on disconnected households and how progressive technology is perceived and experienced among its users. It questions how users appropriate and contest lack of tap water while reshaping their territories, and to what extent the technology undermines the commitments for sustainable and affordable access.
The investigation is set up in two sections of analysis (chapter 4-5), following the discussion (chapter 6) and the recommendations (chapter 7). (Fig. 3.2).
The first chapter of analysis presents the case study overview, with a description of socio-political, economic, biophysical and infrastructural drivers. The analysis

reflects on the resultant conditions of the materialization of flows of water in the periphery of the poor peri-urban areas. Second, it explains the evolution of public water programs for extension of networks in informal areas. The second part of analysis reflects on the aspects of the current state project 'Esquema 400-425' to be implemented in the territory of the case study. It is based on the findings from the fieldwork. It reveals the arrangements for water service provision and categorizes the everyday practices for access to water. It presents the dimensions of co-production of the water services organized in the settlement, shaped by local power struggles and community-based organization.

Figure 3.2 — Framework for analysis
Source: Authors, 2020



4 Urban waterscapes in the periphery. The case of San Juan de Lurigancho (SJL)

Reports from the Housing Ministry (MVCS 2019) state that only 51.7% households access safe water within the urban area while 2.6%, within the rural areas. Despite Sedapal claiming a water supply coverage of 90.9% and sanitation coverage of 89.9% in the metropolis (INEI 2017), the realities of the peripheral urban areas still highlight deeper inequalities in the provision of services (see chapter 2). For instance, NGO Aquafondo states that approximately 1.2 million people in Lima Metropolitan Area (4.7% households) have no access to drinking water (Comercio 2020).

Furthermore, studies state that the main reason for lacking access to water is the illegitimate land tenure status and the occupation of high-risk zones within in hillsides. One representative case is the district of San Juan de Lurigancho (SJL), the most populated district of the metropolis with a high presence of hillsides surrounding the district, and with 52% of spontaneous settlements still in process of formalization (MML 2014b). These spontaneous settlements face both unaffordable and poor quality water and a difficult topography that challenge the conventional provision of services and influence expensive infrastructure.

This chapter frames the understanding of urban waterscapes of the periphery, taking the case of San Juan de Lurigancho district and describing the socio-political, economic, biophysical, and infrastructural drivers that influence the current water supply in informal areas. The temporal dimension of the discussions is since the 1990s when the politicized principles of the water utility transformed into means for extension of networks for the urban poor through the creation of social programs to bridge the gap of water coverage.

4.1. Case study overview: The periphery of SJL

San Juan de Lurigancho (SJL) is a peri-urban district with a population of about 1 million people (table 4.1). According to the last national census (INEI 2017), 12.2% of the total population of Lima lives in SJL. The district currently faces the highest qualitative housing deficit of the metropolis (128,573 units) particularly those located in informal areas (GESTION 2014). In 2012, the rate of poverty in the district was 17.4% and 0.8% in extreme poverty (ENAHO in Lima Como Vamos, 2012). This situation explains the high economic dependency of low-income households living uphill, to meet their water needs.

Table 4.1 — Characteristics of SJL
Source: INEI, 2017; CITY POPULATION, 2017 (https://www.citypopulation.de/)

Table 4.1: Characteristics of district examined in the case study (SJL)

Peri-Urban settlement studied	Population district (inhabitants)	Area (km^2)	Density (inhab. / km^2)	Location/ distance to city center	Annual population growth rate (%)
Jose Carlos Mariategui	1,156,300	131.3	8,810	North-east of Lima city center	1.46

SJL is divided into 8 zones and 18 communas (map 4.1). The subdivision in communas was implemented in 2005 at the municipal level to improve the distribution of resources and for better coordination between communas and official authorities (CENCA 2014).

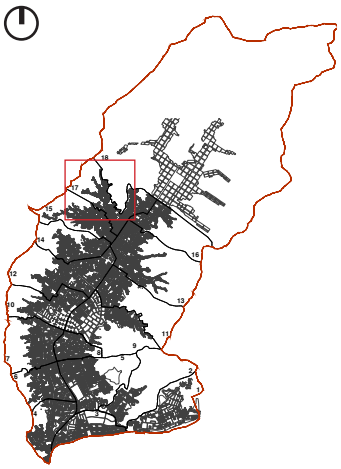
The district lies on the right side of the Rimac river watershed and characterizes by its location surrounded by stony hills with scarce vegetation, and uphill areas with an altitude between 851 to 928 m.a.s.l (MML 2014b) The altitude influences the presence of the Lomas ecosystem (above 400 m.a.s.l.).

Table 4.2 — Water supply in LMA and SJL
Source: INEI, 2017

Table 4.2: Water supply gap in Lima Metropolitan Area (LMA) and San Juan de Lurigancho (SJL)

Source of supply	LMA %	SJL %
Direct connection	83.33	78
Water truck or similar	9	9
Water fountain/ public standpipe	3.8	9
River, ditch, lake, lagoon	0.4	4

According to INEI (2017) 189,671 inhabitants of SJL live without direct connection to tap water, 9% still depend on water trucks and the other 9% rely on water standpipe for provision (Table 4.2).
Moreover, the situation is two-folded in the case of informal settlements. For instance, Metzger et.al. (2015) points out not just the regularity of the supply but the water quality and high costs, as manifestations of the inequalities regarding water access in the peri-urban areas. Map 4.2 highlights the gap of water coverage (22%) in the outskirts of the district.

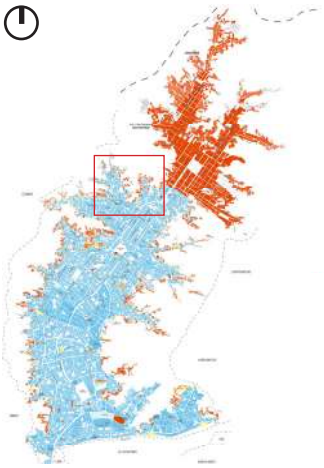


Map 4.1 — SJL district and communas
Source: Author, 2020

4.1.1. Urbanization process

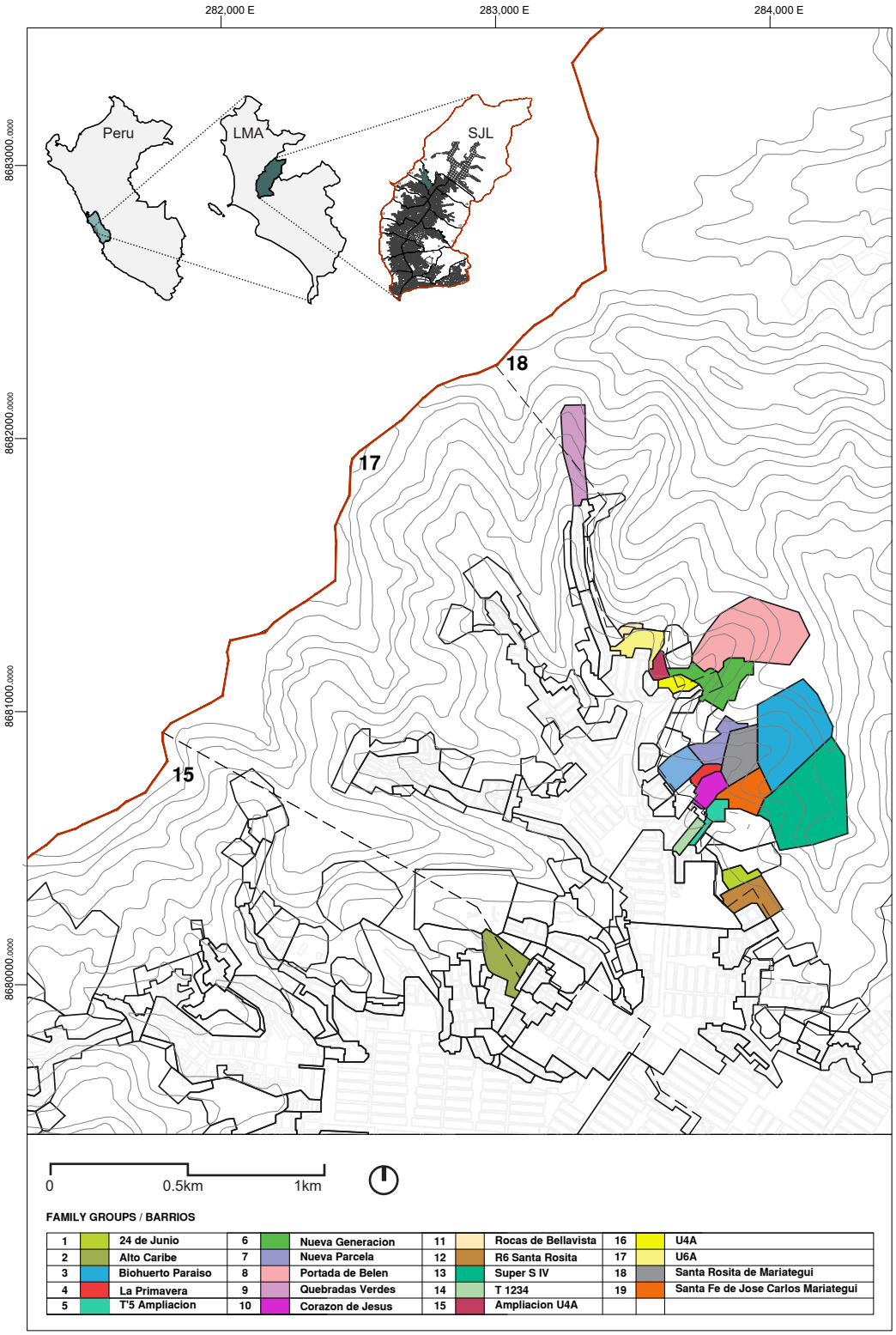
The district of SJL was created in 1967 (CENCA, 2014). The first informal settlements have occupied flat terrain, mostly agricultural land. In contrast, trends of urban growth have been developing in the areas of steep hills surrounding the district. This terrain never had water, making the development and water access harder to cope with. Most of the unplanned settlements have settled in this location, particularly the settlement of Jose Carlos Mariategui (JCM) with about 10% of the total district population (CENCA, 2018).

The case study is the settlement of JCM. It is located in the northeastern area of the district SJL. JCM belongs to communa 17 with a total population of 94'642 inhabitants. It is composed of 19 representative barrios (map 4.3).
Estrada (2015) refers to the incremental illegal occupation in hillsides and traffic land during the development of JCM. Further, the study of Inga states that the expansion of existent irregular settlements seems to evolve around internal filial relationships. In other words, most cases of new dwellers occupying new areas uphill are relatives of the families living downhill,



Map 4.2 — SJL water supply
Source: INEI, 2013

Map 4.3 — Representative barrios of JCM settlement
Source: Author, 2020



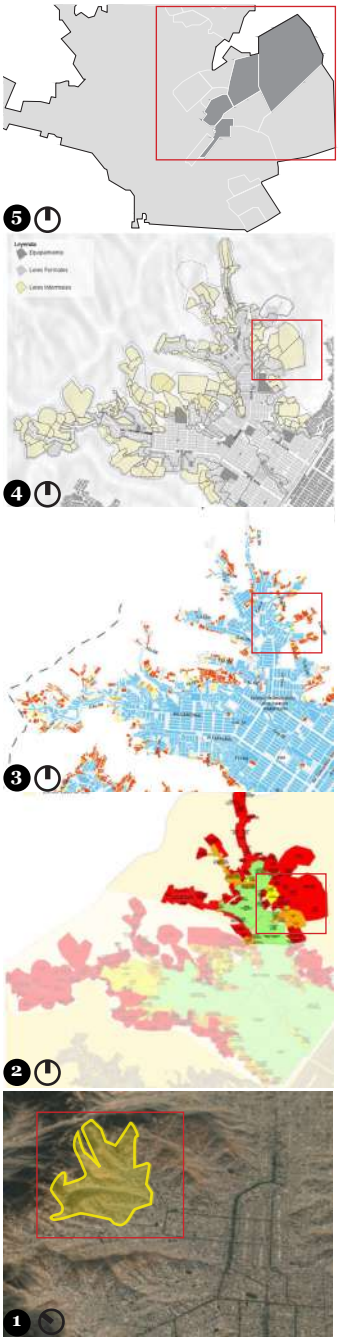
who can secure a better plot over those dwellers without ties (2011, p.18-19). This illustrates the case of Biohuerto barrio, one of the communities located further uphill. It continues being occupied also by relatives of those living in the flat terrains.

The analysis of the research focusses on the findings of three barrios located in the hillsides: Biohuerto el Paraiso, Santa Rosita de Mariategui, and Corazon de Jesus.
The barrio Biohuerto was occupied since 2005 (Interview with community leader). It is composed of 120 households officially recognized by the municipality through certificates of possession but the plots have no legal tenure. Based on the interviews, Biohuerto is projected to expand until 220 plots. Until the date, the barrio Biohuerto lacks water and sewerage services, although the provision is guaranteed through a public water standpipe. Biohuerto has a community board composed of nine members. Each member corresponds to the following areas: economic area, organization, health, sports, setting, actas, general secretary, and sub-general secretary.
The barrio Santa Rosita was occupied since 2004 (Interview with community leader). It is composed of 70 households' plots. The official infrastructure for water and sanitation is absent. The current provision is through a standpipe located in the settlement since 2006. The barrio is in the process of formalization.
The barrio Corazon de Jesus was occupied since 1999 (Interview with community leader). It achieved the connection of water and sanitation services in 2010. Few households who occupied the settlement after 2010 have no direct water supply nor land title.

4.1.2. Urban dynamics of the area

JCM has a predominant residential use in the flat areas and it is surrounded by irregular settlements of low density with a long story of the struggle to sustain livelihoods in the hillsides (Estrada, 2015).

The document of 'Integrated Urban Project Jose Carlos Mariategui' (Proyecto Urbano Integral - PUI) (MML 2014b) describes the main characteristics of urban and social infrastructure within the communa 17. For instance, the location of the settlement in a higher risk area characterized by steep slopes and high exposure to landslides and seismic events. The physical vulnerability becomes relevant for the water utility when executing pipelines uphill.



1 Map macro scale of JCM
2 Map risky areas under seismic event
3 Map water coverage
4 Map of informal settlements in JCM
5 Map of units of analysis
Case study location -3 barrios

Map 4.4 — Case study location
Source: INEI, 2013; google maps; MML (2014a)

The provision of urban services in flat areas is covered, while the irregular areas uphill are limited to the electricity supply. Most disconnected barrios are participating in the current state program 'Esquema 400-425' (CENCA, 2018).

Access to land titles is another recurrent management priority in JCM. By 2005, 57.3% of the barrios have achieved land tittle recognition (Estrada, 2015). Besides, the creation of 'Equipo comunitario JCM' (community team) aims to take part of a regeneration plan for informal barrios and create the tool to improve concertation processes between local authorities and community organizations (CENCA 2018). For this, NGO CENCA provides technical assistance. Currently, only eight barrios are permanent members in the 'Equipo Comunitario'.

The barrios are mostly recognized as 'agrupaciones familiares' or family associations. Based on interviews, the barrios characterize by its communal activities to enable autonomous urbanization. For instance, the communal work or so-called faenas on Sundays, community funding for alternative interventions, and communal roundtables for decision-making at least once per month. The communal work depends on the participation of the residents and the leadership of the community leaders or those supporting the administrative procedures. This illustrates the reciprocity relationships, collective interest, and not work conditioned to salary payment.

4.2. Urban waterscapes under networks extension

4.2.1. Informal Urbanization and policies

Lima Metropolitan Area (LMA) has developed between formal official planning and informal autonomous urbanization, where the 'illegal city' anticipated

any basic urban services (Calderon cited in Criqui 2020). A context of explosive rural-urban migration and lack of affordable housing provision influenced the emergence of informal settlements[1] in both urban and peri-urban areas, private and public land. First, these settlements occupied flat areas but the most recent ones occupy hazardous areas of the periphery. Consequently, the territorial transformation of the Lima urban fringes is the result of sprawling hillside settlements of low density with about 60% of self-built urban areas (Metzger et al 2015).

In the 1960s, the State declared a path-breaking law[2] for marginal areas recognizing its occupation of State land, promoting its physical-legal sanitation and supporting low-cost progressive or self-help housing (Fernandez-Maldonado and Bredenoord cited in Criqui 2013). Although the Law aimed to address the pressures of urban growth, the decades of tolerance towards informality influenced continuous migration to easily accessible land and stimulated land titling as a political tool for gaining election votes (Mcgrath 2014; Ioris 2011).

In the 1980s[3], the consolidated large barriadas portrayed new urban centers and only scarce peripheral areas were available, forcing the new occupations in risky, smaller spaces, desert areas, and steep hillsides (Driant 1991). Moreover, the economic crisis of the decade hampered the water system infrastructure and increased the degradation of basic services for impoverished areas (Ioris 2011).

Figure 4.1 — Informal settlements in JCM. View from the hills of Barrio Biohuerto
Source: Authors, 2020

The 1990s[4] represents a turning period of neoliberal state initiatives that began as a reactive intervention to the crisis of the 1980s and the Cholera outbreak (Ioris 2011). For instance, the privatization of the electricity and communications sectors, and the creation of COFOPRI[5] in 1996 as a strategy to ensure land formalization and titling policies (Criqui 2020). The property title became the main requirement for accessing urban services (Calderon 2004).
The results of this Law were argued by Calderon (2004) and Torres (2018) emphasizing massive formalization without addressing precarious households comprehensively i.e. acknowledging the lack of services and adequate urban facilities of the informal settlements and merely promoting housing as a private good.

4.2.2. Water sector reforms

Numerous literature (Ioris 2011, 2012; Fernandez-Maldonado 2008) share the neoliberal development discourse to argue its influence in the structural changes of the water and sanitation sector in Lima and the reproduction of socio-spatial inequalities.

The following frames an overview of the water reforms to highlight the political orientation of WSS provision at the city level and its influence on the operations of SEDAPAL.
The most relevant neo-liberal reforms in Peru take part since 1990 (Fernandez-Maldonado 2008). In 1994, the general Law for water services was created after the Cholera outbreak of 1991, because the impacts of large-scale inadequate access to urban services became evident in the peripheral areas of Lima. The water sector was opened to private investment to improve the degraded services, restore confidence in the water company, and achieve modernization (Alcazar et al cited in Ioris 2011).

1 Also known as 'barriadas', pueblos jovenes, asentamientos humanos
2 1961: Law of marginal settlements, Law n 13517: : ‚Declaring of public necessity and utility and national interest the remodeling, cleaning and legalization of the marginal neighborhoods or slums, existing in the urban and sub-urban areas of the national territory'. Recognition of legal status of settlements created until 1960, aiming to control the rural-urban migration. The government encourages self-help programs.
3 1980: government prioritized measures against the political violence situation, while impoverished citizens faced increased degradation of basic services. The water system was close to collapse through "severe rationing, networks wasting/leaking water, frequent interruptions" (Ioris, 2011). Economic crisis also hampered the organization of civil society movements.
4 1990: After the epidemic, the crucial mission of public utility became the expansion of networks. Informal settlements were facilitated unconventional ways for provision but the legal tenure was a strong factor for advancement.
5 COFOPRI coordinates the access to formal property through: Municipality validating the risk assessment of the settlement. The informal dwellers require a representative body officially registered as a neighborhood association, and the layout plan.

However, sociopolitical resistance and the political use of water for the poor as favors for electoral votes made the government canceling on privatization means (Ioris 2011). As a result, SEDAPAL remained under the state administration and the regulatory agency SUNASS was created to secure operational recovery, pipeline maintenance, and leakage control (Sepapal in Fernandez-Maldonado 2008). In this regard, Criqui emphasizes on the main phases of Sedapal's increased performance during the period of network extension, "emergency investments and reorganization (1990-1996); rehabilitation, additional sources and leakage reduction (1996-2000); uncertainty (2000-2006); and distribution improvement (2007-2010)" (2020, p.164)

This situation clearly emphasizes a turning phase for the water sector since 1991, which has been influenced by neoliberal ideas, and a convenient aspect for political interest in water. Moreover, the structural adjustments in the water sector only seem to acknowledge the technical and financial scarcities of the utility.

4.2.3. Water service provision in informal peri-urban areas: Implications of programs for networks extension (1991-2016)

Informal settlements are often discriminated against because of their insecurity of tenure. Scholars emphasize the indisposition, indifference, or inability of the state government to deliver basic services efficiently as one of the main causes of lack of water access for all, leading to parallel or alternative systems of informal provision (Allen et al 2006). Jaglin (2014) argues that featuring the 'failures' of the institutional schemes and their management deficiencies promote discourses that stress on the superiority of private and formal delivery systems over the heterogeneity of configurations for service provision. In Lima, the water sector started developing social programs since 1991 to extend the networks for the provision of WSS in the unserved areas of the periphery despite the legal difficulties and technical complexities (Criqui 2020).

Two major investigations have reflected in these programs: Criqui (2013, 2020), and Leveque's thesis (2017).

Criqui (2013) analyzed the pragmatic ways at which SEDAPAL professionals' proposed innovative responses that acknowledge territorial complexities and the relationships between different actors to maneuver the water networks in steep hillside areas. Criqui (2020) adds up to the discussion by deepening the understanding of the socio-technical strategies of the State programs (APPJ, PAC, APT)

Table 4.3: Matrix of characteristics of programs for networks extension					
Program / Variables	**APPJ**		**PAC**	**APT**	**'Programa 148'**
Period	1991-1996	1996-2001	2003-2008	2006-2012	2012-2016
Phases of Network extension	Emergency investments and reorganization	Rehabilitation, additional sources and leakage reduction	Uncertainty	Distribution improvement through the logic of universalization	Universalization of water services inherited from APT
Context	Cholera outbreak. Alberto Fujimori gov.		Alejandro Toledo gov.	Alan Garcia campaign' promise	Ollanta Humala
Public policies/ housing	National Law for Formalization of Irregular Property. Assistencial program for self-construction.		Municipalities gain competences over matters of formalization	Housing subsidy programs. Flexibilitation of requirements for access to WSS services	Tolerated attitude towards informality. Political gain for election votes.
Funding	European Union, 1993-2001		World Bank, 2003-2008	Peru, 2006-2010	Peru
Benef.	335,000 people		160,000 people	730,000 people	n.d.
Social arrangements	Water committee: Operation NGO as assistance for management. Hygiene awareness in schools.		NGO: capacity training in building and maintenance. A caretaker is chosen by the population for the operation of the system.	Inhabitants are informed / Mobilization to demand priority schemes. Prepare ground stability.	Public meetings for concertation to undertake delays.
Technical arrangements	Autonomous system for drinking water: 50 m3 water reservoirs connected to standpipes for delivery by hoses.		Condominial networks: unconventional infrastructure combined with an existent formal network connection.	Conventional infrastructures: individual connections of the Sedapal system.	Conventional infrastructures.
Institutional tools	•Residents association registered •Official layout plan •Property title •Formal integration		•Residents association registered •Official layout plan •Property title •Individual contracting	•Certificate of possession •Community layout plan •Simplified investment process. • Residents association registered	•Certificate of possession •Community layout plan. •Residents association registered
Water company intervention	Sedapal trucks supplied reservoirs. Installment of micro metering in standpipes.		Conflicts with the social team of Sedapal. Considering support only for technical installation, awareness	Identification on-site to verify demand and clear ground for execution. The emergence of Social team: an intermediary between users and Sedapal	Worktables for dialogue Social team: supervision of tasks from consultants social groups
Citizen participation processes	Beneficiaries participate at construction works, organized by the creation of committees. Training and supporting environmental promoters among the community.		Beneficiaries receive training and consultation meeting about the operation of the system. Support for good use, household awareness, hygiene habits, and health progress.	Beneficiaries in charge of cleaning the public space. Residents should delimit the private spaces from public spaces.	Beneficiaries need to pay an application fee. Secure containing walls in the construction of roads

for network extension. Furthermore, Leveque (2017) focuses on the analysis of citizen participation among the development of these programs since 1991-2012.

The following summarizes the findings of the evolution of the programs for network extension to understand the limitations and progress of the SEDAPAL's service delivery for peri-urban settlements (Table 4.3).
Existent literature on water access thus argues the adaptation of the conventional models (Criqui 2020) and its impact on these programs in citizen participation for servicing the urban poor (Leveque, 2017). However, there is still little known about how the community coproduces/collaborates/adapts to emergent arrangements for access to water (self-built or deficiently provided) implemented in informal settlements.

The most recent program is 'Agua es Vida', whom the case study JCM is organizing future WSS provision (see chapter 5). The four past State programs for water networks extension are the following:

a) Program (1991-2001) APPJ[6] 'Agua para pueblos jóvenes'
b) Program (2003-2008) PAC[7] 'Programa de Ampliación de Cobertura'
c) Program (2006-2012) APT[8] 'Agua para todos'
d) Program (2012-2016) 'Programa 148'

Limitations and progress in water service provision of informal areas

- Regarding the engineered perspectives: The provision of networks evolved from developing alternative mechanisms with inclusive participation to conventional infrastructure guiding the recent projects. For instance, one of the challenges during the execution of the alternative condominium system was the social acceptability of the community towards the system. It was not perceived as the ideal of 'modern infrastructure' for the urban poor, despite the advantages of low-cost intervention. The provision of water standpipes that do not secure enough pressure and sufficiency is inefficient because it affects time loss in queues and supply dependency on private water trucks.
- Regarding the management guidelines: Sedapal regulates the micro metering of new connections and operates the infrastructure. Community partic-

Table 4.3 — Matrix of characteristics of programs for networks extension
Elaborated by Author, 2020 from sources Criqui (2020), Leveque (2018), Torres (2018), World Bank (206), World Bank (2009)

ipation evolved from being an active stakeholder in the process of having a passive role within the top-down planning. The role of NGOs in the capacity building also diminished.

- Regarding the application for the provision of basic services: Before, the process of acquisition[9] of urban services required the legal title. The process was facilitated, since 2000, through the certificate of possession and the layout plan validated in the district municipality (Sedapal, interview 2020). The procedures are delivered according to the dedicated area of concession, depending on feasibility studies. The simplified procedure facilitates projects for large-scale extension programs, but encourage more expansion of settlements.

  First, the layout plan constituted "the main tool to design infrastructure networks and it is used extensively as a legal tool for facilitating urban services provision in unplanned areas" (Criqui 2013, p.9). Criqui (2013) argues that despite the legitimation of the layout plan for Sedapal, it has no official value for official authorities e.g. COFOPRI and Municipalities who implement their 'own development strategy' in future projects.
  Second, the certificate of possession is a document confirming the presence of a household that requires access to basic services – water, sanitation, and electricity. It is promulgated by the district municipality without recognizing legal rights for the land. After the creation of this tool, the process of formalization of the informal property remained in a parallel process (Criqui, 2013).

In the irregular settlements located in steep hillsides, the roads and streets - the spatial domain of the infrastructure networks - are not consolidated.
Thus, the construction of retaining walls is required to secure the provision of infrastructure. The Lima water company does not fund or execute these projects. The community uses the layout plan detailing dwelling plots and urban boundaries to apply for funding schemes and negotiate donations with municipalities and/or NGOs.

6 APPJ: Program of Drinking Water for Young Towns of the City of Lima, translation from Spanish
7 PAC: Coverage Expansion Program, translation from Spanish
8 APT: Water for all, translation from Spanish.
9 Law n 28687 „Law of development and complementary to the formalization of informal Property, Access to Land and provision of basic Services".
Requirements for connection of water services: "an official request, a copy of the national identity document, a boundary plan of the plot, and the certificate of verification by a municipal civil servant." (Criqui, 2013, p.4)

It is noted that despite the simplification of legal procedures, the provision of basic services in irregular settlements depends on their financial sustainability. For instance, Criqui (2013) refers to the expenses carried out collectively to hire professionals to elaborate on the plan, to stabilize the ground, and to secure the participation fee to Sedapal.

4.3. Conclusions urban waterscapes in informal peri-urban SJL

The water sector has evolved through different neoliberal policies shaping the operation of services in informal settlements and the waterscapes of the periphery. The infrastructure systems aim to catch up with the informal expansion and fastest-growing urbanization rate of the city.

Despite the difficulties of the topography in hillsides, choices of technology for unconventional networks have adapted to operate as isolated systems managed by the community (autonomous system and condominial system).

Moreover, although the strategy of the new institutional tools (certificate of possession and layout plan) tries to organize the consolidation and the structure of the informal urban fabric, its lack of legitimation to other official authorities reveals the discoordination with services utilities in the decision-making process at the metropolitan level. It hinders a comprehensive scaling-up process in water access for spontaneous settlements.

5 Water provision arrangements in the settlement of Jose Carlos Mariategui (JCM)

The following chapter refers to the analysis of the variety of water provision arrangements implemented in the 'Jose Carlos Mariategui' (JCM) Human Settlement to address access to water daily. The findings shed light on the localized practices of low-income households that are disconnected from the formal infrastructure network and reveal how the urban waterscapes are produced in informal areas of Lima.

To understand the production of urban waterscapes, the findings of the research are two-sided. On one hand, they discuss the operationalization of the upcoming 'formal' supply of the state program for extension of networks 'Agua es Vida'. On the other hand, they highlight the current alternative arrangements of the 'informal' supply to secure water access.

These alternative systems were revised in representative 'agrupaciones familiares' or barrios from JCM settlement (see chapter 4) to demonstrate a progressive evolution of water provision arrangements. The fieldwork focused on the barrios Biohuerto El Paraiso, Santa Rosita de Mariategui, Corazon de Jesus, and T5 Ampliacion (see Annexes). The selection of barrios includes those with official provision of water networks and those without formal connection. The analysis of everyday practices reflects mainly on barrio Biohuerto El Paraiso, a settlement of the periphery located in both unstable steep slopes and fragile Lomas ecosystems.

5.1. Extension for provision: the case of the social program 'Agua es vida'

It refers to the recent social program for extension of water and sanitation networks in spontaneous settlements. The social program 'Agua es Vida' includes the project 'Expansion and Improvement of Drinking Water and Sewerage Services in the Sectors 400 to 425', whereby disconnected barrios of JCM are currently negotiating its future water provision. The findings reveal the socio-technical strategies of the water utility and identify the arenas of contestation from the unserved community.

The data collection is based on the findings from SEDAPAL's reports (table 5.1) to highlight the following aspects of the program: the stakeholders involved within and the factors of the implemented infrastructure. The literature review allows the understanding of SEDAPAL's operations when intervening in informal settlements to achieve total coverage by 2021. The thesis of Leveque (2017) is also an important secondary source to understand the policies of Sedapal within the most recent period (2006-2018). Subsequently, the literature review was complemented with a semi-structured interview with the representative of the Project team of SEDAPAL.

5.1.1. Project environment in JCM 'Esquema 400-425'

'Agua es Vida' social program was created to support the informal neighborhoods that are usually neglected by large infrastructural investments of urban services. Overall, it aims to benefit 506 localities from 15 districts of the Lima Metropolitan Area for 4 years (SEDAPAL 2017). Leveque explains that the services of this social program have a complementary role to major conventional projects, addressing the lack of services until the future formal networks are developed in the settlements (2017, p.62). Its focus is small projects, designed to be executed quickly on a neighborhood scale. The technology characterizes by unconventional networks with reservoirs and pressure systems, and sewerage networks including toilets equipped with a bio digester (Sedapal 2017).

In a presentation report (Sedapal 2017), Francisca Talledo, coordinator of 'Agua es Vida', describes that the settlements participating are evaluated according to their technical feasibility, from which 170 localities belong to SJL. For instance, the settlements in hillsides with updated layout plan registered community organization, and households' owners with a certificate of possession fulfill part

Table 5.1: Secondary sources for data collection		
Type	**Objective**	**Scope**
Annual Report 2018	Management of the Water Utility	City level
Press report 2017	Presentation 'Agua es Vida'	District level
Report: List of Public Audiences 2018	Functions of audiences and working tables within Project 'Esquema 400-425'	District level
Thesis: 'Opportunities and limitations of citizen participation in the face of dysfunctions of water drinking management in Lima'*	Difficulties for the progress of programs for extension of networks. Participation spheres for social dialogue in the program 'Agua es Vida'.	City level

Table 5.1 — Secondary sources for data collection
Source: Author, 2020

of the feasibility requirements. Their physical layout should also guarantee the existence of stabilization walls and roads, previous the implementation of pipelines. In the case of SJL and Huarochiri district, the project 'Esquema 400-425' aims to benefit 940,000 inhabitants (Sedapal 2018, p.9).

5.1.2. Institutional tools in 'formal' supply by Agua es Vida program

The beneficiaries of this project are the settlements located at the top of hills or areas with difficult accessibility and topography. Among the main institutional tools used in the co-production of water networks in irregular areas are:

- The public audiences aim to inform the advancements of the project and the status of the Technical Profile Report to the stakeholders involved. These actors involved are the municipalities, the private consortium, the comptroller general of the republic, the representatives of SEDAPAL from both the Social and Work management team, and the community leaders (Sedapal, 2018). The arena of public audiences is also used for residents who claim to SEDAPAL authorities for greater financing and faster progress for their projects. Some working tables are limited for community organizations according to the topics of discussion.
- The social management team from SEDAPAL has no longer a role for capacity building within the project. Thus, it trains the social teams of the Contractor for the corresponding activities (Sedapal 2017). The contractor becomes the main intermediary between the water utility and the community.
- The layout plan continues as the main spatial criteria employed by the water utility (Baharoglu & Leitmann cited in Criqui, 2020) to define the location of the water or sewerage networks.

- The approval of the plan by the municipality signifies a guarantee for the Water Utility that the infrastructure will prevail and not be relocated (Criqui 2013).

5.2. From Provision to access: The case of Jose Carlos Mariategui (JCM)

Table 5.2 - Roles and responsabilities in program 'Agua es Vida'
Source: Author, 2020

Table 5.2: Roles and responsibilities of Stakeholders in 'Agua es Vida'

Representative	Actor	Roles/Responsibilities	Relationships
The State	Ministry of Housing, Construction and Sanitation (MVCS)	• Monitoring and evaluating PASLC	• Contractual with the service provider • Partnership with constructor company • Non-contractual with community leaders through roundtables
The Provider	SEDAPAL Lima Water company	• Rapid social action for appropriation of unconventional systems (Social management team) • Assessment of beneficiaries • Evaluation/hiring of a private consultant	• Contractual with MVCS • Contractual private consultants
Citizens/ clients	Community Board and water caretaker	• Representing and communicating the interests of the community. • Regulating community-led practices for coping with lack of drinking water.	• Elected by the community in *Asambleas* • Non-contractual with SEDAPAL but agreement to integrate the project • Non-contractual with the private company
The provider/ citizen	Private company 'Consorcio esquema integral consultores'	• Construction works • Supervision works independently	• Contractual with the provider • Non-contractual with customers
Citizens	Hillside barrios in SJL that are part of Project Esquema 400-425	• Paying for water services/ consumption	• Customer contract with water utility SEDAPAL

5.2.1. Access to water during the foundation of the settlement

By the formation of the settlement JCM, the water supply was only possible through water trucks, water selling points, and water gifting.
All these water sources were located downhill in the flat zone of JCM, forcing women and men to spend more than 30 minutes downhill to carry water buckets through the stairs to access their households. Further, water supply by water trucks is more expensive than through the conventional water system (Lopez 2014, p. 153; Fernandez-Maldonado 2008). This situation describes the initial status of informal dwellers, who bear individually the struggles of excessive costs, time loss, and daily workload to secure water access despite their poor living conditions.

In the case of barrio Biohuerto, the settlement was provided a metered shared water standpipe in 2006, after the first two years of occupation. It was still located downhill but closer to the next neighborhood's limits, in Corazon de Jesus Settlement. The costs of implementation of the water standpoint were carried out by the water utility SEDAPAL, but the associated costs for individual access are carried by the inhabitants of Biohuerto, customers of the water provision. It was later possible to move the water point closer uphill until Santa Rosita de Mariategui Settlement, the adjacent neighborhood of Biobuerto, where it is still located until now. As a result, a public water point appears to be the only drinking water source implemented in the settlements of JCM. By law, the water utility regulates the water standpipe provision. It is presented as a temporary solution for 5-10 years, or until the settlement is connected to formal infrastructure networks.

This case exemplifies the most common approach of the water utility to enable the provision of water services in spontaneous settlements. Situations of extended contracts for water standpipes are also possible when the State programs for extension of networks delayed more than 10 years.

5.2.2. The water supply system in the JCM settlement

According to the findings of the research, there exist four main types of water supply co-existing in JCM (figure 5.1). (1) The provision by 'formal' infrastructure networks achieved mainly by State programs. (2) The self-provision by the water trucks. (3) The water gifting/buying from neighbors with water and sewerage connections. (4) The public water standpoint as a primary source for drawing

water into a community-led system.
The differences between these profiles of the water supply reveal a correlation between the location of the settlement within the hill and the type of water available. For instance, the topography levels define three main territories between the lower, middle, and uphill areas of the settlement. Each territory influences the location of the households' blocks, the access roads and stairs, and the type of water provision. The houses located uphill at the top access water mainly through the water standpoints and the community-led system daily because of the few water sources nearby and high costs that water trucks ask for going uphill.

The community-led system is an example of a socio-technical arrangement built by the community and managed collectively. It aims to draw water progressively from the public water standpoint to the household areas further uphill. For instance, barrio Santa Rosita employs one water standpoint and the self-built community system to deliver water to 70 households. Water trucks cannot supply water here because the only access is stairs and the self-built roads are not close-by. Whereas, barrio Biohuerto can get combined arrangements by both the community provision and water trucks.
For the barrio of Biohuerto El Paraiso, the community-led system does not ensure water distribution throughout the settlement. The pressure of water is not high enough to provide a consistent service. This clearly illustrates that the current system has a limited radio influence to work efficiently with the amount of drinking water provided, which excludes specifically the households located further uphill. Therefore, those households who are unable to access the community delivery system, they have to purchase water from trucks or rely on water gifting from the neighbors. Practices of water truck provision are characterized by individual rather than collective strategies.

5.2.3. Water delivery as a community-led system: the creation

For the inhabitants of the barrio Biohuerto El Paraiso, the presence of community organizations, existing since the occupation of the land, is a key factor for advancing beyond the current precarious living conditions. For instance, an official registration document of this community organization was also part of the requirements of the service companies for obtaining the electricity supply in the settlement.
Due to the lack of water supply networks and the increasing individual difficulties, the community decided to secure access to water by an alternative progres-

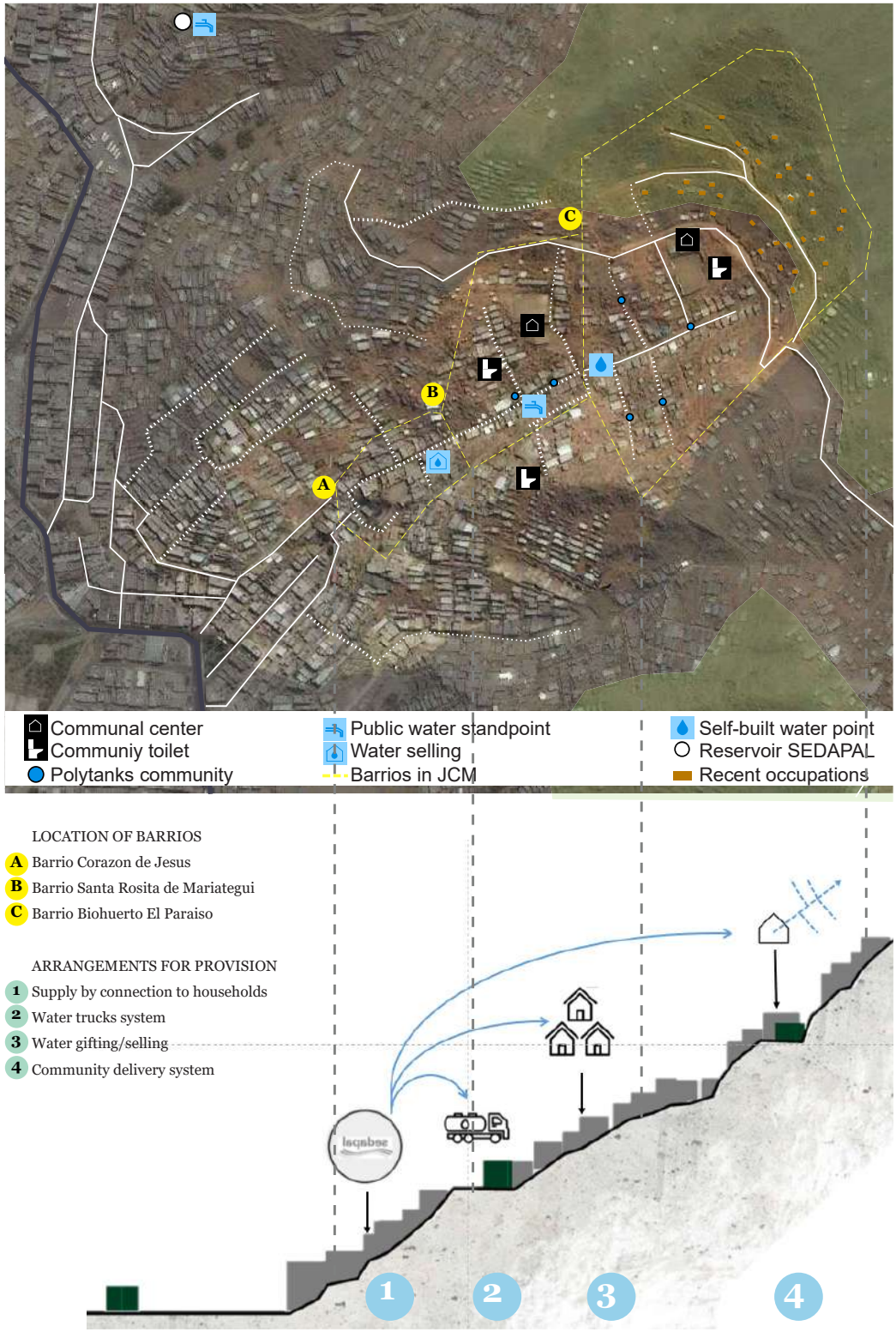


Figure 5.1 - Types of water service arrangements in JCM
Source: Author, 2020. Elaborated from the findings of data collection

sive system, which operates on community-based models and follows both socio-technical arrangements for its operation.

Social arrangements

Findings reveal solidarity responses and negotiation strategies between settlements that have no connection to basic urban services. For instance, the existent water standpipe from Biohuerto is located in barrio Santa Rosita, the adjacent settlement. The location of the standpipe also includes a water tank and a booster pump owned by Biohuerto settlement. Hence, there exists a process of negotiation between the two settlements to facilitate coordinating the costs of electricity fees that operate the water pump and the use of the shared space.

On the other hand, there also exist rules between the two settlements regarding the schedules for pumping water uphill. The barrio Santa Rosita has banned the use of the booster pump after six in the afternoon because of the vibration and noise pollution. As a result, the operation of the alternative system has limited access to the water source, and there is less amount of water collected for barrio Biohuerto especially in the intermediate water tanks.

The arrangements in Biohuerto state rules for an equal distribution of the water available. Based on interviews, it can only serve a maximum of six households per day, and only to those who queue every morning from 5 am until 6 am. Moreover, one person at a time is given a maximum of one hour per turn to secure its water collection despite the total containers present at home. These turns vary for different households every day to ensure the distribution for the next residents. Although, challenges of water pressure and irregular supply affect the amount of water storage in the primary water tank and limit the delivery for two turns on those days.

Technical arrangements

The acquisition of a public standpoint in the proximities of the settlement enabled a closer source of drinking water in Biohuerto El-Paraiso. However, the barrio's location beyond the end of the supply line hinders enough pressure and water quantities. The community has built an alternative water distribution system with its budget and resources to facilitate closer water delivery points within the barrio. This system supplies approximately 150 households with limited daily service.

The water cycle of the system begins with the public standpipe. It drives potable

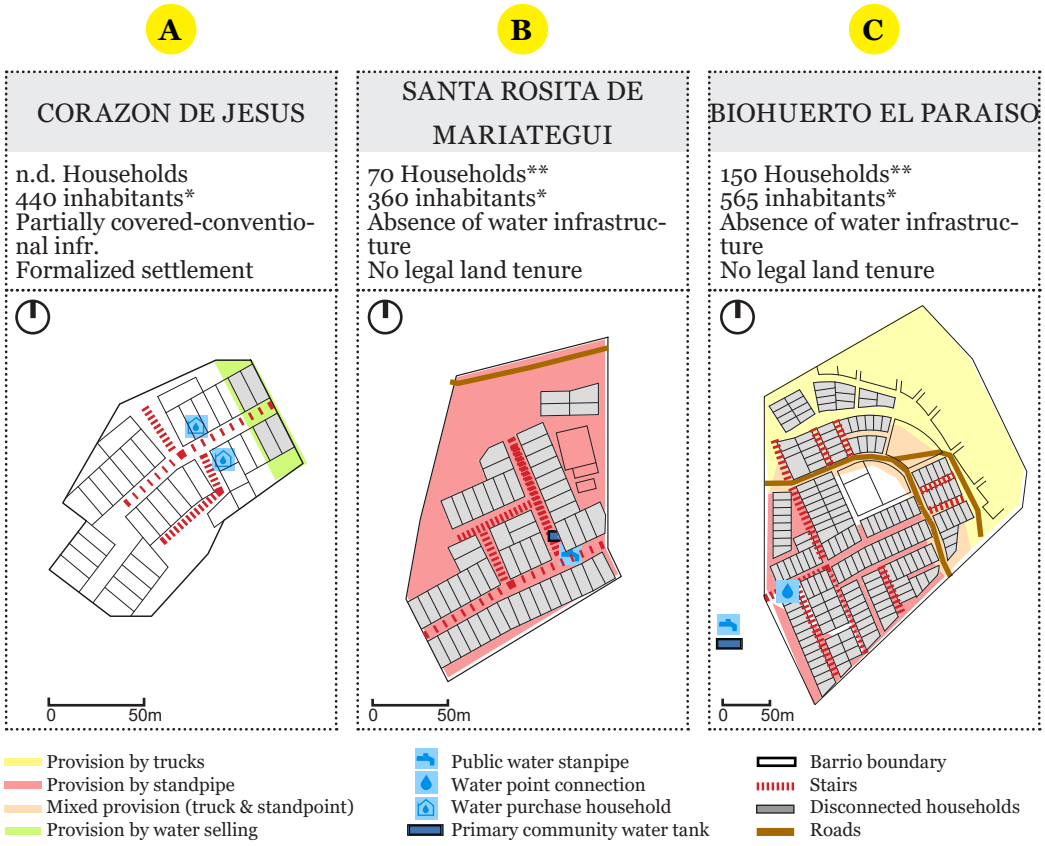


Figure 5.2 - Barrios of analysis and types of provision
Source: Author, 2020
* Based on Cenca (2018)** Based on interviews

water through a primary storage tank of 2.5m3 that is connected to a booster pump. Through a network of plastic pipes that run under the ground, the water flows uphill 50 meters on average via booster pumping before it reaches a self-built public standpoint within Biohuerto's territory. Later, the infrastructure of the community-led system consists of a network of hosepipes or water pipelines, where drinking water flows to secondary water storage tanks located in the open space next to stairs and roads.

It should be noted that the location of each tank aims for maximum coverage of the households around taking into account the length of the hose for drawing water between each water tank. Furthermore, the volume capacity of each tank is decided upon the number of plots that it will serve. For instance, there are 3 tanks of 1m3 and each tank supplies approximately 30 households; while one water tank of 2.5m3 supplies the further away 60 households approximately.

After the water is available in each tank, household members depend on their tools to draw water from the community network to their households. The community delivery scheme is not directly connected to individual households. Each household uses a myriad of water containers that differ in capacity and material, to fulfill their domestic uses.
This self-built system of Biohuerto based on a net of water tanks and pumps to make the water flow uphill deploys three scales of arrangements: the city scale with the water utility provision from the standpipe, the neighborhood scale with the community provision, and the household scale where residents secure water on an individual basis.

At the city scale, there are two types of water and two main providers. The types of water influence differentiated services. In one case, the water supplied by trucks is directly self-provisioned at the household level. On the other hand, drinking water supplied by the utility becomes the source of the community-led system. Additionally, the difference between the private provider (water trucks) and public provider (Sedapal) determines as well the modes of organization depending on the cost and availability of the supply.
The public standpipe provides water regularly but it faces seasonal shortages and limited metering, which affect the number of water volumes that the primary water tank could collect. Hence, the community network can only deliver water to a minimum of two and a maximum of six households daily with a limited amount of water. On the contrary, the water trucks supply water occasionally (every two weeks) but providing the total capacity of the households' water tanks. This situation clearly emphasizes that despite the regularity of the supply, the availability of water impacts the few options for inhabitants, thus the arrangements for access and storage are taken at a household scale, which is explained in-depth in the analysis of everyday practices.

5.2.4. Production of a regulatory association

Although the infrastructure seems inefficient and problematic, it follows a strong organizational logic behind it to control freeriding and to secure regular distribution.
In most of the settlements from Jose Carlos Mariategui (JCM), there exists one person who represents the water committee in each barrio. This water representative organizes the management, the daily water distribution, handling the booster pump padlock, collecting the fees for the water service for paying to the

	A	B	C
	CORAZON DE JESUS	SANTA ROSITA DE MARIATEGUI	BIOHUERTO EL PARAISO
Main source	 Water selling from household already connected to Sedapal.	 Water standpipe from Sedapal. Main source of drinking water for barrio Santa Rosita.	 Primary community water tank. Located in barrio Santa Rosita. Includes community motor pump and connection with standpipe. The pump is locked and only accesible in schedules-for collection (6am-6pm)
Distribution	 Alternative tap, self-constructed outside the household to draw water outdoors.	 Primary community water tank, separatedly from standpipe. The distribution has opening schedule,depending on the water available.	 Water point of connection at the entrance. Community hose of 100 meters long is the main spine of the distributional system for drawing water to the community scheme.
Mechanisms	 The containers of storage locate outdoors next to the house for ease of collection. Some end-users have their own hoses and pumps.	 System of key control for operating the motorpump. The water caretaker delivers the key per turns.	 Secondary community water tanks (total 7), connected through hoses to reach uphill.

Figure 5.3 - Technological arrangements in community-led system for access to water (poly-tanks, booster pumps, public standpoint and hoses).
Source: Author, 2020. Photography taken in March, 2020

utility, and ensuring that the collectors have access to a sufficient amount of the potable water collected within a fair distribution.
The representative lives in the settlement and is not a member of the board of community leaders because, based on the interviews, an independent actor tends to be impartial in regulating finances and conflict management. In Biohuerto El Paraiso, Mrs. Regima Perez has been responsible for water distribution for three years, and it is worth mentioning that there is no payment for any of the community roles.

The water utility SEDAPAL does not charge to individual households, they release a collective bill with the consumption registered in the meter of the water standpoint. The payment is collected monthly in the community meetings and all the households of Biohuerto pay regardless of participating or not in the community-led system. Although access to water is not always guaranteed, there is a strict payment system to continue participating in water delivery.

For instance, the water committee is authorized to suspend the access to the padlocks of the booster pump for drawing water uphill, whereas, frequent non-payments represent a veto for participating in the monthly Assemblies and a consequent fine. In this way, the water utility transfer responsibilities to the Asociacion Vecinal or Community-based organization for the management of the water meter and for collecting the fees. While the transfer of responsibilities to the community influence the production of hierarchies of power, it has not influenced an exclusive control over the water source within the barrio. Although, it seems to bypass the capacity to pay from the marginal households and aggregate extra layers for those located further up-hill who are not directly benefiting from the community-led system.

The maintenance of the community water network is self-organized between the residents of the barrio. It includes the repair of tubes from fissures and cracks and water tanks cleaning. Since various plots in Biohuerto share the distribution from community poly-tanks, the respective households maintain the tank that serves them. While all inhabitants participate in the maintenance of the primary water tank during ‘faenas’ or communal work. Based on interviews, the inhabitants claim that the water tanks have not been maintained since the time they were bought. This lack of maintenance increases the vulnerabilities to unsafe storage and water loss and affects greatly the water security of the settlement.

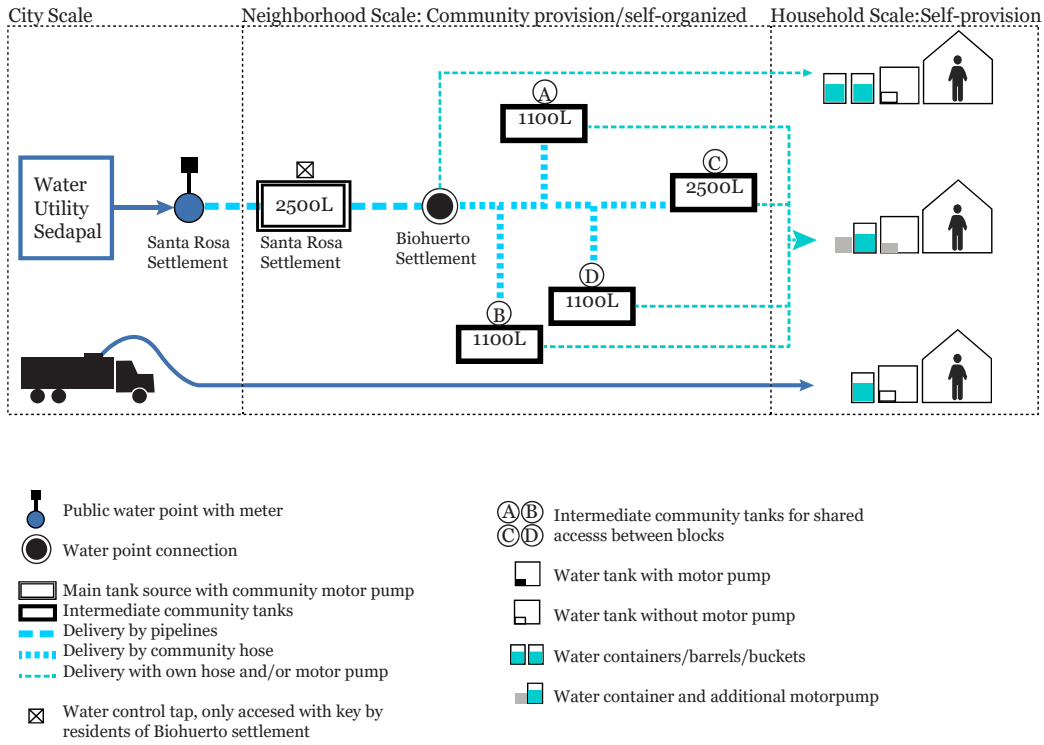


Figure 5.4 - Water delivery configuration in Biohuerto settlement.
Source: Author, 2020. Elaborated from the findings of fieldwork

Figure 5.5 - Community-led system in Biohuerto settlement.
Source: Author, 2020. Photography taken in March, 2020

5.2.5. Decision-making spheres

The monthly Assembly roundtable is the arena to discuss priorities for the autonomous urbanization of the settlement where the participation of at least one person per household is mandatory. For instance, decision-making for upgrading the community led-system involves the community leaders, the water committee, and the residents who decide upon the claims of improvements or deficiencies. Furthermore, when a new resident moves into the area, access to water is not guaranteed as it depends on the location of the new dwelling, and the ways to plug into the community scheme are individually driven.

As mentioned before, the water representative regardless of the amount of water being consumed charges all the residents a fixed amount every month. The revenue from the collection of the fee becomes the funds for the maintenance of the system. However, when the budget for maintenance exceeds the amount of the revenues collected, the CBO shares some funds. Based on the interviews, the capital of the inhabitants is a contingency procedure for collecting funding and mainly collected when there are bigger projects to develop in the barrio.

This circumstance illustrates that the community-led system's upgrading seems to depend exclusively on the spending power of the inhabitants, as the technical or economical support from the water utility is inexistent.
The following table summarizes the community water governance in barrio Biohuerto corresponding to the existent system.

Table 5.3 - Governance model for community provision
Source: Author, 2020 based on basic governance models for public utility (Bakkler 2003, McGranaham and Satterhwaite 2003, Mc Granaham et al. 2001)

Table 5.3: Governance model for community provision in Biohuerto El Paraiso, JCM	
Asset owner	End-users
Asset manager	Water caretaker / Intermediary
Role of consumer	Community members
Organization Structure	Association / Water committee
Accountability	Community norms
Decision-makers	Community leaders with 'Asambleas' participation
Goals	Serving community and time-saving benefits
Incentives to perform	Community opinion and up-scaling to formal connection
Sanctions for failure	Social pressure, no access, precarious livelihood
Customer participation	Collective, bottom-up
Business model	Community cooperative

5.3. Everyday practices for access

The scarcity of the resource and the inefficient regularity of the public standpipe also influence household practices to secure access to water. These everyday practices reflect thus the adaptation strategies of disconnected households. In JCM, everyday practices depend on individual and collective ways for self-provision that develop progressively.

Additionally, the legitimation and consolidation of the practice depend on the meaning and values to water that people acknowledge as 'public' (Lopez 2014). The notions of 'public' articulate claims about access to water as a right to citizenship, and measures to confront water governance institutions (Pilo 2018). Moreover, the production of urban waterscapes seems to structure localized practices and codes of conduct (Ahlers et al 2014). The case of JCM illustrates the diverse practices between households according to their location in the hillside territory, their community norms, and the values of the water resource.

According to the case-study research, the range of practices is based on adaptation, solidarity, recycling methods, transaction and negotiation agreements, and contingency responses.

Figure 5.6 - Categorization of everyday practices in JCM
Source: Author, 2020 based on fieldwork

5.3.1. Chasing alternative tap

Chasing for water is not just about getting a source to access, but it refers to all the implications leading to the security of an 'alternative tap for continuous provision', for instance, the relationships with values of water as a public good, and the challenges of implementing alternative methods such as disruptions and time loss.

In Biohuerto and Santa Rosita settlement, the residents who live close to the water standpipe benefit from facilitated access. They can fill their tanks, barrels, or gallons directly from the water standpipe. Practices differ when the community hose, used for direct delivery, does not reach the house. Then it becomes the tool for drawing water from the public water point to the next secondary water tanks. In this case, the residents adapt the distribution system by using their motor pumps and other provisional hoses to drive water further uphill, but the total amount of time spent on collection duplicates because it might require double pumping.

Another strategy that seemed to improve the issues of water loss and timesaving was the implementation of pipelines to draw water between community water tanks rather than manipulating hoses for mechanical water delivery for every use. However, the pipelines were constantly damaged by constructions on the road because their implementation was not buried, and it was self-constructed with a lack of technical support.

> *Felicita claims that she usually waits more than one hour per person who lined up before her turn. When she finally gets the key for activating the motor pump, she spends almost one hour to collect water in the community tank, which is closer to her home. After that, she uses her motor pump for 30 minutes to deliver that water into her tank. Contrarily, Mrs. Sabina Mamani only spends less than 5 min to reach the water source once it is her turn to obtain the key. She starts the community motor pump to draw water uphill through the hose, but Sabina's containers are already reachable without using any other community tank. Thus, whenever she collects water, she spends from 5-10min to pull and place back the hose and 15 minutes to fill up her containers at home. (Transcription interviews, march 2020)*

As noted, time for access to water involves three main phases in the community-led system of Biohuerto: (1) the time spent waiting for the corresponding turn, (2) the time spent to reach the water source, and (3) the time spent when filling

up the water containers at home.
Practices during the first phase involve turn-based queuing to receive the key that starts the motor pump in the public standpipe. The water representative under restrictions of limited time (1 hour) organizes the turns every day. In the second phase, the time spent to reach the water source varies from 3-10 minutes. Filling a primary storage tank though takes over an hour, indicating the queuing timing does not match the needs of the residents. For this, residents employ two shifts within the hour allowed in the first phase. First, they collect the necessary amount of water needed in the primary water tank. The second shift is dedicated to pumping the potable water uphill, which takes on average 30-40 minutes. Finally, inhabitants take from 15 min to 60 min to fill up the containers at home depending on the number of household containers.

These instances explain the timesaving issues when chasing for water. The first phase of turn-based queueing seems to be the determinant factor leading to significant timesaving benefits.

Furthermore, the majority of residents interviewed expressed their desire to have individual meters instead of a collective meter. A reason seems to involve the relationships between rights for urban services and property rights. For instance, although there is a lack of land tenure, most of the barrios have achieved access to electricity through programs for extension of networks (Criqui 2013). The Electricity Company ENEL through individual connections provides it legally. This way, inhabitants of JCM pay monthly for the service and can reclaim the security of a permanent connection. Likewise, achieving the individual water connection signifies a process of recognition that encourages households' goal to obtain land tenure. Another reason seems to relate to better control of their expenses and water consumption practices accordingly.

5.3.2. Lending and renting as solidarity

The primary source in the settlements of Biohuerto and Santa Rosita is the public water standpoint. When this source is scarce, water supply from trucks becomes necessary for all the residents. The water trucks are private operators that frequent the settlements uphill only when at least five families have contacted them for provision, reproducing as well more scarcity situations. Consequently, individual strategies have been developed based on solidarity responses, depending mostly on the relationships among family members, friends, and neighbors. For

instance through the following: water gifting from neighbors of Biohuerto and in-between settlements with water buckets without costs, or extending hosepipes between houses. Some other prevailing practices to augment water access are the purchase of water from neighbors per bucket or water bottles at the store. This is the case of some households from the settlements of Corazon de Jesus and T5'Ampliacion, barrios connected to the formal networks of potable water, which become water suppliers of the adjacent disconnected settlements.

Mrs. Sabina Mamani declares that when there is not enough water coming from the public water point, she goes downhill the stairs with her empty water bottles to collect water from her daughter's house, who has the water and drainage connection. Sabina collects approximately 21L to get by until the next day when she can collect from the public water point again. She also employs in total almost an hour, which is 20 minutes going downhill and from 30 to 40 min carrying her full water bottles back uphill. Even though she bears more difficulties through this secondary water source, she prefers not to buy water from the trucks because it becomes more expensive when buying just a few liters. Besides, Mr. Julio Ricaldi also collects water from their neighbors, their relatives living downhill. Since his house is next to the surrounding road, he drives through the hills with tuktuk instead of going downhills by the stairs. Julio can take more containers up to 50L to get by until the next day and a total of 40 min for the water collection.

Another form of solidarity identified as a short-term solution is moving temporarily to the house of a family member. This household has a connection to WSS and is mainly located in the flat areas of JCM. While moving temporarily, the WSS and fees are shared. Finally, there exist practices when households do not have the necessary budget for buying a booster pump. These include lending the equipment per day at the price of 10 soles (3 dollars), from one neighbor to the other. These examples display that adaptation practices focus more on regaining access to water through different suppliers, facing scarcity and uncertainty collectively or individually, rather than undertaking illegal practices.

The community leaders also emphasize the aspect of no proliferation of illegal connections into the community-led system, but frequent issues of water theft at the household level. It is worth mentioning that this fact can be biased, as the

ones taking part in illegal activities are both unlikely to admit it and also less likely to take part in the research.

Figure 5.7 - Results of everyday practices in JCM
Source: Author, 2020 based on fieldwork

5.3.3. Recycling disciplining consumption

Flows of water define the spending practices of quantity and consumption. Although their instrumental uses state the obvious domestic tasks of cooking, dishwashing, laundry, personal cleanliness, drinking consumption, etc., in every study. The relevance of consumption practices lies beyond this material functionality and focuses on the symbolic and cultural value of water (Ahlers et al 2014). In low-income settlements, scarce resources such as water influence a high value on recycling daily.

In JCM, the most recent irregular settlements, such as Biohuerto, have a status of dormitory cities with less water consumption throughout the weekdays as dwellings are used only for sleeping. Due to the frequent shortages, residents define their activities per day depending on the abundance of the resource. For instance, interviewees claim that laundry as a handwashing activity is done usually twice a month and that there is a need for employing a fluid to reduce the amount of necessary water for the rinse phase. Recycling water is an important quantity-saving practice in Biohuerto, showing values of appreciation of the scarce good. A small percentage (12.5%) seems to employ clean water for cleaning purposes, while the majority prioritize recycling practices. For instance, through the utilization of the water left after washing fruits and vegetables to watering the green areas and the dusty ground around the homes, the use the water left after rinsing (65%) or after dishwashing (44%) to wash out their latrine and clean the house.

The practices of recycling are strongly linked with the discipline of water users to store water efficiently and cope with a longer length of the water collected. The seasonality is also another factor that seems to affect consumption practices. Similar volumes of water stored last twice the amount in winter than in summer.

> *Mrs. Isabel stated that her children stay longer at the house during summer because of vacation periods. Additionally, the cold temperatures of uphill areas influence the frequency of laundry purposes and personal cleanliness. Thus, the water that lasts 15 days in summer can last 25 days in winter… Mrs. Isabel Carrera, who lives with her three children and her husband, owns one 1100L tank, one 90L plastic container, and two 20L containers. Through this practice, she can collect water for up to 20days in average. (Interviews, March 2020).*

It is noted that differences in water sufficiency vary according to the water management at the household level, the existent water containers, and the household member's size (approximately 20L per day). Observation on-site revealed that the residents who have purchased their water tank are mostly the households of families with children to secure more water for incremental purposes. The other households of residents employ a diversity of smaller plastic containers to store water. The residents who own a tank can store more than one week, water supply. The residents who own plastic barrels of water can store water for up to a week if availability is guaranteed.

Overall, the levels of water consumption in unserved areas are very low compared to the consumption in the central districts. Inhabitants of the settlement are aware of poor flows and the centralized municipal water systems while living under scarce conditions of their 'public good' for over ten years. Despite that, the community keeps on expanding and is certain on being provisioned to another public standpoint to improve the community-led system. It is challenging to control the consumption levels stated in the water infrastructure because the number of inhabitants constantly grows.

5.3.4. Spending power of households matters

Another issue that appeared through the interviews was the affordability of all the expenses involved within the access to water. Many inhabitants are aware of the excessive costs that represent alternative water provision rather than the formal water connection. In Biohuerto, prices depend on the type of supply adopted as an alternative method. Some, despite the affordable fees of the community-led system, prefer to pay more for access by water trucks to avoid time loss.

For instance, the monthly bill of the communal meter is shared between the households of Biohuerto, resulting in a fixed amount of three or four soles each house (0.88 to 1.20 dollars) regardless of their consumption. However, since some residents require collecting water from the secondary water tanks via booster pumping, the use of additional booster pumps and electricity supply aggregates to the final amount of individual expenses. When households do not own their motor pumps, they usually negotiate the rent of their neighbors' equipment for a price of 10 soles (approx. 3 dollars).

On the other hand, the expenses of self-provision by water trucks vary from 25 to 50 soles (7.35 to 14.80 dollars) monthly – almost seven times higher than the collection fess of the community-led system. The variations of costs depend

on the capacity of the water container and the location of the household, which means an additional 15 soles charge (4.20 dollars) to pump up the water from the truck to households, settled further uphill the road for accessibility. Due to the excessive costs, most of the residents who live further uphill own their water tanks or bigger storage containers to enable less frequent purchases from the water trucks.

> *Mr. Rayler explains that he pays 25 soles (almost 7.50 dollars) per tank of 1100L, adding a total monthly expense of 50 soles for his two tanks whose water lasts for three weeks. Even though he still pays the monthly fee for the community provision, Mr. Rayler states that he prefers to pay more instead of bearing constantly the conflicts in the water distribution queue and the lack of pressure of the community scheme, which makes it unable to reach his containers with enough water. (Interviews, march 2020)*

These examples clearly state that prices go beyond the ability to pay for the water service provision alone. The conditions of the topography hinder the mobility of water trucks around the settlement and influence prices in the delivery. While the location of the dwelling also reflects the necessity of acquiring additional equipment for access to water and storing. This issue illustrates an extension of the overall disparities e.g. not only high-income districts paying less for water services than informal settlements in Lima (see chapter 2) but the same dynamics are seen in the settlement. Within the spontaneous settlements, those who are worse off further with less spending power pay finally more than those close to the pumps.

5.3.5. Between seller and buyer transactions

The water utility (seller) provides a metered standpipe whereby the unofficial community system of Biohuerto (buyer) taps into. For this, there is a contract of ten years in between that can be renovated if formal networks are still not implemented.

The agreement involves a monthly payment to Sedapal and the contract is settled with a representative of the CBO. The contract signifies for the community the provision of quality drinking water although through a water standpipe with low pressure and erratic supply. Based on interviews, if there are continuous days of scarcity, the water utility ensures a free provision of water through private water trucks until the water standpipe operates again,

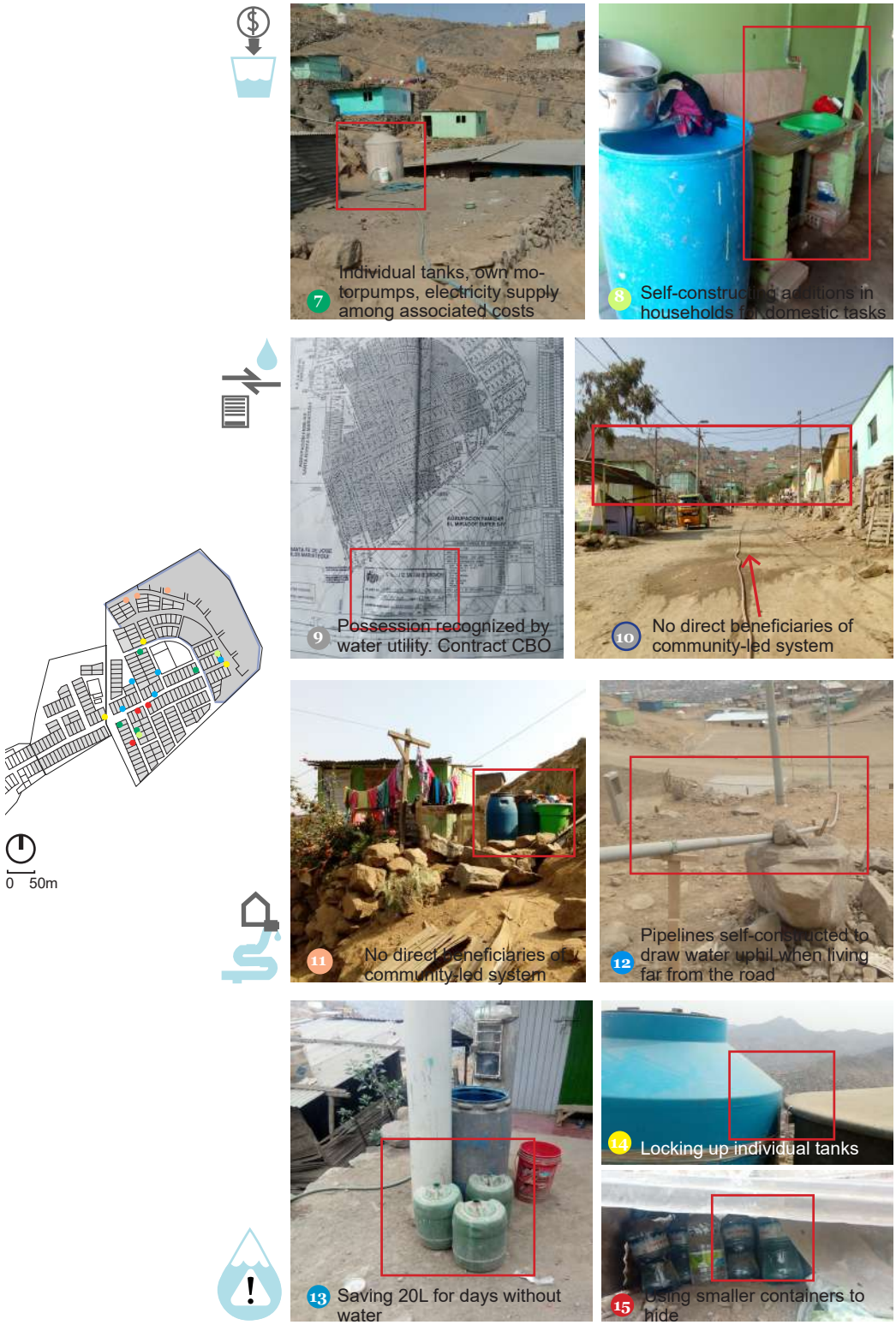


Figure 5.8 - Results of everyday practices in JCM (continuation)
Source: Author, 2020 based on fieldwork

Moreover, the possibility of service cuts conditioned to non-payments seems to influence a strict payment system within the communities to continue participating in water delivery. Even though, (new) households at the top of the hill are not direct beneficiaries, they are required to fulfill the payment, as it becomes part of community funding for future interventions in the barrio.
This illustrates the conditions of connection and disconnection a water offer co-existing with self-arrangements and community rules.

5.3.6. A place uphill for household access

The adaptation strategies depend on the facilities present in households. In Biohuerto, only 12.5% have implemented hand basins at home, while 87.5% continue using buckets with jars for hand washing, cooking, etc. During fieldwork, it was observed that cases of improvised tap display several patterns that influence the configuration of the household spaces. For instance, the implementation of water taps is always outdoors because it is connected to the water tank of the household. This poly-tank locates next to the house, within the plot, and near the common roads or stairs for better proximity to hosepipes and/or ease for water truck provision. Improvised taps are thus separated from the house and the toilet. The toilet is a latrine's hollow constructed further away from the main rooms of the house but within the same plot.

> *For instance, Mrs. Ruth built a big hand basin in her yard and connected it with her tank to draw water and use it for laundry, washing hands, and fruits or vegetables. However, the main cooking activity is done indoors. Further, Mr. Rayler could also upgrade his bathroom with the respective sanitary facilities. His bathroom and his tank are located outdoors near each other facilitating the connection to draw water, but he does not have any other washing facilities indoors. (Interviews, march 2020)*

Practices at the household level also depict the predominant role women have in water collection and management at home. First, 56.25% of household women were largely responsible for water collection. In 25% cases, women still participate in this role but the partner or spouse also supports water collection, while in 12.5% of households, the male is in charge of the collection. Second, the differences within the relationships of water tasks and gender roles are more explicit in the management of water. In 68.75%, the woman is the one regulating the use of water storage, while there are also cases of households sharing tasks between

partners (6.25%) or only organized by the household head (18.75%). Women and children spend abundant time waiting for a turn and managing access to water.

5.3.7. Contingency responses

For the inhabitants of Biohuerto, the irregularity of the water supply of the communal standpipe influences their strategies for the prevention of physical scarcity, employing rain harvesting and water storing practices.

Based on the interviews, both the water collection from the community-led system and supply by water trucks are possible once a day per turn and only during the mornings. Despite the daily water provision, there exist frequent shortages in summer that are also impacted by the lack of pressure of the communal water standpipe. Although, water regularity seems to vary greatly during winter with enough frequency to enable water collection also in the afternoon. These situations describe the relationships between seasonal issues, the amount of water distributed versus the demand for domestic use, which affects daily practices of water-saving and stored, particularly in summer when the water consumption is higher.

One of the main challenges for water storing is constant water theft at night or during the working day. Therefore, practices to secure the water containers forced residents to use smaller bottles, easier to hide indoors than buckets or barrels lying in front or next to the houses; whereas, padlocks are used in the water tanks' lids. On the other hand, there are not systems of rainwater harvesting according to the majority of the households surveyed, because they (93.75%) feel the rain is not enough to arrange a system for its collection. Few cases, such as Mrs. Flor de Maria's claim to be able to get two buckets after strong precipitation adding a total of 5 liters approximately, that she uses to water her garden.

Besides recycling water, inhabitants try to secure at least 20L or one gallon as a contingency method for emergencies. This measure alerts the inhabitants of the scarce volume of water collected that is left and the water collection process starts again. Almost 75% of the residents have adapted these `practices of water-saving against frequent shortages or undesirable events such as a fire. The findings of the length of water stored reveal that an 18.75% plots can store water from 3 to 4 days; 12.5% of plots have water from 4 to 6 days, 37.5% have a water duration of 7 to 9 days; another 18.75% plots, from 10 to 15 days, and another 12.5% of plots, from 16 to 21 days.

6 Framework for discussions

This chapter discusses the production of urban waterscapes in areas of absence or insufficient coverage of water and sanitation services (WSS) to shed light on the self-organized systems for water provision in informal settlements.

The discussion is divided into three sections and a conclusion. First, it displays the interlinkages between 'formal' supply from the programs for network extension in irregular settlements and the 'informal' supply from small-scale operators such as water trucks and water gifting or purchase from adjoining settlements with pipe connections. It argues that JCM consolidation processes have been shaped by progressive access to infrastructure provision resulting in hybrid landscapes. The second section focuses on the new settlements located further uphill that face more difficulties to be part of the formal water connection. The discussion highlight the disparities in access to urban services and the cross-cutting links between the everyday practices and the discursive meaning of water. Lastly, it examines the sustainability aspects encompassing the community-led system of barrio Biohuerto. It also argues the spatial, managerial, and techno-environmental framework to demonstrate that the arrangements of co-production of urban services encourage affordable and adequate urban services.

6.1. Beyond formal-informal urban waterscapes

Urban waterscapes are the outcomes of the political, historical, ecological, and socio-economic implications in the territory, producing a 'tapestry of formality-informality' (Misra 2014; Ahlers et al 2014). In Lima Metropolitan Area, informal settlements are denied access to urban services due to their illegal land tenure status. The rise of populist governments started the efforts for inclusion

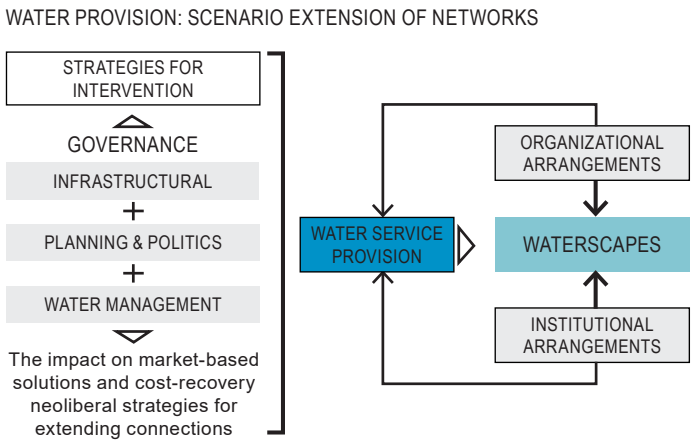
of the poor in the political agenda; water provision has been the subject of presidential campaigns in the name of integration policies. Thus, social pressure and reforms on the water sector since the 90s have influenced the accountability of irregular areas within programs for extension of networks.
In JCM, some irregular settlements participated in the State program APT for the provision of water networks (Nueva Esperanza, Portada de Belen, T5 Ampliacion, Corazon de Jesus). Water standpipes with micro metering are part of the current waterscapes in settlements uphill. Those with no official networks are still negotiating access with SEDAPAL through the project 'Esquema 400-425' (Santa Rosita and Biohuerto). The process followed a vertical top-down engagement instead of a 'local horizontal' governance to involve civil society.

The state water programs share neoliberal strategies for cost-recovery due to the lack of public investment and political commitment to social change. The public provision of water services in spontaneous settlements encompasses 'formality' in the supply. For instance, through the public ownership of the program, i.e. Sedapal regulates and operates the infrastructure for service provision.
Although, the technology implemented is a combination of condominial networks or systems of reservoir and pipelines depending on the topography of the settlement. It is not considered modern technology and it requires low investments for implementation (Bonfiglio 2006). Thus, according to the debates of formal-informal provision, the picture of formality is contradicted by the technology used.

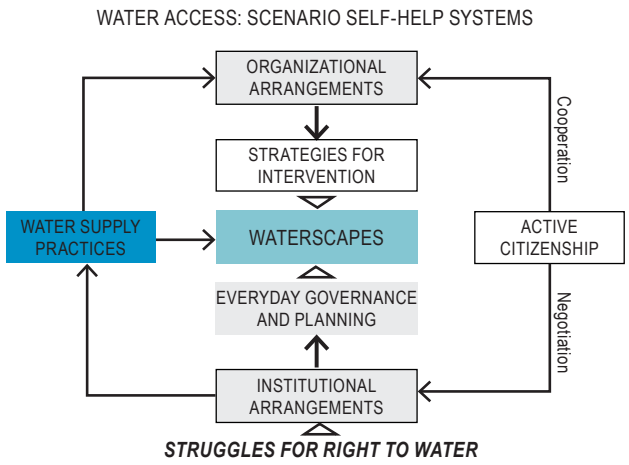
The diversity of water provision systems in JCM coexisting in the same space reinforces the heterogeneous materiality of water, but it is argued the existence of 'formal' linkages in the construction of their informalities. Literature that exemplifies 'informal' systems refer to self-provisioning, private vending, group provisioning, and illegal drawing from the municipal supply (Misra 2014).
However, most of the arrangements for water access in JCM are supplied by the public water utility (SEDAPAL) under a social tariff. For instance, private vending occurs in barrio Corazon de Jesus, a settlement with official water and sanitation networks since 2010 (based on interviews). Household-level adaptations in Corazon de Jesus allow the implementation of external taps in the extension of the house to sell water to neighbors with no connection to formal networks. This case illustrates that the configuration of the formal water provision made viable the entrepreneurial 'informal' activity to cover the water demand.

Likewise, the operation of water pumps to 'informally' drive water uphill is made viable the electricity provision –in some cases- from registered household connections regulated by the utility ENEL. It also depends on the water resource of public standpipes, which is the most common technology in hillsides provided and regulated by Sedapal. Moreover, the residents' associations of each barrio from the settlement JCM are legally registered, but the water caretakers managing the system are not recognized. The case of the community-led system of Biohuerto and Santa Rosita taps into the metered water standpipes under a contract of ten years with the utility. It is paid monthly, but the community is not registered as the client, only one of the representatives from the residents association.

Figure 6.1 - System configuration beyond formal-informal.
Source: Author, 2020



The water sector has evolved through different neoliberal policies shaping the operation of services, provision of services in informal settlements and the waterscapes of the periphery.



In contrast, the water delivery configurations develops a responsive cycle of organizational and institutional arrangements that encourage active citizenship.

As explained, markers of formality exist in the diverse modes of self and group provisioning in JCM. Misra (2014) argues that the formal-informal categorization of water provision delegitimizes alternative modalities over 'formal' systems and those organizational-institutional understandings of formality frame better the practices of water provision within the reality of developing locations. Following this conceptualization, the case of the community-led system in Biohuerto presents 'formal' attributes in their group-provisioning system and describes better the 'hybrid landscape'.

The community organization is deliberately created and registered in the municipality. It emerged originally due to collective interest in shaping the occupied territory but it achieved recognition and evolved progressively ensuring common needs. At the community level, there are rules, codes of conduct, and particular transactions for user fees and collective water charges. Moreover, inhabitants installed and built themselves the unofficial system of water tanks, pumps and hoses, employing a formal water source (standpipe) coming from SEDAPAL networks and highly regulated by a water caretaker from the community.
Misra's conceptualization helps to emphasize the valued attributes of formality in the informal self-provisioning systems in JCM, where formal rules and procedures of the water utility coexist with informal norms, structures and patterns of behavior. Therefore, the dynamics in fluid formal-informal waterscapes help to recognize the possibilities of other sustainable arrangements.

6.2. Citizenship recognition through collective and individual struggle

In Lima Metropolitan Area, there is a myriad of fragmented responsibilities and institutions within the water subsector, thus different ministries, overlapping functions, regulate environmental or health impacts. A centralized state with a lack of comprehensive policies, lack of political pressure for water, and sanitation improvements have influenced top-down and engineered perspectives which consider solutions on supply augmentation and cost-recovery as priorities such as disconnection for non-payment, micro metering for revenue., bypassing qualitative and affordable provision.
According to Pilo (2018), the lack of urban services in informal settlements have restructured the power relations for urban inhabitants shifting away the state control impacting self-building of services and housing as a way to construct right to the city themselves and to demand recognition from the state (Pilo, 2018, p.17). Furthermore, the infrastructure provision appears to re-shape the urbani-

zation process of irregular settlements because it becomes a source of legitimization to occupy the area and eventually achieve legal recognition.
The programs of extension of networks set up the conditions under which the inhabitants are included in the normative network. For Jaglin (2002, p.231) there is a compromise between the provision of universal access and principles of cost-recovery to include the participation of the poor.

Despite the aim to target people of low-income levels, there are other technical arrangements such as preparing the ground and building the retaining walls for stabilizing the roads where infrastructure will locate. These arrangements are not implemented by the water utility. The inhabitants apply for funding for materials and build themselves – mostly without technical assistance- to reduce costs. Thus, the measures implemented defy the spending power of the community and the exclusion of poorer disconnected settlements.

6.2.1. Crosscutting links with water supply practices

The discussion also highlights the following conditions that intersect with insecure water access and influence greater challenges for daily supply. For instance, gender inequality, sanitation practices, illegality, levels of access depending on affordability, quality and quantity.

Gender and water

In informal settlements, the lack of connection to the formal network leads to the perpetual mechanisms of improvisation influencing health problems, water insecurity, and gender inequalities. The community-led system manages the water collection tasks based on daily turns to a limited amount of people. It demonstrates a major workload of women and their children, who spend a considerable amount of time and energy in the queue waiting for the turns of distribution, while men hardly take part in these domestic roles. Women spend most of their time ‘under the expenses of employment and free time’. Children suffer from health problems because of carrying heavy buckets while helping their mothers, and because of the hygienic conditions that they are exposed to.

Participation and water

Sustainable growth is strongly linked with collective action and capacity building to reduce shared water risk. The engagement of stakeholders and civil society for the affordability and accountability of infrastructural services, particularly

water and sanitation services, is lacking within the recent programs of network extension. Comprehensive management of urban waters to promote water access for all, involve recognizing the linkages between infrastructure system and dialog among actors.

Sanitation and water

The sanitation service of the community interlinks with the water supply system and living conditions. For Biohuerto El Paraiso, lack of sanitation and infrastructure for waste and water disposal has forced the residents to depend on self-built latrines privately owned, where approximately 82% of residents have a latrine located in the back of their houses. Some residents have further installed toilets, while fewer continue using just the latrine hole. Based on interviews, the residents implemented waste disposal pipelines outside their plots during the first years of occupation, thus black water and fecal waste were discharged in the common road and stairs. This situation lasted two years before the implementation of latrines, because of the health impacts identified and the drawbacks that it could generate in the feasibility evaluation for the future provision of WSS.

In the case of the construction of community toilets, these are located in public spaces in the open air and do not include washing facilities. The facilities are decentralized, built, financed, and maintained by the community. Additionally, Santa Rosita Mariategui's settlement is self-provisioning its first three community toilets, while in barrio Biohuerto, there is a future implementation under construction.

One particular finding in barrio Biohuerto was the perception of the unsafety of dry toilets. Overall, there is a positive perception of latrines' use as hygienic, good control of odors, and easier use, where 94% of residents emphasize these advantages over dry toilets. It is also worth mentioning that the perceptions of risk refer to the presence of insects or mice inhabiting the latrine, and the accidents that can happen with little children with a hole in the ground. The settlement does not identify any gender-related threats in these facilities.

Illegality and water

Cases of illegal connections within formal networks are punished by the water utility. However, the implementation of an unofficial system is not considered illegal as the water standpipe was legally acquired. In a way, tapping into the public source allowed the transfer of power to community leaders to manage easier distribution. Moreover, increased cases of water theft between the households

who could secure the collection and those who cannot afford any of the systems reflects the vulnerability of poorer families not benefiting from a service that they are expected to finance.

Affordability and water

Securing access to water not only depends on purchasing water or paying the monthly charge fee for the standpipe source. The expenses of extra mechanisms such as water pumps, bigger poly tanks, and personal hose become relevant to guarantee easier collection and storage for a longer time. Moreover, the consumption of the resource is also a crucial factor for many disconnected households. For instance, minimizing the use of water allows reducing spending expenses for access to new sources in times of scarcity, because the water standpoints are linked to negative outcomes i.e. frequent shortages, unreliable services and increased household stresses.

On the other hand, the nexus of water-energy-food for planning sustainable cities signifies an alternative focus for the water-poor. It could enable productive scenarios for the neighborhood development or the application of sensitive water-food systems as pathways out of poverty.

6.3. CBOs and water practices in informal settlements

As explained in chapter 5, the barrios of JCM access water via Community-based organizations (CBOs), self-help (water pumping), small-scale vendors (water gifting), and government agencies (social programs). Moreover, the differences in the provision of official water networks vary according to the date of the settlement. For instance, older occupations are settled downhill and have achieved the individual connection to conventional networks of WSS, while the provision uphill relies on unconventional networks and suffers from the intermittent supply. In these settlements uphill, the CBO and water caretakers perform important roles to prevail in a functional and equitable water supply. The NGO CENCA has been a major player in JCM in negotiating for access to land titles but not directly for water access.

Jaglin (2014, p.434) argues that the vitality and multiplicity of service delivery systems lie in those configurations with a range of provisions. The multiplicity of water supply is present in JCM, within a network of actors, tools, knowledge, and values. Particularly, the case of Biohuerto illustrates these dynamic processes within the community provision and helps to identify the heterogeneity of a water system in peri-urban settlements of hillsides.

First, the mix of different stakeholders in the provision of Biohuerto refers to, the public utility that provides a water standpipe for water services, the private sellers through water trucks, and civil society. In Biohuerto, the water standpipe has been the main source for over 11 years (until the time of the interview). There was a process of co-planning the location of the standpipe, whereby Sedapal negotiated with the CBO. CBO involves specific representatives referred to as 'Asociacion Vecinal' - a group of communal authorities with self-experience in executive capacities for budgeting and willingness to manage the settlement.
The CBO is autonomous from the state but formally recognized by the municipality - whereas the water committee works as an independent body regulated by this association.

The unofficial water system has promoted a scenario of easier user-interface for water collection despite the difficulties of its self-built infrastructure in steep hillsides. The efficiency in the distribution and regularity of the resource is still challenging the precarious conditions of new households' occupation. There is a disproportionate increase of dwellers compared to the scarce capacities of the resource. This describes the disadvantages of isolated self-built systems, which cannot cope with increased demand by depending on unreliable conditions of the same amount of water. Moreover, the community-led system does not employ advantageous use of other types of water such as wastewater or rainwater, perpetuating living conditions with physical scarcity and dependency of water trucks.

6.4. Community provision and sustainable urban water supply

The following discusses the implications of the community-led system to guarantee sustainability for water access in barrio Biohuerto. It involves the analysis of economic, socio-technical, organizational, socio-cultural, and environmental capacities (Dakyaga et al 2018).

6.4.1. Socio-technical layer

The technological capacities refer to the infrastructure whereby water flows from the extraction point to the household. The implications of the chosen technology and type of water within the existent resources in the settlement, the land topography, and the seasonal variation. For instance, hydrological resources in JCM such as groundwater and surface water are almost inexistent, rainwater is unexploited and thus the water supplied by trucks and potable water from the Sedapal

becomes the main sources. The climatic features of Lomas ecosystem in uphill areas generate a potential source of water due to the high fog density, although the fog water is not safe for domestic supply.
For the case of Biohuerto, the water community delivery system uses household electricity supply to pump water uphill, with PVC pipes, connected hoses, and community poly-tanks for water distribution. The efficiency of the system is strongly linked with the location of the household in the hill. The characteristics of the urban morphology and the topography of Biohuerto have also influenced the design of the infrastructure and the location of poly-tanks for maximum advantage of water storage and distribution. The challenges after a failure of the technology force residents in walking down long distances by the stairs to purchase water from private sellers and carrying heavy buckets for over 20 minutes.

Overall, there is an incremental performance in the arrangements for water provision. Influencing different benefits for the households, depending on where they are located. As noted, access to water goes beyond the collection because its level of security is affected by the mechanisms of storage. Households with water tanks can improve their daily access and avoid frequent time loss for water collection. The acquisition of improved equipment depends on the spending power of the household.

6.4.2. Organizational & Institutional layer

The CBO and the water caretaker guide operations of end-users through a regulatory framework.
In Biohuerto, the community-led system distinguishes its level of co-delivery, between the water utility providing the main resource and the community as end-users extending a distributional system by their means to secure access to water progressively. The intermediaries include the civil society organizations and representatives of the water committee and Asociacion Vecinal, who are not directly connected to the local government but they are nominated and elected by residents of the settlement.

The case of providers exemplifies the two scales of operations for provision in Biohuerto such as the existence of the water standpoint through the water utility and the decentralized system built by the community as the neighborhood supplier. The provision in informal settlements is part of a debate that limits of responsibility the public investment and defines new roles of agency in their lev-

els of involvement. For instance, Sedapal does not provide funding and technical support for extending infrastructure beyond the water standpipe location but it secures the maintenance and water quality of the potable water.
There is an existent strong institutional apparatus at the community level, but it does not strengthen an incremental performance between barrios. Moreover, the community strategies for control and regulation do not address uncertainty in emergency times. It is at this level where individual strategies prevail for securing access to water.

6.4.3. Economic layer

The CBO bear the associated costs to install the water delivery scheme tapping into the standpoint. Both, the community practices of access to water and the individual practices differ due to the economic power of the household or the community. In Biohuerto, driving urban expansion for instance the fee of more newcomers allowed for the occupation of new plots generates financial capital for the Asociacion Vecinal. Although, this allows a secure budget for upcoming interventions, ignoring the cycle of inaction-expansion affects particularly the demand for water as a scarce resource.
Economic sustainability also depends on the levels of investment that the State secures for interventions of network extension in the irregular areas. Both barrios of Biohuerto and Santa Rosita have started in 2019 their application in Esquema 400-425, almost 15 years after their creation. However, the application does not guarantee the execution of the project. According to interviews, the residents expect waiting over 5 years until the formal connection is finally executed. Due to the lack of public investment, the communities depend on other funding schemes for upgrading their self-built networks. The creation of the unofficial system has only been achieved through community funding and the selling of land plots to new dwellers. In other settlements such as T5,' the donations of materials or water tanks have been facilitated through the municipality. In both cases, the community has the main role of construction.

6.4.4. Socio-cultural layer

In scarcity times, the practices for access to water have a strong dependency on the filial relationships between families of different barrios. Moreover, the history of the settlement illustrates how conditions of informality have repercussions in the social organization, bottom-up informally driven mechanisms, and the definition of decision-making spheres.

Since the water caretaker is a resident from the settlement, there is a familiarity with the water consumption needs and local norms of the community. The delivery service is (seemingly) flexible because it empowers self-collection arrangements, but the amount of water collected and time using the supply are both regulated. There is room for credit purchase unlike the provision through water trucks that require immediate cash.
The community delivery system has developed limited to the immediate neighbors' supply (150 households) because of the low water pressure and poor financial supply. As a result, the experience of the users living further uphill (70 households) and their satisfaction with the coverage are affected.
Overall, the community-led system aims for the community-provision as a system of self-help not as a commercial water supplier, thus making the water committee mutual and collaborative between neighbors.
The limitations of the community provision influence self-awareness about the importance of water as a scarce resource. The system is designed with an incremental modus operandi of the technology to blend with different arrangements.

Another layer influencing social sustainability is the emergence of conflicts between barrios and between end-users from the same community. The time restrictions to manipulate the water pump from the community-led system generate a feeling of dependency. The low pressure does not secure firsthand continuous access and the restriction increment the scarcity of water. However, unlike Biohuerto, Santa Rosita only secure access through the standpipe. While Biohuerto in times of scarcity can purchase water from trucks. The case study of Biohuerto and Santa Rosita shows a sense of trust with the water caretaker, but the conflicts arise when the turns of end-users are limited to few people daily because of the short quantities to collect. On the contrary, there is a sense of mistrust between the community board and the residents because of the delay in accomplishing projects for the barrio. This sense of mistrust makes the participation of residents difficult in communal meetings or Asambleas. For this, the creation of fines is a regular procedure to secure participation. However, it has affected the strength of collective action, particularly in Biohuerto.

On the other hand, the state project of network extension lacks a comprehensive participation system and it only focuses on informing the communities about the administrative procedures and requirements for the execution of the infrastructure.

6.4.5. Environmental and safety layer

The community delivery system fetches water from the standpoint is of improved quality. However, the low maintenance of technology is evident on-site. For instance, the regular handling of the hose and high exposure of poly-tanks to the outdoors influence water quality degradation (turbidity). Moreover, issues in the disinfection of poly-tanks reveal the lack of awareness or willingness to safe storage. Interviewees state that water tanks have not been washed for years. The use of water treatment pills per household was an institutional strategy from the Ministry of Health to cope with low standards of water storage at home or those without filtration methods in taps. It illustrates that public authorities were aware of the deteriorated conditions for water access in informal settlements, but measures were only preventive against waterborne disease.

Furthermore, the unplanned expansion depletes extensively the Lomas ecosystem of the hillsides, due to both the occupation and contamination of the soil through wastewater disposed on the ground. It influences the increment of arid areas and strong levels of erosion. This context of hillside settlements and the lack of formal networks have positioned technology's low cost against water insecurity, but its improvement is ineffective if the resource dynamics (ecological, socio-economic, and political) are neglected as a whole.

6.5. Challenges for water access sustainability

In JCM, urban growth is one of the main factors of risk for sustainable access to water; the settlement continues expanding without having a clear limit on the final population. This unplanned growth reproduces the insufficiency of safe and efficient service provision to sustain the livelihood of the community. Moreover, the impacts of climate change affect the availability of the resource, thus generating scarce flows of water at the neighborhood and city level to supply increased demand. Consequently, rapid growth challenge actions for mitigating risk and allowing necessary offer when upscaling the community water networks.

Among the main challenges of the community delivery system for sustainable water supply, the following corresponds to the main issues identified as disincentives for domestic supply: (1) the low-pressure of the supply, (2) the long waiting time, (3) the frequent water shortages, (4) the long distance to the source, and (5) the location of water points. These circumstances cause conflicts between residents. According to the persons interviewed, 75% of the households consider the low water pressure as

the biggest problem for the settlement. Frequent shortages and struggles for longer waiting time increase during the summer season. Thus, conflicts for queues occur while there are delays in every turn of the water distribution. On the other hand, water prices and water quality are not arenas where the community can act upon as they depend on the water utility tariffs. The scheme of the community provision has located the community tanks in strategic locations trying to comply with easier access from households to the source and faster connection from the main water pump. Despite the apparent close distance to the source, there is a need for a double workload to operate the community-led system when going to the source for unlocking the padlocks and maneuvering the hose to reach the respective containers for collection.

Moreover, the complexities of water-related development issues increase the challenges in low-income settlements of peri-urban areas.
The water problems in Lima go beyond networks. They have a root in the peculiar geography of the country. Almost 10 million people live in the semi-arid coast of the city characterized by a lack of precipitation. Researchers stressed on the 2% of the total hydrological resources to serve the capital, in comparison with the total water reserves of Peru. According to Aquafondo (2015), these reserves (330-million de m^3) represent only 30% of what other capital cities of ten million people have as water reserves. Increased global warming and high rates of urban expansion seem to intensify the access to water in the future, especially for the more vulnerable settlements. Besides, diverse assessments of the status of water services prove the gravity of deficits in water supply and increasing demand in the Lima Metropolitan Area, e.g. in 2015, the water demand 26.67 m3/s and water supply 20.83 m3/s (AQUAFONDO, 2015; McGrath, 2014). Consequently, ensuring efficient water coverage for all with 24 hr. the provision seems not to only require plain measures in infrastructure augmentation but innovative methods that adapt to the geographic conditions and cope with the risky availability of resources.

7 Lessons & recommendations

This chapter focusses on communicating the lessons on the theoretical framework regarding water services in informal settlements. It enquires on the analysis per topic below such as informal urbanization, urban waterscapes of low-income settlements located in hillsides and their impact on water supply practices.

Moreover, the recommendations highlight the importance of a comprehensive approach to water supply that identifies points of entry for sustained water access. It recognizes the everyday practices of disconnection in households and acknowledges the experience and perception of actors regarding the progressive performance of diverse practices. It is highly important to change the (seemingly) paradoxical situation for the water-poor and their marginalized realities.

7.1. Lessons on informal urbanization

Everyday practices for water security show two main characteristics in informal settlements.

The levels of contestation

- Water connection is perceived as a citizenship right. Whereby, disconnected households have a way to urge claims for regularity, quality, and efficiency. The barrios aim of being part of the large water networks for direct access to tap water.
- In their efforts to access to the formal city, the barrios develop a certain mode of organization autonomous of the state. Community leaders are actively contesting rights and pressing for solutions to the issues of housing, land tenure, and disconnection.

- The lack of access to basic services, especially clean water and sanitation services has empowered the community to find their means for supply. People in disconnected barrios become the infrastructure themselves to have fresh water at home. However, for women, it is mostly disproportionally affecting them than empowering them.
- The communal work or faenas are an important participatory tool for intervening the territory. This way both end-users and CBO collaborate to overcome the needs of the community. However, the lack of total compromise affects the progress of interventions. It became necessary to establish sanctions for mandating constant participation.

The nature of urbanization

- The expansion of spontaneous settlements in hillsides follows a market logic of illegal selling of new land plots, as it constitutes the means for getting financial capital. This revenue is managed at community level to self-fund projects in their physical urban environment. However, the cycle of inaction-expansion in empty areas impacts strongly the future trends of increased demand for water supply. Therefore, there is a need of realizing sustainable growth with reduced shared water risk.
- Access to clean water is the most pressing problem of informal settlements since their creation. The erratic water supply challenges the everyday doing, even though alternative systems have improved progressively the water collection tasks or formal water infrastructure is present. It perpetuates recycling and lending practices throughout the consolidation process.
- Residents struggle on average for 10 years with inexistent infrastructure and limited quantities of water on an everyday basis. As a result, issues of household water insecurity translate into challenges to improve the health and hygiene of the population affecting greatly their spending power.
- According to interviews, most of the recent informal dwellers who live in the recent settlements uphill are relatives of those living in the adjacent formal settlements. This situation appears to explain the social bonds of collaboration for areas with poor water supply.

7.2. Lessons on urban waterscapes

The urban waterscapes constitute a particular lens through which to examine the geographies of formal-informal linkages in the water supply.

The socio-territorial landscape of spontaneous settlements comprises these ur-

ban waterscapes in the hillsides of the periphery of Lima city, where illegality of occupation sharpens limited water infrastructure.

Natural system

- The landscape on the periphery characterizes by desert stony areas with scarce freshwater resources and steep topography with increased vulnerability for human settlements.
- Additionally, the presence of the Lomas ecosystem above 400 m.a.s.l. and a particular microclimate with high humidity appears to be a potential scenario for seasonal alternative resources. Fog water and rainwater represent secondary sources for settlements without water that are not often employed. Its use is only for irrigation and no for drinking. Fog water is not recognized, nor regularized within the institutional frameworks of the water sector.
- Successful projects with fog catchers (Eba Lomas project, 2020) reveal that the infrastructure alone is not beneficial in the long term if community organizations lack the ecosystem's awareness and are not interested in appropriating the system and its maintenance.

Materiality of water

- The urban waterscape is conceived as both the main problem for water scarcity and as the primary opportunity for intervention and improvement. Whereby, the persistence of water scarcity signifies not only the physical water stress situation but also the politicized principles of resource allocation in marginalized areas (Ioris, 2011), where access to services was impacted only in clientelism scenarios.
- Since the neo-liberalization of the economy, the water utility developed programs with socio-technical infrastructure under market-oriented practices, which moved forward without strengthening social and technical capabilities of communities.
- Moreover, official authorities control non-payments for standpipes and formal networks through water cut-offs, disregarding the household income of poor settlements and room for price negotiation. This scenario influences the particularities of uneven urban waterscapes and the lack of pro-poor water policies (Lopez, 2013).

7.3. Lessons on multiple supply practices

Spatial domain

- Technical and financial challenges of water utility defy water quality provision and availability in cities of rapid urbanization and environmental degradation.
- Community-based organizations (CBO) require financial autonomy and technical assistance to allow sustained interventions and post-projects for improvement. Currently, the situation of finite budget and resources depends on collective funds. The spending power cannot afford large-scale repairs of the system, nor associated costs of health impacts.
- The community-delivery system follows a group provisioning for shared distribution and improved spatial accessibility to water sources, but struggles of unreliable water supply, conflicts in queues, un-affordable associated costs affect the upgrading of the system.

Managerial domain

- The institutional frameworks in JCM empower residents to take part in leadership roles within the community organization and the water representative duties. Since only those who live in the community can lead to managerial functions. Moreover, the community has the power to vote for next representatives and to decide on new elections.
- The community governance can be capitalized with assistance provision and funding donors for their community projects, where institutional arrangements are transparent.
- Local power shape the features of heterogeneity in water supply practices interlinking legal/illegal, formal/informal, governmental/non-governmental actors and institutions from community provision to individual access.
- The inhabitants, CBO, water caretaker know well what they need at community level. However, the lack of unified vision towards the development of the settlement influences isolated projects per barrio and imbalanced decision-making for priorities. On the other hand, the municipality is not directly involved in the water service provision nor the recognition of land tenure. There is a state of blindness to the organizational-institutional arrangements of communities switching the municipal resources away from comprehensive improvement in spontaneous settlements.
- The process of co-production projects for extension of networks prioritizes the implementation of conventional networks as the solution to water coverage. It follows a linear process of top-down planning with omitted capacity

building and training for communities that diminishes social empowerment and informed decisions.

Techno-environmental domain

- Despite the presence of the unofficial community-led system for securing water provision, the lack of water pressure defies regular supply. It influences no satisfaction coverage within the barrio that affects social bonds and trust. Additionally, systems are working in isolation.
- The performance of community practices embraces a responsive logical organization that manages scarce resources. It is though necessary to prevent dependency on one single source (standpipe) for operating diverse systems.
- The use of unconventional methods for supply is mostly linked to negative results such as intermittent services and increased household burden. In the case of informal settlements, the variety of types of water supply practices represents a dynamic catalog of self-help mechanisms that supports the involvement of the urban poor.
- Although 'informal' mechanisms are referred to as low-tech and temporal, un-conventional technology seems to adapt to the territory and needs of the community. However, its technology is not resilient to seasonal changes such as intermittent services in summer, while in winter dirty floodwaters affect water points, shared hoses and tanks.

7.4. Recommendations for sustained access to water

As stated in the research, access to water is impacted by the physical performance of the water system and the total coverage. The 'pragmatic' infrastructures for provision (WSS interventions) consider the landscape and topography conditions but underestimate the complexity of actors on control and social norms shaping the territory for a sustained post-intervention.

The recommendations in the short, medium, and long-term follow the premise of integrated and reliable water service provision that sustain safe and affordable water for the urban poor. Despite the necessary socio-economical changes and transformation of political principles to address water coverage and quality for all, the research frames such a change as uncertain shortly.

The recommendations are situated in the present context, and acknowledge that conventional upgrades are not efficient in times of climate change. They capitalize on the strength and limitations of community organizations to trigger a direct

impact on their livelihoods, despite the limited interest and capacities of stakeholders in the Lima Metropolitan Area.

7.4.1. Short term measures

Community capabilities

The promotion of incentives for personal development can enhance the compromise to continuous participation in 'faenas' and rebuild social bonds. For instance, NGO Cenca could include a program for training interested household members in teams of community builders. Moreover, stronger links between civil society and academia help to assist community leaders in project budgeting and consulting, so they can reflect on their limitations and opportunities of organizational-institutional frameworks with experts' assistance.

Another scenario of structural change constitutes the transformation of the disproportionate workload of women and children of the communities, with a system equally distributed.

Coordinated vision

The group 'Red Comunitaria' aims for improved participatory decision making beyond community level. The community leaders in the group facilitate transfer of knowledge, practices. Although spheres of coordination aim now for upgrading the settlement beyond individual interests, it has mainly focused in accessibility roads, while some barrios prefer to detach from their peers due to their delays in the legalization procedures. It is necessary to avoid self-isolated projects and promote cooperation of official authorities to upscale projects that benefit all barrios in need.

Availability of resources

In a territory of scarce resources, it is key to find alternative water sources and create means for productive waterscapes as a source of income for residents. For instance, capitalizing on climatic seasonal variation and land topography to harvest fog water for irrigation purposes. It will enable the preservation of the ecosystem, the presence of green areas and erosion control on hillside territories. Moreover, taking advantage of a wastewater system will support recycling practices and reduce environmental degradation. The system should not disregard awareness and training activities.

On the other hand, the community leaders should be aware that restrictions of

sprawl benefit themselves greatly with the availability of the limited supply. However, the regulations at community or municipal level will not stop expansion if there are no other means for community funding.

Better infrastructure systems

For the sustainability of the infrastructure portfolio in low-income settlements: The low-tech solutions need a system accountable for its maintenance, paying cleaners/managers, water representatives. Public investment should support with technical assistance and comprehensive participation. The water utility should be accountable for a regular rehabilitation of water standpipe.

Furthermore, official authorities should acknowledge community-managed models and multiple supply practices to co-regulate upscaling. This way, it is easier to monitor public health issues, lack of maintenance, and constant change of leadership.

7.4.2. Medium-term measures

Improved water governance

It is necessary to bridge the gap between the State and the CBO for planning the consolidation and sustainable development of disconnected neighborhoods. Therefore, the acknowledgment of diverse practices within public policy requires strengthening the capacity of private, public and community actors to improve stewardship and go beyond agreements and procedures. For instance, periodic meetings of coordination, and dissemination of results of monitoring can be established by the water utility. While the policy lessons should include training for leadership and self-management.

Financial independence

Encourage financial independence of barrios through a new focus based on community savings. The planning of a budget and an agenda of priorities can help monitor expenses and consider funding schemes in advance.

Coordinating body

A coordinating body is a permanent planning advisor assisting spontaneous settlements especially the ‘Red Comunitaria’. It assists also the water utility authorities into specific planned interventions that will guide the allocation of investment from isolated large scale projects. Then, social programs will develop a

more productive interaction between government and civil society. The company also focuses on mega-projects for extraction and treatment of sufficient water supply in the metropolis. However, projects from the state are autonomously operating, while focusing on distribution and coverage augmentation rather than improvements for access methods.

Wastewater systems

The settlements of JCM perceive water as a finite resource. A reduction in consumption followed by improved practices helps to decrease everyday water costs and demand. A system for wastewater benefits recycling behavior, and reduces waste disposal. Moreover, it promotes the recognition of the environmental dimension as a fundamental aspect of conventional water services.

7.4.3. Long term measures

In the long term, the formal connection of service networks by program Esquema 400 is implemented; there is an increased population in barrios and diverse resources to cope with intermittent water supply. The following measures will assure the progress of progressive socio-territorial practices that are aware of the environmental risks of erosion, scarcity, and illegality.

State accountability for the right to water

Structural change is strongly linked with the equality principles within the planning apparatus and participation models aiming for the development of current urbanizing areas. The state recognizes the multiplicity of service delivery in spontaneous settlements. Obtaining public subsidy and partnerships with funding agencies will cover the financial challenges of the water utility to deliver comprehensive projects in hillsides areas in a shorter timeframe.

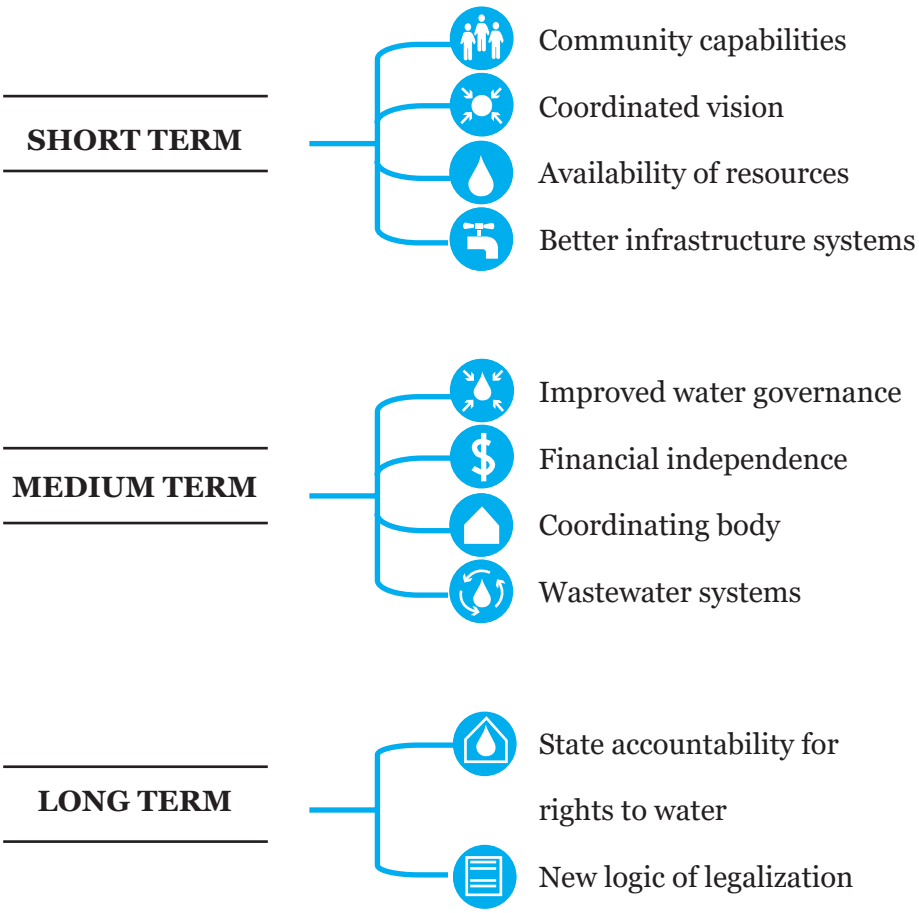
New logic of legalization

In the case of irregular settlements, legal recognition by the state and technical support for self-construction will lead to increased improvement and strengthen social cohesion. For this, the clientelist approach should aim for principles of equality in development to address the needs of communities. Neighborhood upgrading should not focus only on accessibility mechanisms of roads and staircases that encourage further expansion and do not enable productivity.

On the other hand, while socio-technical tools, such as the layout plan and certificate of possession, have facilitated provision of urban services in informal areas;

differentiated procedures for the legalization of land tenure, lack of regulation and coordination continued the urban sprawl. When acknowledging the 'legalization of water' (shift to formal water networks), the implementation of facilitated solutions should include informed negotiations between all actors of the water service.

Figure 7.1 — JCM and proposed recommendations in the short-medium-long term
Source: Authors, 2020



8 Conclusions

This research examined the relationship between urban waterscapes and water service provision beyond the binary formal/informal. It explores the case study of Jose Carlos Mariategui (JCM) settlement to reveal the diverse ways in which people access to water, and how the absence of water infrastructure shapes daily practices both at household levels and at community levels.

The practices for water service provision refer to concrete everyday doings for access to water. These practices are materialized in the territory shaping urban waterscapes. In informal settlements, other social practices such as dwelling, building, and communal working mobilize through space to claim a right to the territory. The significance of analyzing these practices is to highlight the networks and strategies from the perspective of the actual informal dwellers, and their logic for collective gain within institutional arrangements.

The following considerations for investigation can enable practitioners, scholars, activists to deepen the understanding of water service provision in informal settlements, and to explore alternatives of more equal provision of urban services, and sustainable water supply systems.

8.1. Implications

Research

The research attempts to contribute to the literature on the provision of water and sanitation services in the global south. It thus adds a window for state accountability on the development of informal settlements, where negotiation spheres ac-

knowledge and improve social assets within future water policies for low-income areas. Particularly since current efforts from the State to upgrade spontaneous settlements are not being developed comprehensively or are almost inexistent.

The research complements the lack of literature in water and sanitation services from Latin America versus the abundance of case studies from Africa.
Complementing both research and geographical representation helps moving forward the discussion of materialization of water practices into means of communication and representation of the unserved population to official authorities.

Policy and practice

Lack of access to clean water is not a new topic in low-income settlements of the global south. Despite the geographical differences between its regions, scarce resources and increased water demand are global issues evolving rapidly in the context of climate change and rapid urban growth. Particularly, the resilience of the urban water poor in Lima Metropolitan Area has been greatly affected by additional aspects of the desertic geography and broaden gaps of inequality. There are still 1 million people without direct access to tap water in Lima within a continuous consolidation of informal settlements.
While formal interventions of extension of service networks focus on catching up with informal urbanization and future large investment programs, on conventional infrastructure. The geographies of informality persist within projects for the formalization of urban services, such as in the ways to govern socio-territorial capacities.

As a result, innovative dynamics to solve water provision are being 'remade' into hybrid infrastructure. It plugs both formal supply and alternative systems in the middle of contested territories. Alongside next first-hand priorities such as housing, food security, education, and health issues, water is key for the development of any human settlement. Implications for policy and practice should thus acknowledge daily challenges of access to water and recognize the active participation of communities to develop contextualized policies to the realities of urban poor.

A shift in co-design of water services can help to create improved payment modalities and fee programs to ensure accessible and sustained water services. The water utility thus will maintain closer cooperation with low-income users.

8.2. Limitations of further research

This conclusive section describes points to consider in consequent investigations.

Research methodology

Primary sources are an important aspect of this exploratory research. However, lockdown and curfew measures regarding the spread of Coronavirus limited the sample of data collection. Potential future research should bear the challenges of remote qualitative approaches in low-income settlements that often lack internet connection. A major sample includes a better comprehension of all the water supply practices existent in the settlement. However, the selection of barrios in three relevant territories of the hillside enabled an accurate definition of the challenges and consequent strategies for water supply. Further research should acknowledge a major sample (30-40 questionnaires per barrio) to complete the case study comparison.

Conceptual framework

The framework of co-production of urban services enabled a clear understanding of cross-cutting links between actors, the physicality of the urban space and resultant infrastructure. However, the case of the water sector in Lima includes issues of land tenure illegality and definitions of informality that can not be excluded.

Whenever researching informal settlements, the understanding of the historical process helps to question the social bonds within the geographies of the existent barrios. Hence, further research should include a deeper understanding of how the physical urban environment and community organization has been formed and is still forming the urban waterscapes in the periphery. For instance, aspects of educational background and monthly income play a crucial role in understanding why certain practices are preferred over others.

The findings based on governmental reports but further steps should prioritize on-site information as a primary source.

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Annexes

Annex 1

Activities in fieldwork Lima (March - June 2020)

Table A.1 — List of activities
Source: Author, 2020

List of activities Fieldwork		
Nr.	**Date**	**Activity**
1	07-08.03.20	First visit to sites
2	11.03.20	Meeting Roundtable for presentation to Ngo Cenca
3	11.03.20	Visits to water utility
4	12-16.03.20	Interview with community leaders + Household questionnaire
-	16.03.20	Beginning of lockdown measures
5	03.04.20	Online interviews with expert 1
6	04.05.20	Online interviews with expert 2

Annex 2

Experts and community leaders interviewed

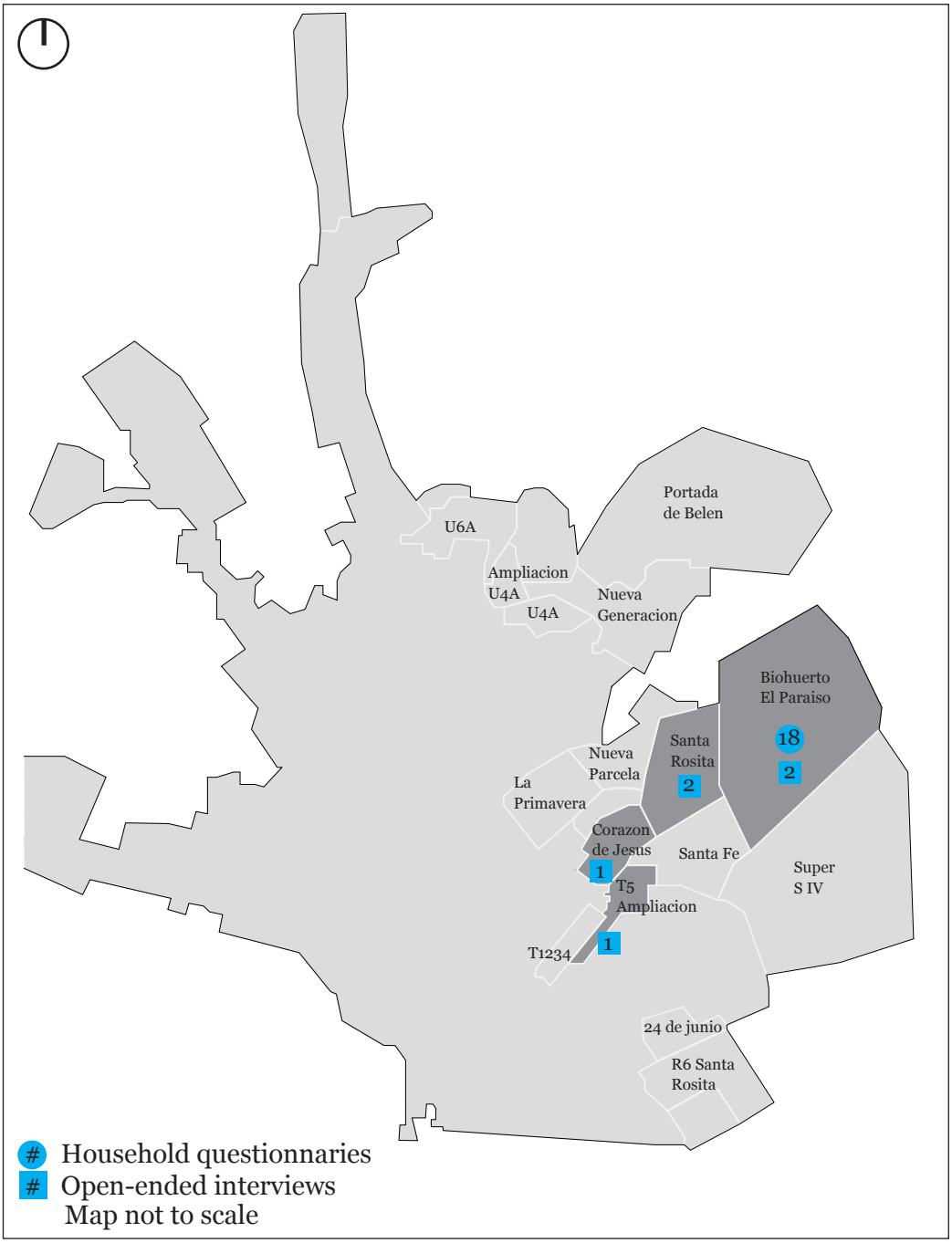
Table A.2 — List of participants interviewed
Source: Author, 2020

List of experts interviewed (March 3 – June 13, 2020)			
Nr.	**Date**	**Interviews**	**Type**
1	07.03.20	Water Utility Company SEDAPAL Ing. Orlando Cabrera	Expert in charge of operations for new water and sewerage connections. Past coordinator of Social Department in Centre sector
2	09.03.20	Dr. Christian Leon	Expert Academia – LIWA project 'Sustainable Water and Wastewater Management in Urban Growth Centres'
3	11.03.20	CENCA Arq. Carlos Escalante	Expert NGO CENCA
4	03.04.20	Geogr. Ricardo Leon	Expert Coordinator Eba Lomas
List of community leaders interviewed (March 3 – June 13, 2020)			
Nr.	**Date**	**Interviews**	**Type**
1	04.03.20	Sr. Alejandro Torre	Barrio Biohuerto el Paraíso
2	13.06.20	Sr. Wilder Ayzanoa	Barrio Biohuerto el Paraíso
3	16.03.20	Sr. Anibal Estrella	Barrio Corazón de Jesús
4	16.03.20	Sra. Mercedes	Barrio Santa Rosita de Mariátegui
5	13.06.20	Sra. Delia	Barrio Santa Rosita de Mariátegui
6	16.03.20	Sr. Carlos	Barrio T5' Ampliacion

Annex 3

Fieldwork areas in JCM settlement, where household questionnaires and open-ended interviews were conducted

Map A.1 — Base map of Jose Carlos Mariategui (JCM) settlement and barrios of analysis
Elaborated by author, 2020



Annex 4

Profile of the questionnarie participants

The household questionnaire was developed in March in the community of 'Biohuerto El Paraiso'. The following table shows the characteristics of the participants. Until this date, 18 people living in the settlement have participated.

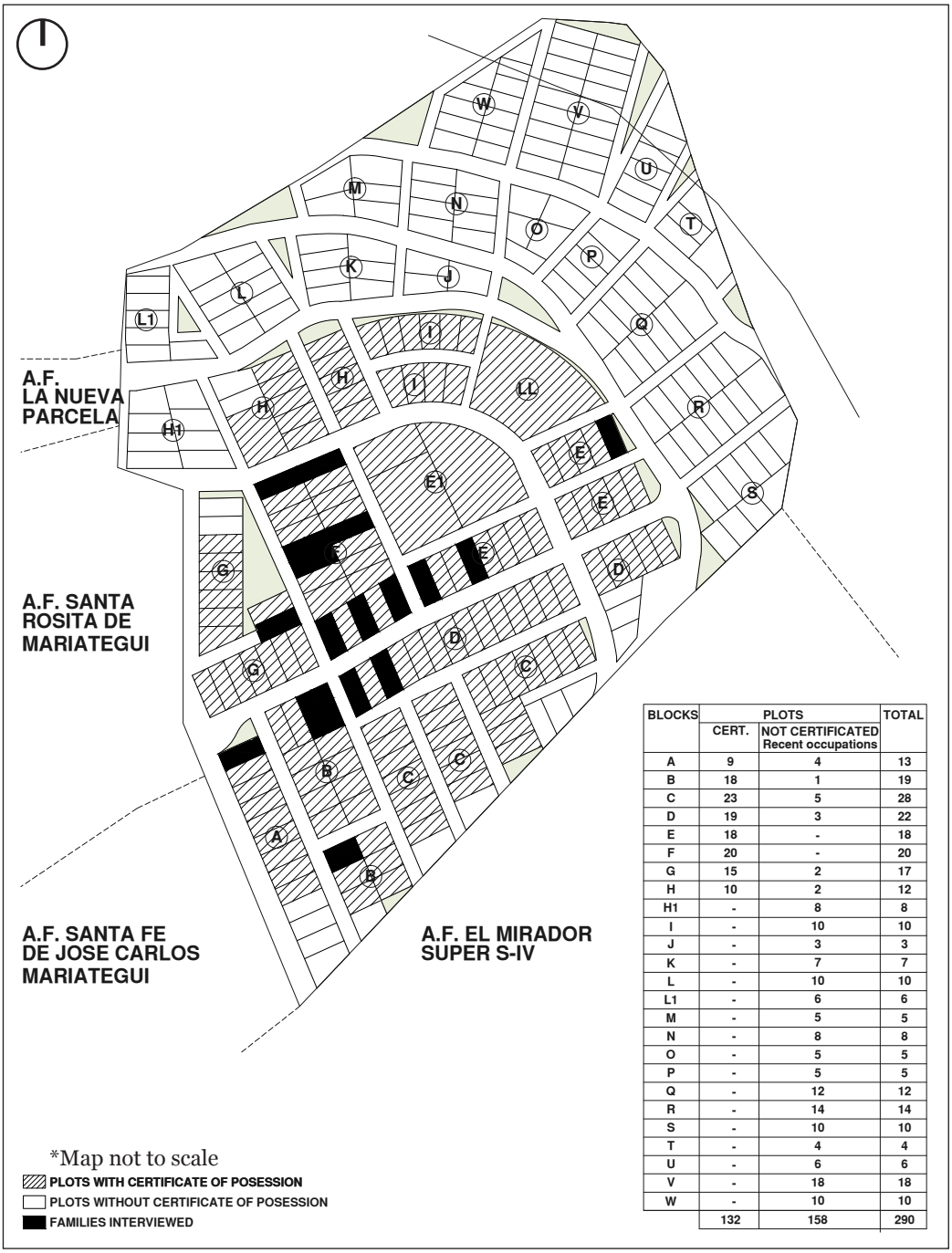
Table A.3 — Profile of the household questionnarie participants
Source: Author, 2020

Profile of household questionnaire participants			
Variable		**Frequency**	**Percentage**
Age	<20	-	-
	20-29	2	11.1 %
	30-39	4	22.23 %
	40-49	4	22.23 %
	50-59	6	33.33%
	>60	1	5.55 %
	No information provided	1	5.55 %
Gender	Male	8	44.4 %
	Female	10	55.6 %
Years lived in the area	1-4	2	11.11 %
	5-9	7	38.89 %
	10-14	6	33.34 %
	15-19	3	16.6 %
	>20	-	-
Household size	1-3	11	61.2 %
	4-6	7	38.8 %
	>7	-	-
Ownership of house	Household head	13	72.2 %
	Spouse of the household head	1	5.55 %
	Rented from external	-	-
	Owned by relative	4	22.23 %

Annex 5

Barrio Biohuerto El Paraiso. Case study

Map A.2 — Layout map of barrio Biohuerto El Paraiso and households participating in questionarie
Elaborated by author, 2020



BLOCKS	PLOTS		TOTAL
	CERT.	NOT CERTIFICATED Recent occupations	
A	9	4	13
B	18	1	19
C	23	5	28
D	19	3	22
E	18	-	18
F	20	-	20
G	15	2	17
H	10	2	12
H1	-	8	8
I	-	10	10
J	-	3	3
K	-	7	7
L	-	10	10
L1	-	6	6
M	-	5	5
N	-	8	8
O	-	5	5
P	-	5	5
Q	-	12	12
R	-	14	14
S	-	10	10
T	-	4	4
U	-	6	6
V	-	18	18
W	-	10	10
	132	158	290

Annex 6

Household questionnaire

The following refers to the transcription of the original document in Spanish.

Table A.4 — Household questionnaire
Source: Author, 2020

MSc. Integrated Urbanism and Sustainable Design
Ain Shams University & University of Stuttgart

HOUSEHOLD QUESTIONNAIRES

0____

Profile of the interviewee:

Name:
Address:
Place of birth:

Years lived in the settlement
- ☐ 1 to 10 years
- ☐ 11 to 20 years
- ☐ 21 to 30 years
- ☐ 31 to 40 years
- ☐ > 40 years

Ownership of the house
- ☐ Household head
- ☐ Spouse of household head
- ☐ Rented from external owner
- ☐ Owned by a relative

Genre:
- ☐ Male
- ☐ Female

Age:
- ☐ <20
- ☐ 20-29
- ☐ 30-39
- ☐ 40-49
- ☐ 50-59
- ☐ >60

Household size:
- ☐ 1 to 3 members
- ☐ 4 to 6 members
- ☐ > 7 members

About water delivery configuration:

1 How do you have access to water?
- ☐ connection to households
- ☐ through hoses
- ☐ water tap within the plot
- ☐ through individual pipelines
- ☐ connection to the barrio
- ☐ water tank at home
- ☐ No connection
- ☐ water reservoirs at home

2 What is your main source of drinking water?
- ☐ water standpoint
- ☐ community water tank
- ☐ water truck
- ☐ bottled water

3 What is your secondary source of drinking water?
- ☐ water standpoint
- ☐ neighbors gift
- ☐ community tank
- ☐ Other sources
- ☐ water truck
- ☐ bottled water

4 How far do you walk to access the main water source?
- ☐ Less than 5 min
- ☐ from 5-10 min
- ☐ from 10-20 min
- ☐ more than 30 min

5 How many times a day do you get / collect water?
- ☐ just one time
- ☐ from 2 to 3 times
- ☐ from 4 to 5 times
- ☐ more than 6 times

6 If you have a water tank in the house, how long does it take to fill the tank?
- ☐ from 5-20 minutes
- ☐ from 20-40 minutes
- ☐ from 40 min to 1 hour
- ☐ more than 1 hour

7 If you don't have a water tank in the house, how long does it take to collect water? Time in line and filling up water
- ☐ from 5-20 minutes
- ☐ from 20-40 minutes
- ☐ from 40 min to 1 hour
- ☐ more than 1 hour

8 How long does the stored water last?
- ☐ I don't store water
- ☐ from 1 to 2 days
- ☐ 3-4 days
- ☐ more than 4 days

9 Who mainly collects / obtains water at home?
- ☐ household head
- ☐ boy child under 15
- ☐ girl child under 15
- ☐ spouse/women household head

10 Who is responsible for maintaining the household water supply?
- ☐ household head
- ☐ boy child under 15
- ☐ girl child under 15
- ☐ spouse/women household head

About water use:

11 How do you use the water you have? Which tasks requires more water?
- ☐ to cook
- ☐ to wash the dishes
- ☐ for shower/personal hygiene
- ☐ for handwashing laundry
- ☐ for toilet/latrine
- ☐ to water
- ☐ to clean the house
- ☐ to drink

Annex 6 (continuation)

Household questionnaire

MSc. Integrated Urbanism and Sustainable Design
Ain Shams University & University of Stuttgart

HOUSEHOLD QUESTIONNAIRES

0____

12 How do you reuse water?

☐ to cook ☐ for shower/personal hygiene ☐ for toilet/latrine ☐ to clean the house
☐ to wash the dishes ☐ for handwashing laundry ☐ to water ☐ to drink

13 Do you do any water treatment before using it?

☐ yes ☐ just for drinking water ☐ no

14 Do you store rainwater? How many liters do you collect approximately? How do you use it?

☐ yes; _____liters ☐ no

15 How much is the water consumption in summer and winter? (approximately)

☐ in summer
☐ in winter

About dimensions of level of access:

16 How often is the service available to people and when?

☐ daily ☐ only the mornings /daily ☐ only at night/daily ☐ every other day

17 How much water is available per person per day?

☐ ltrs community water tank ☐ ltrs water standpoint

18 How much is paid for water monthly?

☐ soles for water standpoint ☐ soles for water truck ☐ soles for combined arrangements

19 What are the supply arrangements with the highest operating costs?

☐ water standpoint ☐ community water tank ☐ water truck ☐ bottled water
☐ neighbors gift ☐ water tank at home ☐ tank and booster pump ☐ others

20 How much are you willing to pay once the formal connection?

☐ ? ☐ standard water fee ☐ fee according to the metering

21 What is the quality of the service facilities available?

☐ Regular ☐ risky ☐ good ☐ bad

22 What are the problems when accessing water?

☐ Long distance to the source ☐ bad water quality ☐ high cost of water ☐ others
☐ frequente shortages ☐ Innaccesible water points ☐ long waiting time ☐ low water pressure

About hygiene and sanitation facilities:

23 What are the hygiene and sanitation services that you have at home?

☐ individual dry toilet ☐ hand basin in bathroom ☐ latrine with toilet ☐ latrine outdoors
☐ shared dry toilet ☐ hand basin in kitchen

24 How do you consider the use of a dry toilet over latrine?

☐ hygienic ☐ unsafe for women ☐ risky ☐ good

25 How do you manage water disposal?

☐ external pipelines ☐ hole in the ground ☐ disposal in gardens ☐ others

About local institutional arrangement:

26 Who is responsible for the distribution of the water?
27 Who controls clandestine connections / illegal water sellers?
28 Who maintains the water system? How are system improvements decided?
29 Who organizes or decides new connections to the service?
30 What is the role of the water committee?
31 What are the operating costs at the water source to facilitate community provision?

Annex 7

Results Water Delivery Configurations in Barrio Biohuerto

Table A.5 — Summarized results water delivery configurations
Source: Author, 2020

Code	Block	Plot	Water delivery configuration									
			Main method of access	Method of storage	Main water source	Secondary water source	Frequency	Duration of water storaged	Time to reach the water source	Time for collection	Time of water storage	Responsible for collection	Responsible for managing
001	B	4	Community Provision/Hose	Cilinders	Water point	neighbor	once a day	one week	Less than 5min	5 to 10 min (pulling the hose)	15 min	Woman household head	Woman household head
002	D	1	Community Provision/Hose	Gallons and own tank	Water point	neighbor	once a day	one week / 20days	less than 5min	1 hour waiting when queuing	40 min	Woman household head and son	Woman household head
003	E	1	Community Provision/Hose	Cilinders	Water point	water bottle	once a day	one week	5 min	10 min	30 min	Woman household head	Woman household head
004	D	2	Community Provision/Hose	Cilinders and gallons	Water point	water truck	once a day	4 to 6 days	5 to 10 min	2 hours waiting	20 to 30 min	Woman household head and son	Woman household head
005	F	3	Community Provision/Hose	Tambors and gallons	Water point	water truck	once a day	3 to 4 days	5 min	15 min	15 min	Household head and daughter	Spouse of household head
006	F	5	Community Provision/Hose	Cilinders and jerrycans	Water point	water truck	once a day	one week	10 min	30 min	30 min	Woman household head and grandson	Woman household head
007	E	14	Self-provision	Own tank	water truck	Water point	once a day	two weeks	less than 5min		30 min	Household head and spouse	Spouse of household head
008	F	19	Community Provision	Own tank and motorpump	Tank C	water bottle	once a day	three weeks	5 to 10 min	1 hour waiting for pumping	30 min	Woman household head	Woman household head
009	F	13	Community Provision	Own tank and motorpump	Tank C	water truck	once a day	4 to 6 days	less than 5min	1 hour waiting for pumping	40 min	Household head and spouse	Household head and spouse
010	E	14	Community Provision	Cilinders	Water point	neighbor	once a day					Woman household head	Woman household head
011	F	14	Self-provision	Own tank, rent motorpump	water truck	Tank C	once a day	8 days	less than 5min	2 hours from community	30 min water truck	Household head	Household head
012	F	6	Community Provision	Own tank and motorpump	Tank C	neighbor	once a day	15 days	5 min		50 min	Household head and spouse	Household head
013	B	14	Community Provision/Hose	Cilinders and gallons	Water point	Tank B	once a day	one week	5 to 10 min		50 min	Woman household head	Woman household head
014	B	3	Community Provision/Hose	Tambors and gallons	Water point	neighbor	once a day	3to 4 days	less than 5min	20 min to 1 hour when queuing	20 min	Household head and spouse	Household head
015	F	18	Community Provision	Gallons and own tank	Tank A	neighbor	once a day	15 days	less than 5min	1 hour waiting for pumping	60 min		
016	F	1	Community Provision/Hose	Cilinders and jerrycans	Tank A	neighbor	once a day	3to 4 days	5 to 10 min	15 minto 1 hour waiting	15 min	Woman household head	Woman household head

Annex 7 (Continuation)

Results Water Delivery Configurations in Barrio Biohuerto

Table A.6 — Summarized results in levels of access
Source: Author, 2020

Code	Block	Plot	Regularity	Sufficiency	Quality	Afordability			Water problems			Supply source
						Price	Operating cost	Future cost for access				
001	B	4	morning/ daily	S:15 bidones & W:5 bidones	good	3 to 4 soles	motorpump	depend on meter	long time waiting	low pressure		Tank A-2500l
002	D	1	morning/ daily	S:15 days & W:25days	regular	3 to 4 soles	own tank	depend on meter	long time waiting	low pressure		Tank A-2500l
003	E	1	morning/ daily	S:1and half cilinder & W:1 cilinder	regular	3 to 4 soles	Cilinders	depend on meter	long time waiting	low pressure		Tank B-1100l
004	D	2	morning/ daily	S:1 week & W: 2weeks	bad	3 to 4 soles	Cilinders	depend on meter	long time waiting	low pressure	bad location of water tanks	Tank C-2500l
005	F	3	morning/ inter daily	S:1 week & W: 2weeks	regular	3 to 4 soles	own tank	depend on meter	frequent outages	low pressure		Tank C-2500l
006	F	5	morning/ daily	S:3 days & W: 1week	bad	3 to 4 soles		depend on meter	frequent outages	water scarce		Tank C-2500l
007	E	14	morning/ inter daily	S:1 week & W: 2weeks	good		own tank		long time waiting	conflicts		
008	F	19	morning/ inter daily	S:3 weeks & W: almost a month	regular	3 to 4 soles	motorpump	depend on meter	water scarce	low pressure		Tank B-1100l
009	F	13	morning/ daily	S: 3days & W: 6 days	regular	3 & 25 soles	motorpump/ own tank	depend on meter	frequent outages	low pressure		Tank C-2500l
010	E	14	morning/ daily	S: 8 days & W: 8 days	regular	3 & 50 soles	motorpump/ own tank	depend on meter	long time waiting	frequent outages	long distance to the source	Tank C-2500l
011	F	14	morning/ daily	S: 15 days & W: 15 days	regular	50 soles	motorpump/ own tank	depend on meter	long time waiting	frequent outages		water truck
012	F	6	morning/ daily		bad	3 to 4 soles	motorpump	depend on meter	long time waiting	low pressure	conflicts	Tank A-2500l
013	B	14	morning/ daily	S: 1 cilinder week & W: same	good	3 to 4 soles	own motorpump	depend on meter	long time waiting	low pressure	frequent outages	Tank B-1100l
014	B	3	morning/ daily	S: 4days & W: 8 days	good	3 to 4 soles	Cilinders	depend on meter	frequent outages	low pressure		Tank A-2500l
015	F	18	_	_	–	–	–	–	–	–	–	–
016	F	1	morning/ daily	S: 3 or 4days & W: same	regular	3 to 4 soles	Cilinders	depend on meter	long time waiting	low pressure	frequent outages	Tank B-1100l
				S (summer) & W (winter)								

Annex 7 (Continuation)

Results Water Delivery Configurations in Barrio Biohuerto

Table A.7 — Summarized results hygiene and sanitation facilities
Source: Author, 2020

Code	Block	Plot	Hygiene and sanitation facilities					
			Access to drinking water and sanitation	Sanitation Facility	Washing facility	Hand basin	Perspective	Water disposal
001	B	4	No	Neighbor	buckets	no	—	hole in the ground
002	D	1	No	Latrine with toilet	buckets	no	risky	hole in the ground
003	E	1	No	Latrine with toilet	buckets	no	regular	hole in the ground
004	D	2	No	Latrine with toilet	buckets	no	risky/unsafe	hole in the ground
005	F	3	No	Latrine with toilet	buckets	no	unsafe	hole in the ground
006	F	5	No	dry toilet	buckets	no	hygienic	hole in the ground
007	E	14	No	Latrine with toilet	buckets	no	good	hole in the ground
008	F	19	No	Latrine with toilet	buckets	no	risky	hole in the ground
009	F	13	No	Latrine with toilet	buckets	no	risky	hole in the ground
010	E	14	No	Latrine with toilet	buckets	no	hygienic	hole in the ground
011	F	14	No	Latrine with toilet	hand basin	yes	hygienic	hole in the ground
012	F	6	No	Latrine with toilet	buckets	no	good	hole in the ground
013	B	14	No	Latrine with toilet	hand basin	yes	good	hole in the ground
014	B	3	No	latrine	buckets	no	regular	hole in the ground
015	F	18	No	—	—	—	—	—
016	F	1	No	latrine	buckets	no	regular	hole in the ground

Annex 8

Findings Barrio Biohuerto El Paraiso and Barrio Santa Rosita de Mariategui

The following shows the heterogeneity of equipment to collect and storage drinking water from the alternative systems.

Table A.8 — Findings. Methods of storage
Source: Author, 2020

Methods of storage in Barrio Biohuerto and Santa Rosita de Mariategui		
Plastic conteiner Type1: 33L 	Plastic conteiner Type2: 75L 	Plastic gallons 20L 
Plastic bucket 20L, 10L, 16L 	Plastic conteiner Type3: 90L 	Barrel plastic drum 200L 
Ibc container, 1000L 	Water bottle 20L and 7L 	Water tank, 1100L 

نبذة مختصرة

تواجه المناطق الحضرية في ليما ، الواقعة على ساحل جاف ، صعوبات في الحفاظ على الأمن المائي. المستوطنات العشوائية الحضرية في الأطراف معرضة للخطر بشكل خاص بسبب الافتقار إلى شبكات البنية التحتية الرسمية (من Sedapal) والإمداد غير المنتظم من مقدمي الخدمات من القطاع الخاص (شاحنات المياه).
تعتمد الوثيقة على فهم المعرفة في المناظر المائية الحضرية ، وتكوينات توصيل المياه والتحضر غير الرسمي. علاوة على ذلك ، فإنه ينعكس في إطارين نظريين حول الإنتاج المشترك لخدمات المياه (Faldi et al ، 2019) وإمدادات المياه المستدامة (2018 ، et alDakyaga) وفقًا لذلك.
الغرض من هذا البحث هو استكشاف حقائق ممارسات إمدادات المياه في المناطق الحضرية الفقيرة الواقعة في ضواحي مدينة ليما. يتبع دراسة استكشافية ووصفية من خلال نهج قائم على الحالة. لتحقيق هذا الهدف ، يجمع البحث أدلة من العمل الميداني في ثلاثة أحياء من مستوطنة خوسيه كارلوس مارياتغي الواقعة في منطقة سان خوان دي لوريجانشو. يوضح البحث كيف يتشكل المشهد المائي الحضري ويتشكل من خلال التنظيم الاجتماعي المكاني للمستوطنة ، والممارسات اليومية للوصول إلى المياه الأساسية والخطابات السياسية الحالية لمرفق المياه.
تكشف نتائج دراسة الحالة عن فرص وتحديات التزويد الذاتي التدريجي والمخططات التي يقودها المجتمع. إنه يوضح نظامًا ترقيعيًا لتوزيع المياه يستمد عمومًا من الروابط المتبادلة بين التزويد الرسمي وغير الرسمي (على سبيل المثال ، مواسير المياه العامة ذات الترتيبات غير الرسمية). وبالتالي ، تظهر طرائق تقديم الخدمة المختلطة لتأمين الاحتياجات اليومية. يتم بناؤه من خلال استراتيجيات التكيف ، والسلوك الاجتماعي مثل أنماط الطعن والثقة ، والترتيبات المؤسسية والتنظيمية للتشغيل والصيانة.
يسعى البحث إلى المساهمة في النقاشات الأكاديمية حول تكوينات إمدادات المياه في جنوب الكرة الأرضية وتعميق الفهم لتوفير المياه المستدام في المناطق العشوائية.
الكلمات المفتاحية: المناظر المائية الحضرية ، المستوطنات العشوائية ، الوصول إلى المياه ، الممارسات اليومية

إقرار

هذه الرسالة مقدمة في جامعة عين شمس وجامعة شوتجارت للحصول على درجة العمران المتكامل والتصميم المستدام. إن العمل الذي تحويه هذه الرسالة قد تم إنجازه بمعرفة الباحث سنة ...

هذا ويقر الباحث أن العمل المقدم هو خلاصة بحثه الشخصي وأنه قد اتبع الإسلوب العلمي السليم في الإشارة إلى المواد المؤخوذه من المراجع العلمية كلٌ في مكانه في مختلف أجزاء الرسالة..

وهذا إقرار مني بذلك،،،

التوقيع:

الباحث:

التاريخ: /

المناظر الطبيعية للمياه الحضرية وتوفير خدمات المياه في المستوطنات غير الرسمية.
دروس للحصول على المياه المستدامة في ليما ، بيرو

مقدمة للحصول على درجة الماجستير في العمران المتكامل والتصميم المستدام

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جامعة .....

التوقيع

أ.د.....
أستاذ.....
جامعة .....

أ.د.....
أستاذ.....
جامعة .....

تاريخ المناقشة:.....

الدراسات العليا

ختم الإجازة
موافقة مجلس الكلية .../.../...

أجيزت الرسالة بتاريخ:.....
موافقة مجلس الجامعة .../.../...

جامعة عين شـــــمس

جامعة شتوتجارت

08/16/2020

جامعة عين شـــــمس
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المناظر الطبيعية للمياه الحضرية وتوفير خدمات المياه في المستوطنات غير الرسمية دروس للحصول على المياه المستدامة في ليما ، بيرو

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